THURSTON COUNTY
WASHINGTON
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Thurston County

Drainage Design and Erosion Control Manual

December 2016 Edition. Adopted October 2016.
Effective December 31, 2016

Thurston County

DRAINAGE DESIGN
AND
EROSION CONTROL MANUAL

December 2016

ORDINANCE NO. 15355

AN ORDINANCE RELATING TO LOW IMPACT DEVELOPMENT; ADOPTING THE THURSTON COUNTY DRAINAGE DESIGN AND EROSION CONTROL MANUAL (2016) AND AMENDING TITLE 14, TITLE 15, TITLE 18, AND TITLE 20 OF THE THURSTON COUNTY CODE.

WHEREAS, the Federal Clean Water Act sets a national goal to "restore and maintain the chemical, physical, and biological integrity of the nation's water" and prohibits the discharge of pollutants from any point source; and

WHEREAS, the U.S. Environmental Protection Agency delegates administration of the National Pollutant Discharge Elimination System (NPDES) Permit to the state Department of Ecology under the federal Clean Water Act; and

WHEREAS, the Washington Department of Ecology issued the Western Washington Phase II Municipal Stormwater Permit for smaller Western Washington municipalities (Phase II Permit) in 2007 with the most recent permit issuance in 2013; and

WHEREAS, the Washington Department of Ecology, as authorized by chapter 90.48 RCW (Washington State Water Pollution Control Act), also takes action through the Phase II Permit to control impacts of stormwater discharges to all waters of Washington State, including ground waters, unless the discharges are authorized by another regulatory program; and

WHEREAS, the Phase II Permit requires permittees to "review, revise and make effective their local development-related codes, rules, standards, or other enforceable documents to incorporate and require Low Impact Development (LID) principles and LID BMPs" no later than December 31, 2016; and

WHEREAS, the intent of that review "shall be to make LID the preferred and commonly-used approach to site development;" and

WHEREAS, the Phase II Permit also requires the adoption of a Drainage Manual that is consistent with the Department of Ecology's *2012 Stormwater Management Manual for Western Washington, as Amended in December 2014*; and

WHEREAS, Thurston County staff conducted a multiyear process to revise Thurston County's development standards to support low impact development approaches and techniques; and

WHEREAS, Thurston County is required to plan under chapter 36.70A RCW, the Growth Management Act (GMA), and has performed professional review, public notice and comment with respect to these development code amendments; and

WHEREAS, the GMA requires a process of early and continuous citizen participation for amending the development regulations; and

WHEREAS, an open house was advertised and held on June 15, 2016, and a technical workshop was held on July 19, 2016; and

WHEREAS, the Thurston County Planning Commission held a duly noticed public hearing on June 15, 2016 and recommended the development code amendments to the Board of County Commissioners (Board) following a work session on August 3, 2016, to discuss changes made to the proposal in regards to public comments and input; and

WHEREAS, the Board held a duly noticed public hearing on September 27, 2016, to receive comments on the proposed amendments; and

WHEREAS, the Board agrees with the findings of the Thurston County Planning Commission and has determined that the amendments contained in this ordinance are consistent with the Thurston County Code (TCC) and other titles, chapters and sections of the TCC; and

WHEREAS, pursuant to 36.70A.106, the State of Washington Department of Commerce was notified on August 11, 2016; and

WHEREAS, a determination of non-significance was issued by Thurston County under the State Environmental Policy Act (chapter 43.21C RCW) for the changes contained in this ordinance on August 26, 2016 becoming final on September 16, 2016.

WHEREAS, this ordinance implements changes to Title 14, 15, 18, and 20 of the Thurston County Code.

NOW, THEREFORE, BE IT ORDAINED BY THE BOARD OF COUNTY COMMISSIONERS OF THURSTON COUNTY, AS FOLLOWS:

SECTION 1. AMENDMENTS TO THURSTON COUNTY CODE. The Thurston County Code is hereby amended as shown in Attachment A. Affected titles include Title 14 TCC Buildings and Construction, Title 15 TCC Public Works, Title 18 TCC Platting and Subdivisions, and Title 20 TCC Zoning.

SECTION 2. SEVERABILITY. If any section, subsection, sentence, clause, phrase or other portion of this Ordinance or its application to any person is, for any reason, declared invalid, illegal or unconstitutional in whole or in part by any court or agency of competent jurisdiction, said decision shall not affect the validity of the remaining portions hereof.

SECTION 3. EFFECTIVE DATE. This Ordinance shall take effect on December 31, 2016.

ADOPTED: October 18, 2016

ATTEST:

LaBonita J. Bowman
Clerk of the Board

APPROVED AS TO FORM:

JON TUNHEIM
PROSECUTING ATTORNEY

Rick Peters
Deputy Prosecuting Attorney

BOARD OF COUNTY COMMISSIONERS
Thurston County, Washington

Sandra Romero
Chair

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Commissioner

Thurston County Drainage Design and Erosion Control Manual

Volume I – Core Technical Requirements and Site Planning

Volume II – Construction Stormwater Pollution Prevention

Volume III – Hydrologic Analysis and Stormwater Conveyance

Volume IV – Source Control

Volume V – Stormwater BMPs

Prepared by
Thurston County Water Resources Division
Department of Resource Stewardship

December 2016

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Acknowledgments

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Additional Sources

Washington Department of Ecology Stormwater Management Manual for Western Washington, August 2012

Pierce County Stormwater Management and Site Development Manual, 2015

Low Impact Development Technical Guidance Manual for Puget Sound, December 2012
Washington State Department of Transportation, Highway Runoff Manual, March 2014

I. Introduction

Purpose

The Thurston County Drainage Design and Erosion Control Manual (DDECM) establishes requirements and provides guidance on measures necessary to control the quantity and quality of stormwater runoff produced by development and redevelopment such that they comply with water quality standards and contribute to the protection of beneficial uses of receiving waters in Thurston County. This Manual is an update to the 2009 DDECM, which was adopted by Thurston County on November 19, 2009. The 2009 DDECM was a completely revised update to the 1994 Thurston County DDECM. This updated DDECM is intended to comply with the requirement of the National Pollutant Discharge Elimination System (NPDES) Phase II permit issued to Thurston County by the Department of Ecology to adopt a stormwater management manual equivalent to the *Stormwater Management Manual for Western Washington* (Ecology 2012) by December 31, 2016.

The Manual establishes Core Requirements for development and redevelopment projects of all sizes and types and provides guidance on how to prepare and implement drainage plans to demonstrate compliance with the Core Requirements.

Applicability

The Thurston County DDECM applies to all unincorporated areas of Thurston County. Except that, within specific Urban Growth Areas (UGAs) associated with incorporated cities that have adopted a Drainage Manual equivalent to the *201205 Washington State Department of Ecology Stormwater Management Manual for Western Washington*, the associated city may request more stringent standards depending on the project location.

The requirements of the Manual also apply to cross-jurisdictional projects (e.g., utility, port, irrigation, drainage or flood control district, city, town, county, or other local, state, or federal government entity) located totally, or partly within the unincorporated area of the County unless one of the following applies:

- Activity is exempted from the Core Requirements (see Volume I, Section 2.2)
- Development/redevelopment and stormwater activities are conducted in accordance with an approved stormwater management manual consistent with Thurston County's NPDES Phase II permit and the *2012 Washington State Department of Ecology Stormwater Management Manual for Western Washington* and with approval of the Thurston County Drainage Manual Administrator.

Administrator May Impose Additional Controls

The Drainage Manual Administrator is authorized to request information or to impose controls beyond those specified in this Manual. In doing so, the Administrator shall act reasonably, exercising best professional judgment based on available information. Reasons that the Administrator may act include, but are not limited to, one of the following:

- To protect the health, safety, and welfare of the public
- To prevent water quality degradation and stream bank erosion
- To prevent flooding that may present a risk to life, safety, vital services, or property
- Due to known flooding, downstream problems, additional requirements, reports, analysis may be required
- To prevent landslides along unstable slopes that may present a risk to life, safety, property, or critical areas
- To implement regulatory mandates such at Total Maximum Daily Load (TMDL) requirements within a watershed
- Where the Administrator's direction is needed to correct errors and omissions in order to clarify, augment, or update Manual text. Where this is required, the Administrator will, in a timely and appropriate manner, revise the text and provide the revisions to Manual users. Users are advised to check the Thurston County Stormwater website or contact the County for Manual updates, corrections, and/or errata, policies, and administrator memos that have been adopted to update design and implementation guidelines.

Stormwater Management Approach

The use of "on-site measures" (Low Impact Development) will be an integral part of the planning and design of all future development in Thurston County. The ultimate goal of stormwater management for new development and redevelopment will be to mimic the natural pre-development hydrologic conditions of the site as closely as possible with respect to infiltration, evapotranspiration, water quality, and quantity of surface water and groundwater release from the site. To this end, the design for stormwater management systems for development shall be a sequential process described as follows:

1st Minimize disturbed areas and maximize open space and native vegetation retention.

2nd Limit impervious surface to the minimum necessary and implement source control measures to prevent contact of stormwater with pollutant generating sources.

3rd Use "on-site" (LID) measures such as full dispersion, bio-retention (or rain gardens), and small scale infiltration to the maximum extent technically feasible to reduce or eliminate concentrated flows of stormwater.

4th Disconnect impervious surfaces to the maximum extent practicable to slow the runoff of stormwater from a site and increase the time of concentration. Examples include filter strips, porous paving, sheet flow and concentrated flow dispersion of runoff to native vegetation, and bioretention or rain gardens.

5th For any remaining concentrated stormwater flows that exceed specific thresholds, provide treatment and infiltrate to the maximum extent technically feasible.

6th Minimize release of surface water to protect stream channels and downstream properties by meeting design criteria established for peak flow rates, duration, and volume per drainage manual requirements.

7th Implement controls to manage stormwater runoff during construction to eliminate discharge of sediment-laden water offsite and maintain these controls until the site is stabilized.

8th Establish and implement a plan for the operations and maintenance of the stormwater facilities and provide ongoing maintenance, repair, and operations for those facilities to ensure continued protection of water quality and flow control.

The Best Management Practices (BMPs) described in this Manual help meet the following water quality standards and protect beneficial uses of the receiving waters:

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

Presumptive Approach and AKART

Stormwater management techniques applied in accordance with this Manual are presumed to meet the technology-based treatment requirements 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 the State water quality standards listed above.

The BMPs presented in this Manual are approved by Thurston County and the Department of Ecology and are *presumed* to protect water quality and in-stream habitat – and meet the stated environmental objectives of the regulations described in this chapter. Project proponents always have the option of not following the stormwater management practices in this Manual. However, if a project proponent chooses not to follow the practices in the Manual, then the project proponent will be required to individually *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. Projects interested in pursuing the demonstrative approach should contact Thurston County Drainage Manual Administrator[1] early in the process.

Where requirements in this document are also covered in any other law, ordinance, resolution, rule, regulation, or similar requirement, the more restrictive shall govern.

Stormwater Retrofits

This Manual can also help to identify options for retrofitting BMPs in existing developments. Application of BMPs from this Manual is encouraged when retrofitting existing development; however, there can be site constraints that make the strict application of these BMPs difficult, and deviations from the standards of this Manual may be necessary. In these instances, the BMPs presented here can be modified using best professional judgment to provide reasonable improvements in stormwater management. Please contact the Manual Administrator for assistance.

Relationship to Thurston County Code

This Manual has been adopted by the Thurston County Board of Commissioners and is part of Thurston County Code. Title 15.05 of Thurston County Code adopts the 2016 DDECM as if set out in full. Failure to comply may trigger administrative or enforcement action and result in project delays, fines, civil, or criminal penalties.

How This Manual is Organized

Overview of Manual Content

The Manual includes the following:

- *Core Requirements* that cover a range of issues, such as preparation of drainage plans and reports, construction stormwater pollution prevention, treatment of runoff, control of stormwater flow volumes, protection of wetlands, and long-term operation and maintenance requirements. The Core Requirements applicable to a project vary depending on the type and size of the proposed project.

- *Best Management Practices (BMPs)* that can be used to meet the Core Requirements. 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 that cover management of the volume and timing of stormwater flows, prevention of pollution from potential sources, and treatment of runoff to remove sediment and other pollutants.

[1] Please call 360-754-4681, Option 5

- *Guidance on how to prepare required submittals* including Abbreviated and Engineered Abbreviated Drainage Plans and full Drainage and Erosion Control Plans. The full Drainage and Erosion Control Plan is a comprehensive report and plan that describes existing conditions, explains development plans, examines potential off-site effects, identifies applicable Core Requirements, and proposes stormwater controls for both the construction phase and long-term stormwater management. Depending on the project type and size, one of these plans will be submitted to the County to evaluate a proposed project for compliance with stormwater requirements.

The Manual is organized into five volumes, each addressing a specific aspect of stormwater management in Thurston County:

- **Volume I** summarizes Core Requirements, describes submittal requirements, and contains detailed guidance for the selection of Best Management Practices (BMPs) for on-site measures, Low Impact Development (LID), water quality treatment, and flow control.

- **Volume II** describes BMPs and submittal requirements for temporary stormwater management (erosion and sediment control) at construction sites.

- **Volume III** explains hydrologic analysis, modeling, BMP sizing techniques and requirements for conveyance design. Volume III also provides guidance on field and analytical methods to determine infiltration rates and site suitability criteria, to ensure that infiltration facilities are sited in a manner that protects groundwater.

- **Volume IV** describes source control BMPs used to minimize pollution generated by pollution sources on developed sites.

- **Volume V** describes and provides detailed design guidance for BMPs to control stormwater flows and treat runoff that contains sediment or other pollutants from developed sites.

How to Use this Manual

This Manual has applications for a variety of users. Project proponents should start by:

- Review Chapter 2 of Volume I to determine which of the 11 Core Requirements apply to their project,

- Go on to Chapter 3 of Volume I to determine what submittals will be required, what the submittals shall contain and what site investigations, studies, and mapping will be required.

- Chapter 4 of Volume I will help determine what BMPs should be applied to meet the requirements for on-site measures (LID), flow control and runoff treatment.

- Use the guidance in Volume II to prepare a Construction Stormwater Pollution Prevention Plan (Temporary Erosion and Sediment Control Plan) for your project.

- Volume III provides detailed guidance on hydrologic modeling, conveyance system (pipes, outfalls, etc.) design and establishing design infiltration rates for infiltration facilities (ponds, trenches, bioretention, etc.).

- Once the appropriate BMPs are selected, use Volume V to site and design the selected BMPs. Pay particular attention to Appendix E of Volume V for minimum setbacks from stormwater facilities to drinking water wells, steep slopes, buildings, drainfields, etc.

Related Plans, Permits, and Manuals

The Puget Sound Action Agenda

The Puget Sound Partnership's 2014/2015 Action Agenda identifies a coordinated, regional approach to reducing the sources of water pollution in Puget Sound that reflects six primary objectives. Urban stormwater is the focus of objective #2:

Use a comprehensive integrated approach to managing urban stormwater and rural surface water runoff to reduce stormwater volumes and pollutant loadings.

The Actions that the Action Agenda identifies to achieve this objective that are applicable to Thurston County include:

- Implement the municipal stormwater Phase II permit to achieve overall water quality standards and reduce discharges from municipal stormwater systems.

- Advance the use of LID approaches to stormwater management and provide comprehensive guidance and standards regarding LID practices.

- Prioritize and implement stormwater retrofits in urbanized areas, including roads.

Publication of this *DDECM* contributes to meeting the objectives of the Action Agenda for Thurston County. For more information, see the Puget Sound Partnership website at: <http://www.psp.wa.gov/>.

Phase II NPDES and State Waste Discharge Stormwater Permits for Municipalities

In western Washington, the Washington State Department of Ecology ("Ecology") has issued joint NPDES and state waste discharge permits to regulate stormwater discharges from municipal separate storm sewer systems (MS4) operated by small cities and counties, including the urban parts of Thurston County. There are over 100 municipalities and counties in Washington that are subject to the Phase II requirements.

Ecology first issued a Western Washington Phase II Municipal Stormwater Permit in 2007. The current Phase II NPDES Municipal Stormwater Permit was issued on August 1, 2012 and is effective from August 1, 2013 to July 31, 2018. It is available on Ecology's website: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/PermitsPermittees.html.

As a Phase II NPDES permittee, Thurston County must refer to Appendix 1 of the permit rather than relying on Ecology's 2012 Stormwater Management Manual for Western Washington (SWMMWW) to establish Core Requirements, thresholds, and definitions that must be implemented within the urban areas of the County. The permit also directs the County to require site planning processes and BMP selection and design criteria contained within Ecology's 2012 SWMMWW or an Ecology approved equivalent manual.

The current Phase II NPDES Municipal Stormwater Permit also includes language that makes the use of Low Impact Development stormwater management techniques mandatory, where feasible. This Manual has adopted those requirements for all of Thurston County; however, some areas may have different requirements from other areas. For instance, urban areas of Thurston County (inside the Phase II NPDES Permit boundary or inside an Urban Growth area) have different requirements than the rural areas of the County.

The Phase II NPDES Municipal Stormwater Permit is reissued approximately every 5 years. Future permits may require additional stormwater requirements. Within the timeframes required by future permits, Thurston County will update this DDECM to reflect the new permit conditions.

Only those areas of unincorporated Thurston County that have population densities meeting the criteria of the NPDES Phase II program are covered by the permit. This is principally the area surrounding the incorporated cities of Lacey, Olympia, and Tumwater and includes portions of areas designated as urban growth areas as well as areas outside of the urban growth areas. The applicant should check with Thurston County to determine the current NPDES permit boundary if this information is necessary for the project.

NPDES and State Waste Discharge Baseline General Permit for Stormwater Discharges Associated With Industrial Activities (Industrial Stormwater Permit)

Businesses subject to the *Baseline General Permit for Stormwater Discharges Associated with Industrial Activities* must manage stormwater in accordance with specific terms and conditions including the preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP), monitoring, reporting, and ongoing adaptive management based on sampling and inspections. See the following website for more information: <http://www.ecy.wa.gov/programs/wq/stormwater/industrial/index.html>.

New development and redevelopment subject to the Industrial Stormwater Permit are also required to comply with the applicable provisions of the Thurston County *DDECM*. Where the Industrial Stormwater Permit and the requirements of this Manual conflict, the more restrictive provisions will govern.

NPDES Construction Stormwater General Permit

Coverage under Ecology's Construction Stormwater General Permit is generally required for any clearing, grading, or excavating if the project site:

- Discharges stormwater from the site into surface water(s) of the State, or
- Discharges into storm drainage systems that discharges to surface water(s) of the State, or
- Discharges to or causes trackout that could enter the Thurston County MS4

And

- Disturbs one or more acres of land area, or
- Disturbs 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 and/or Thurston County determines to be a significant contributor of pollutants to waters of the State may also require permit coverage, regardless of project size.

WSDOT Highway Runoff Manual (HRM)

The HRM addresses stormwater runoff issues for typical WSDOT roadway construction and maintenance activities. It has been granted equivalent status by Ecology and can, therefore, be adopted by other jurisdictions. Thurston County Public Works Department road projects may use the HRM or the DDECM to meet stormwater requirements for the project. The most recent version of the HRM including any amendments, revisions or addendum, shall be used and can be found at the following website: <http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm>.

2012 Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual)

The LID Manual is published by the Puget Sound Partnership and provides current guidance on LID techniques and design procedures in Washington State. The Ecology Manual recognizes the LID Manual and references it in its *Stormwater Management Manual for Western Washington*. The LID Manual was updated in 2012 and can be found at the following website: <http://www.psp.wa.gov/documents.php>.

Other State and Federal Permits

Your project may require additional permits, depending on location and type of development. These permits may include one or more of the following, which are described in detail in the Ecology *Stormwater Management Manual for Western Washington*:

- **Endangered Species Act** (ESA): Potentially restricts construction and development activities that affect ESA-listed species or their habitat.

Consultation with the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries), or the U.S. Fish and Wildlife Service (USFWS) may be required and conditions imposed such as preparation of a Habitat Conservation Plan or issuance of a permit for “incidental takes.”

- **Section 401 Water Quality Certifications**: Certification required for projects that require a fill or dredge permit under Section 404 of the Clean Water Act. Ecology must certify to the U.S. Army Corps of Engineers that the proposed project will not violate water quality standards. Ecology may condition its certification to require application of more stringent standards than those included in this Manual.

- **Hydraulic Project Approvals**: Permit issued by Washington State Department of Fish and Wildlife (WDFW), required when project-related stormwater discharges would change the natural flow or bed of state waters or work is required below the ordinary high water level of a lake or stream. WDFW may require application of more stringent requirements than those included in this Manual if determined necessary to protect fish and wildlife.

- **Aquatic Lands Use Authorizations**: The Washington State Department of Natural Resources (WDNR), as the steward of public aquatic lands, may require a stormwater outfall to have a valid use authorization and to avoid or mitigate resource impacts. WDNR may require application of more stringent requirements than those included in this Manual if deemed necessary to protect the quality of the state’s aquatic lands.

- **Underground injection control program**: An Ecology program (WAC 173-218) which may require registration or restrictions for certain infiltration systems (see Volume V, Section 3.1.3 for more information).

Local Government Permits

Your project will require some form of permit or land use review/acceptance from Thurston County depending on the location and type of project/development. Many of these permits also require a drainage review in accordance with the Manual. These permits can include the following:

- Building Permit

- Construction Permit (Excavation, Grading, Clearing & Erosion Control)

- Short Plat Subdivision

- Large Lot Subdivision

- Long Subdivision

- Class IV Forest Practices Permit

- SEPA Approval
- Critical Areas Review
- Road Encroachment Permit
- Site Plan Review
- Binding Site Plan
- Design Review
- Contact Thurston County Permit Assistance Center for help in determining the permits that apply to your project: <www.co.thurston.wa.us/permitting>.

Requirements Identified through Watershed and Basin Planning or Total Maximum Daily Loads (TMDLs)

Some requirements in this Manual may be superseded by adopting ordinances and rules to implement watershed or basin plan recommendations.

Basin plans are thorough investigations of water problems and potential solutions for a specific drainage basin. Basin plans address issues such as flooding, poor water quality, erosion, and the degradation of aquatic habitat. Basin plans are reviewed and approved by the elected officials of each participating agency. Basin plans in Thurston County are usually written jointly by the County and cities. The plan itself does not fund or authorize projects; however, Thurston County refers to these basin plans when deciding which stormwater construction projects to finance.

Information on Thurston County's basin planning process, including links to current County basin plans, can be found at the following website: <http://www.co.thurston.wa.us/waterresources/basin/basin-home.htm>.

A requirement of this Manual can also be superseded or added to through the adoption of actions and requirements identified in a total Maximum Daily Load (TMDL) that is approved by EPA. Currently TMDLs are either in progress or completed for the following areas:

- Deschutes River
- Henderson Inlet (Including Woodard Creek & Woodland Creek)
- Nisqually River
- Chehalis & Black Rivers

Ecology develops and maintains the TMDLs. They can be found at Ecology's website at http://www.ecy.wa.gov/programs/wq/tmdl/TMDLsbyWria/TMDLbyWria.html

Definitions—Generally

For the purposes of interpreting this Manual, unless it is plainly evident from the context that a different meaning is intended, certain words and terms are defined in this section as follows:

- The words "shall," “will,” and “must” are always mandatory, while the word "should" is situation-specific and not mandatory, and "may" is situation-specific and permissive. For any project, the Administrator or designee is authorized to determine if situation-specific requirements are applicable.
- Words in the present tense include the future, the singular includes the plural and the plural includes the singular.
- The word "and" indicates that all connected items or provisions apply.
- The word "or" indicates that the connected items or provisions may apply singularly or in any combination.
- The term "either or" indicates that the connected items or provisions shall apply singularly but not in combination.
- Where terms are not specifically defined in this Manual (see Glossary at end of this Chapter), the following sources, in order of their use, shall be referred to by the Drainage Manual Administrator to establish a definition of the term:

  Washington State Department of Ecology Stormwater Management Manual for Western Washington (2012)

  Pierce County Stormwater and Site Development Manual. Other Phase I NPDES Permittee Ecology approved equivalent stormwater manuals for jurisdictions located in Western Washington (City of Tacoma, King County, Clark County, City of Seattle, Snohomish County)

  Other Phase II NPDES Permittee stormwater management manuals for jurisdictions located in Western Washington.

  Low Impact Development Manual for Puget Sound (PSP, 2012).

  Thurston County Code

Current industry standard text books, guidance documents, or reports

If not defined in the above sources, then words shall have their ordinary accepted meanings within the context with which they are used. Webster's Third New International Dictionary of the English Language, Unabridged, 1986 Edition, shall be considered in determining ordinarily accepted meanings.

Illustrations found in this Manual are not intended to supersede or replace written definitions, restrictions, or standards.

II. Glossary

303(d) waterbody	A list of lakes, rivers, and streams designated as impaired or threatened by a pollutant for which one or more TMDLs are needed. "Impaired" means the water is not meeting water quality standards.
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.
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 Core Requirement to a particular project. Adjustments provide substantially equivalent environmental protection.
Administrator	The Drainage Manual Administrator is the Thurston County official authorized to make decisions in regard to Adjustments and Exceptions/Variances, issue clarifications and modifications to the DDECM approve or accept specific actions where such approval or acceptance is required by the DDECM, provide interpretations when requested, and initiate formal policy documents related to the DDECM with Departmental Director and Board of County Commissioner approval, as required. The Drainage Manual Administer is currently the Water Resources Program Manager or his/her designee (TCC Title 15.05).
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.
Applicable BMPs	As used in Volume IV (Source Control), applicable BMPs are those source control BMPs required at new development and redevelopment sites. Applicable BMPs may also be required for existing development when subject to source control planning and pollution prevention in accordance with other provisions of Thurston County code such as the IDDE Ordinance (TCC Title 15.07).
Applicant	The person who has applied for a development permit or approval, typically the owner, but may be a developer or owner's representative.

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 strata containing water that can be withdrawn and used for human purposes.
Arterial	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. Also referred to as "record drawings."
Backwater	Water upstream from an obstruction which is deeper than it would normally be without the obstruction.
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 1929 (NGVD).
Basin	Any area draining to a point of interest.
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.
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 divided 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.
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 particulate 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.
Bioretention BMP	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 Volume V, Chapter 2 for Bioretention BMP types and design specifications.
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 Thurston County to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all County requirements.
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.
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.
Cation Exchange Capacity (CEC)	The amount of exchangeable cations that a soil can adsorb. 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 7.0 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 the Washington State Department of Ecology (Ecology) (see BMP C160 in Volume II). 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.

Channel	A feature that conveys surface water and is open to the air.
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.
Check dam	Small dam constructed in a channel, swale, gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.
Civil engineer	A professional engineer licensed in the State of Washington in Civil Engineering.
Clay lens	A naturally occurring, localized area of clay which acts as an impermeable layer to runoff infiltration.
Clearing	The destruction, removal, or disposal of vegetation by manual, mechanical, or chemical methods. Clearing includes logging, even when the understory of vegetation is not being removed.
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.
Commercial agriculture	Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or 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 to determine permit requirements and thresholds for application of Core Requirements.
Compost	Organic solid waste 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. Natural decay of organic solid waste under uncontrolled conditions does not result in composted material.
Composted mulch	Mulch prepared from decomposed organic materials that have undergone a controlled process to minimize weed seeds. Acceptable feedstocks include, but are not limited to, yard debris, wood waste, land clearing debris, brush, and branches.
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.
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.
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.
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 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.
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 areas are those areas as defined by Thurston County Code, Titles 17 and 24, as applicable.
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.
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.
Curb and gutter barrier	An element of a roadway that prevents sheet flow of runoff from the roadway surface at the road edge and concentrates the flow for conveyance through a gutter to either a point of discharge or a catch basin structure and/or piping system. This includes rolled curbs, inverted crown roadway, asphalt wedge curbs and concrete curb and gutters.
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.
Depression storage	The amount of precipitation that is trapped in depressions on the surface of the ground.
Design engineer	The professional civil engineer licensed in the State of Washington who prepares and stamps 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.
Development	New development, redevelopment or both. See definitions for each.

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 from a developed area or drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a 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.
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 Plan or Drainage and Erosion Control Plan	The comprehensive report containing all the technical information and analysis necessary for Thurston County to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Drainage Plan will vary with the type and size of the project, and individual site characteristics. It may include a Construction Stormwater Pollution Prevention Plan (Construction SWPPP, Drainage Report, Pollution Source Control Plan, Maintenance Plan, Geotechnical Report and Construction Drawings (Permanent Stormwater Control Plan).
Drainage, soil	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 cop 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 (Refr. NRCS Soil Survey): • Excessively drained – Water moves through the soil very rapidly. Internal free water commonly is very rare or very deep. The soils are commonly course-textured and have very high saturated hydraulic conductivity.

	• Somewhat excessively drained – Water moves through the soil rapidly. Internal free water commonly is very rare or very deep. The soils are commonly course-textured and have high saturated hydraulic conductivity. • Well drained -- Excess water drains away readily, but not rapidly and no mottling occurs within 36 inches of the surface. The soil commonly has a moderate saturated hydraulic conductivity. • Moderately well drained – Water moves through the soil slowly during some periods of the year. The soil is wet for only a short time within the rooting depth during the growing season. The soil commonly has a moderately low, or lower saturated hydraulic conductivity. • 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. The soil commonly has a low or very low saturated hydraulic conductivity, or a high water table, or receives water from lateral flow, or persistent rainfall, or some combination of these factors. • 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. Typical low or very low saturated hydraulic conductivity. • 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	Lower of the water surface (in open channel flow), water table or piezometric surface (in ground water flow) resulting from a withdrawal of water.
Dry season	The season in which little rainfall occurs. In Western Washington, from May 1 through September 30.
Earth material	Any rock, natural soil or fill and/or any combination thereof. Earth material shall not be considered topsoil used for landscape purposes. Topsoil used for landscaped purposes shall comply with ASTM D 5268 specifications. Engineered soil/landscape systems are also defined independently.
Easement	The legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owner's use of the land.
Ecology	Washington Department of Ecology. The agency responsible for implementing the stormwater control required by the Clean Water Act.

Embankment	A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.
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.
ESA	Endangered Species Act
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 LID.11 – “Full Dispersion,” as described in Volume V, Chapter 2; 2) residential roof runoff is infiltrated in accordance with Downspout Full Infiltration Systems in BMP LID.04 in Volume V, Chapter 2; or 3) approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.
Emergency spillway	A spall lined or vegetated earth channel used to safely convey flood discharges in excess of the capacity of the principal spillway.
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 dissipater	Any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.
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).
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.
Erodible soils or earth	Any surface where soils grindings, or other materials may be capable of being displaced and transported by rain, wind, or surface water runoff.

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 (Variance)	Relief from the application of a Core 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.
Fertilizer	Any material or mixture used to supply one or more of the essential plant nutrients.
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 (silt 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.

Fish bearing stream	A stream is generally considered fish-bearing in Western Washington if it is 2 feet or greater in width and has a gradient of 20 percent or less. Intermittent streams may also be fish-bearing for those times during which the stream is flowing. Includes lakes or ponds connected to a known fish-bearing water by a stream channel of similar dimensions as above.
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 hazard areas	Those areas subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions.
Floodplain	The total area subject to inundation by a flood including the flood fringe and floodway.
Floodway	The channel of the river or stream and those portions of the adjoining floodplains that are reasonably required to carry and discharge the base flood flow. The portions of the adjoining floodplains which are considered to be "reasonably required" is defined by flood hazard regulations.
Flow control 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.
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.
Freeboard	The vertical distance between the design water surface elevation and the elevation of the barrier that contains the water.

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 (base flood) designation is of the Federal Emergency Management Agency and the National Flood Insurance Program or as defined by Thurston County Code.
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.
Geologically hazardous areas	Also known as “geologic hazard areas”, are 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. See also Thurston County Critical Areas Ordinance, TCC Title 24.
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.
Ground water	Water in a saturated zone or stratum beneath the land surface or a surface waterbody. Refer to chapter 173-200 WAC.
Groundwater 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.
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.

Heavy metals	Metals of high specific gravity, present in municipal and industrial wastes that pose long-term environmental hazards. Such metals include cadmium, chromium, cobalt, lead, mercury, nickel, 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 county 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 improvements.
Highway	A main public road connecting towns and cities.
Hog fuel	Wood-based mulch.
Hydraulic conductivity	The quality of a saturated soil that enables water or air to move through it. Also known as permeability coefficient.
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. Natural Resources Conservation Service (formerly 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.
Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.
Hydroperiod	A seasonal occurrence of flooding and/or soil saturation; it encompasses depth, frequency, duration, and seasonal pattern of inundation.
Hyetograph	A graph of percentages of total precipitation for a series of time steps representing the total time in which precipitation occurs.
Illicit connection	Any man-made conveyance that is connected to a municipal storm drainage facility without a permit or other form of written approval by the Director, excluding roof drains and other similar type connections. Examples of illicit connections include but are not limited to sanitary sewer connections, floor drains, channels, pipelines, conduits, inlets, or outlets that are connected directly to a municipal storm drainage facility.
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. See also Thurston County IDDE ordinance, TCC 15.07.
Impact basin	A device 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 Core 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.
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.
Ineffective Impervious Surfaces	Impervious surfaces are considered ineffective if: 1) the runoff is dispersed through at least one hundred feet of native vegetation in accordance with 65/10 Dispersion as described in Volume V, Chapter 2; 2) residential roof runoff is infiltrated in accordance with Downspout Full Infiltration Systems Volume V, Chapter 2; or 3) approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.
Infiltration	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 percolation, to dispose of surface and stormwater runoff.
Infiltration rate	The rate, usually expressed in inches/hour, at which water moves downward (percolates) through the soil profile. Short-term infiltration rates may be inferred from soil analysis or texture or derived from

	field measurements. Long-term infiltration rates are affected by variability in soils and subsurface conditions at the site, the effectiveness of pretreatment or influent control, and the degree of long-term maintenance of the infiltration facility.
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.
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.
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.
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 or permanent 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.
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 project design.
Low Impact Development (LID) Best Management Practices	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, bioretention/rain gardens, permeable pavements, roof downspout controls, dispersion, soil quality and depth, minimal excavation foundations, vegetated roofs, and water re-use.
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 permeable liner	A layer of compacted till or clay, or a geomembrane.
Maintenance	Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and results in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include replacement of dysfunctioning facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. 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 maintenance standards of Volume V, Appendix V-C. See also Pavement Maintenance exemptions in Section 2.2 of Volume I.
Maximum extent practicable	Refers to paragraph 402(p)(3)(B)(iii) of the federal Clean Water Act which reads as follows: Permits for discharges from municipal storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system, design, and engineering methods, and other such provisions as the Administrator or the State determines appropriate for the control of such pollutants. The NPDES permit requires permittees to reduce the discharge of pollutants to the maximum extent practicable (MEP). Permittees who

	choose to use the site planning process, and BMP selection and design criteria in the 2012 Stormwater Management Manual for Western Washington, or an equivalent manual approved by Ecology, may cite this choice as their sole documentation to meet this requirement. When used in conjunction with application of BMPs such as LID it means those measures that are feasible taking into consideration all factors such as site conditions, soils, type of project, cost, maintenance, human health and the environment.
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.
Municipal Separate Storm Sewer System (MS4)	Means a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (i) Owned or operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of Washington State. (ii) Designed or used for collecting or conveying stormwater. (iii) Which is not a combined sewer; and (iv) Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.; and (v) Which is defined as “large” or “medium” or “small” or otherwise designated by Ecology pursuant to 40 CFR 122.26.

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, but are not limited to, 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 timber land 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 Hard Surface	Hard surface created on or added to a site or structural development including construction, installation, or expansion of a building or other structure. Includes the addition of a hard or compacted surface like roofs, pavement, gravel, or dirt; or the addition of a more compacted surface, like paving over predevelopment existing dirt or gravel. New hard surface may also include existing hard surface that is removed and replaced. To be considered new, the removal and replacement activity must result in significant changes in hard surface locations, grade, and/or drainage system features, and/or must involve construction, installation, or expansion of a building or structure after complete or substantial intentional demolition thereof by or for the benefit of the applicant.
Non-point source (NPS) pollutants	Pollution that comes from many different, hard-to-trace sources with no obvious point of discharge, unlike wastewater treatment plant

	discharges, for example. NPS pollutants come from roadways, fertilizers on lawns, rooftops, agricultural and forestry practices, and many other diffuse sources.
NPDES	The National Pollutant Discharge Elimination System as established by the Federal Clean Water Act. Under NPDES regulations, point source dischargers must obtain permits.
NPDES Phase II Boundary	The boundary of those areas of Thurston County which have sufficient population density based on the criteria established for the NPDES program managed by Ecology to be subject to the requirements of the NPDES Phase II permit. The boundary is subject to revision based on census data or regulatory changes. A map of the NPDES Phase II Boundary is available for review at the offices of the Thurston County Water Resources Unit of the Department of Resource Stewardship.
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, 1986*. With the change in name to the Natural Resources Conservation Service, the method may be referred to as the NRCS Method.
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.
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.
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).

Outwash soils	Soils formed from highly permeable sands and gravels.
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.
Pasture	A vegetated area on a project site characterized by a lack of forest cover (mature, or emergent, e.g. replanted under a forest practice permit) and subject to limited or no landscape maintenance. Pasture may include native scrub/shrub, non-native unmaintained vegetation, pasture grasses, recently logged but not replanted areas, and prairies.
Peak flow rate or discharge	The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event, such as a 25-year, 24-hour event.
Permanent Stormwater Control (PSC) Plan	See Drainage Plan.
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 NRCS 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.
Phase 1 stormwater permit	The part of the NPDES program that deals with large cities, >100,000 population, or heavily urbanized areas.
Phase 2 stormwater permit	The part of the NPDES program that deals with small cities, generally between 10,000 and 100,000 in population.
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-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: 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); or roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities. A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways. The following are not considered regularly-used surfaces: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, and infrequently used maintenance access roads.
Pollution-generating pervious surface (PGPS)	Any non-impervious surface subject to 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 includes 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 predeveloped condition shall be assumed to be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.
Pretreatment	The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a Basic Treatment BMP prior to infiltration.

Professional civil engineer	A person registered with the state of Washington as a professional engineer in civil engineering.
Project engineer	See design engineer.
Project proponent	The person with overall responsibility for directing the project as a representative of the owner (may be the owner, architect, developer or project engineer).
Project	Any proposed action to alter or develop a site. The proposed action of a permit application or an approval, which requires drainage review.
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.
Property Owner's Association	A non-profit corporation established for the purposes of enforcing subdivision covenants, conditions and restrictions and for operating, maintaining and repairing private facilities associated with the subdivision such as roads, stormwater facilities, open space, water and sewer systems, as applicable. As used in this Manual, it is synonymous with Home Owner's Association, Lot Owner's Association, Condominium Association, etc.
Rain garden	A non-engineered, shallow, landscaped depression, with compost-amended native soils or imported soils, and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. Refer to the *Rain Garden Handbook for Western Washington Homeowners (WSU*, 2007 or as revised) for rain garden specifications and construction guidance.
Rational method	A means of computing storm drainage flows (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 may be used under limited circumstances for conveyance system design only.
Receiving waters	Bodies of water or surface water systems to which surface runoff is discharged via a point source of stormwater or via sheet flow. Ground water to which surface runoff is directed by infiltration.
Recharge	The addition of water to the zone of saturation (i.e., an aquifer).
Redevelopment	On a site that is already 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 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, subbasin, or basin.
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 or including the foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement. Replaced impervious surface also includes the construction of a new building over existing asphalt or concrete paved impervious surface.
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 for a short period of time and then release it to the surface and stormwater management system.
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.
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.
Rural areas	For purposes of the Manual, rural areas are defined as those areas outside of the Phase II NPDES permit boundary and outside of any

	Urban Growth Area, including the Urban Growth Areas of Rochester, Bucoda, Yelm, Rainier, Tenino, and Grand Mound.
Salmonid	A member of the fish family Salmonidae. Chinook, coho, chum, sockeye and pink salmon; cutthroat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.
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.
Soil group, hydrologic	A classification of soils by the National Resources Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little or no runoff, to D soils, which are not very permeable and produce much more runoff.
Soil horizon	A layer of soil, approximately parallel to the surface, which has distinct characteristics produced by soil-forming factors.
Soil profile	A vertical section of the soil from the surface through all horizon, including C horizons.
Soil Texture Class	The relative proportion, by weight, of particle sizes, based on the USDA system, of individual soil grains less than 2mm 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, silt loam, silt, clay loam, sandy clay, silty clay, and clay.
Source control	Control of pollution by preventing it from entering stormwater such as covering materials, rather than treating it after it enters stormwater.
Source control BMP	A structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This Manual separates source control BMPs into two types. *Structural Source Control BMPs* are physical, structural, or mechanical devices, or facilities that are intended to prevent pollutants from entering stormwater. *Operational BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV for details.
Spill control device	A Tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze. Spill control devices are passive and must be cleaned-out for the spilled pollutant to actually be removed.

Spillway	A passage such as a paved 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.
Steep slope	Slopes of 40 percent gradient or steeper within vertical elevation changes 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 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% and 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 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.
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.
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. An engineered or natural dispersion area that is dedicated to stormwater use is also considered a stormwater facility for purposes of this Manual.
Stormwater Management Manual for Western Washington (Ecology Stormwater Manual)	The manual, as prepared by the Washington State Department of Ecology that contains BMPs to prevent, control or treat pollution in stormwater and reduce other stormwater related impacts to waters of the State. The Ecology Stormwater Manual is intended to provide guidance on measures necessary in western Washington to control the quantity and quality of stormwater runoff from new development and redevelopment.
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.
Subdrain	A pervious backfilled trench containing stone or a pipe for intercepting ground water or seepage.
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.
SWPPP	Storm Water Pollution Prevention Plan
TESC	Temporary erosion and sediment control.
Threshold Discharge Area	An on-site area 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). For an example, see Figure 2.3.1. of Volume I of Ecology's Stormwater Management Manual for Western Washington (2012). The purpose of this definition is to clarify how the thresholds of this Manual are applied to project sites with multiple discharge points.
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.
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.
Topsoil	Topsoil shall be per ASTM D5268 standard specification, and water permeability shall be 0.6 inches per hour or greater. Organic matter shall have not more than 10 percent of nutrients in mineralized water soluble forms. Topsoil shall not have phytotoxic characteristics.
Total Maximum Daily Load (TMDL)	A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL (also known as a Water Cleanup Plan) is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The

	calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic 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 Suspended Solids (TSS)	Suspended solids are 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. TSS refers to the solids that can be captured on a standard glass filter.
Tract	A legally created parcel of property designated for special nonresidential and noncommercial uses.
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.
Underdrain	Plastic pipes with holes drilled through the top (or slots), installed on the bottom of an infiltration BMP, which are used to collect and remove excess runoff.
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.
Variance	See Exception.
Vehicular use	Regular use of a hard surface or pervious surface by motor vehicles. The following are subject to regular vehicle use: roads, un-vegetated road shoulders, bike lanes within the traveled land 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: 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.

Water table	The upper surface or top of the saturated portion of the soil or bedrock layer indicates the uppermost extent of ground water.
Waters of the state	Those waters defined as “waters of the United States” in 40 CFR Subpart 122.2 within the geographic boundaries of Washington State and “waters of the state” as defined in chapter 90.48 RCW which includes lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and water courses within the jurisdiction of the State of Washington.
Wet season	The season in which most of the rainfall occurs. In Western Washington, from October 1 through April 30.
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, constructed wetlands for water quality treatment, 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 for conversion of wetlands.
WSDOT	Washington State Department of Transportation
WSDOT Standard Plans	The most current version of the Washington State Department of Transportation’s Standard Plans.
WSDOT Standard Specifications	The most current version of the Standard Specifications for Road, Bridge and Municipal Construction prepared and promulgated by the Washington State Department of Transportation and any revisions thereof.

Thurston County
Drainage Design and Erosion Control Manual

Volume I
Core Technical Requirements and Site Planning

Prepared by
Thurston County Water Resources Division,
Department of Resource Stewardship

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Chapter 1 - Introduction

1.1 Volume I Overview

Chapters in this volume will determine the applicable requirements for your project, your submittal requirements, and provide guidance on selection of BMPs. It also directs you to other volumes of the Manual for topics relevant to specific hydrologic design methods and infiltration testing (Volume III), BMP design guidance (Volumes IV and V), and construction stormwater management practices (Volume II).

- *Chapter 1: Introduction* describes the contents and organization of Volume I and where it applies.
- *Chapter 2: Core Requirements for New Development and Redevelopment* describes Core Requirements for stormwater management for all new development and redevelopment projects. There are eleven Core Requirements, and their applicability to a project varies depending on the type and size of the proposed project.
- *Chapter 3: Stormwater Submittal Requirements* describes the submittal process required to meet Thurston County requirements. Submittal requirements vary depending on the project size and type and which Core Requirements apply to the project.
- *Chapter 4: Stormwater BMP Selection Process* explains how to select BMPs for long-term management of stormwater flows and quality. BMP selection for construction stormwater management and source control of pollution are not included in Volume I but can be found in Volume II and Volume IV respectively.
- Appendices are included to support these topics.

1.2 Development of Best Management Practices for Stormwater Management

1.2.1 Best Management Practices (BMPs)

This Manual controls the adverse impacts of development and redevelopment through the application of Best Management Practices.

This Manual defines Best Management Practices 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 types of BMPs include source control, treatment, and flow control. This Manual often refers to BMPs that involve construction of engineered structures as "facilities". For instance, the menus of Chapters 5 through 8 in Volume V refers to BMPs as treatment facilities.

BMPs protect beneficial uses of water resources through the reduction of: 1) pollutant loads and concentrations, 2) discharges (volumetric flow rates) causing stream channel erosion, and 3) deviations from natural hydrology. If beneficial uses remain threatened or impaired after the implementation of BMPs advocated in this Manual, then additional controls may be required.

1.2.2 Source Control BMPs

Source control BMPs typically **prevent** pollution, or other adverse effects of stormwater, from occurring. Ecology further classifies source control BMPs as operational or structural. Examples of source control BMPs include methods as various as using mulches and covers on disturbed soil, putting roofs over outside storage areas, and berming areas to prevent stormwater run-on and pollutant runoff.

It is generally more cost effective to use source control to **prevent** pollutants from entering runoff, than to treat runoff to remove pollutants in the runoff. However, since source controls cannot prevent all impacts, some combination of preventative and treatment measures will always be needed.

1.2.3 Treatment BMPs

Treatment BMPs include facilities that remove pollutants by gravity settling of particulate pollutants, centrifugal separation, filtration, biological uptake, and media or soil adsorption. Treatment BMPs can accomplish significant levels of pollutant load reductions if properly designed and maintained.

1.2.4 Flow Control BMPs

Flow control BMPs typically control the volume, rate, frequency, and flow duration of stormwater surface runoff. The need to provide flow control BMPs depends on whether a development site discharges to a stream system or wetland, either directly or indirectly. Stream channel erosion control can be accomplished by BMPs that detain runoff flows and also by those which physically stabilize eroding streambanks. Urban watersheds may require both types of measures. This Manual only covers the former.

Construction of a detention pond is the most common means of meeting flow control requirements. Construction of an infiltration facility is the preferred option, but is feasible only where more porous soils exist.

Detention accomplishes its objective by collecting runoff from a developed area and releasing it at a slower rate than it enters the collection system. The reduced release rate requires temporary storage of the excess amounts in a pond with release occurring over a few hours or days. The volume of storage needed depends 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 leaves the detention pond (i.e., the target release rates).

The earliest versions of the Thurston County Drainage Design and Erosion Control Manual (DDECM) (1994) 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, requires controlling 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 capable of moving sediments. This target will translate into lower release rates and significantly larger detention ponds than the 1994 DDECM standard. The size of such a facility can be reduced by changing the extent to which a site is disturbed. In addition, the County encourages project proponents to look for means to improve or restore natural conditions to compliment, or in lieu of, traditional flow control measures. The on-site stormwater management BMPs presented in Volume V will help accomplish this goal.

In regard to wetlands, the goal is to not alter the natural hydroperiod. This requires the control of input flows such that the wetland falls within certain elevations at different times of the year and short-term elevation changes fall within the desired limits. Increases in the amount of surface runoff draining to a wetland due to land conversion from forested to impervious areas may require bypassing some water around the wetland in the wet season. (Bypassed stormwater must still meet flow control and treatment requirements applicable to the receiving water.) If however, the wetland was fed by local ground water elevations during the dry season, the impervious surface additions and the bypassing practice may cause variations from the dry season elevations.

Because of the difficulty in modeling water surface elevation changes, especially for riverine and slope wetlands, the new regulatory strategy involves trying to match the pre-project surface and ground water inputs that drive the water surface elevations in wetlands. An estimate of what should be done to match inputs requires the use of a continuous runoff model. The Western Washington Hydrologic Model (WWHM), 2012 version has been modified to include a wetlands analysis. See Section 2.4.9 for more information.

1.2.5 Construction Stormwater BMPs and On-Site Stormwater Management BMPs.

Construction stormwater BMPs include source control, treatment, or flow control BMPs. Examples include stabilized construction entrances, silt fences, check dams, and sediment traps. Volume II of this Manual contains construction stormwater BMPs.

On-site stormwater management BMPs, also known as low impact development (LID) BMPs, can provide treatment or flow control. BMPs in this category serve to infiltrate, disperse, and retain stormwater on-site. Examples include bioretention, rain gardens, and permeable pavements. Other examples include downspout infiltration, downspout dispersion, and perforated stub-out connection. All these on-site BMPS can be found in Chapter 2 of Volume V.

Chapter 2 - **Core Requirements for New Development and Redevelopment**

2.1 Overview

Section 2.2 of this chapter provides a list of projects which are exempt from the Core Requirements. If you are unsure whether your project is exempt or not, check with the Drainage Manual Administrator[1]. The next section, Section 2.3, identifies which Core Requirements apply to your project, and Section 2.4 describes each of the Core Requirements in more detail and how to apply those requirements to your project. The remaining sections of this Chapter address special circumstances such as deeds, easements, exceptions and adjustments

The eleven Core Requirements for stormwater management applicable to new development and redevelopment sites are:

1. Stormwater Site Planning
2. Construction Stormwater Pollution Prevention
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems and Outfalls
5. On-site Stormwater Management
6. Runoff Treatment
7. Flow Control
8. Wetlands Protection
9. Operation and Maintenance
10. Financial Liability
11. Offsite Analysis and Mitigation

Depending on the type and size of the proposed project, different combinations of these Core Requirements apply. In general, small sites are required to control erosion and sedimentation from construction activities and to apply simpler approaches to treatment and flow control of stormwater runoff from the developed site. Controlling flows from small sites is important because of the cumulative effect of uncontrolled flows from many small sites can be as damaging as those from a single large site. Section 2.3 provides additional information on the applicability of the Core Requirements to different types of sites and projects.

[1] Call 360-754-4681, Option 5

After determining that your project is not exempt from the Core Requirements, you can use this chapter to determine the Core Requirements that apply to your project. You will need to know the following for your overall project and for each threshold discharge area within the project:

- Area of existing and new impervious surface
- Area of replaced impervious surface
- Area of pervious surface converted to impervious (i.e., landscape converted to pavement)
- Total disturbed area (logged, cleared, graded or otherwise disturbed as part of the project)
- Area converted from native vegetation to landscape or impervious
- Area converted from native vegetation to pasture.

The glossary defines each of the terms used above and should be referred to in calculating the applicable areas.

Applicants for development and redevelopment projects are to demonstrate compliance with the applicable Core Requirement through preparation of a Drainage Design and Erosion Control Plan. The plan contents are described in detail in Chapter 3. Two major components of this plan are a Construction Stormwater Pollution Prevention Plan (SWPPP) and a Permanent Stormwater Control Plan (PSCP). Applicants must submit these plans for review by Thurston County if they add or replace 2,000 square feet or more of hard surface or disturb 7,000 square feet or more of land.

2.1.1 Roadway Frontage Improvements

If your property abuts a public roadway, roadway frontage improvements may be required for development and redevelopment projects. This may include roadway widening, right-of-way dedication, and/or upgrade to urban features. Check with the Thurston County Permit Assistance Center to determine the requirements for your project. The abutting property is responsible for the management of stormwater drainage from the public right-of-way. This may include construction of treatment and flow control facilities or allowance for dispersion areas in accordance with this Manual.

Any land disturbing activity or addition of impervious surfaces associated with frontage improvements shall be included in the area calculations for determining the Core Requirements. Plans and reports prepared in accordance with this Manual shall include management of runoff from the roadway frontage abutting the project site. See the Thurston County Road Standards for more information on frontage improvements and road drainage requirements.

2.1.2 Cumulative Impact Mitigation Requirement

The determination of thresholds for a project site shall be based on the total new or replaced impervious surfaces[2] and the conversion of native vegetation to landscape area or pasture that have occurred within the previous five years. The County will consider the cumulative impacts of all permits issued within the previous five years from the date of project submittal by the applicant.

The purpose of this Cumulative Impact Mitigation Requirement is to adequately mitigate the stormwater from improvements on a project site that are submitted under separate permits. The separate submittals could have project areas that do not meet thresholds, but would meet the thresholds if the projects were combined as one project. While all projects in the past five years are used to establish project thresholds, the thresholds and associated Core Requirement only apply to the new or replaced impervious surfaces or converted pervious surfaces for the current project.

2.2 Exemptions

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

2.2.1 Forest Practices

Forest practices regulated under Title 222 WAC, except for Class IV General Forest practices that are conversions from timber land to other uses, are exempt from the Core Requirement.

2.2.2 Commercial Agriculture

Commercial agriculture practices involving working the land for production are generally exempt. However, conversion from timberland to agriculture and construction of impervious surfaces are <u>NOT</u> exempt.

2.2.3 Pavement Maintenance Practices

The following pavement maintenance practices are exempt but should use appropriate BMPs to minimize erosion and sediment transport:

- Pothole and square cut patching
- Road projects completely within the right-of-way which do not add impervious surface, such as overlaying existing asphalt or concrete pavement without expanding the area of coverage (Note: this does not include paving over existing gravel surfaces)
- Shoulder grading

[2] Also includes new plus replaced impervious surfaces.

- Reshaping or regrading drainage systems to restore as-built conditions
- Crack sealing or resurfacing with in-kind material without expanding the road prism
- Vegetation maintenance[3]

The following pavement maintenance practices are considered redevelopment, and therefore are not categorically exempt:

- **Removing and replacing a paved surface to base course or lower, or repairing the roadway base**. If impervious surfaces are not expanded, Core Requirements #1 through #5 apply. Where appropriate, for privately maintained roads, project proponents are encouraged to use permeable and porous pavements if feasible.
- **Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders**. These are considered new impervious surfaces and are subject to the Core Requirement that apply when the project reaches identified thresholds for new or redevelopment.
- **Resurfacing by upgrading from dirt to gravel, asphalt, or concrete; upgrading from gravel to asphalt, or concrete; or upgrading from a bituminous surface treatment ("chip seal") to asphalt or concrete**. These are considered new impervious surfaces and are subject to the Core Requirement that apply when the project meets or exceeds identified thresholds for new or redevelopment.

2.2.4 Underground Utility Projects

Underground utility projects that are linear in nature and replace the ground surface with in-kind material or materials with similar runoff characteristics are only subject to Core Requirement #2, Construction Stormwater Pollution Prevention.

All other development is subject to one or more of the Core Requirement.

2.2.5 Public Drainage Facilities

Drainage facilities conceived, designed, or constructed by or through an agent of the County shall be exempted from the submittal and permitting requirements of this Manual. The County shall meet the intent and specific requirements of this Manual on all projects relative to drainage or incorporating drainage components and shall maintain records adequate to reflect such compliance. These records shall be available upon request per the State Public Disclosure of Information Act, RCW 42.17.

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[3] Vegetation may be an integral element to the functioning of a stormwater BMP. Call 360-754-4681 before performing vegetation maintenance in a stormwater BMP.

The County shall incorporate the provisions of this Manual into the design calculations, drawings, and specifications of all projects released for public bid. These provisions shall also apply to projects constructed by County staff.

This exclusion from submittal and permitting requirements only applies to this Manual and does not relax any requirements of other applicable ordinances, regulations, or legislation except that superseded by this Manual.

2.3 Applying Core Requirements

If your project is not exempt, you must determine which Core Requirement apply to it. Use the flowcharts in Figure 2-1and Figure 2-2 and the discussion in this section to help determine which Core Requirement apply to your project. The Core Requirement themselves are presented in Section 2.4.

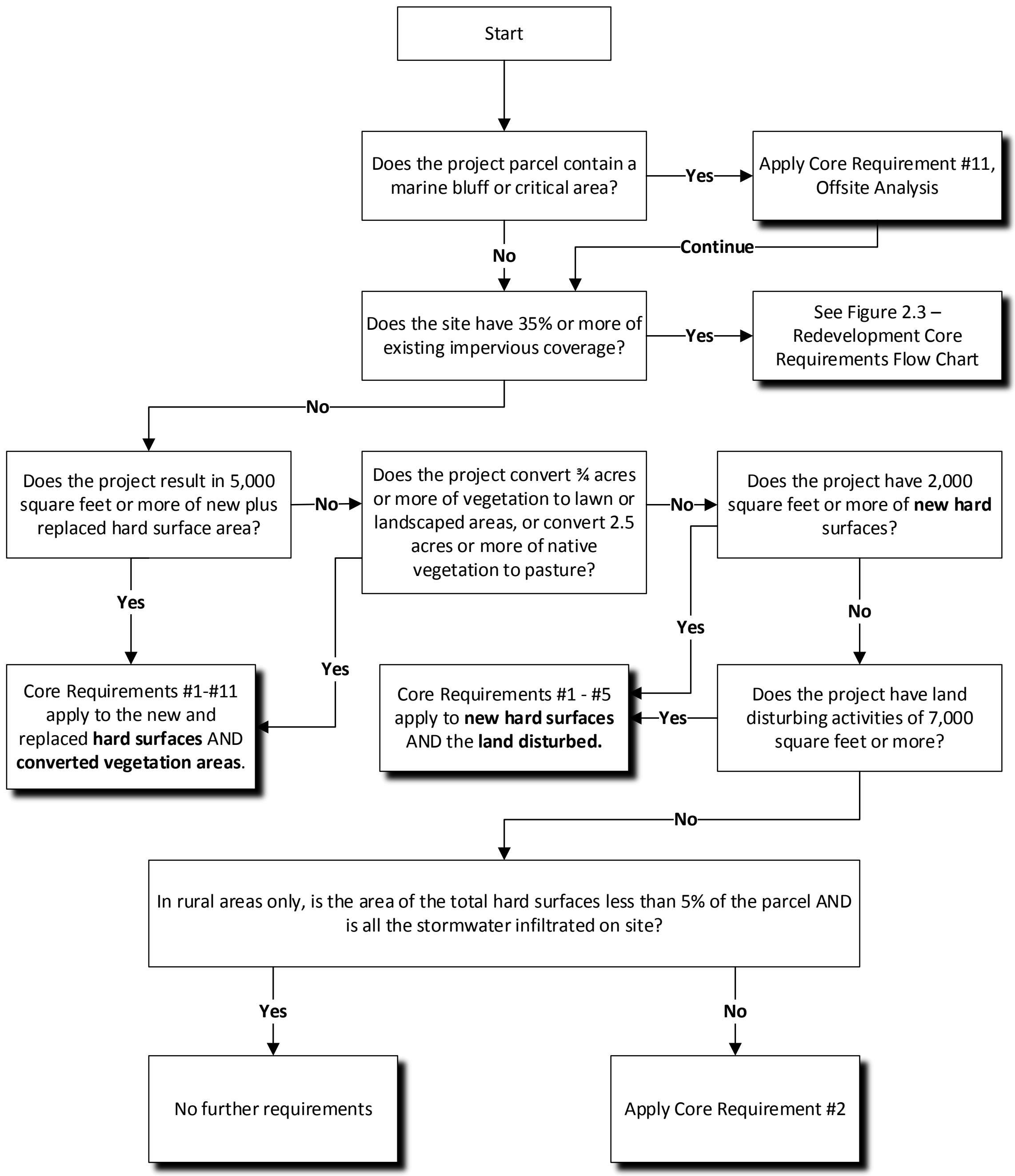


Figure 2.1 – Flow Chart for Determining Requirements for New Development

Figure 2-1 Flow Chart for Determining Requirements for New Development.

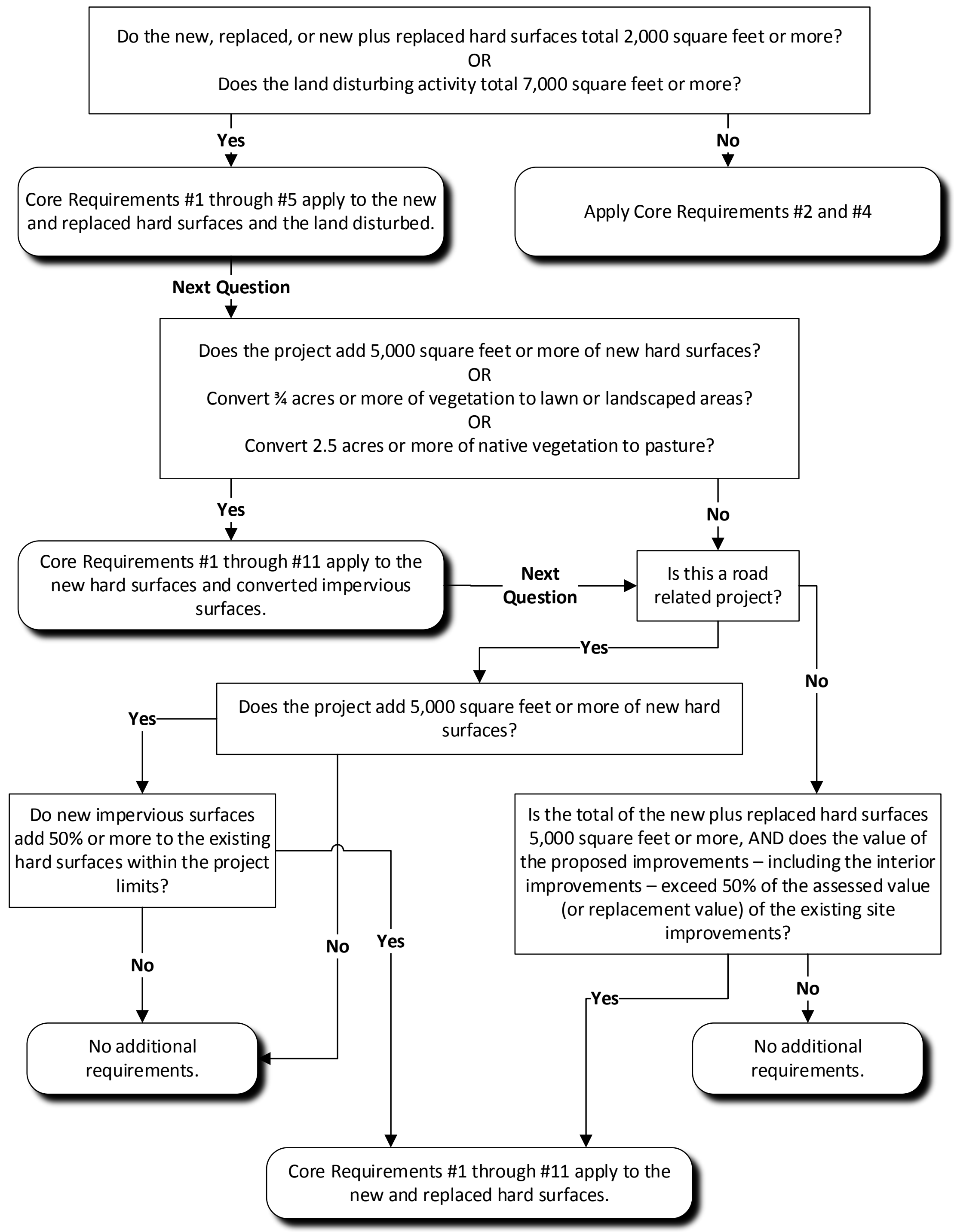


Figure 2.2 – Flow Chart for Determining Requirements for Redevelopment

Figure 2-2 Flow Chart for Determining Requirements for Redevelopment.

2.3.1 New Development

Figure 2-1illustrates the process for determining the applicable Core Requirement for new development. In calculating project areas to determine thresholds, any required public roadway frontage improvements shall be included in the total for determining the thresholds.

1. All new development shall comply with Core Requirement #2, Construction Stormwater Pollution Prevention, and implement to the maximum extent practicable, the following BMPs:

- Restore native vegetation (BMP LID.01)
- Post-Construction Soil Quality and Depth (BMP LID.02) – All disturbed areas of the project to be landscaped shall implement BMP LID.02 to restore soil quality and depth
- Downspout infiltration systems (BMP LID.04)
- Dispersion of roof and driveway runoff (BMP LID.05; LID.06; LID.07)
- Bioretention (BMP LID.08).

In rural areas only, if the total of all impervious surfaces (including existing) is less than 5 percent of the parcel[4], AND proposed land disturbing activity is less than 10% of the parcel, AND proposed grading is less than 5,000 cubic yard, AND all stormwater is infiltrated on site, then the project has no other requirements.

New development that does either of the following shall comply with Core Requirements #1 through #5 and Core Requirement #11 (off-site analysis and mitigation) for new and replaced impervious surfaces and the land disturbed:

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

New development that does any of the following shall comply with Core Requirements #1 through #11 for new and replaced hard surfaces and the converted vegetation areas:

- Creates or adds 5,000 square feet or more of new plus replaced hard surface area
- Converts 3/4 of an acre or more of vegetation to lawn or landscaped areas
- Converts 2.5 acres or more of vegetation to pasture.

[4] If the property abuts a public roadway frontage, the area of the roadway frontage contributing to the site shall be included in the impervious area computation.

2.3.1.1 Supplemental Guidelines – Residential Subdivisions

For purposes of applying the above thresholds to a proposed single family residential subdivision (i.e. a plat, short plat, or large lot plat) use the following:

- For each lot less than 1 acre, assume 4,200 square feet of hard surface (1,000 square feet of which is considered pollution generating),
- For each lot 1 acre or greater, assume 8,000 square feet of hard surface (2,500 square feet of which is considered pollution generating) or the maximum impervious (or hard) coverage permitted by Thurston County code, whichever is less.

  Pervious surface coverage for proposed residential subdivision projects shall be estimated for each specific project as follows:

- Pervious surface coverage within proposed rights-of-way, private street tracts, other dedicated tracts, and other common use areas shall be assumed to be the entire area of the right-of-way, private street tract, dedicated tract or common area, except the assumed impervious portion and any portion in which native conditions are preserved by covenant, tract, or easement. New pervious surface shall be assumed to be 100% lawn or landscaped areas.
- The area of a subdivision project assumed to be forest shall only be those areas of on-site forest/shrub cover, irrespective of age planted at densities sufficient to ensure 80% canopy cover within 5 years and that are permanently protected by covenant, tract, or easement.
- For individual lots within residential subdivisions, the extent of new pervious surface shall be assumed to be the entire lot area, except the assumed impervious portion and any portion in which native or forested conditions are preserved by covenant, tract, or easement.
- New pervious surface on individual lots shall be assumed to be 100% lawn or landscape within the Urban Growth Area (UGA) and 50% grass/50% pasture if located outside the UGA.

A lower hard (impervious) surface area, or pervious surface coverage than required above may be assumed per lot, or for selected lots within a proposed subdivision, if the lower impervious surface coverage or pervious surface coverage is set as the maximum allowed through a declaration of covenant recorded for the lot and this is noted on the face of the final plat. The declaration of covenant shall be prepared by the applicant and recorded against each lot for which an impervious surface or converted pervious surface limit less than the standard amount is used in designing stormwater facilities for the project. The declaration of covenant shall be submitted to Thurston County for acceptance as to form prior to being recorded.

A subdivision project, including construction of homes on each lot is considered a single project with respect to applicable stormwater Core Requirement such as flow control and runoff treatment. Once the threshold is exceeded for a Core Requirement, then all future development of the plat must also demonstrate compliance with that Core Requirement.

2.3.1.2 Supplemental Guidelines – Other Considerations

Regional stormwater facilities may be used as an alternative method of meeting Core Requirements #6, #7, and #8, through documented engineering reports detailing how the proposed facilities meet these requirements for the sites that drain to them. Such facilities must be operational prior to and must have capacity for new development.

Where new development projects require improvements (e.g. frontage improvements) that are not within the same threshold discharge area, the Core Requirement may be met for an equivalent (flow and pollution characteristics) area that drains to the same receiving water.

Special basin considerations see Section 2.3.3 below.

2.3.2 Redevelopment

Figure 2-2 illustrates the process for determining the applicable Core Requirement for redevelopment.

All redevelopment shall comply with Core Requirement #2 and implement, to the maximum extent practicable the following BMPs:

- Restore native vegetation (BMP LID.01)
  - Post-Construction Soil Quality and Depth (BMP LID.02) – All disturbed areas of the project to be landscaped shall implement BMP LID.02 to restore soil quality and depth
- Downspout infiltration systems (BMP LID.04)
  - Dispersion of roof and driveway runoff (BMP LID.05; LID.06; LID.07)
- Bioretention (BMP LID.08).

The following redevelopment shall comply with Core Requirements 1 through 5 and 11 for the new and replaced hard surfaces and the land disturbed:

No. 11, The *new plus replaced* hard surface area is 2,000 square feet or more, or

There is 7,000 square feet or more of land disturbing activities.

Redevelopment that does any of the following shall comply with Core Requirements 1 through 11 for the *new* hard surfaces and converted vegetated areas:

Adds 5,000 square feet or more of new hard surfaces or, Converts 3/4 of an acre, or more, of vegetation to lawn or landscaped areas, or

Converts 2.5 acres, or more, of vegetation to pasture.

If runoff from new hard surfaces and converted pervious surfaces is not separated from other surface runoff on the project site, stormwater treatment facilities must be sized for the entire flow directed to them. The Thurston County Drainage Manual Administrator may allow the Core Requirement to be met for an equivalent area within the same site and the same threshold discharge area. For public roadway projects, the equivalent area does not have to be within the project limits, but must drain to the same receiving water (public roadway projects performed by Thurston County may use the most recent version of WSDOT's Highway Runoff Manual, for redevelopment guidance.)

2.3.2.1 Additional Requirements for Redevelopment Project Sites

2.3.2.1.1 Treatment of Replaced Hard Surfaces

For road-related projects, runoff from the replaced and new hard surfaces (including pavement, shoulders, curbs, and sidewalks) and the converted vegetated areas shall meet all the Core Requirement if the new hard surfaces total 5,000 square feet or more and total 50% or more of the existing hard surfaces within the project limits. The project limits shall be defined by the length of the project and the width of the right-of-way.

For other types of redevelopment projects, runoff from the new and replaced hard surfaces and the converted vegetated areas shall meet all the Core Requirements if the total of new plus replaced hard surfaces is 5,000 square feet or more, and the valuation of proposed improvements – including interior improvements – exceeds 50% of the assessed value of the existing site improvements as determined by the County Building Official.

2.3.2.2 Financial Cap on Stormwater Mitigation

The total cost of stormwater improvements to mitigate replaced hard surfaces, existing impervious surfaces and pollution generating pervious surfaces shall be capped at a maximum expenditure of 30% of the total project costs excluding the cost of stormwater mitigation for existing surfaces.

For example, if the total project cost including managing runoff created by new or replaced hard surfaces, but excluding stormwater retrofit or replaced surface mitigation costs, is $1.0 million, and the cost to fully mitigate the replaced hard surfaces, existing impervious and existing pollution generating pervious surfaces is $500,000, then the applicant shall expend at least $300,000 toward mitigating replaced hard surfaces, existing impervious and pollution generating pervious surfaces making the total project cost including stormwater replaced hard surface and retrofit mitigation at least $1.3 million. The applicant shall consult with Thurston County Drainage Manual Administrator regarding priorities for mitigation if the financial cap is in effect. The proposed stormwater mitigation improvements and cost data for stormwater mitigation and the total project cost shall be submitted with the Drainage Report for the project.

2.3.3 Basin Planning

Thurston County basin plans may have additional requirements for projects located within the basin. If your project is located within a basin subject to an adopted basin plan additional runoff treatment (Core Requirement 6), flow control (Core Requirement 7), or wetlands protection (Core Requirement 8) restrictions may apply

As of February 2014, the following basins in Thurston County have adopted basin plans:

- Green Cove Creek Basin (North of Olympia, Cooper Point)
- Salmon Creek Basin (South of Tumwater, Vicinity I-5 and 93rd)
- Chambers/Ward/Hewitt Creek Basin (South of Olympia, Vicinity Yelm Highway & Rich Road)
- Indian/Moxlie Creek Basin (East side of City of Olympia and along South Bay Road)
- McCallister/Eaton Creek Basin (East of Lacey paralleling the Nisqually River)
- Percival Creek Basin (Southwest of Olympia from Black Lake to Capitol Lake)
- Woodland/Woodard Creek Basin (City of Lacey / north, south and east of Lacey).

Information on Thurston County's basin planning process and links to current basin plans may be found on Thurston County's web site:

http://www.co.thurston.wa.us/waterresources/basin/basin-home.htm

2.3.3.1 TMDL's

Total Maximum Daily Load Studies (TMDL, also known as a water cleanup plans) have been and are being developed for selected basins within Thurston County. In some cases additional requirements may be imposed on new development and redevelopment based on a completed and approved TMDL.

As of February 2014, the following basins in Thurston County have an approved TMDL in place:

- Henderson Inlet (Woodland and Woodard Creek).
- Nisqually River
- Chehalis/Black River

[Note: A TMDL for the Deschutes River is currently being developed. Any requirements related to stormwater management established by the final approved Deschutes TMDL will be subject to additional requirements.]

2.4 Core Requirements

This section describes Core Requirement for stormwater management at development and redevelopment sites. See Section 2.3 of this Volume to determine which requirements apply. Volumes II through V of this Manual describe BMPs and sizing criteria for use in meeting Core Requirement.

2.4.1 About Threshold Discharge Areas

Core Requirements 6 and 7 refer to *threshold discharge areas*. A threshold discharge area is an on-site area draining to one or more natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). For a detailed description and example of mapping threshold discharge areas, see Section 4-2.5 of the *Highway Runoff Manual* (WSDOT 2014).

2.4.2 Core Requirement #1: Stormwater Site Planning

The main stormwater planning components of Core Requirement #1 are: (1) Construction Stormwater Pollution Prevention Planning, and (2) Permanent Stormwater Control Planning. Numerous documents are used to fulfill the objective of this requirement depending on the nature and location of the project.

All projects meeting the thresholds in Section 2.3 shall conduct stormwater site planning in accordance with this section. Stormwater site planning shall use site-appropriate development principles, as required and encouraged by Thurston County development codes, to retain native vegetation and minimize impervious surfaces to the extent feasible.

The following types of submittals, as applicable to the project, when prepared as described in Chapter 3, will satisfy Core Requirement #1:

- Abbreviated Drainage Plan
- Engineered Abbreviated Drainage Plan
- Short Form Construction Stormwater Pollution Prevention Plan
- Drainage and Erosion Control Plan (includes a drainage report, permanent stormwater control plan (drawings and specifications) and a maintenance plan)
- Construction Stormwater Pollution Prevention Plan (includes temporary erosion and sediment control drawings and a narrative).

All non-exempt projects are required to prepare one or more of the above submittals for County review. Projects that require public roadway frontage improvements will be required to demonstrate how the roadway runoff is accommodated.

The County may require a project to prepare a "scoping report" and the applicant or County may request a "scoping meeting" early in the project to discuss the development site's conceptual stormwater approach. This process may also be used to identify potential problems and to outline submittal requirements, scope, and content. See Section 3.2.2 for more information on scoping reports contents and when a scoping report is required.

2.4.3 Core Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP)

All new development and redevelopment projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters. Projects in which the new plus replaced hard surfaces total 2,000 square feet or more, or which disturb 7,000 square feet or more of land must prepare a Construction SWPPP (narrative and drawings) as part of Stormwater Site Planning (see Section 2.4.2 of Volume II)

The SWPPP shall include a narrative and drawings, as described in Volume II. Volume II also has a template for a Short Form Construction SWPPP for projects that are eligible (see Chapter 3). All BMPs shall be clearly referenced in the narrative and marked on the drawings. The SWPPP narrative shall include documentation to explain and justify the pollution prevention decisions made for the project. Each of the 13 elements must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and exemption from that element is clearly justified in the SWPPP narrative.

The SWPPP shall be implemented beginning with initial land disturbance and until final stabilization. The SWPPP shall be prepared in accordance with the requirements Volume II and Sediment and Erosion control BMPs shall be consistent with the BMPs contained in Volume II.

Projects that add or replace less than 2,000 square feet of hard surface or disturb less than 7,000 square feet of land are not required to prepare a Construction SWPPP, but must consider all of the 13 elements of a Construction SWPPP listed below, and develop controls for all elements that pertain to the project site. This can be demonstrated through the submittals required of all non-exempt projects as outlined in Chapter 3 (for example, an abbreviated or engineered abbreviated drainage plan).

These elements address general water quality protection strategies for limiting site impacts, preventing erosion and sedimentation, and managing activities and pollutant sources during construction.

The elements of a Construction SWPPP are:

1. Mark clearing limits/preserve vegetation

2. Establish construction access

3. Control flow rates

4. Install sediment controls

5. Stabilize soils

6. Protect slopes

7. Protect drain inlets

8. Stabilize channels and outlets

9. Control pollutants

10. Control dewatering

11. Maintain BMPs

12. Manage the project

13. Protect Low Impact Development BMPs

Each of the above elements, and applicable requirements, are described in detail in Volume II. If the project is required to obtain coverage under Ecology's NPDES Stormwater Construction permit program for project sites greater than 1-acre, the applicant shall provide a copy of the Notice of Intent and the SWPPP prepared for the NPDES Construction stormwater permit to Thurston County.

Seasonal Work Limitations -- From October 1 through April 30, clearing, grading, and other soil disturbing activities will not be allowed unless it can be demonstrated that silt-laden runoff will be prevented from leaving the site through a combination of the following:

- Favorable site conditions such as vegetative coverage, no severe slopes, erosion-resistant soil types, and distance from receiving waters

- Limitations on activities and the extent of disturbed areas

- Proposed erosion and sediment control measures.

The County may expand or restrict the seasonal limitation on site disturbance based on site inspections, local weather conditions, or other information. If, during the course of any construction activity or soil disturbance during the seasonal limitation period, silt-laden runoff leaving the construction site causes 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 County may take enforcement action, including but not limited to a notice of violation, administrative order, fine/penalty, stop-work order, or correction notice.

Activities and conditions exempt from seasonal controls are:

- Routine maintenance and repair of erosion and sediment control BMPs
- Routine maintenance of public facilities or existing utility structures that do not expose bare soil.
- Activities where there is 100 percent infiltration of stormwater within the site in approved and installed erosion and sediment control (ESC) facilities.

2.4.4 Core Requirement #3: Source Control of Pollution

All known, available and reasonable source control BMPs shall be applied to all projects. Source control BMPs shall be selected, designed, and maintained according to Volume IV, Chapter 3, of this Manual.

Source control BMPs are used to prevent stormwater from contacting pollutants. They are a cost-effective means of reducing pollutants in stormwater and should be considered first in all projects, before applying treatment measures. Source control BMPs include operational and structural source control BMPs. See Volume IV for design details and the selection of source control BMPs. For construction sites, see Volume II.

Core Requirement #3 applies to all non-exempt projects that meet the thresholds described in Chapter 2. Source control of pollutants (sediment/erosion control and spill prevention) during construction applies to all projects per Core Requirement #2. Core Requirement #3 is not required for single family residential projects that are not subject to Core Requirement #9.

Depending on the project location, there may be an adopted basin plan) or a TMDL plan (also known as a Water Cleanup Plan) with more stringent source control requirements for a specific basin.

Structural source control BMPs shall be identified on the permanent stormwater control plan, shown on other applicable plans submitted for review and approval, and the design shall be documented in the Drainage Report. Any required maintenance or operations required for a structural source control BMP shall be included in the Maintenance Plan.

Operational source control BMPs shall be included in the Stormwater Pollution Prevention Source Control Plan prepared for the project. Templates for a commercial source control plan and a residential source control plan are available from Thurston County (www.co.thurston.wa.us/stormwater/manual/). The use of the source control plan template is optional; however, the source control plan describing operational source control BMPs shall be included with other submittals and upon acceptance by the County shall be recorded with the County auditor for the subject property.

2.4.5 Core Requirement #4: 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.

Core Requirement #4 applies to all non-exempt projects that meet the thresholds described in Chapter 2, to the maximum extent practicable.

Preserving natural drainage systems to the fullest extent provides multiple stormwater benefits and minimizes erosion and sediment problems at and downstream from the discharge location.

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.

If flows for a given outfall are not channeled in the pre-development condition, runoff concentrated by the proposed project must be discharged overland through a dispersal system or to surface water through an energy dissipation BMP before leaving the project outfall. Dispersal systems include rock pads, dispersal trenches, level spreaders, and diffuser pipes. Typical energy dissipaters include rock pads and drop structures. These systems are described in Volume III, Chapter 3, *Conveyance Systems and Hydraulic Structures*.

In some instances, a diversion of flow from the existing (pre-development) discharge location may be beneficial to the downstream properties or receiving water bodies. Examples include situations where existing downstream flooding or channel erosion is occurring. If it is determined that a flow diversion may be warranted, the applicant should consult with Thurston County to confirm this conclusion and its application for the project.

As part of the project submittals, the applicant shall identify the location of natural drainage, topography, historic drainage information and any potential impacts. The discharge of stormwater from the project to adjacent properties may be subject to additional requirements (see Volume III, Chapter 3, *Conveyance Systems and Hydraulic Structures* and Core Requirement #11, *Offsite Analysis and Mitigation*).

Drainage easements from downstream property owners, if required, shall be obtained prior to approval of engineering plans. Offsite improvements proposed by the applicant may also require the applicant to obtain easements from the owners of any property where work occurs. Stormwater control or treatment structures shall 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.

2.4.6 Core Requirement #5: Onsite Stormwater Management

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

Core Requirement #5 applies to all projects that meet the thresholds described in Chapter 2. All projects, including those not meeting the thresholds of Chapter 2, shall use on-site measures to the maximum extent practicable for the control of stormwater.

Projects qualifying as flow control exempt in accordance with Section 2.4.8, *Flow Control*, do not have to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List 1 or List 2. However, these projects must implement the following LID BMPS if feasible:

- Restore native vegetation (BMP LID.01)
- Post-Construction Soil Quality and Depth (BMP LID.02) – All disturbed areas of the project to be landscaped shall implement BMP LID.02 to restore soil quality and depth.
- Dispersion of roof and driveway runoff (BMP LID.05, LID.06, and/or LID.07)

The use of Low Impact Development BMPs is more effective in reducing disruptions to the site’s natural hydrologic characteristics and preferable to more traditional BMPs such as detention ponds. In some cases, the application of on-site measures can result in reducing post-development flows or reducing the effective impervious surface and/or effective pollution generating impervious surface within a threshold discharge area to the extent that additional flow control or water quality treatment facilities (Core Requirements #6 and #7) are not required.

Use Figure 2-3 and the subsequent text to determine the project requirements for Core Requirement #5.

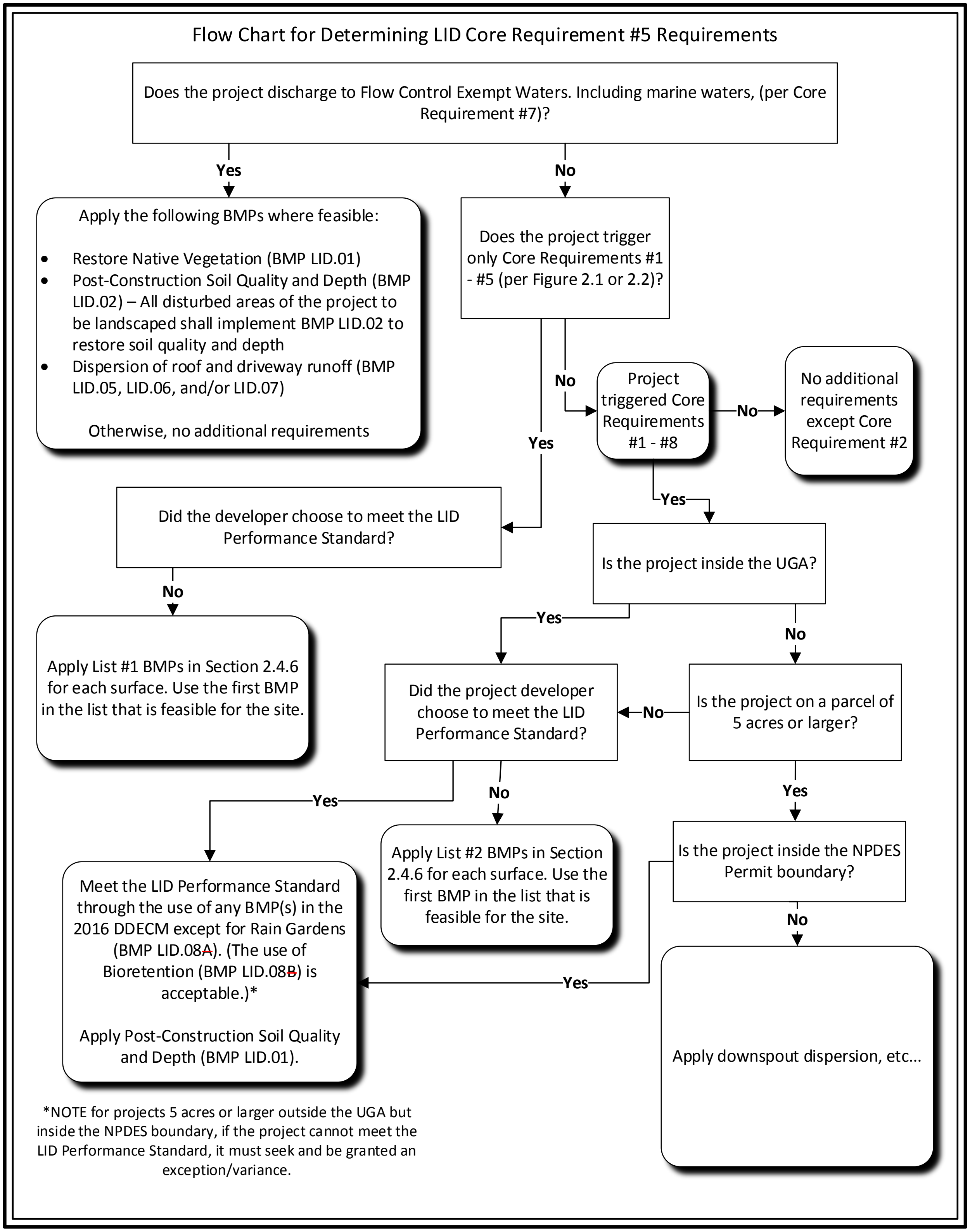


Figure 2-3. Flow chart for determining LID Core Requirement #5

Typo correction 01/05/2017

2. Projects that do not trigger Core Requirements #6 through #10 shall either:

   a. Use On-site Stormwater Management BMPs from List #1 for all surfaces within each type of surface in List #1; or

   b. Demonstrate compliance with the LID Performance Standard. Projects selecting this option cannot use Rain Gardens; however, they may choose to use Bioretention BMPs as described in Chapter 2 of Volume V to achieve the LID Performance Standard.

3. Projects that trigger Core Requirements #1 through #11, must meet the requirements in Table 2-1.

Table 2-1 On-Site Stormwater Management Requirements for Projects Triggering Core Requirements #1-#11

Project Type and Location	Requirement
New development or redevelopment on any parcel inside the UGA or outside the UGA on a parcel less than 5 acres.	LID Performance Standard and BMP LID.02; or List 2 (applicant option).
New development or redevelopment outside of the UGA on a parcel of 5 acres or larger	LID Performance Standard and BMP LID.02.
Projects in rural areas on a parcel of 1 acre or larger.	See item 4 below.
All projects where compliance with MR 5 is determined to be not feasible.	Off-site mitigation or payment of in-lieu fee in accordance with program requirements at such future time as an in-lieu fee program is developed by Thurston County. For off-site mitigation, applicant shall submit an off-site mitigation proposal demonstrating that an equivalent amount of mitigation is provided to off-set the impacts due to inability to meet the LID standard on the project site.

4. Projects where LID is determined to be not feasible and projects in the rural areas of the County on lots that exceed 1-acre in size may demonstrate compliance with Core Requirement #5, either through the applicable requirements described above, or through implementing, to the maximum extent practicable the following BMPs:

- Restore native vegetation (BMP LID.01)
- Post-Construction Soil Quality and Depth (BMP LID.02) – All disturbed areas of the project to be landscaped shall implement BMP LID.02 to restore soil quality and depth
- Downspout infiltration systems (BMP LID.04)
- Dispersion of roof and driveway runoff (BMP LID.05; LID.06; LID.07)
- Bioretention (BMP LID.08).

Where roof downspout controls are planned, the following three types shall be considered in descending order of preference:

- Downspout infiltration systems including bioretention (rain gardens)
- Downspout dispersion systems, only if infiltration is not feasible
- Collect and convey to the County or private stormwater system if other alternatives are not feasible. If discharging to a ditch, use a dispersion trench parallel to the ditch rather than a point discharge.

2.4.6.1 Low Impact Development Performance Standard

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 Standard Flow Control Requirement section in Core Requirement #7 – flow control -- for information about the assignment of the pre-developed condition. Project sites that must also meet Core Requirement #7 must match flow durations between 8% of the 2-year flow through the full 50-year flow.

2.4.6.2 List #1: On-site Stormwater Management BMPs for Projects Not Triggering Core Requirements #6 through #10

For each surface, consider the BMP’s in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. Feasibility shall be determined by evaluation against:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this Manual; and

2. Competing Needs Criteria listed below.

2.4.6.2.1 Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth in accordance with BMP LID.02 in Chapter 2 of Volume V.

2.4.6.2.2 Roofs:

1. Full Dispersion in accordance with BMP LID.11 in Chapter 2 of Volume V, or Downspout Full Infiltration Systems in accordance with BMP LID.04 in Chapter 2 of Volume V.

2. Rain Gardens in accordance with BMP LID.08~~A~~ in Chapter 2 of Volume V, or Bioretention in accordance with BMP LID.08~~B~~ in Chapter 2 of Volume V. The rain garden or bioretention facility must have a minimum horizontal projected surface area below the overflow which is at least 5% of the total surface area draining to it.

3. Downspout Dispersion Systems in accordance with BMP LID.05 in Chapter 2 of Volume V.

4. Perforated Stub-out Connections in accordance with BMP X.X in Chapter 2 of Volume V.

2.4.6.2.3 Other Hard Surfaces:

1. Full Dispersion in accordance with BMP LID.11 in Chapter 2 of Volume V.

2. Alternative Paving Surfaces (e.g. permeable pavement)[1] in accordance with BMP LID.09 in Chapter 2 of Volume V, or Rain Gardens or Bioretention in accordance with BMP LID.08 in Chapter 2 of Volume V. The rain garden or bioretention facility must have a minimum horizontally projected surface area below the overflow which is at least 5% of the area draining to it.

3. Sheet Flow Dispersion in accordance with BMP LID.06, or Concentrated Flow Dispersion in accordance with BMP LID.07 in Chapter 2 of Volume V.

[1]This is not a requirement to pave these surfaces. Where pavement is proposed, it must be permeable to the extent feasible unless full dispersion is employed.

Typo correction 01/05/2017

2.4.6.3 List #2: On-site Stormwater Management BMPs for Projects Triggering Core Requirements #1 through #11

For each surface, consider the BMP's in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. Feasibility shall be determined by evaluation against:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this Manual; and

2. Competing Needs Criteria listed below.

2.4.6.3.1 Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth in accordance with BMP LID.02 in Chapter 2 of Volume V.

2.4.6.3.2 Roofs:

1. Full Dispersion in accordance with BMP LID.11 in Chapter 2 of Volume V, or Downspout Full Infiltration Systems in accordance with BMP LID.04 in Chapter 2 of Volume V.

2. Bioretention in accordance with BMP LID.08 in Chapter 2 of Volume V. The bioretention facility must have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

3. Downspout Dispersion Systems in accordance with BMP LID.05 in Chapter 2 of Volume V.

4. Perforated Stub-out Connections in accordance with BMP X.X in Chapter 2 of Volume V.

2.4.6.3.3 Other Hard Surfaces:

1. Full Dispersion in accordance with BMP LID.11 in Chapter 2 of Volume V.

2. Alternative Paving Surfaces (e.g. permeable pavement)[1] in accordance with BMP LID.09 in Chapter 2 of Volume V.

3. Bioretention BMPs in accordance with BMP LID.08 in Chapter 2 of Volume V. The bioretention facility must have a minimum horizontally projected surface area below the overflow which is at least 5% of the area draining to it.

4. Sheet Flow Dispersion in accordance with BMP LID.06, or Concentrated Flow Dispersion in accordance with BMP LID.07 in Chapter 2 of Volume V.

[1]This is not a requirement to pave these surfaces. Where pavement is proposed, it must be permeable to the extent feasible unless full dispersion is employed.

2.4.6.3.4 Competing Needs

The onsite stormwater management 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 <www.dahp.wa.gov/learn-and-research/preservation-laws>, Federal Superfund or Washington State Model Toxics Control Act, Federal Aviation Administration requirements for airports, Americans with Disabilities Act.

- Where an LID requirement has been found to be in conflict with zoning design criteria found in TCC Title 18, 20, 21, 22, and 23 the existing local codes may supersede or reduce the LID requirement.

- Critical Area Ordinance – TCC Title 17 and 24 that provides protection of tree species, critical aquifer recharge areas and wellhead protection areas, geologic hazard areas, frequently flooded areas, fish and wildlife habitat conservation areas, and wetlands.

- Public health and safety standards.

- Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.

Chapter 4 provides guidance on BMP selection, including on-site stormwater management BMPs required by this Core Requirement. Design guidelines and sizing tables for the BMPs listed above are provided in Volume V.

Compliance with the LID Performance Standard and/or List 1 or List 2 as applicable, for each threshold discharge area shall be included in the Drainage Report for the project. Onsite measures and Low Impact Development BMPs shall be shown on the project drawings and design calculations shall be included in the Drainage Report. Maintenance and operations requirements for these BMPs shall be included in the Maintenance Plan for the project. For projects in which a Maintenance Plan is not required, the operations and maintenance criteria for on-site measures shall be shown on and described in the other submittal documents required for the project.

2.4.7 Core Requirement #6: Runoff Treatment

Projects must provide runoff treatment to reduce the water quality impacts of stormwater runoff from pollution-generating surfaces.

2.4.7.1 Thresholds

When assessing a project against the following thresholds, only consider those hard and pervious surfaces that are subject to this Core Requirement as determined in Section 2.3 of this Chapter.

Stormwater treatment facilities shall be constructed if the following criteria are met within a threshold discharge area (see Table 2-2):

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

Table 2-2 Treatment Requirements by Threshold Discharge Area

	<¾ Acres of PGPS	≥¾ Acres PGPS	<5,000 sf PGHS	≥5,000 sf PGHS
Treatment Facilities		✔		✔
Onsite Stormwater BMPs	✔	✔	✔	✔

PGPS = pollution-generating pervious surfaces
PGHS = pollution-generating hard surfaces
sf = square feet

The above thresholds apply to both a project's on-site and off-site improvements. Once the project triggers this Core Requirement, all new and replaced pollution generating hard surfaces are required to receive runoff treatment.

Pollution generating hard surfaces dispersed in accordance with BMPs LID.05 through BMP LID.07 of Chapter 2 of Volume V will still be considered pollution generating hard surface and subject to treatment in a treatment facility if the discharge from the dispersed area is collected in a conveyance system prior to leaving the project site, such as when the dispersed areas are conveyed to a flow control facility.

With respect to the runoff treatment requirements of this section, a "net" total of pollution generating hard surfaces associated with a given project will not be considered when dealing with replaced hard surfaces or hard surfaces converted to pervious surfaces. For example, construction of new surfaces that do not generate pollution (i.e., replacing old surfaces that were pollution generating with non-pollution generating surfaces such as roofs) does not balance the environmental impacts of newly created pollution generating surfaces. All new or replaced pollution generating surfaces that meet the thresholds for new development or redevelopment and create, add, and/or replace 5,000 square feet of pollution generating hard surface shall provide runoff treatment.

2.4.7.2 Treatment Facility Sizing

Size stormwater treatment facilities for the entire area that drains to them, even if some of those areas are not pollution-generating, or were not included in the project site threshold decision or the treatment threshold decisions of this Core Requirement. For example, if runoff from the total new PGHS and that portion of any replaced PGHS that requires treatment cannot be separated from the existing PGHS runoff, treatment facilities must be sized to treat all of the runoff.

Runoff treatment facilities shall be sized using the water quality design storm flow rates and volumes as described in Chapter 2 of Volume III.

2.4.7.3 Treatment Facility Selection, Design, and Maintenance

Stormwater treatment facilities shall be selected using the process described in Chapter 4, designed in accordance with the design criteria in Volume V, and maintained in accordance with the maintenance schedule in Appendix V-C and the requirements of Core Requirement #9

Depending on the activities and likely pollutants at the project site, required BMPs may be basic, enhanced, phosphorus control, or oil control. Chapter 4, BMP Selection explains when each type is required.

2.4.7.4 Additional Requirements

Direct discharge of untreated stormwater from pollution-generating hard surfaces to ground water is prohibited, except for the discharge achieved by infiltration or dispersion of runoff through use of On-site Stormwater Management BMPs, in accordance with Core Requirement #5 and applicable BMPs of Chapter 2 of Volume V; or by infiltration through soils meeting the soil suitability criteria in Chapter 2 of Volume III.

Impervious surfaces that are “fully dispersed” in accordance with BMP’s LID.11 (Full Dispersion), LID.12 (Rural Roads Natural Dispersion) or LID.13 (Rural Roads Engineered Dispersion) are not considered effective impervious surfaces. Impervious surfaces that are only “dispersed” in accordance with BMPs LID.05 (Downspout Dispersion Systems), LID.06 (Sheet Flow Dispersion) or LID.07 (Concentrated Flow Dispersion) are still considered effective surfaces though they may be modeled as pervious surfaces if flow path lengths meet the specified minima. See Volume III for a more complete description of hydrologic representation of On-site Stormwater Management BMPs.

Water quality treatment facilities shall be shown on the project drawings and include details and construction notes for their proper construction. Design calculations for each BMP shall be included in the Drainage Report along with any supporting documents (geotechnical reports, material specifications, soils testing, etc.). Maintenance and operations requirements for these BMPs shall be included in the Maintenance Plan for the project. If a justification for not providing treatment facilities for a threshold discharge area based on a reduction in effective impervious surfaces due to LID techniques, this justification shall be documented in the Drainage Report for acceptance by Thurston County.

Treatment facilities applied consistent with this Manual are presumed to meet the requirements of state law to provide all known available and reasonable methods of treatment (RCW 90.52.040, RCW 90.48.010). This technology based treatment requirement does not excuse any discharge from the obligation to apply whatever technology is necessary to comply with state water quality standards, Chapter 173-200 WAC; state sediment management standards, Chapter 173-204 WAC; and the underground injection control program, Chapter 173-218 WAC. Additional treatment to meet those standards may be required by the County, state or federal government.

2.4.8 Core Requirement #7: Flow Control

Projects must provide flow control to reduce the impacts of stormwater runoff from hard surfaces and land cover conversions.

2.4.8.1 Applicability

Exempt Waterbodies Flow Control is not required for projects that discharge directly to, or indirectly to the following waters of Thurston County:

- Skookumchuck River: From its mouth to 1 mile upstream of Bucoda at SR507 mile post 11.0
- Nisqually River: From its mouth to its confluence with Big Creek.
- Chehalis River: From its mouth to 1,500 feet downstream of confluence with Stowe Creek.
- Capital Lake / Deschutes River: Downstream of Tumwater Falls.
- Alder Lake
- All Saltwater Bodies

The requirements below apply to projects that discharge stormwater directly or indirectly through a conveyance system, into an exempt receiving water including a salt water body:

- The direct discharge must 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; and
- Flow splitting devices or drainage BMPs shall be applied to route the natural runoff volumes from the project site to any downstream Type 5 stream or Category IV wetland:

- Design of flow splitting devices or drainage BMPs will be based on continuous hydrologic modeling analysis. The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50 percent of the 2-year to the 50-year peak flow.

- Flow splitting devices or drainage BMPs that deliver flow to Category IV wetlands will also be designed using continuous simulation hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by Thurston County; and

- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection, etc.) and extends to the ordinary high water line of the exempt receiving water; and

- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and

- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

For discharges to a conveyance system discharging to salt water see Core Requirement #11 for additional requirements. Flow control may be required if the conveyance system capacity is limited.

2.4.8.1.1 Other Freshwater Bodies

The standard flow control requirement below applies to projects that discharge stormwater directly or indirectly through a conveyance system, into a fresh waterbody.

- Stormwater discharges from a threshold discharge area shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow and,

- The predevelopment condition to be matched shall be a forested land cover, unless reasonable historic information is available that indicates the site was prairie prior to settlement (modeled as “pasture” in the Western Washington Hydrology Model).

The above discharge requirement is waived for sites that will reliably infiltrate all runoff from hard surfaces and converted vegetation areas.

2.4.8.2 Thresholds

When assessing a project against the following thresholds, consider only those impervious, hard, and pervious surfaces that are subject to this core requirement as determined in Section 2.3 of this Chapter.

The following circumstances require achievement of the standard flow control requirement (see Table 2-3):

- Projects in which the total of effective impervious surfaces is 10,000 square feet or more in a threshold discharge area, or
- Projects that convert 3/4 of an acre or more of vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture in a threshold discharge area, and from which there is a surface discharge in a conveyance system (natural or man-made) from the site, or
- Projects that, through a combination of effective hard surfaces and converted pervious surfaces, cause a 0.15 cubic feet per second increase in the 100-year flow frequency from a threshold discharge area, as estimated using the WWHM, MGSFlood, or other approved model using 15-minute time steps. The 0.15 cfs increase is a comparison of the post-project runoff to the existing condition runoff. For purposes of applying this threshold, the existing condition is the pre-project (i.e. existing) land cover.

Table 2-3 Flow Control Requirements by Threshold Discharge Area

	Flow Control Facilities	Onsite Stormwater Management BMPs
<3/4 acres conversion to lawn/landscape, or <2.5 acres to pasture		✔
≥3/4 acres conversion to lawn/landscape, or ≥2.5 acres to pasture	✔	✔
<10,000 square feet of effective impervious area		✔
≥10,000 square feet of effective impervious area	✔	✔
≥0.15 cubic feet per second increase in the 100-year flood frequency	✔	✔

2.4.8.3 Additional Requirements and Guidelines

If the discharge from the project site is to a stream that leads to a wetland, or to a wetland that has an outflow to a stream, both this flow control requirement and Core Requirement #8 apply.

Flow control facilities shall be selected using the process described in Chapter 4, designed in accordance with the design criteria in Volume V, and maintained in accordance with the maintenance schedule in Appendix V-C and the requirements of Core Requirement #9.

Application of sufficient types of On-site Stormwater Management BMPs can result in reducing the effective impervious area and the converted vegetation areas such that a flow control facility is not required. Application of “Full Dispersion” (BMP LID.11) also results in eliminating the flow control facility requirement for those areas that are “fully dispersed.”

2.4.9 Core Requirement #8: Wetlands Protection

Discharges to wetlands (directly or indirectly through conveyance systems) shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

2.4.9.1 Applicability

This core requirement applies to all non-exempt projects that meet the thresholds of section 2.3 of this Chapter and where stormwater discharges into a wetland, either directly or indirectly, through a conveyance system.

2.4.9.2 Thresholds

The thresholds identified in Core Requirement #6: Runoff Treatment and Core Requirement #7: Flow Control shall also apply to determine the applicability of this requirement to discharges to wetlands.

2.4.9.3 Standard Requirement

Projects shall comply with Guide Sheets 1 through 3 in Appendix I-D of Ecology’s 2012 Stormwater Management Manual for Western (SWMMWW). The hydrologic analysis shall use the existing land cover condition to determine the existing hydrologic conditions, unless directed otherwise by the County or other regulatory agency.

2.4.9.4 Additional Requirements

Stormwater treatment and flow control facilities shall not be built within a natural vegetated wetland buffer, except for:

- Necessary conveyance systems as approved by the County; or,
- As allowed in wetlands approved for hydrologic modification and/or treatment in accordance with Guide Sheet 2 in Appendix I-D of the 2012 Ecology SWMMWW.

2.4.9.5 Objective

To ensure that wetlands receive the same level of protection as any other waters of the state. Wetlands are extremely important natural resources which provide multiple stormwater benefits, 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 natural hydrologic functioning of the wetland system. Changes in water levels and the frequency and duration of inundations are of particular concern.

2.4.9.6 Supplemental Guidelines

A wetland can be considered for hydrologic modification or stormwater treatment only in accordance with Thurston County Critical Areas Ordinance TCC Titles 17 or 24.

Appendix I-D of Ecology's 2012 Stormwater Management Manual for Western Washington, *Guidelines for Wetlands when Managing Stormwater*, shall be used for discharges to natural wetlands and wetlands constructed as mitigation. While it is always necessary to pre-treat stormwater prior to discharge to a wetland, there are limited circumstances where wetlands may be used for additional treatment and detention of stormwater. These situations are considered in Guide Sheet 2 of Appendix I-D of Ecology's 2012 SWMMWW.

Note that if selected runoff bypass is an alternative being considered to maintain the hydroperiod of a wetland, the hydrologic analysis must consider the impacts of the bypassed flow. For instances, if the bypassed flow is eventually directed to a stream, the flow duration standard, Core Requirement #7, applies to the bypass.

2.4.10 Core Requirement #9: Operation and Maintenance

A Maintenance Plan that is consistent with the provisions in this Manual shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified.

For private facilities, a project-specific agreement to maintain stormwater facilities and implement a pollution source control plan consistent with the provisions in Appendix I-E, for a single family residence, residential subdivision or commercial/industrial project, shall be executed by the party (or parties) responsible for maintenance of stormwater facilities and BMPs. The agreement shall normally be signed by the property owner and recorded with the Thurston County Auditor's Office prior to final project acceptance by Thurston County. A draft copy of the agreement shall be included with the submittal of the Maintenance Plan for County review and acceptance. The maintenance agreement shall run with the land and be transferred automatically to all subsequent owners. Publicly owned facilities, such as those owned by Thurston County Public Works, Central Services, and Resource Stewardship departments, are not required to execute an agreement.

2.4.10.1 Property Owners' Association Required

If the project is a subdivision, the Proponent shall form a Property Owners' Association. The document creating the Property Owners' Association shall, at a minimum, make provision for the following:

- Members of the Property Owners' Association shall be responsible for maintenance of storm drainage facilities as described in the Maintenance Plan

- Inclusion by reference of the Maintenance Plan prepared by the Project Engineer in accordance with Chapter 3 of this volume

- Power to assess fees to maintain storm drainage facilities

- Sanctions in the event that Thurston County has to take action to maintain facilities. The following or substantially similar words shall appear in the document creating the Property Owner's Association:

In the event Project Proponent (or successors or the Property Owners' Association), in the judgment of Thurston County, fails to maintain drainage facilities within the plat, or if the Proponent or successors willfully or accidentally reduces the capacity of the drainage system or renders any part of the drainage system unusable, the Proponent or successors agree to the following remedy: After 30 days' notice by registered mail to the Proponent or successors, Thurston County may correct the problem or maintain facilities as necessary to restore the full design capacity of the drainage system. Thurston County will bill the Proponent or successors for all costs associated with the engineering and construction of the remedial work. Thurston County may charge interest as allowed by law from the date of completion of construction. Thurston County will place a lien on the property and/or on lots in the Property Owners' Association for payments in arrears. Costs or fees incurred by Thurston County, should legal action be required to collect such payments, shall be borne by the Proponent or successors.

- A Maintenance Covenant stating the Property Owners' Association's specific maintenance responsibilities shall be recorded on the plat and recorded against each lot in the subdivision. The covenant shall include the following or substantially similar language:

MAINTENANCE COVENANT

Easements are hereby granted for the installation, inspection, and maintenance of utilities and drainage facilities as delineated on the plat for subdivision______________ including unrestricted access for Thurston County staff to any and all stormwater system features for the purpose of routine inspections and/or performing maintenance, repair and/or retrofit as may become necessary. No encroachment will be placed within the easements shown on the plat which may damage or interfere with the installation, inspection, and maintenance of utilities. Maintenance and expense thereof of the utilities and drainage facilities shall be the responsibility of the Property Owners' Association as established by covenant recorded under Auditor's file number _____________.

Additional Requirements Inadequate maintenance is a common cause of failure for stormwater control facilities. Volume V, Appendix C, provides detailed maintenance guidelines and standards for each BMP presented in this Manual. The applicable checklists from Volume V shall be included in the Maintenance Plan for the project.

At private facilities, a copy of the Maintenance Plan shall be retained on-site or be reasonably accessible from the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the Maintenance Plan shall be retained in the appropriate department. A log of maintenance activity shall be kept and be available for inspection by the County. An annual report on maintenance activities during the previous year is required to be submitted annually no later than August 31^{st} Chapter 3 describes Maintenance Plan submittal requirements, which are included as part of the Drainage and Erosion Control Plan for the project.

2.4.11 Core Requirement #10: Financial Liability

To ensure compliance with these standards, performance bonding or other appropriate financial instruments shall be required for all projects.

2.4.11.1 Financial Guarantees

In accordance with Thurston County Code Title 15.05.040, the project proponent/owner shall provide financial guarantees to insure that:

- The project will operate according to the design approved by the project engineer, and
- Operation of erosion control facilities will provide protection against siltation of surface water, erosion, and damage to adjacent properties.

The project proponent/owner shall provide a financial guarantee to the Administrator to ensure satisfactory maintenance of drainage facilities for a minimum of 2 years from final plat acceptance or acceptance of the project, whichever is later, in accordance with the Maintenance Plan submitted as part of the Drainage and Erosion Control Plan. The financial guarantee shall continue in effect until the drainage facilities are fully established, functioning per design and determined not to have substantial maintenance problems. Upon acceptance of the project by Thurston County and after minimum time requirements and other conditions have been met the project proponent shall request in writing that the financial guarantee be released. Said request shall document that the requirements for financial guarantee release have been met.

If the stormwater system is dependent on a property owners' association (POA) for maintenance, then the applicant shall present evidence of a POA being established and active before the financial guarantee is released. The holder of the financial guarantee shall establish a mechanism prior to sale of all or part of the project that ensures that the financial agreement holder has the legal right and ability to perform required stormwater system maintenance while the financial guarantee is in effect. Proof of same shall be provided to the Administrator prior to acceptance of the financial guarantee.

The mechanism may include a replacement of the financial guarantee by an identical guarantee from a third party (such as a POA) who takes responsibility for stormwater system maintenance. The original financial guarantee shall not be released until the replacement guarantee is accepted by the Administrator and legally recorded.

The amount of the guarantee shall be 25 percent of the construction cost of the drainage facilities. The applicant shall submit an itemized work sheet for the cost of facilities, acceptable to the Administrator before the financial guarantee amount is fixed. The bond quantities worksheet provided in Appendix I-D shall be used to prepare the cost estimate.

With County acceptance, and to the extent allowed by law, all project guarantees may be replaced by a single guarantee, provided that the total amount guaranteed shall at no time be less than the sum of the separate guarantees replaced. Furthermore, such guarantees shall clearly delineate those separate guarantees which they are intended to replace.

Subject to County acceptance, financial guarantees may be any of the following:

- Cash deposit escrow account
- Assignment of interest in a bank account
- Irrevocable letter of credit from a financial institution
- A bond.

All financial guarantees shall run continuously until released by the County.

2.4.12 Core Requirement #11: Offsite Analysis and Mitigation

An analysis consistent with the following guidelines shall be submitted with appropriate plan per Volume I, Chapter 3.

2.4.12.1 Applicability

Core Requirement #11 applies to those projects meeting the thresholds outlined in Chapter 2. The Project Engineer or applicant (for abbreviated plans) shall submit an off-site analysis that assesses the potential off-site impacts of the project's stormwater discharges.

When downstream drainage courses are inadequate, systems are undersized, or when (in the opinion of the Administrator or designee) property may be adversely affected by existing or proposed stormwater release rates, additional stormwater flow control measures may be required. Such determination by the Administrator or designee may be based upon information submitted by the applicant, existing information indicating problem areas, information received from or statements from property owners or residents near the project site, or current or past drainage problem litigation near the project. Additional information, calculations, or studies may be required of the applicant to assist the Administrator in making this determination.

2.4.12.2 Requirements

All projects shall perform a *qualitative analysis* downstream from the site to the receiving water or up to one mile, whichever is less, even if 100 percent infiltration is proposed. If the receiving water is within one-quarter mile, 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 to a point where any backwater effects created by the project cease. The analysis shall meet the requirements in Chapter 3.

A *quantitative* analysis may be required for any project deemed to need additional downstream information or where the Project Engineer or the Administrator or designee determine that a quantitative analysis is necessary to evaluate the off-site impacts or the capacity of the conveyance system.

This quantitative analysis shall determine conveyance system performance for the appropriate design events (see Volume III), both with and without the proposed development and based on full development of the contributing basin based on land use zoning. The Administrator or designee shall have the discretion to specify the distance and level of detail to be provided by the Project Engineer. The Administrator or designee shall consider factors such as the relative size of the new development, availability of other hydrologic work for the drainage area, and results of the qualitative analysis in making this determination.

If downstream conveyance system capacity is determined to be inadequate or undersized based on an evaluation of the entire contributing area at full build-out based on the current zoning, the applicant has the following options:

- Provide additional flow control, LID, or infiltration measures as required by the County to reduce stormwater discharge rates and/or volumes to pre-development conditions, or
- Correct or improve downstream drainage conditions so that the capacity is adequate to convey drainage from all contributing properties, or
- At such time as the County establishes a program for payment in lieu of improvements, the applicant may contribute to a dedicated fund to provide the downstream improvements required per the provisions of the program.

Any off-site improvements proposed by the applicant will require the applicant to obtain easements from the owners of any property where work occurs.

The Administrator or designee may impose stricter discharge, infiltration or detention standards, or require off-site mitigation work to an existing conveyance system if the discharge from the Project is reasonably expected to result in any of the following:

- Flooding
- Loss of aquatic habitat due to either high or low flows
- Property damage
- Water quality problems such as violations of surface water quality standards as identified in a Basin Plan or TMDL (Water Clean-up Plan); or violations of ground water standards in a wellhead protection area.

- Erosion (upland erosion impacts, including landslide hazards, or stream channel erosion at the outfall location).

- An unacceptable interruption of vital services

- Exceeding the capacity of a downstream conveyance system based on full basin development.

If the Project Engineer (or Administrator or designee) determines that greater treatment, infiltration or storage volumes, lower release rates, or downstream improvements are needed, he or she shall specify project design criteria or other means to relieve the downstream problems, providing that such a solution will not violate minimum standards established in this DDECM. The Administrator or designee shall have the final decision as to the scope and depth of the analysis.

Other means might include increases in downstream flow capacity or off-site detention and infiltration facilities. Plans and financing for these alternatives will be subject to the acceptance of the Administrator or designee.

The Offsite Analysis shall also include how the runoff from any public roadway frontage abutting the property is managed (qualitative at minimum, quantitative if meets above conditions). The project shall incorporate any runoff from public roadway frontage into the drainage system for the project.

2.4.12.3 Objective

To identify and evaluate off-site water quality, erosion, slope stability, and drainage impacts that may be caused or aggravated by a proposed project, and to determine measures for preventing impacts and for not aggravating existing impacts. Aggravated shall mean increasing the frequency of occurrence and/or severity of a problem.

2.5 Deeds and Easements

The following deeds and easements shall be used to convey property or rights to Thurston County:

- Statutory warranty deed (individual, partnership, or corporate): conveys real property to Thurston County

- Storm sewer easement: conveys to Thurston County the right to have and maintain a storm sewer system across a specific parcel of property

- Stormwater Maintenance Agreement: delineates responsibilities of party responsible for stormwater system maintenance and grants to Thurston County the right to have access to stormwater facilities for purposes of inspection, maintenance, or repair if the party responsible for maintenance fails to take required actions in accordance with the maintenance agreement.

- Slope and utility easement: conveys the right to have fill material or a cut slope and utilities on private property

- Quitclaim deed: conveys maintained but undocumented right-of-way to Thurston County

- Drainage Easement: conveys to Thurston County the right to access, use, and maintain a specific area of a parcel of property for purposes of storm drainage. This may include stormwater facilities for water quality treatment or flow control, dispersion, conveyance, or other purposes.

Prior to final project acceptance by Thurston County, all easements, dedicated tracts, buffers, or similar features associated with the stormwater facilities of a development, including a subdivision, shall be shown on the face of the plat or project site plan. In addition, written legal documents shall be prepared and recorded against all parcels to which the easement or dedication applies. Easements or tracts providing access to stormwater facilities shall be delineated in the field with permanent markers to prevent encroachment. See Section 3.9.6.2 for signage requirements.

2.6 Acceptance of New Stormwater Facilities

The developer of a stormwater facility is responsible for construction and maintenance of the facility, which must be in compliance with this Manual.

2.6.1 Public Ownership

The County does not accept maintenance responsibility for private stormwater facilities constructed by private developers.

2.6.2 Private Ownership – Subdivision Projects

If the project is a subdivision or short subdivision, the project proponent/owner shall form a property owners' association (POA). The document creating the association shall provide for the following, at a minimum:

- The POA shall be responsible for maintenance of storm drainage facilities

- Inclusion by reference of the Maintenance Plan prepared by the project engineer in accordance with this Manual

- Power to assess fees to maintain storm drainage facilities

- Responsibility for payment of financial sanctions/repayments should the County have to conduct repairs due to hazardous conditions.

The maintenance covenant and statement of sanctions described under Core Requirement #9, Section 2.4.11 will be included in the document establishing the POA and shall be recorded with the Thurston County Auditor for the plat and recorded against each lot within the subdivision or short division.

2.6.3 Private Ownership – Other Projects

If the project is other than a subdivision, short subdivision, or large lot division, the applicant will describe the organization or persons that will own and maintain the facility and provide evidence that maintenance activities will be performed and are adequately financed.

2.7 Adjustments

Adjustments to the Core Requirement may be granted prior to permit acceptance and construction. The Administrator may grant an adjustment subject to a written finding of fact that documents the following:

- The adjustment provides substantially equivalent environmental protection
- Meeting the objectives of safety, function, environmental protection and facility maintenance, based upon sound engineering.

2.8 Exceptions/Variances

The Administrator may grant exceptions to the Core Requirement or variances from the design standards, submittal requirements, or any other standards provided in the Manual provided that the applicant demonstrates their projects will substantially meet flow control and water quality performance goals established by or implicit in these standards per the guidelines below.

2.8.1 Exceptions/Variances to Core Requirements

Exceptions to the Core Requirement shall only be granted after legal public notice of an application for an exception; legal public notice of the Administrator's decision on the application and a written finding of fact that documents the Administrator's decision to grant an exception to the Core Requirement.

The Administrator may grant an exception to the Core Requirement 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 Administrator 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 Core Requirement(s) restricts the proposed use of the site compared to the restrictions that existed prior to the adoption of the Core Requirement; 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 Core Requirement; and

- A comparison of the estimated amount and percentage of value loss as a result of the Core Requirement versus the estimated amount and percentage of value loss as a result of requirements that existed prior to adoption of the Core Requirement; and

- The feasibility for the owner to alter the project to apply the Core Requirement.

2.8.2 Variances/Exceptions from Design Standards, Submittal Requirements, etc.

The Administrator may grant a variance to design standards, submittal requirements, or any other standards provided in the Manual, not including exceptions to the Core Requirement (addressed above) subject to a written finding of fact that documents the following:

- There are special physical circumstances or conditions peculiar to the land, such as size, shape, topography, or location, such that the strict application of these provisions would deprive the property owner of rights commonly enjoyed by other properties similarly situated; OR

- The site is being redeveloped and certain site investigations or installed stormwater facilities would require that existing structures be removed or damaged; OR

- The site is being redeveloped and the changes are either very small or configured in such a way that in the Administrator's or designee's opinion some requirements of the Manual cannot practically be met; OR

- The project is to be completed within an existing right-of-way which is of inadequate size to install required facilities and which cannot be expanded due to encroaching structures or setbacks;

Additional Criteria:

<u>In addition, any exception/variance must meet the following criteria:</u>

- That the granting of the exception/variance 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 Manual; AND

- A fee-in-lieu, based on the avoided cost or value of the exception or variance, may be collected by the County subject to specific requirements regarding fee-in-lieu set by Thurston County at such time as a fee-in-lieu program is established.

2.8.3 Supplemental Guidelines

The adjustment, exception and variance provisions are important elements of the plan review and enforcement programs. They are intended to maintain a necessary flexible working relationship between the applicant and the County. The Administrator will 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.

2.9 Interpretations and Appeals

Any person who disagrees with any decision of the Administrator or Thurston County regarding application of this Manual may request an interpretation. The request for an interpretation shall be submitted in writing to the Administrator or designee as defined herein. The Administrator or designee shall respond to that person in 30 days.

Appeals from an Administrative decision may be taken to the Hearings Examiner by any aggrieved person or by an officer, department, board, or commission of the jurisdiction affected by any order, requirement, permit, decision, or determination made by the Administrator or designee in the administration or enforcement of this Manual or any subsequent amendment thereto. The appeals procedure shall be identical to the appeal procedures of the Thurston County zoning code which requires the appeal to be in writing and made within 14 days of the administrative decision being appealed. A fee is required to be paid for an appeal.

2.10 Severability

If any provisions of this Manual or their application to any person or property are amended or held to be invalid, the remainder of the provisions in this Manual in their application to other persons or circumstances shall not be affected.

Chapter 3 - Stormwater Submittal Requirements

3.1 Introduction

Completion of submittals described in this chapter documents compliance with Core Requirement# 1 (Stormwater Site Planning) and Core Requirement #2 (Construction SWPPP), as described in Chapter 2. The following submittals, and their applicability to different types and sizes of projects, are described in this Chapter:

- Abbreviated Drainage Plan
- Engineered Abbreviated Drainage Plan
- Short Form Construction Stormwater Pollution Prevention Plan
- Drainage and Erosion Control Plan --includes a Drainage and Erosion Control Report, Permanent Stormwater Control Plan (drawings and specifications) and a Maintenance Plan.
- Construction Stormwater Pollution Prevention Plan (includes temporary erosion and sediment control drawings and a narrative).

All non-exempt projects are required to prepare one or more of the above submittals for County review and acceptance.

The County may require a project to prepare a “scoping report” and the applicant or County may request a “scoping meeting” early in the project to discuss the development site’s conceptual stormwater approach. This process may also be used to identify potential problems and to outline submittal requirements, scope, and content.

This chapter describes the submittal process for drainage review of projects submitted to Thurston County for permits. However, the site characterization and stormwater planning process should begin before submittal preparation.

3.1.1 Site Characterization

Site planning and design are integrated with stormwater management requirements. The manner in which a site is developed will impact the extent and cost of stormwater treatment and flow control. This section provides techniques that should be implemented to reduce both the impacts of projects on receiving waters and the overall cost of the stormwater management system.

Low impact development site design is intended to complement the predevelopment conditions on the site. However, not all sites are appropriate for a complete LID project, as site conditions determine the feasibility of using LID techniques. The development context shall be established by an initial site analysis consistent with the requirements of this section.

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 minimizing the pre- development natural hydrologic conditions on the site.

Take an inventory of the site prior to design activities and identify the following:

3.1.1.1 Soils Analysis

Use of many of the BMPs described in this Manual requires a detailed understanding of site soils. A preliminary soils analysis of the overall site to identify the locations of different soil types, the layering of soils, existence of hardpan, etc. should be conducted prior to major site planning. The objective of site planning should be to locate new impervious surfaces over soils that are less permeable and locate proposed stormwater facilities over soils that are more permeable to promote infiltration.

A preliminary assessment of infiltration rates of soils throughout the site should be considered early in the process for establishing potential BMP locations. More detailed infiltration evaluation as described in Volume III can occur once preliminary locations of infiltration facilities are established. Establishing an estimated overall site infiltration rate will also determine whether the minimum infiltration volume requirement of Core Requirement #7 will apply to the project.

A few strategically located test pits or borings are generally adequate for this preliminary soils assessment.

3.1.1.2 Critical Areas (e.g., wetlands, streams, or stream buffers)

Sites that have streams, wetlands, high groundwater, steep slopes, geologic hazard areas, well head protection areas or a number of other features are considered critical areas as defined by Thurston County Code Title 17 and Title 24. Many have been assigned buffer zones that restrict activities that can occur within them. These critical areas and associated buffers must be indicated on site plans and methods to protect them must be instituted from the start of development.

3.1.1.3 Natural Drainage Systems and Outfalls

Core Requirement #4 stipulates that natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable (see Chapter 2). By identifying natural drainage patterns at the start of the project, the designer can ensure that drainage routes are protected and that (where possible) the site is designed to minimize the conveyance facilities required to transport stormwater to natural drainage locations. Preserving natural drainage also decreases the likelihood of flooding or other problems downstream.

3.1.1.4 Significant Trees and Native Vegetation

By designing the site to protect significant trees and native vegetation, the designer will have more opportunities to use LID BMPs such as infiltration and dispersion for stormwater management. Native vegetation areas suitable for dispersion and where trees can be retained without risk of toppling should be mapped and included in the site plan.

3.1.1.5 Steep Slopes

Unless preventive measures are taken, stormwater runoff from development will cause additional erosion problems or even landslides on steep slopes. Many stormwater BMPs do not work well in areas with steep slopes, and their use is limited in those locations. Identify through topographic mapping and site visits the location of slopes greater than 10 to 15 percent and show these on the site maps. Special studies may be required for facilities located within setback distances to steep slopes. Marine bluffs are a special case of steep slopes for properties located along the marine waterfront. Thurston County Code, Title 17, includes specific requirements related to properties along marine bluffs.

3.1.1.6 Existing Topography

How does the undeveloped site deal with stormwater? If most stormwater currently infiltrates rather than running off the site, the finished site should use infiltration as the main method of stormwater management. This lessens the need for constructing new drainage channels or installing pipe, lessens the likelihood of downstream flooding, and protects downstream water quality.

If the topography provides large areas of surface storage through many small dips and hollows, consider providing on-site storage. If the existing topography already drains to a natural channel, designing the drainage system to follow this means less grading and less likelihood of erosion, if existing channel vegetation is preserved.

Design practices that consider and adapt to a site's characteristics, like the features listed above, are sometimes referred to as Low Impact Development. LID techniques are intended to more closely mimic predevelopment watershed hydrologic functions than traditional development practices.

LID techniques are emphasized throughout this Manual. These techniques include reducing impervious surfaces (described in BMP LID.03), preserving native vegetation (BMP LID.01), and protecting soils (BMP LID.02). They require advance planning, but will likely reduce costs associated with grading, stormwater treatment, flow control, stormwater conveyance, paving materials, curbs, and landscaping (if native vegetation is preserved). The County's NPDES Phase II permit also requires LID measures be given preferential consideration.

Preliminary sources of topographic information such as USGS maps and the Thurston County Geodata system can be used for preliminary evaluation of a site; however, topographic surveying by licensed surveyors and site visits to verify conditions by the project engineer or designer should be conducted to support design and before construction.

3.1.2 Site Design – Smart Design and Low Impact Development

Knowing how the site processed stormwater historically is important in determining appropriate better site design strategies. The site analysis (see Section 3.1.1) will provide information on how the site and the surrounding areas process stormwater both currently and historically (before any land use changes had altered those processes). This information will aid the designer in determining preferred site layout options, and in deciding what appropriate site design BMPs will help either maintain or restore natural pre-developed stormwater processes.

As presented in Chapter 1, and as required by Core Requirement #5, to effectively protect critical areas and receiving waters while taking advantage of a site's overland and subsurface flow, infiltration, storage, and evapotranspiration characteristics, the applicant shall consider first the following Low Impact Development strategies:

- Minimize effective impervious area (EIA): By avoiding the use of curbs (where permitted), designing reverse slope sidewalks, and allowing impervious surfaces to drain overland to pervious areas, a site can be designed to avoid concentrating runoff allowing for a higher time of concentration and greater infiltration. Ecology allows a flow credit for reverse slope sidewalks that drain onto native soils (see BMP LID.03). When impervious surfaces drain onto lawn or gravel prior to being collected in the site stormwater system, peak flows and volumes of stormwater from the site are reduced, thereby reducing stormwater management costs.

- Onsite stormwater management: Many parts of Thurston County have soils with high infiltration rates. By designing your site so that small areas drain to localized facilities, such as bioretention facilities (BMP LID.08), you may be able to manage your runoff entirely on-site, using areas not much larger than those needed for traditional landscaping. This practice also assures compliance with Core Requirement #5.

- Alternative paving surfaces: For areas of private developments with low traffic volume and where allowed by Thurston County road standards for private roads, alternative paving surfaces (BMP LID.09) such as porous concrete or asphalt, permeable interlocking concrete pavers, or grid systems can be highly effective at reducing or eliminating stormwater runoff and associated stormwater treatment, flow control, and conveyance costs. Even with very low infiltration rates of underlying soils, alternative paving surfaces are highly effective at controlling stormwater runoff. Alternative paving surfaces are not allowed within the public right-of-way or for private roadways which may be dedicated to the County.

3.2 Submittal Review and Acceptance Process

This is a conceptual overview of a typical submittal review and acceptance process, shown in Figure 3-1. For the latest information on submittal requirements and the acceptance process, contact the Permit Assistance Center or see Thurston County's permit website at: <http://www.co.thurston.wa.us/permitting/>.

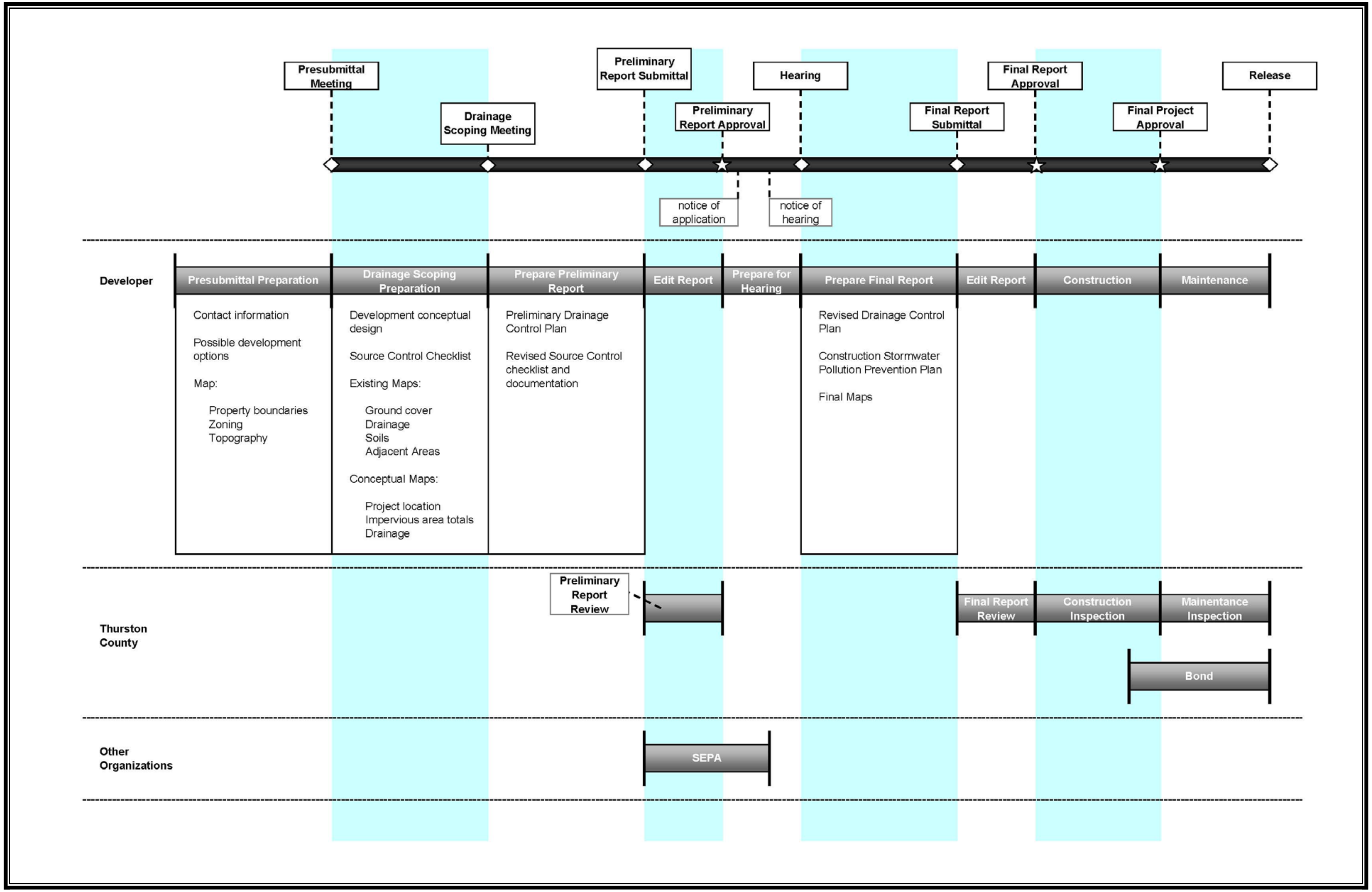


Figure 3-1 Submittal Review and Approval Process.

3.2.1 Presubmittal Meeting

A presubmittal meeting is an informal meeting between a project applicant and County and local government staff who will review the proposal. The applicant may have advisors present (e.g., realtor, surveyor, and engineer). Since this is an informal meeting and no decisions will be made, public comment is limited to the applicant and their advisors.

The project applicant must provide contact information, possible development options, and a map showing the property boundaries, topography, and zoning.

Sometimes, a presubmittal meeting is a required first step in a land use or subdivision process. The meeting is also a good way to obtain important information before beginning your project. For more information about the presubmittal meeting, see Thurston County's permit website at: <http://www.co.thurston.wa.us/permitting/>.

Drainage Scoping Report/Meeting

For any project exceeding the thresholds of Chapter 2 for which Core Requirements #6 (Runoff Treatment), and/or 7 (Flow Control) apply, a Drainage Scoping Report shall be submitted prior to project application submittal. Based on the review of the Drainage Scoping Report, or at the request of the applicant, a drainage scoping meeting may be scheduled to assist the applicant in complying with stormwater requirements.

The Drainage Scoping Report shall include the following:

- A letter of transmittal requesting a Drainage Scoping Report review and including applicant, property owner, and parcel information required to identify the property and its location
- A written description of the project including overall stormwater management strategy proposed for the site including a strategy for meeting Core Requirement #5, i.e., will the project use the BMP menu approach, the LID Flow Duration Standard, or LID is infeasible on the site
- Maps of the site's existing conditions showing ground cover, existing drainage, topography, soils, and adjacent areas
- A general vicinity map showing surrounding properties including topography, downstream, and upstream areas of the project
- Results of preliminary geotechnical investigations, test pits, etc. as well as Natural Resources Conservation Service (NRCS) soils mapping information
- A completed conceptual site plan, including a scale drawing with topography of the site and showing conceptual lot and building locations, impervious area totals, proposed drainage facilities, zoning information including any limits on impervious surfaces, tree retention requirements, landscape buffers, etc.

- If the project is a redevelopment project, a preliminary estimate of project construction costs should be submitted.

- The applicant shall also submit a completed source control checklist (see Volume IV, Source Control).

Upon review of the Drainage Scoping Report, Thurston County will prepare a response letter accepting the report and providing any additional information, studies, recommendations, suggestions, or additional requirements that might apply to the project that should be included in the submittal documents. If the County determines that a drainage scoping meeting is required, this will be included in the response letter.

3.2.2 Preliminary Report Submittal

Based on comments received from the Drainage Scoping Report review and drainage scoping meeting, the applicant then produces a preliminary Drainage and Erosion Control Plan including a preliminary drainage report, Permanent Stormwater Control Plan, and a revised source control checklist for inclusion in the permit or land use application package.

3.2.3 Final Report Submittal

After receiving preliminary acceptance of the project (Preliminary Plat Approval, Site Plan Review Approval, etc.) the applicant shall submit a final Drainage and Erosion Control Plan including a complete, Drainage Report, Maintenance Plan, Construction SWPPP, and final Permanent Stormwater Control Plan (construction drawings) for the project for County review.

Drainage and Erosion Control Plans submitted to the County will be routed to the Administrator or designee for review concurrently with other project plans (e.g., vegetation removal and clearing, final grading, landscaping, water and sewer, community on-site sanitary waste disposal system, roads, utilities plans). Incomplete Drainage and Erosion Control Plans will be returned to the applicant without being reviewed.

Until the Administrator or designee accepts the submittal and confirms that erosion control devices are in place as per the plan, the County will not:

- Grant any development, building, or other related permit except as needed to install erosion and sediment control facilities

- Allow project clearing, earthwork, demolition, site work, or construction to begin

- Allow construction of footings for structures.

3.2.4 Final Report Acceptance

After the applicant completes changes to the final report required by the County, the County shall issue a Final Report Acceptance, allowing construction to begin.

3.2.5 Final Project Acceptance

The following must be completed before the County will accept plats, grant certificates of occupancy, release financial securities related to drainage and erosion control, or accept final construction.

For those filing Drainage and Erosion Control Plans:

- Drainage and Erosion Control Plan accepted by the County
- Stormwater Facilities Maintenance Plan accepted by the County
- Construction Inspection Report and as-built drawings in electronic format (PDF and CAD)
- Special requirements on the cover sheet of a plat, such as BMP volumes or other design criteria, and a general easement for protection and maintenance
- Filing of covenants on lots, the POA articles of incorporation and CC&R's, maintenance agreements, easements, agreements with adjacent property owners, conservation easements, and similar documents as required in the Drainage and Erosion Control Plan and Thurston County Code.
- Conditions of acceptance fulfilled
- Site permanently stabilized and restored, and temporary erosion control measures removed.

For Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan projects:

- All conditions of the Abbreviated or Engineered Abbreviated Drainage Plan must be met, except that replanting may be delayed with the concurrence of the County.
- An 8½ x 11" version of the Abbreviated or Engineered Abbreviated Drainage Plan showing the location of drainage structures, conveyances, drywells, and dispersion areas shall be created and recorded with the Thurston County Auditor for the subject property.

Abbreviated Drainage Plans must be submitted with the application for permit or preliminary project acceptance.

3.3 Submittal Format

Submittals shall be in accordance with submittal requirements of the Thurston County Code and Development Services appropriate for the project type. At least one copy of all submitted documents shall be in electronic (Adobe PDF) format. Where required, full size plans shall be 22" x 34" and all information and text shall be of sufficient size to be readable when reduced to

11” x 17” size. Where plot plans are required, such as for abbreviated plan submittals, they shall be 11” x 17”. Examples are available from the County.

3.4 Submittal Types

Submittals required for drainage review depend on the project’s type, size, location, and proposed treatment. Figure 3-2 summarizes required submittals, depending on whether the project is 1) eligible for an Abbreviated Drainage Plan; 2) located within or near a critical area; and 3) subject to Core Requirement #2, Construction Stormwater Pollution Prevention Plan (SWPPP). Consult relevant sections of this Manual to determine whether these categories apply to the proposed project.

In terms of submittals, there are four categories of Thurston County projects:

1. Projects exempt from submittal requirements

2. Projects eligible for an Abbreviated Drainage Plan

3. Projects requiring an Engineered Abbreviated Drainage Plan

4. Projects requiring a complete Drainage and Erosion Control Plan.

Projects that may submit an Abbreviated Drainage Plan or an Engineered Abbreviated Drainage Plan may have additional submittal requirements (e.g., a Short Form Construction SWPPP and Source Control Plan) if they are subject to Core Requirement #2 or #3. These submittals are briefly described below.

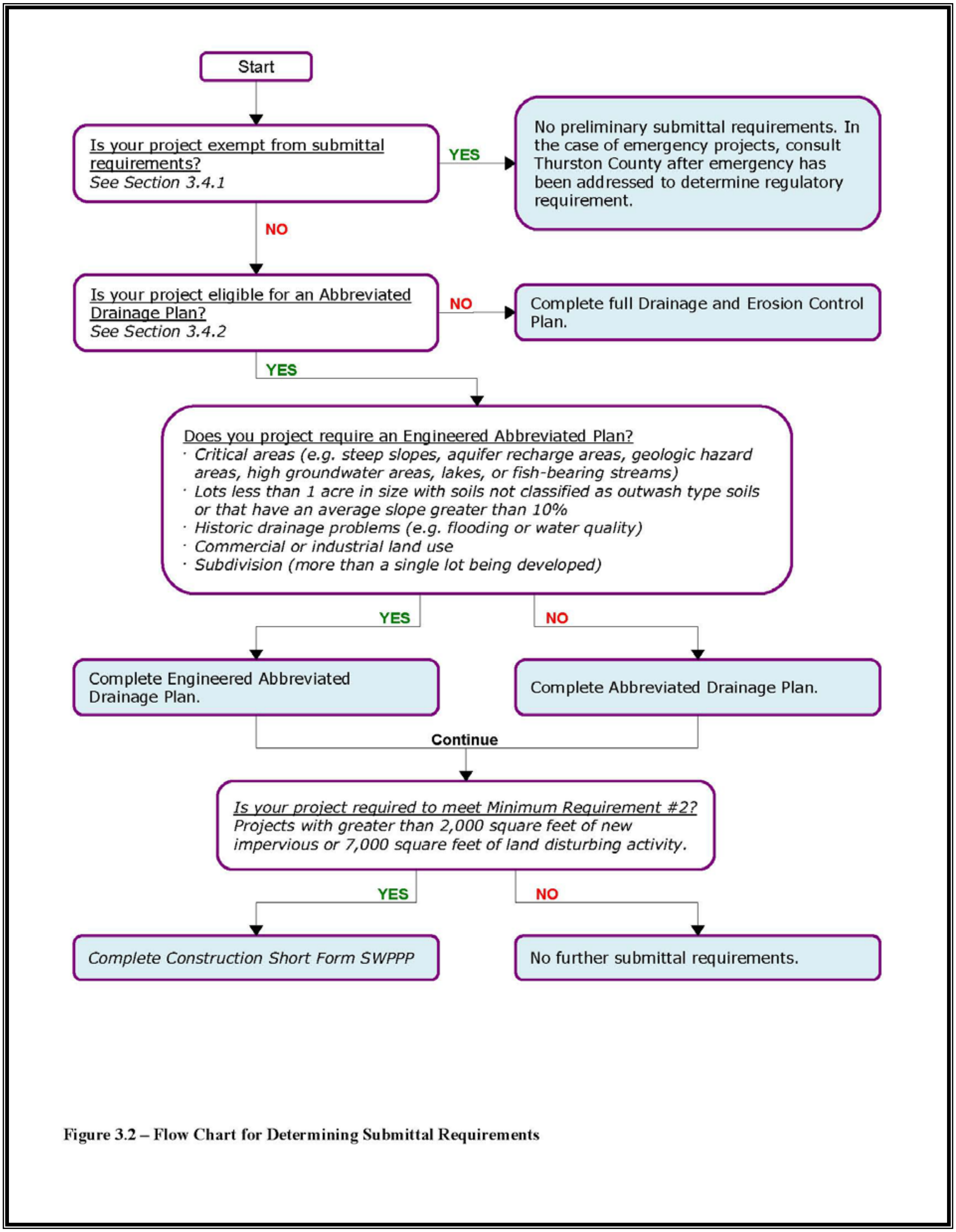


Figure 3-2 Flow Chart for Determining Submittal Requirements

Table 3.1 Thresholds for Abbreviated Plans, Stormwater Pollution Prevention Plans, and Drainage Control Plans

Category [1,2]		$\geq$500 sf New or Replaced Impervious/Hard Surface	$\geq$2,000 sf New or Replaced Impervious/Hard Surface or $\geq$7,000 sf Land Disturbed	$\geq$5,000 sf New or Replaced Impervious/Hard Surface, or $\geq$0.75ac of Vegetation Converted to Lawn, or >2.5 ac Native Vegetation Converted to Pasture, or $\geq$250 cy Materials Moved
1	Subdivision, Short Plats, Large Lots, one-Lot Subdivisions	AP	AP, SWPPP	SWPPP. DCP
2	Creation of New Impervious/Hard Surface [6]	AP	AP, SWPPP	SWPPP, DCP
3	Construction of Roads, Shared Accesses, and Alleyways		AP, SWPPP	SWPPP, DCP
4	Maintenance and Repair of Roads, Shared Accesses, and Alleyways		AP, SWPPP	SWPPP, DCP
5	Utility Line Work (construction or maintenance – inside R/W) [4]		AP, SWPPP	SWPPP, DCP
6	Utility Line Work (construction or Maintenance – outside R/W) [5, 6]		AP, SWPPP	SWPPP, DCP
7	Building Permit	AP	AP, SWPPP	SWPPP, DCP
8	Clearing	AP	AP, SWPPP	SWPPP, DCP
9	Grading	AP	AP, SWPPP	SWPPP, DCP
10	Driveway culvert installation in Roadside Swales/Ditches [7]			

AP = Abbreviated Plan
DCP = Drainage Control Plan

3.4.1 Projects Exempt from Submittal Requirements

In addition to those projects that are categorically exempt from the requirements of this Manual (see Section 2.2) the following projects are exempt from the submittal requirements but shall be designed and constructed consistent with the requirements of this Manual:

- Emergency projects which if not performed immediately would substantially endanger life or property are exempt from submittal requirements. Upon resolution of the emergency, the property owner must either restore the site to its original condition or comply with the requirements of this Manual. Contact Thurston County to determine which regulatory requirements must still be met after the emergency situation has been addressed.

- Public works road projects completely within the right-of-way which do not add impervious surface and for which previously dispersed flows are not concentrated (i.e., adding curb and gutter).

- Public works road widening projects including minor right-of-way acquisitions and for which no change in the type of conveyance system (i.e., from open channel to piped system) is proposed and for which previously dispersed flows are not concentrated (i.e., adding curb and gutter).

- Projects in rural areas (outside the NPDES boundary) which add or modify hard surfaces and the total of existing hard surfaces (including the modified hard surfaces) plus the new hard surfaces is less than 5% of the parcel, and grading is less than 5,000 cubic yards, and land disturbing activity is less than 10% of the parcel—providing that there is no increase in runoff or sediment discharge to adjoining property or to waters of the United States. If the property abuts a public roadway frontage, the area of the roadway frontage contributing drainage to the site shall be included in the impervious area computation and runoff from the roadway shall be accounted for.

3.4.2 Abbreviated Drainage Plan

Abbreviated Drainage Plans are streamlined submittals allowed for projects on land zoned residential, agriculture, or forestry, where none of the special conditions requiring an Engineered Abbreviated Plan apply and the project meets one or a combination of the following criteria:

- Project on a single lot where less than 2,000 square feet of new impervious surface is created and less than 7,000 square feet of land is disturbed.

- Project on a single lot where greater than 85 percent of the lot area can be classified as Type A/B (outwash) soils and where less than 5,000 square feet of new impervious surface is created, less than ¾ acre is converted to lawn/landscape, and less than 2.5 acres are converted to pasture.

- Project subject to a building permit on a single lot of any size, if the lot is within a development that has a previously accepted and currently functioning stormwater system that includes the future development of that lot.

- Project converting less than 3/4 of an acre from native vegetation to lawn or landscaped areas and creating less than 2000 square feet of new impervious surface or meeting one of the other conditions of this section related to limits on impervious surface.

- Project converting less than 2.5 acres from native vegetation to pasture or timberland to commercial agriculture and creating less than 2000 square feet of new impervious surface or meeting one of the other conditions of this section related to limits on impervious surface.

- Project on a parcel of greater than 1 acre outside the NPDES Phase II permit boundary where 85% of the parcel area can be classified as Type A/B (outwash) soils on which new, replaced, and existing hard surfaces including any public roadway frontages are less than 10 percent of the site, and total non-native pervious plus impervious surfaces are less than 35 percent of the site, and no substantial (>0.15 cfs using a 15 minute time step) increase in runoff or sediment discharges to adjoining property or to waters of the United States occurs as a result of the project.

- Project on a parcel of greater than 2.5 acres outside the NPDES Phase II permit boundary with any soil type on which new, replaced, and existing hard surfaces are less than 10 percent of the site, and total non-native pervious plus hard surfaces are less than 35 percent of the site, and no substantial (>0.15 cfs using a 15 minute time step) increase in runoff or sediment discharges to adjoining property or to waters of the United States occurs as a result of the project

- Grading project requiring a permit, where total grading is less than 500 cubic yards with less than 2,000 square feet of hard surface added and less than 7,000 square feet of land disturbing activity occurs and no change to existing drainage occurs.

In computing the area thresholds above, if the project site abuts a public roadway and roadway frontage improvements are required, the hard surfaces and disturbed areas associated with the frontage improvements shall be included in the area calculations. In calculating existing hard surfaces the area to the centerline of the public road fronting the property shall be included.

Additional submittals (such as a Construction SWPPP or Source Control Plan) may be required to comply with Core Requirements #2 and #3 or for projects with critical areas as described below.

3.4.3 Engineered Abbreviated Drainage Plan

An Engineered Abbreviated Drainage Plan is a streamlined submittal similar to an Abbreviated Drainage Plan that must be prepared by a civil engineer licensed in the State of Washington and includes additional design, calculations and specifications beyond those required by an Abbreviated Drainage Plan (see Section 3.7). An Engineered Abbreviated Drainage Plan is allowed for the following project types:

- Project that meets the general requirements for an Abbreviated Drainage Plan, but has any of the following special conditions:
  - Any critical areas as defined by Thurston County Code, Title 17 (e.g., wetlands, aquifer recharge areas, geologic hazard areas, high groundwater areas, special management areas, flood hazard areas, shoreline protection areas, lakes, streams, etc.) exist within 200 feet of the boundaries of the disturbed area of the project site
  - Any project located within 200 feet of a Marine Bluff Hazard Area as defined by Thurston County Code, Title 17. (Note: Any project located within the Marine Bluff Hazard Area shall prepare a full Drainage and Erosion Control Report in accordance with Title 17, TCC)
  - For lots less than 1 acre in size with soils not classified as predominately Type A/B (outwash) soils, or where the average slope across the parcel is greater than 10 percent or any slope 15 percent or greater with 10 foot or greater height exists
  - Project is located in an area that has historically had drainage problems including flooding and/or water quality problems
  - Proposed or existing land use is commercial, industrial, or multi-family residential
  - Subdivision (more than a single lot being developed)
- Other Single Family Residential or Duplex projects on a single lot not meeting criteria for an Abbreviated Drainage Plan and not located within a Marine Bluff Hazard Area
- Grading projects requiring a permit, where total grading is less than 5,000 cubic yards with less than 5,000 square feet of impervious surface added and less than ¾ of an acre of native vegetation converted to lawn or landscape and no change to existing drainage occurs.

Engineered Abbreviated Drainage Plans shall be stamped by and prepared by, or under the direct supervision of, a civil engineer licensed in the State of Washington. All Core Requirement applicable to the project as described in Chapter 2 shall be addressed by the Engineered Abbreviated Drainage Plan.

3.4.4 Drainage and Erosion Control Plan

Applicants with projects not eligible for an Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan shall submit a Drainage and Erosion Control Plan. All such plans shall be stamped by and prepared by, or under the direct supervision of, a civil engineer licensed to practice in the State of Washington (hereinafter referred to as the "Project Engineer").

3.5 Abbreviated Drainage Plan

This section summarizes the Core Requirement of an Abbreviated Drainage Plan. The Administrator or designee may increase plan submission and runoff control requirements for projects expected to have a significant impact on sensitive natural resources, or projects that could exacerbate existing flooding or water quality problems.

An Abbreviated Drainage Plan consists of a written project summary, a plot plan, and any other requirements set by the Administrator or designee. Abbreviated Drainage Plans need not be stamped with the seal of a licensed Professional Engineer.

For projects which are required to address more than Core Requirement #2 (Construction SWPPP), the Abbreviated Drainage Plan shall address all Core Requirement applicable to the project.

3.5.1 Plot Plan

The plot plan submitted for the Abbreviated Drainage Plan shall be sufficiently clear to see the footprint of structures and other features described below. Drawings shall be 11" by 17" in size. Lines shall be drawn with a straight edge and features shall be to scale.

The plot plan shall contain the following information:

- Name, address, and telephone of the applicant, project proponent and property owner (may be the same person)
- Name, address, and telephone of the person preparing the plot plan
- How disturbed areas will meet requirements for Post Construction Soil Quality and Depth (BMP LID.02)
- Parcel number(s)
- County Project/Permit number
- DDECM version, i.e., year published
- Scale and north arrow

- Legend, if symbols are used
- Vicinity map of sufficient clarity to locate the property and the receiving water body
- Property boundaries, dimensions, and area
- Contour lines from the best available source (specify datum used)
- Adjoining street names
- Existing and proposed structures and other impervious surfaces such as driveways, patios, green houses, barns, etc. Include the area of each impervious surface.
- Location of waste treatment systems
- Utility easements
- Established buffers, significant trees, and natural vegetation easements
- Natural drainage channels, wetlands, canyons, gullies, water bodies, etc.
- Clearing limits and total area being cleared
- Areas to be graded, filled, excavated, or otherwise disturbed
- Location of known wells, underground storage tanks, septic tanks
- The location and type of erosion and sediment control measures.
- If the project triggers Core Requirement #5, the plan shall show how the project will meet the Core Requirement or indicate where and why LID is infeasible.

The plan shall be kept on the project site during construction and made available to the County's inspectors on demand. Any changes to the plot plan shall be submitted to Thurston County for review and acceptance prior to performing the work in the field. All changes from the original plot plan shall be recorded and a record drawing (as-built) prepared showing the final constructed improvements. This as-built shall be submitted to Thurston County prior to final project acceptance.

3.5.2 Conditions

The Administrator or designee will attach conditions to the project as necessary to control erosion and runoff. These conditions shall include but not be limited to:

- An evaluation of the need for downspout infiltration systems (BMP LID.04), downspout dispersion systems (BMP LID.05), bioretention facilities (BMP

LID.08), or other on-site facilities for disposal of runoff from roofs and other impervious surfaces. Size of facilities shall be determined through application of requirements specified in Volume V.

- Routing for storm drainage as necessary and appropriate for the size of project.

- Erosion control devices (e.g., construction entrances, filter fabric fences, stockpile protection, buffers for Critical Areas, and other measures).

- Easements and setbacks as required to ensure maintenance access, buffers, proper drainage, dispersion area protection, or other functions cited in this Manual

- Management of tributary runoff from private or public roadway frontages abutting the project site.

3.6 Short Form Construction SWPPP

A Short Form Construction SWPPP is provided for projects with a disturbed area of less than 1 acre that are eligible for the Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan and are required to meet Core Requirement #2, i.e., projects with greater than 2,000 square feet of new impervious or 7,000 square feet of land disturbing activity.

The template for the short form Construction SWPPP, which includes an abbreviated erosion and sediment control plan, is provided in Volume II.

3.7 Engineered Abbreviated Drainage Plan

The Engineered Abbreviated Plan must consider the following in accordance with the hydrologic design criteria of Volume III for flow control, water quality treatment, and conveyance system design:

- Provision of adequate slope of surfaces toward drains

- Sizing of catch basins, drains, swales, ditches, pipes, and other conveyance facilities

- Bedding or anchoring of pipes

- Safe routing of runoff away from, over, or through critical areas including marine bluffs, geologic hazard areas, landslide hazard areas, wetlands, etc.

- Design of infiltration systems including drywells, bioretention areas, infiltration ponds, or trenches

- Design of flow control and runoff treatment facilities for stormwater released from the site, as required

- A map showing the location of newly planted and retained trees claimed for flow reduction credits

- Design of dispersion areas required to disperse concentrated or other runoff in accordance with the applicable BMP

- Other factors pertinent to safely convey runoff.

In addition to the requirements for submittal of an Abbreviated Drainage Plan, the Engineered Abbreviated Plan shall include narrative, calculations, drawings of facilities and specifications sufficient for construction.

The plan shall address all Core Requirement applicable to the project based on the criteria of Chapter 2.

For a project within a marine bluff hazard area or landslide hazard area Thurston County Code, Title 17, 17.15.630, has additional requirements that shall be addressed by the applicant.

3.8 Drainage and Erosion Control Plan

Drainage and Erosion Control Plans shall contain the following:

- A Drainage Report (described below)

- A Construction SWPPP (as described in Volume II)

- Drawings and Specifications

- A Maintenance Plan.

3.8.1 Drainage Report

The report shall be bound and 8-1/2" x 11" with map pockets for plan sheets (22" x 34" maximum size) and 11" x 17" drawings folded to 8-1/2" x 11" size unless the County approves another submittal format. The complete drainage report including appendices and drawings shall also be converted to PDF format and included in the submittal.

The report shall contain the following:

- Cover Sheet: Include the project name, applicant, owner and project proponent's name, address, and telephone number, project engineer's name, address and phone number, date of submittal, County project/ permit number, contact's name, address, and telephone number, and the name, address and phone number of the contractor, if known.

- Table of Contents: Show the page number for each section of the report and appendices.

- Project Engineer's Certification: The Drainage Report must be developed by a professional engineer licensed to practice in the State of Washington. For projects where a PE is required, all plans and specifications, calculations, certifications, “as-built” drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer's official seal and signature.

The Drainage Report shall contain a page with the project engineer's seal with the following statement:

> *"I hereby state that this Drainage and Erosion Control Plan/Construction SWPPP for (insert name of project) has been prepared by me or under my supervision and meets the requirements of the Thurston County Drainage Design and Erosion Control Manual and the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that Thurston County does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me."*

- Facility Summary Form (see example in Appendix I-D)
- Bond Quantities Worksheet (use Thurston County’s format, Appendix I-B)
- Drainage Report Narrative (10 sections, described below)
- Construction SWPPP (12 sections, summarized in Volume II, can be bound separately or together with the Drainage Report).

3.8.1.1 Drainage Report Section 1 – Proposed Project Description

The Drainage Report shall include the following information. Where appropriate, features should be shown on the drawings.

3.8.1.1.1 Permit

Describe the type of permit being applied for. Describe other permits required (e.g., hydraulic permits, 404 permit, marine bluff, etc.).

3.8.1.1.2 Project Location

Determine precise location of the construction site, adjacent roads and receiving waters:

- Indicate locations on Vicinity Map.
- Describe project including locations in Project Description.

3.8.1.1.3 Property Boundaries and Zoning

Determine the legal property boundaries and zoning requirements for the site:

- Indicate Legal Property Boundaries and Zoning on Site Map.
- Discuss zoning requirements in Existing Site Conditions.

3.8.1.1.4 Project Description

Provide a brief description of the development project, including the anticipated timing of the project.

3.8.1.1.5 Timing of the Project

An important consideration in selecting BMPs is the timing and duration of the project. 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.

- Provide a timeline for the project based on applicant's best estimate of project start date.
- Describe and show design considerations based on project timing
- Include 13 elements of Construction SWPPP in timeline as applicable.

3.8.1.2 Drainage Report Section 2 – Existing Site Conditions

This section describes the existing conditions and what is required to be shown on the existing conditions scale drawing of the site to be included in a map pocket or an 11" x 17" drawing.

Low impact development site design in particular is intended to complement the existing conditions on the site. However, not all sites are appropriate for all LID and on-site stormwater management BMPs, as site conditions often determine the feasibility of using these techniques. The existing conditions site analysis, consistent with the requirements of this section, shall determine the feasibility of using these BMPs. The plan shall show areas were LID is infeasible.

3.8.1.2.1 Topography

Prepare a topographic drawing of the site to show existing contour elevations at intervals of 1 to 5 feet, depending upon the slope of the terrain (see Section 3.8.3 for drawing protocols). Evaluate topography for erosion potential. The primary topographic considerations are slope steepness and slope length. The longer and steeper the slope, the greater the erosion potential. Erosion potential should be determined by a qualified engineer, soil professional, or certified erosion control specialist. Site topography shall be based on field survey by a licensed professional surveyor for any area of the project disturbed or where structures, roadways, or stormwater facilities will be located including dispersion areas.

- Show Topography on Site Map
- Discuss site topography in Existing Site Conditions.

3.8.1.2.2 Ground Cover

Label existing vegetation on the drawing. Show features such as tree clusters, grassy areas, and unique or sensitive vegetation. Indicate existing denuded or exposed soil areas. Where available, provide the most recent aerial photograph of the site.

Ground cover is the most important factor in erosion prevention. Existing vegetation that can be saved will prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider practices like phasing construction, temporary seeding, and mulching. Phasing of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

- Show vegetation on Site Map
- Include aerial photograph in Drainage Report
- Discuss vegetation in Existing Site Conditions.

3.8.1.2.3 Drainage

Locate and clearly mark existing drainage ditches, closed depressions, and storm drain systems on the site map. Identify the point(s) of exit of drainage from the property. The drawings should distinguish between natural and constructed drainage. Identify off-site drainage contributing to the project site, and characterize the quantity and quality of off-site water. Document existing erosion or flooding problems. Identify closed depressions, areas where stormwater appears to infiltrate, and potential sites for temporary stormwater retention and detention.

- Show existing Drainage on Site Map
- Discuss Drainage in Existing Site Conditions.

3.8.1.2.4 Soils

Identify and label soil type(s) and erodibility (slight, moderate, severe, very severe or an index value from the NRCS Manual) on the drawing. Soils information usually can be obtained from a county soil survey. If a soil survey is not available, a request can be made to a district Natural Resource Conservation Service Office. Show the location of any test pits or borings conducted for the project. Include description of the soils and the boring or test pit logs in the Drainage Report. Estimate the overall pre-development infiltration rate for the site based on preliminary soils data.

- Show soils information on Site Map and location of any borings or test pits
- Discuss in Soils section of drainage report
- Include boring or test pit logs in drainage report.

3.8.1.2.5 Critical Areas

Delineate critical areas adjacent to or within the site on the drawing. Show features such as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas. Delineate setbacks and buffer limits for these features on the drawings.

Other related jurisdictional boundaries such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base floodplain should also be shown on the drawings. Critical areas per Thurston County Code 17.15.100 may include but not be limited to critical aquifer recharge areas, geologic hazard areas, important habitats, flood and channel migration hazard areas, and wetlands. Critical areas and their buffers shall be delineated on drawings and clearly flagged in the field. 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.

- Show critical areas on Site Map
- Discuss critical areas in Critical Areas section.

3.8.1.2.6 Adjacent Areas

Identify existing buildings, roads, and facilities adjacent to and on the project site on the drawings. Identify existing utility locations on the drawings. An analysis of adjacent properties should focus on areas 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.

- Show adjacent areas on Site Map
- Discuss adjacent areas in Adjacent Areas.

3.8.1.2.7 Precipitation Records

Refer to Volume III to determine the required rainfall records and the method of analysis for design of BMPs.

- Include rainfall data needed for sizing.

3.8.1.2.8 Reports and Studies

Include references to relevant reports such as basin plans, flood studies, groundwater studies, wetland designation, sensitive area designation, environmental impact statements, lake restoration plans, and water quality reports. When such reports impose additional conditions on the applicant, state these conditions.

3.8.1.3 Drainage Report Section 3 - Geotechnical Report

A geotechnical report may be required for grading or, where infiltration BMPs are proposed, a geotechnical report must be prepared in accordance with Section 2.3.2 of Volume III. Section 3 of the drainage report shall summarize soil types, geotechnical recommendations, infiltration testing methods and locations, and design infiltration rates. The entire report shall be included as an appendix.

If an infiltration or detention facility is near the top of a slope that is greater than 15 percent or otherwise regulated by Thurston County, then a geotechnical report addressing effects of seepage and the potential for slope failure during any precipitation event through the 100-year, 24-hour event may be required as part of the Drainage and Erosion Control Plan.

Any assessment of the infiltration receptor and/or mounding analysis shall be included in the geotechnical report or in another report and included in the Drainage Report.

This section should address all suitability criteria for infiltration facilities as described in Volume III.

3.8.1.4 Drainage Report Section 4 – Wells and Septic Systems

The Project Engineer shall make a diligent search to identify wells and septic systems "of record", on the site, and on adjacent property within the setback distance for stormwater retention/detention facilities identified in Volume V, Appendix E. The Project Engineer shall inquire with Thurston County Environmental Health and neighboring property owners as necessary to obtain the location of wells and septic systems that are not "of record." Wells and septic systems thus found, both active and abandoned, shall also be called out on the plans or as-builts (if found during construction).

The Project Engineer shall also identify whether the project site is located within the designated Well Head Protection Area (WHPA) of any public (Group A) water system. Thurston County Code, Title 17 and this Drainage Manual imposes additional requirements for projects within a designated WHPA.

The proper abandonment of wells is a matter regulated by state law (WAC 173-160). If a well on the site has not been properly sealed, the applicant shall be responsible for contacting Thurston County Environmental Health and Ecology. Ecology's procedure shall be followed for sealing the well. Proof of proper abandonment (e.g., copies of the well log and invoice from a firm qualified to perform such work) shall be supplied to the County at or prior to final project acceptance. Indicate if no wells or septic systems were found.

3.8.1.5 Drainage Report Section 5 – Fuel Tanks

The Project Engineer shall report after making a diligent search of records and project site the existence of fuel tanks, in-use or abandoned. Fuel tanks shall be shown on the plans or as-builts (if found during construction). If fuel tanks will be abandoned, contact Thurston County Environmental Health for specific instructions. If no fuel tanks were found, indicate so.

3.8.1.6 Drainage Report Section 6 – Analysis of the 100-Year Flood

If the project contains or abuts a stream, show the 100-year flood hazard zone on the plans. If the zone has not been established (or the Administrator or designee determines that it is in error), the County may require the applicant to establish the 100-year flood plain for the proposed Project to be submitted with the Drainage and Erosion Control Plan. Analysis will be for the 100-year flood for build out at maximum density allowed by zoning (making reasonable assumptions regarding future stormwater management). The Project Engineer shall use the applicable program (HEC-HMS/RAS) for backwater analysis or another on acceptance of the Administrator or designee.

3.8.1.7 Drainage Report Section 7 – Aesthetic Considerations for Facilities

Describe the effort made to make the facilities aesthetically pleasing, how facilities will provide usable open space, and how the facilities will fit into the landscaping plan for the property.

Drainage facilities shall be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping facilities and to consider aesthetics when choosing design alternatives (e.g., parking lot paving, conveyance systems, detention facilities, weirs, check structures). See Volume V and Appendix V-E for aesthetic and landscaping criteria.

The applicant shall provide an informational sign for all aboveground stormwater facilities located within the development tract. Signs shall be constructed and worded as specified for each BMP and in Appendix V-E or as directed by the Administrator.

3.8.1.8 Drainage Report Section 8 – Facility Sizing and Offsite Analysis

3.8.1.8.1 Impervious and Pervious Area Tabulations

Include a tabulation of the pervious and impervious surfaces by threshold discharge area, including the following (see Glossary in the Preface volume for definitions):

- Existing impervious surfaces
- Converted pervious surfaces
- Replaced impervious surface
- New impervious surface
- Disturbed areas (area subject to “land disturbing activities”)
- Undisturbed pervious surfaces
- Existing significant trees and native vegetation.

Basins and sub-basins shall be labeled on the work map(s) and descriptors assigned that match the basin and sub-basin descriptors included in any hydrologic modeling. The work maps shall be included in the Drainage Report in a map pocket.

3.8.1.8.2 Proposed BMP Design

Describe which on-site and LID BMPs have been incorporated into the design and include design calculations where applicable. For Core Requirement 5, indicate whether the project used the mandatory list option, or the LID performance standard option, and complete documentation demonstrating compliance with either approach.

For projects using the list option for Core Requirement #5, an explanation and documentation, including citation of site conditions identified in a soils report, for any determination that an on-site stormwater management BMP was considered infeasible for the site. Information obtained and documented in the Existing Conditions Description (Section 2, see below) shall be used to substantiate any BMP infeasibility determinations. (See also Volume III, Appendix III-D for a summary of infeasibility criteria for all BMPs.)

If natural drainage patterns have not been preserved, explain why not and how hydrologic impacts to receiving waters will be mitigated.

Discuss vegetation establishment and soils management plans for all BMPs.

Provide calculations in an appendix documenting that conveyance facilities are sized in accordance with the standards in Volume III and runoff treatment and flow control facilities are designed to meet the design standards in Volumes III and V:

- All calculations shall be keyed to features shown on the work map.
- If hydrologic modeling is required, the Project Engineer shall state methods, assumptions, model parameters, data sources, and all other relevant information to the analysis. The input parameters to the model including basin characteristics, soil types, areas, etc. shall be tabulated within the drainage report and shall match the input parameters shown in any model output reports included as an appendix.
- If model parameters are used that are outside the recommended ranges discussed in Volume III or if parameters are different than those discussed in Volume III, justify parameters. Include an electronic copy of the computer model data file and the site plan in AutoCAD format.
- Include copies of all calculations for capacity of channels, culverts, drains, gutters, etc. If used, include nomographs and tables indicating how they were used. Show headwater and tailwater analysis for culverts when necessary. Provide details on references and sources of information used.
- Describe capacities, design flows, and velocities in each link.

- Projects taking an impervious surface reduction credit for newly planted or retained trees (see tree planting and tree retention in Volume V, Section 2.2.11) must provide those calculations and documentation on site plans for the locations of the trees.

- Projects using Full Dispersion or full downspout infiltration BMPs must provide information to confirm conformance with design requirements that allow removal of the associated drainage areas from computer model input.

- Describe required materials or specifications for the design (e.g., rock lining for channels when velocity is exceeded; high density polyethylene pipe needed for steep slope). Regardless of whether the calculations are made using computer software or by hand, all relevant work shall be submitted for review. Complete calculations, including hydrologic modeling analyses where required, must be included with the report. It is recommended that these be placed in appendices and be referenced where appropriate. At Thurston County's request, submit electronic data for computer work including associated data files and settings.

3.8.1.8.3 Offsite Analysis

At a minimum, the qualitative analysis shall include the following:

- Site map showing project limits, existing and proposed storm drains (including pipe diameter, length, materials and slopes where available), existing and proposed ditches (including slope, width, bank slope, and bed materials), downstream drainage path to receiving water, and other contributing areas and up-stream and other off-site drainage entering or passing through the site.

- Review of available information, including but not limited to basin plans, record drawings, FEMA maps, drainage studies, critical areas maps, and Thurston County maintenance records.

- Field visit conducted by Project Engineer. The Project Engineer shall verify drainage basins, inspect on-site and off-site drainage systems, identify and document (with photographs and notations on site map) drainage problems (erosion, flooding, capacity problems, channel scour or incision).

If a quantitative analysis is required by the Administrator or designee (see Chapter 2, Core Requirement #11), the quantitative downstream analysis will include modeling the hydraulics of the proposed project and all other sources of runoff tributary to the receiving water body for the appropriate Design Event. The Project Engineer shall include an analysis of the impact of the 24-hour, 100-year event (in addition to "Design Event" analysis) for each component of the system including pond spillway.

Describe the proposed approach for managing run-on from upstream properties including whether run-on will be diverted around the project or incorporated into the site's stormwater system. The off-site analysis upstream of the property will include all properties located topographically uphill from the project that do, or may, contribute flow through the project site.

Describe how runoff from any public road frontage is managed. If runoff from the road is not collected in a roadway ditch or other public conveyance system then the project shall incorporate any roadway runoff into the Permanent Stormwater Control Plans for the site.

Summarize measures that will be used to protect properties and waterways downstream from the development site from erosion due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site. Describe how flow from the project site will be discharged to adjacent properties per the requirements of Volume III (i.e., easement, dispersion, spreader, etc.).

3.8.1.9 Drainage Report Section 9 – Utilities

Describe how utilities will be installed to ensure no conflicts with proposed stormwater quantity and quality control measures.

3.8.1.10 Drainage Report Section 10 — Covenants, Dedications, Easements

Describe legal instruments needed to guarantee preservation of drainage system and access for maintenance purposes. (Attach copies.) Describe the organization which will be responsible for operation and maintenance of storm drainage facilities.

3.8.1.11 Drainage Report Section 11 – Property Owners Association Articles of Incorporation

Attach a copy of the Articles of Incorporation, if applicable.

3.8.1.12 Drainage Report Section 12 – Other Permits or Conditions Placed on the Project

Construction of road and drainage facilities may require additional permits from other agencies. These additional permits may contain more restrictive drainage control requirements. This section should provide the title of any other necessary permits, the agencies requiring the other permits, and identify the permit requirements that affect the project.

Other agencies including, but not limited to, those listed below may require drainage review for a proposed project's impact on surface and stormwater and conveyance systems. The applicant should take care to note that these other agency drainage requirements are separate from, and in addition to, Thurston County's drainage requirements. The applicant will be responsible to coordinate joint agency drainage review, including resolution of any conflicting requirements between agencies.

The additional agencies that may require permits for some projects are listed in

Table 3-1. However, this is not a complete list of permits that may be required.

Table 3-1 Other Potential Permits

Agency	Permit/Approval
Thurston County Public Health and Social Services Department – Environmental Health Division	Onsite Sewage Disposal and Well Permits
Washington State Department of Transportation (WSDOT)	Developer/Local Agency Agreement
Washington State Department of Ecology	Short Term Water Quality Modification Approval
Washington State Department of Fish and Wildlife	Hydraulic Project Approval
Washington State Department of Ecology	Dam Safety Permit
United States Army Corps of Engineers	Section 10 Permit
United States Army Corps of Engineers	Section 401 Certification
United States Army Corps of Engineers	Section 404 Permit
Thurston County	Shoreline Permit
Thurston County	ROW Permit
Thurston County	Wetlands Permit

3.8.2 Construction SWPPP Elements

The elements of a Construction SWPPP (below) are addressed in the Drainage and Erosion Control Report following the Drainage Report Sections:

1. Mark clearing limits/preserve vegetation
2. Establish construction access
3. Control flow rates
4. Install sediment controls
5. Stabilize soils
6. Protect slopes
7. Protect drain inlets
8. Stabilize channels and outlets
9. Control pollutants
10. Control dewatering
11. Maintain BMPs
12. Manage the project.

13. Protect LID BMPs

SWPPP elements are described in detail in Volume II.

3.8.3 Drawings and Specifications

It is the responsibility of the Project Engineer to ensure that engineering plans supporting the Drainage and Erosion Control Plan shall be sufficiently clear to construct the Project in proper sequence, using specified methods and materials, with sufficient dimensions to fulfill intent of drainage laws and ordinances and these design guidelines.

3.8.3.1 Required Drawing Size

Required sheet size is 22” x 34” and text and details shall be of such size as to be legible at ½ size (11” x 17”). Submittals shall include full size drawings, half size (11” x 17”) drawings, as well as PDF files and AutoCAD drawing files.

3.8.3.2 Required Drawing Protocol

All drawings shall generally comply with the requirements of the Thurston County Road standards, Chapter 3, “Plan Format” and Thurston County CAD standards. These are available from Thurston County Department of Public Works. Where those standards conflict with the standards of this Manual this Manual shall govern.

3.8.3.3 Number of Sheets - Content

Plans will include sheets adequate to clearly display the following:

3.8.3.3.1 Vicinity Map

Show Project boundaries, sub-basin boundaries, and off-site area tributary to the project. Show contours, major drainage features (such as channels and detention facilities and floodways), and flow path to receiving waters. Identify existing buildings, roads, and facilities adjacent to or within the project site on the drawings. Identify existing and proposed utility locations, and construction clearing limits on the drawings.

3.8.3.3.2 Site Map

On a topographic map, show existing conditions and the proposed Project including (as applicable) but not limited to:

- Existing topography for the site and at least 50 feet beyond site boundaries
- Finished grades
- Existing structures within 100 feet of project boundaries
- Utilities

- Easements both existing and proposed

- Environmentally sensitive areas (e.g., gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, wetlands, creeks, lakes, etc). For natural drainage features, show direction of flow.

- 100-year flood plain boundary (if applicable)

- Existing and proposed wells on-site and on adjacent properties (both "of record" and not "of record") within setbacks as specified in Appendix V-E

- Existing and proposed fuel tanks

- Existing and proposed on-site sanitary systems within setbacks as specified in Appendix V-E

- Proposed structures including roads, parking surfaces

- Lot dimensions and areas

- Proposed drainage facilities and sufficient cross sections and details to build

- Standard stormwater plan notes. Example notes are found in Appendix G of this volume (Volume I). Provide only those notes that apply.

Topography must be field verified for all areas where site improvements are to be constructed including drainage easements and conveyance systems. Contour intervals on site plan shall be as follows:

- 0 to 15 percent slope: 2 foot contour intervals

- 16 to 40 percent slope: 5 foot contour intervals

- Greater than 40 percent slope: 10 foot contour intervals.

3.8.3.3.3 Permanent Stormwater Control Plan

Show the following information:

Plans or worksheets of open channel systems shall show water surface elevation for the design storm, invert elevations at breaks in grade, design discharge, design velocity, and any other data that facilitates plan review including:

- Schedule of catch basins with the following information:

    - Catch Basin/Manhole Identifier

    - Street Name

    - Cross Street
    - Stationing
    - Street side
    - Catch Basin diameter or size
    - Invert in/out
    - Pipe Diameter in/out.
    - Cover/rim elevation
- Detention/Infiltration/Wet Ponds to include:
    - Catch points for cuts and fills
    - Max design water level, water quality water level, overflow level
    - Clear path of overflow to downstream collection point
    - Outfalls and energy dissipation at outfalls
    - Inlet and outlet pipe invert elevations, slopes and pipe lengths.
- Drainage Details and Notes
    - Details of all BMPs, including plan and profile, materials used, and depths, i.e., soils, liners, pipes
    - Construction notes and specifications for all BMPs
    - Cross-sections (ponds, swales, roadways, etc.).
    - A map showing the location of newly planted and retained trees claimed for flow reduction credits.
    - Table showing which Core Requirements the BMP is designed for (CR's #5. #6, and/or #7)

3.8.3.3.4 Other Required Plans/Drawings

Include copies of other required plans such as:

- Soil Management Plan
- Landscape Plan

- Road profiles & roadway sections.
- Utility plans (sewer, water, septic).

3.8.3.3.5 Work Map (or maps) (bound into Drainage Report)

On a topographic map at the same scale and contour interval as the site map, show:

- Unit areas contributing to a reach of swale or to a catch basin including off-site area. Identify areas contributing to retention/detention facilities. Show the following on the work map (or on a schedule) for unit areas: area, percent impervious, average slope, and estimated ultimate infiltration rate.
- Conveyance data, identifier (for reference to model output), length, slope, inverts up and down
- Overland flow paths and distances
- Soil types
- Locations of soil pits and infiltration tests
- Spot water surface elevations discharges and velocities for the Design Event.

The SWPPP drawing shall show:

- Construction entrance detail
- Silt fences and traps
- Mulching and vegetation plan
- Clearing and grubbing limits
- Existing and finished grade
- Standard erosion control plan notes. Example notes are found in the individual BMP design guidelines in Volume II.

3.8.3.4 Plans and Specifications

The most recent editions of Standard Specifications and Standard Plans (see Appendix I-A, Glossary) shall be the standards for all design and construction of drainage facilities not explicitly described herein. In the event of a conflict between the Standard Specifications, Standard Plans, and this DDECM, this Manual shall prevail.

3.8.4 Maintenance Plan

The Maintenance Plan will be prepared as a standalone document, including all necessary figures, maps, and drawings. The Maintenance Plan should be bound separately and submitted for review and acceptance by Thurston County at the time of submittal of the Final Drainage and Erosion Control Plan for the project. Acceptance of the Maintenance Plan by Thurston County is required prior to final project acceptance.

3.8.4.1 Contents of Plan

The Project Engineer will prepare a Maintenance Plan including the following:

- A statement of where the Maintenance Plan will be kept and that it must be made available for inspection by Thurston County upon request
- A copy of the Maintenance Agreement (Commercial/Industrial or Residential) executed by the property owner and accepted as to form by Thurston County
- A maintenance activity log in a format that includes sufficient space to list maintenance activities completed as a result of inspections
- Facility Summary Forms prepared for each stormwater facility as part of final permitting
- A written description of each flow control and treatment facility and an over view of the stormwater system for the site explaining the principles of operations and general maintenance requirements and providing such information from the Drainage Report as might be necessary to the future maintenance of the stormwater facilities. This might include the design capacity of conveyance facilities, slope of pipes and swales, size and dimensions of infiltration and/or detention facilities and calculated release rates for various storm events.
- A drawing showing all stormwater facilities, drainage easements, access easements, etc., with a key referencing the applicable maintenance checklists required to be used in performing routine inspection and maintenance for the facility
- Engineering drawings of the stormwater facilities including details and specifications shall be included. Drawings may be 11” x 17” or 22” x 34” and included in a map pocket.
- All applicable maintenance checklists for facilities included in the project. The applicant shall only include those checklists that apply to the project.
- Vegetation Management Plan
- Identification of the responsible maintenance organization

- A description of the required maintenance frequency for each facility
- A description of required recordkeeping and reports and frequency of submittal of reports to Thurston County
- An estimate of the average annual cost of maintenance will be included. The annual cost shall include the annualized cost of major maintenance items such as sediment removal from ponds, etc.
- A pollution source control plan per Volume IV. Language that prohibits unauthorized modifications, unless approved by the County
- Language that provides for a county approval process and allows modification to the covenant, or to the Maintenance and Source Control Manual
- Language that provides for a county process (remedies) for situations where the responsible party fails to perform the required maintenance or fails to implement the pollution source control measures
- Language that provides access authority to the County for purposes of inspection, maintenance, and repair
- Language that provides for reimbursement to the County by the responsible party in the event that the County incurs costs related to maintenance or repair

See Appendix V-C and Appendix I-E for additional guidance.

3.8.4.2 Identify Organization Responsible for Maintenance

It is Thurston County's policy that the property owner(s) shall maintain storm drainage facilities, or in the case of a subdivision, the POA shall maintain drainage facilities. The Maintenance Plan shall be prepared to Thurston County's specifications and held by the property owner or for a subdivision, included by reference in the articles of incorporation of the Property Owners Association.

3.8.4.3 Vegetation Management Plan

A vegetation management plan shall be included in the Stormwater Facilities Maintenance Plan for the project and shall include recommended plantings for each stormwater facility and specifications for maintenance and replacement plantings. The effectiveness of many stormwater facilities will depend on the species planted in them and their proper maintenance. Consult Appendix V-E regarding proper species for the design condition and for their requirements for maintenance.

3.8.4.4 Pollution Source Control

Pollution source control is the application of pollution prevention practices on a developed site to reduce contamination of stormwater runoff **at its source.** Best management practices (BMPs) and resource management systems are designed to reduce the amount of contaminants used or discharged to the environment.

The Maintenance Plan shall contain language regarding pollution source control that is specifically developed for the type of site covered by the plan. The pollution source control section of the plan shall incorporate the relevant information found in Volume IV of this Manual, unless otherwise accepted by the Administrator or designee.

3.8.4.5 Annual Report Required

The owner shall submit an annual report to Thurston County by August 31st of each calendar year to include, at a minimum, the following:

- Name, address, and telephone number of the businesses, persons, or firms responsible for plan implementation, and the person completing the report
- Time period covered by the report
- A chronological summary of activities conducted to implement the programs required by the Maintenance Plan. A photocopy of the applicable section of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties, include a copy of the invoice for services.
- An outline of planned activities for the next year.

The annual report shall be submitted to the Water Resources Division of the Thurston County Department of Resource Stewardship.

3.8.5 Project Completion Criteria

3.8.5.1 Inspection Report – Drainage and Erosion Control Plans

For Drainage and Erosion Control Plans, in addition to inspection performed by Thurston County, the applicant must retain a licensed Civil Engineer to inspect or oversee inspection of the project as directed by the Drainage and Erosion Control Plan and/or the Administrator or designee. (See inspection reporting requirements, Appendix I-C.) The Engineer must file a construction inspection report with Thurston County as shown in Appendix I-C before the project is made final. The report will consist of a completed form and sufficient additional text to describe all factors relating to the construction and operation of the system to meet treatment, erosion control, detention/retention, flow control, and conveyance requirements.

The Engineer or his/her designee shall keep records of inspections of drainage and erosion control facilities. Records of inspection shall be submitted to the County upon request at any time during the course of the project.

3.8.5.2 As-Built Submittal – Drainage and Erosion Control Plans

For Drainage and Erosion Control Plans, the Project Engineer shall submit as-built drawings bearing the Project Engineer's seal showing all final locations and elevations, materials, and changes from the design. Final elevations, locations, slopes, grades, roadway alignments, etc. shall be based on a field survey conducted by a licensed professional surveyor and shall be stamped by the surveyor as a record of the final constructed location and elevation of facilities shown. The volume of any ponds, vaults, tanks, etc. included in the design shall be calculated based on the as-built survey and this information shall be noted on the as-built drawing. Changes from the approved plans shall be clearly identified using clouding, bold text or other methods to clearly identify those items that were changed during construction. Note that changes from the accepted plan will be reviewed by the County and may be subject to action by the Administrator or designee.

3.8.5.3 Phased Projects Submittals – Drainage and Erosion Control Plans

A plan showing the overall project, clearly delineating phase boundaries, and estimating dates of construction, shall be part of any initial submittal. Phased projects shall be completed in accordance with accepted plans and in accordance with standard phased development requirements for Thurston County. The thresholds of Chapter 2 shall apply to the entire development including all phases.

3.9 Additional Submittal Information

3.9.1 Qualifications of Project Engineers

The Project Engineer responsible for completion of Drainage and Erosion Control Plans and Engineered Abbreviated Drainage Plans shall be a Civil Engineer with a current State of Washington Professional Engineer's license. All plans and specifications, calculations, construction inspection reports, and all other submittals which will become part of the permanent record of the Project must bear the Project Engineer's official seal.

3.9.2 Review and Acceptance Does Not Confer Responsibility

Thurston County will review all drainage related submittals for general compliance with specific criteria. Acceptance by the County does not relieve the applicant or Project Engineer of responsibility for ensuring that all facilities are safe and that calculations, plans, specifications, construction, and as-built drawings comply with normal engineering standards, this Manual, and applicable federal, state, and local laws and codes.

3.9.3 Time Limitations of Acceptance for Plans

Drainage and Erosion Control Plans and Abbreviated Drainage Plans shall expire when acceptance for the permitted activity (e.g., preliminary plat, clearing, grading, building permit) expires. After expiration, a new Drainage and Erosion Control Plan must be completed subject to conditions and requirements applicable at that time.

3.9.4 Aesthetic Considerations

Drainage facilities shall be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping facilities and to consider aesthetics when choosing design alternatives (e.g., parking lot paving, conveyance systems, detention facilities, weirs, check structures). See Volume V and Appendix V-E for aesthetic and landscaping criteria.

The applicant shall provide an informational sign for all aboveground stormwater facilities located within the development tract. The sign for storm ponds shall be constructed and worded as specified in Appendix V-E. Other stormwater facilities including swales, rain gardens, dispersion areas, etc. shall also include signage and fencing identifying the area as a stormwater facility and not to disturb. Individual BMPs also include requirements for signage and fencing. See Volume V for more information.

3.9.5 Drainage Plans for Environmentally Sensitive Areas

3.9.5.1 Development in an Environmentally Sensitive Area

Where buffer zones have been established by the County to restrict development near an environmentally sensitive area or critical area, the applicant shall obtain and implement the requirements of those regulations in addition to any requirements of this Manual.

3.9.5.2 Acceptance of Dedication of Buffers

Buffers for natural drainage features can provide water quality benefits. Consult the jurisdiction regarding their policy on acceptance of buffers.

3.9.6 Easements and Access

3.9.6.1 Easements for Natural Channels and Stormwater Facilities

All man-made drainage facilities, conveyances, and all natural channels (including swales, stream channels, lake shores, wetlands, potholes, estuaries, gullies, ravines, etc.) shall be located within easements. Easements shall contain the natural features and facilities and shall allow jurisdiction access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

3.9.6.2 Easements for Access

Specific access requirements for ponds are included in Volume V, Appendix V-E. Generally a minimum 15-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way and shall provide a 12-foot minimum width drivable path surfaced with lattice block pavement, crushed rock, or other acceptable surface to allow year-round equipment access to the facility. The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100 feet along the length of the easement. Contact Thurston County Water Resources Division for additional information on easement marker requirements.

3.9.6.3 Easements for Conveyance Systems

Easement requirements for conveyance systems are described in Volume III, Section 3.6.2.

Chapter 4 - Stormwater BMP Selection Process

This chapter aids in the selection of appropriate LID, infiltration, flow control, and runoff treatment BMPs to meet Core Requirements #5 (Onsite measures), 6 (Runoff Treatment), and 7 (Flow Control). This chapter is organized as follows:

- **Section 4.1**: Types of BMPs and satisfying Core Requirement
- **Section 4.2**: Step-by-step process for determining the level of treatment and flow control and selecting BMPs
- **Section 4.3**: Supplemental information for selecting and applying oil control BMPs
- **Section 4.4**: Supplemental information for selecting and applying phosphorus treatment BMPs
- **Section 4.5**: Supplemental information for selecting and applying enhanced treatment BMPs
- **Section 4.6**: Supplemental information for selecting and applying basic treatment BMPs
- **Section 4.7**: Additional treatment facility selection factors, including pollutants of concern and BMPs for specific land uses.

4.1 Introduction

Thurston County's pollution control strategy is to emphasize pollution prevention first, through the application of source control BMPs. Then the application of appropriate on-site, treatment, and flow control facilities fulfills the statutory obligation to provide AKART, or "all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the State of Washington." (RCW 90.48.010) Stormwater BMPs described in this chapter focus on reducing or mitigating the hydrologic and water quality impacts of development. These BMPs address the following Core Requirements:

4.1.1.1 Core Requirement #5: Onsite Stormwater Management

- LID BMPs are site design and stormwater management techniques that seek to minimize the stormwater impacts of development by mimicking natural hydrologic processes. LID BMPs are required if feasible. See Appendix III-D, Volume III for LID feasibility criteria.
- Onsite BMPs are measures to protect soils and control roof drainage and other runoff to prevent stormwater from leaving the site as much as possible.

4.1.1.2 Core Requirement #6: Runoff Treatment

- Basic treatment BMPs remove sediment from the water column to prevent sedimentation of receiving waters and the adverse effects of sedimentation on fish and amphibians. Sediments can also carry other pollutants, and sediment removal reduces the level of these other pollutants in the runoff.

- Enhanced treatment BMPs provide a greater degree of removal of dissolved metals than "basic" runoff treatment BMPs. (Dissolved metals are toxic to salmon and other endangered species.)

- Phosphorus treatment BMPs include larger wet pond facilities, media filtration BMPs, and treatment trains intended to reduce total phosphorus concentrations in nutrient-sensitive lakes and streams.

- Oil control BMPs remove non-polar, hydrophobic substances (oil and grease) from stormwater by trapping the floating material with baffles or other physical barriers or by filtration through filter media or compost amended biofiltration swales. They are required for high use sites.

4.1.1.3 Core Requirement #7: Flow Control

- Flow control BMPs are infiltration and/or detention BMPs that control the hydrologic impacts of stormwater by matching predevelopment peak flows, flow durations, and levels of infiltration.

- Applying LID and on-site BMPs within a threshold discharge area is encouraged and may decrease the size of or eliminate the need for traditional flow control BMPs.

Selection of construction-phase stormwater pollution prevention BMPs to meet Core Requirement #2 is described in Volume II. Selection of post-construction source control BMPs to meet Core Requirement #3 is described in Volume IV.

4.2 Step-by-Step BMP Selection Process

Selecting appropriate BMPs for a project site requires knowledge of:

- The receiving water(s) of the project site's discharge

- Whether Thurston County, Ecology, or the EPA have identified the receiving water as subject to phosphorus control requirements

- Site conditions that may require oil control or enhanced runoff treatment.

Figure 4-1, Figure 4-2, Figure 4-3, and Figure 4-4 illustrates the BMP selection process. The steps of this process are described in detail below.

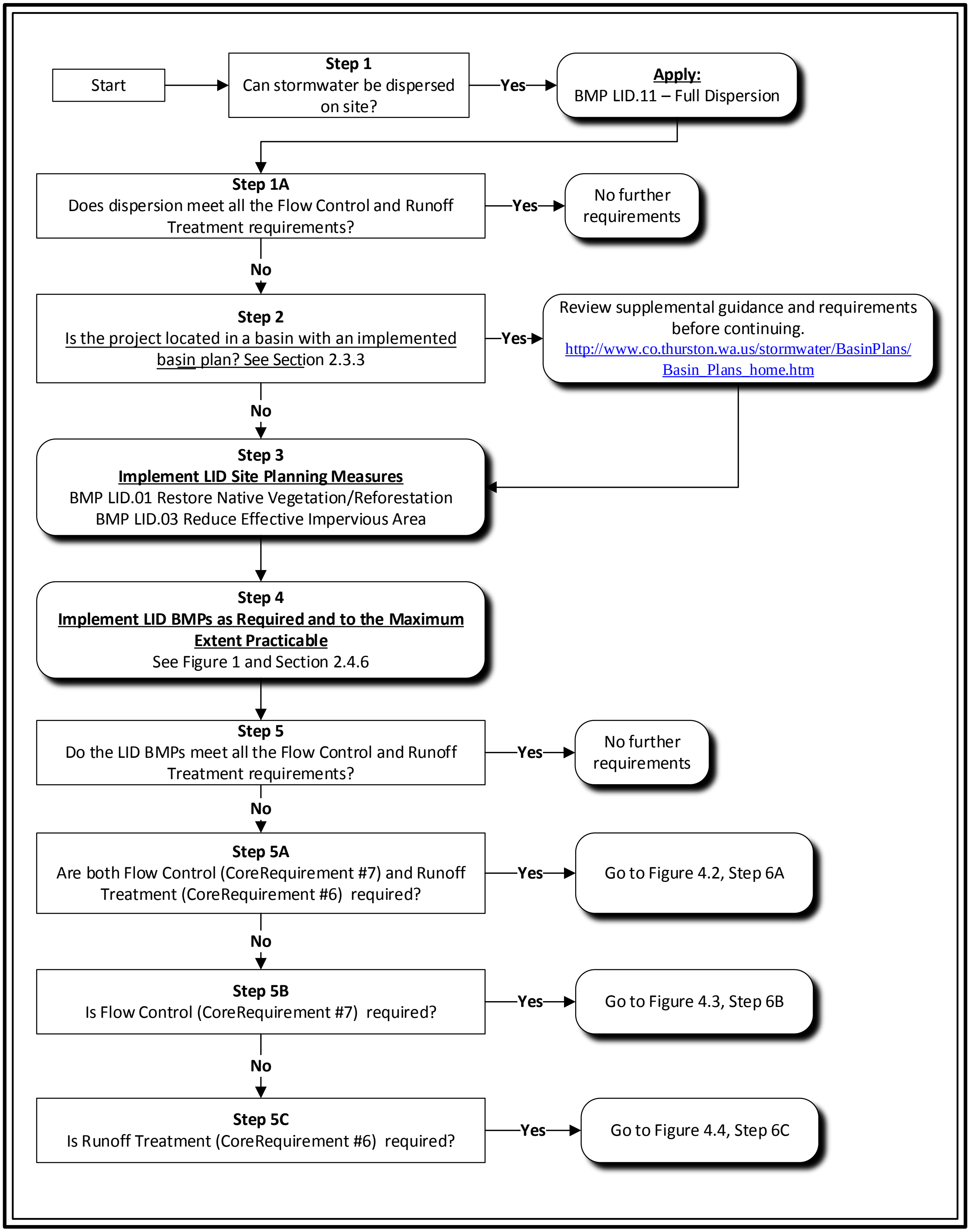


Figure 4-1 Stormwater BMP Selection Flow Chart

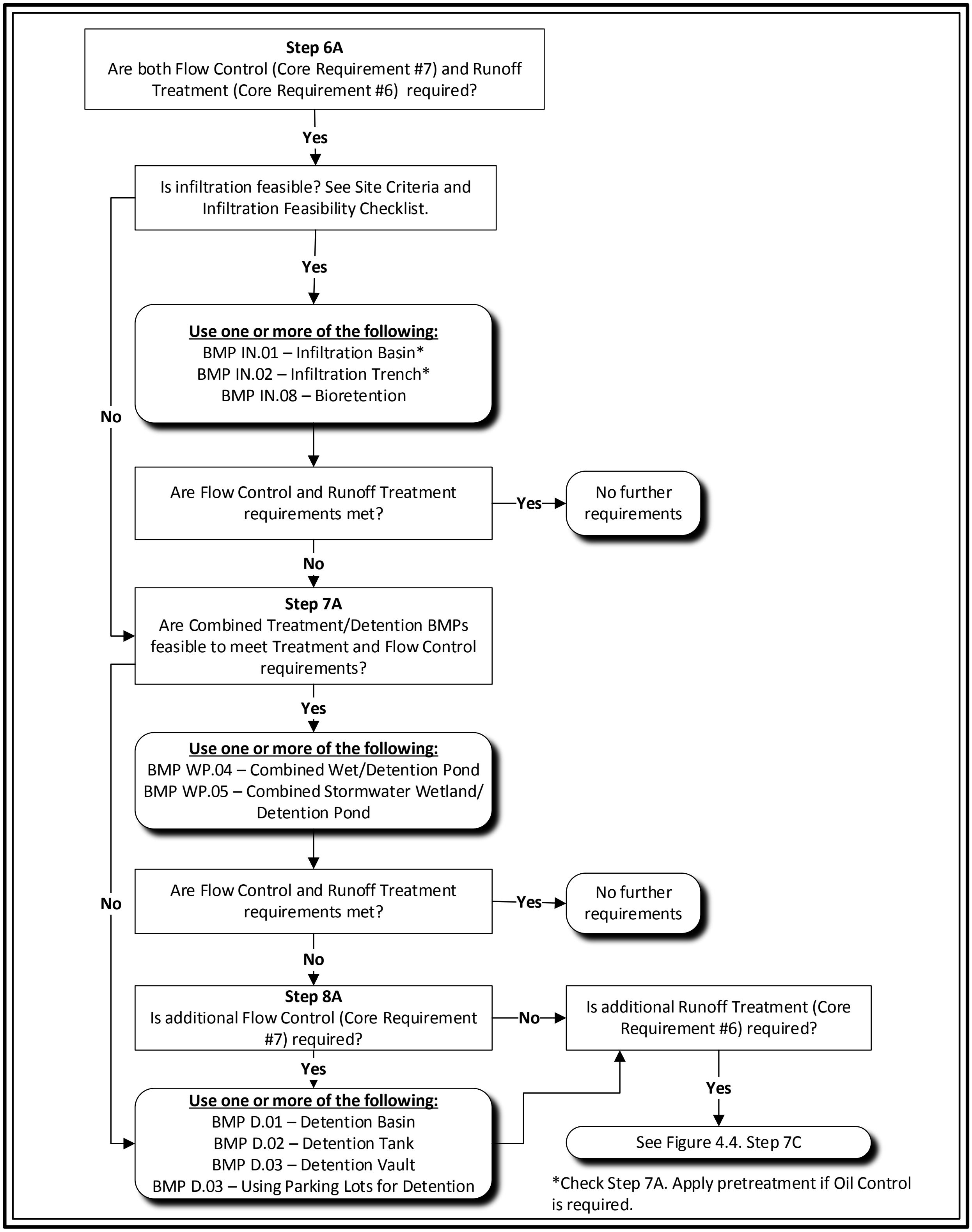
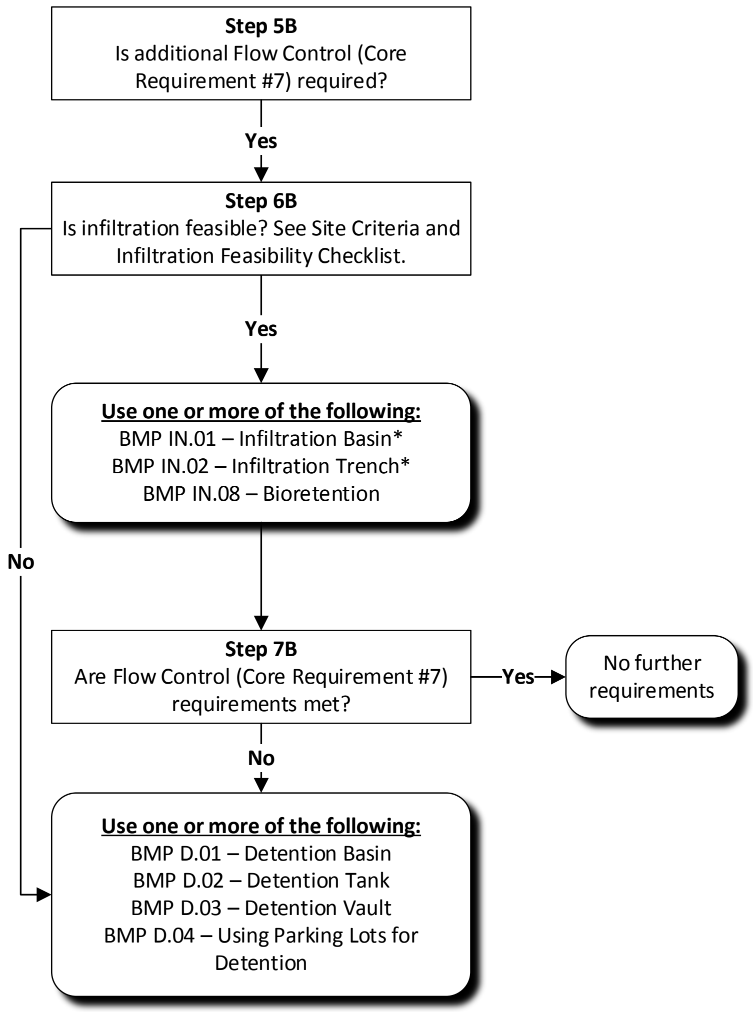


Figure 4-2 Stormwater BMP Selection Process Flow Chart, Flow Control and Runoff Treatment



*Check Step 7A. Apply pretreatment if Oil Control is required.

Figure 4-3 Stormwater BMP Selection Process Flow Chart, Flow Control

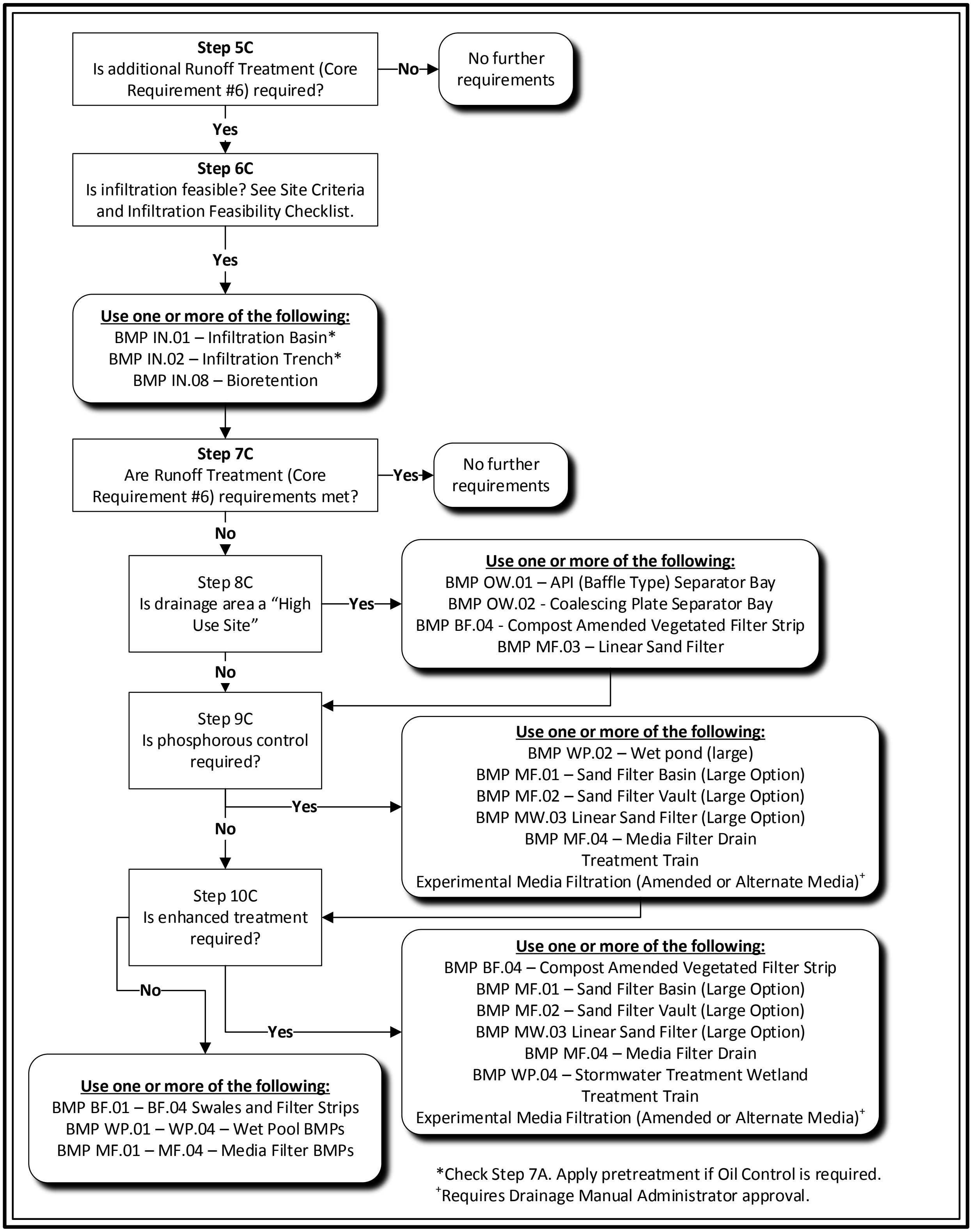


Figure 4-4 Stormwater BMP Selection Process Flow Chart, Runoff Treatment

4.2.1 Step 1: Determine if Stormwater can be Dispersed On Site

4.2.1.1 Can full dispersion be used to treat stormwater?

If yes, apply BMP LID.11 – Full Dispersion to the site.

Step 1A - Check to see if Full Dispersion meets all the Flow Control (Core Requirement #7) and Runoff Treatment (Core Requirement #6), if so, there are no further requirements.

If *No*, go to Step 2.

4.2.2 Step 2: Determine if the Project Site is in a Basin with an Implemented Basin Plan

4.2.2.1 Does Your Project Drain to a Basin with an Implemented Basin Plan?

If so, see the applicable basin plan or the Thurston County basin planning website to determine if there are applicable requirements or restrictions for runoff treatment, flow control, and infiltration. You must meet the more stringent of either of the controls described in this section or those in the basin plan. See the Thurston County basin planning website for more information: <http://www.co.thurston.wa.us/stormwater/BasinPlans/Basin_Plans_home.htm>.

4.2.3 Step 3: Implement LID Site Planning Measures

Thoughtful site design can significantly reduce both the cost and land area required for stormwater management and the hydrologic and water quality impacts of your project. Volume V provides ideas for smart design and LID measures to consider and, where feasible, implement at the earliest planning stages. Site planning LID BMPs include:

- BMP LID.01: Restore Native Vegetation
- BMP LID.03: Reduce Effective Impervious Areas Associated with Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas.

4.2.4 Step 4: Implement LID BMPs as Required and to the Maximum Extent Feasible

To meet Core Requirement #5: See Section 2.4.6 to determine the Core Requirement for the project. Check site to determine if LID is feasible and apply the appropriate BMPs from List 1, List 2, or choose to meet the LID Flow Duration Standard.

Roadway projects may use the WSDOT 2014 HRM, or current edition to determine and meet Core Requirement #5 conditions.

4.2.5 Step 5: Determine Applicability of Core Requirements #6 and #7

After implementing LID BMPs, see the Core Requirements (Chapter 2 of this volume) to determine whether additional flow control (Core Requirement #7) or runoff treatment (Core

Requirement #6) BMPs are required. The implementation of LID BMPs will help reduce the amount of flow control runoff treatment facilities required.

4.2.5.1 Do the LID BMPs meet all the Flow Control and Runoff Treatment Requirements?

If YES, there are no further requirements.

If NO, proceed to Step 5A.

4.2.5.2 Step 5A, Are Both Flow Control and Runoff Treatment Required?

If YES, proceed to Step 6A.

If NO, proceed to Step 5B.

4.2.5.3 Step 5B, Is Flow Control Required?

If YES, proceed to Step 6B.

If NO, proceed to Step 5C.

4.2.5.4 Step 5C, Is Runoff Treatment Required?

If YES, proceed to Step 6C.

4.2.6 Step 6: Select infiltration BMP

4.2.6.1 Step 6A: Determine Feasibility and Select Infiltration BMP for Both Flow Control and Runoff Treatment

4.2.6.1.1 Is infiltration feasible for your site? Check the Site Suitability Criteria in Volume III, Section 2.3 for hydrologic and soil suitability for runoff treatment criteria in Section 2.3 of Volume III?

If YES, select from the following BMPs to provide both flow control and runoff treatment. Also, check Step 9C to determine if oil control is needed prior to infiltration. If so, select an oil control BMP from the list and implement. However, do not continue to Step 8C at this time. If after implementing one of the following BMPs the discharge to surface water exceeds flow control thresholds, proceed to Step 10A and implement detention BMP to meet flow control requirements:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP LID.08**: Bioretention Facilities.

If NO, proceed to Step 8A.

4.2.6.2 Step 6B: Determine Feasibility and Select Infiltration BMP for Flow Control

4.2.6.2.1 Is infiltration feasible for your site? Check the Site Suitability Criteria in Volume III, Section 2.3 for hydrologic and soil suitability to determine if pretreatment is required.

If YES, select from the following BMPs to provide flow control:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP IN.04**: Bio-Infiltration Swale.

If after implementing one of the above BMPs there is a discharge to surface water that exceeds flow control requirements, proceed to Step 7B and implement detention BMP to meet flow control requirements.

Check Step 8C to determine if pretreatment is required. If pretreatment is required, select runoff treatment BMP(s) located upstream of the infiltration BMP. If not, BMP selection is complete.

If NO, proceed to Step 7A.

If NO *and no runoff treatment is required*, proceed to Step 6B.

4.2.6.3 Step 6C: Determine Feasibility and Select Infiltration BMP for Runoff Treatment

4.2.6.3.1 Is infiltration feasible and do your site and soils meet the site suitability and runoff treatment criteria in Section 2.3 of Volume III?

If YES, select from the following BMPs:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP IN.04**: Bio-Infiltration Swale
- **BMP LID.08**: Bioretention Facilities.

Also, check Step 8C to determine if oil control is needed prior to infiltration. If so, select an oil control BMP from the list and implement. However, do not continue to Step 9C at this time.

If NO, proceed to Step 8C.

4.2.7 Step 7: Select Detention BMP

4.2.7.1 Step 7A: Determine Feasibility and Select Combined Treatment/Flow Control BMP

4.2.7.1.1 Is a combined treatment/flow control BMP feasible?

If YES, select from the following BMPs:

- **BMP WP.04**: Combined wet/detention pond
- **BMP WP.05**: Combined stormwater wetland/detention pond.

Proceed to Step 8C to evaluate the need for additional oil control BMPs, and to verify that the combined BMP selected above meets the necessary treatment level.

If NO, proceed to Step 7B.

4.2.7.2 Step 7B: Select Detention BMP

Select from the following BMPs:

- **BMP D.01**: Detention Ponds
- **BMP D.02**: Detention Tanks
- **BMP D.03**: Detention Vaults
- **BMP D.04**: Use of Parking Lots for Detention.

If *runoff treatment (Core Requirement #6) is required* for your project, proceed to Step 7C.

If *no runoff treatment is required*, BMP selection is complete.

4.2.8 Step 7C: Select Runoff Treatment BMP

4.2.8.1 Step 8C: Determine Feasibility and Select Oil Control BMP

4.2.8.1.1 Is your project a "high use site"?

"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 (see Section 4.3 for guidance on estimating traffic counts)
- 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 average daily traffic (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.

Section 4.3 has supplemental information on oil control, including land uses that are likely to have areas that fall within the definition of "high use sites".

If YES, select one of the following BMPs and proceed to Step 8B:

- **BMP OW.01**: API (Baffle type) Separator Bay

- **BMP OW.02**: Coalescing Plate (CP) Separator Bay

- **BMP OW.03**: Oil Containment Booms. (not allowed for private development)

Alternately, the following BMPs can be used to meet oil control requirements and other treatment levels. If these BMPs are selected, steps 9C, and 10C must be completed to ensure that they meet the appropriate level of treatment:

- **BMP MF.03**: Linear Sand Filter (if amended to provide phosphorus treatment)

- **BMP WP.03**: Wet vaults (if designed to include a baffle)

- **BMP BF.04**: Compost-Amended Vegetated Filter Strip.

If NO, proceed to Step 9C.

4.2.8.2 Step 9: Phosphorus Control BMP

The following Thurston County lakes are reported under Section 305(b) of the Clean Water Act and designated as not supporting beneficial uses due to phosphorus.

- Black Lake

- Capitol Lake

- Clear Lake

- Lawrence Lake

- Long Lake

- Pattison Lake (south arm).

Projects within any of these lakes' basins will be required to provide phosphorus treatment, unless a TMDL or County-approved lake management plan specifically identified phosphorus treatment as unnecessary.

Phosphorous treatment is also required for any projects meeting the thresholds for requiring runoff treatment in the Woodard Creek Basin.

If there is no lake management plan or TMDL for one of the above water bodies, and your project has the potential to contribute phosphorus to it (e.g., landscaped areas that will be fertilized, bare soils that could be transported off-site), phosphorus treatment is required. Section 4.4 has more information about phosphorous treatment requirements and BMPs.

If phosphorus treatment is required, select and apply a phosphorous treatment facility from the list below:

- **BMP MF.04**: Media Filter Drain
- **BMP MF.01**: Sand Filter Basin (if amended to provide phosphorus treatment)
- **BMP MF.03**: Linear Sand Filter (if amended to provide phosphorus treatment)
- **BMP MF.02**: Sand Filter Vault (if amended to provide phosphorus treatment)
- **BMP WP.02**: Wet ponds (if designed to be a large wet pond)
- **BMP WP.03**: Wet vaults (if designed to be a large wet vault)
- **BMP WP.04**: Combined detention/wet pool facilities (if designed with a large wet pool).

Note: Project sites subject to the Phosphorus Treatment requirement could also be subject to the Enhanced Treatment requirement (see Step 10C). In that event, apply a facility or a treatment train that is listed both above and under Step 10C. Infiltration treatment also provides phosphorous treatment.

Proceed to Step 10C.

4.2.8.3 Step 10C: Enhanced Treatment BMP

4.2.8.3.1 Does your project provide infiltration within a designated Well Head Protection Area for a public water supply serving over 1,000 connections?

If NO, proceed to next question. If YES, select enhanced treatment BMPs per the list at the end of Step 7C.

4.2.8.3.2 Does your project discharge to fish-bearing streams, lakes, or to waters or conveyance systems tributary to fish-bearing streams or lakes?

If NO, Apply Basic Treatment BMPs.

If YES, proceed to next question.

4.2.8.3.3 Does your project drain directly (or, indirectly through a municipal storm sewer system) to a salt water body?

If YES, Apply Basic Treatment BMPs.

If NO:

4.2.8.3.4 Does your project include any of the following?

- Infiltration facility within a designated Well Head Protection Area for a public water supply serving over 1,000 connections.
- Industrial project sites,
- Commercial project sites,
- Multi-family project sites, and
- High Annual Average Daily Traffic (AADT) roads as follows:

  Within Urban Growth Management Areas:

  - Fully controlled and partially controlled limited access highways with AADT counts of 15,000 or more
  - All other roads with an AADT of 7,500 or greater

  Outside of Urban Growth Management Areas:

  - Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger
  - Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

However, areas of the project sites listed above that are identified as subject to Basic Treatment requirements (see Section 4.6) are also not subject to Enhanced Treatment requirements. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area. See Section 4.5 for more information on Enhanced Treatment.

If YES, select enhanced treatment BMPs for your site or for those areas subject to enhanced treatment BMPs.

- **BMP LID.08**: Bioretention Facilities
- **BMP BF.04**: Compost-Amended Vegetated Filter Strip
- **BMP WP.01**: Stormwater treatment wetland
- **BMP MF.04**: Media Filter Drain
- **BMP MF.01**: Sand Filter Basin (if amended to provide enhanced treatment)
- **BMP MF.03**: Linear Sand Filter (if amended to provide enhanced treatment)
- **BMP MF.02**: Sand Filter Vault (if amended to provide enhanced treatment).

4.2.8.4 Basic Treatment BMP

The following are options for basic treatment BMPs:

- **BMP BF.01**: Basic Biofiltration Swale
- **BMP BF.02**: Wet Biofiltration Swale
- **BMP BF.03**: Continuous Inflow Biofiltration Swale
- **BMP BF.04**: Basic Filter Strip
- **BMP BF.05**: Narrow area filter strip
- **BMP WP.01**: Stormwater treatment wetland
- **BMP WP.02**: Wet ponds
- **BMP WP.03**: Wet vaults
- **BMP WP.04**: Combined detention/wet pool facilities
- **Any BMP providing enhanced treatment**.

This completes the treatment facility selection process.

4.3 Oil Control BMPs: Supplemental Information

4.3.1 Applicability

The traffic count (to determine whether a site is considered "high use") can be estimated using information from *Trip Generation*, published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

The following urban land uses are likely to have areas that fall within the definition of “high use sites” or have sufficient quantities of free oil present that can be treated by an API or CP-type oil and water separator:

- Industrial Machinery and Equipment, and Railroad Equipment Maintenance
- Log Storage and Sorting Yards
- Aircraft Maintenance Areas
- Railroad Yards
- Fueling Stations
- Vehicle Maintenance and Repair
- Construction Businesses (paving, heavy equipment storage and maintenance, storage of petroleum products).

Oil control facilities should also be used on other sites that generate high concentrations of oil. All-day parking areas are not intended to be defined as high use sites and should not require the oil control options listed in this menu**.** Gasoline stations, with or without small food stores, will likely exceed the high use site threshold. The petroleum storage and transfer criterion is intended to address regular transfer operations such as gasoline service stations, not occasional filling of heating oil tanks.

4.3.2 Application on the Project Site

Oil control facilities are to be placed upstream of other facilities, as close to the source of oil generation as possible. For high use sites located within a larger commercial center, only the impervious surface associated with the high use portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the high use business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.

High use roadway intersections shall treat 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 treatable area shall begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

4.3.3 Performance Goal

The facility choices in the Oil Control Menu are 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 Ecology Publication No. ECY 97-602, Analytical Methods for Petroleum Hydrocarbons to determine oil concentrations. If the concentration of gasoline is of interest, the method for NWTPH-Gx should be used to analyze grab samples.

4.3.4 Oil Control Menu

4.3.4.1 Options

Oil control options include facilities that are small, treat runoff from a limited area, and require frequent maintenance. The options also include facilities that treat runoff from larger areas and generally have less frequent maintenance needs.

- **BMP OW.01**: API-Type Oil/Water Separator
- **BMP OW.02**: Coalescing Plate Oil/Water Separator
- **BMP MF.03**: Linear Sand Filter
- **BMP BF.04**: Compost-Amended Vegetated Filter Strip.
- **BMP WP.03**: Wet vaults (if designed to include a baffle).

Note: The linear sand filter is also used in the Basic, Enhanced, and Phosphorus Treatment menus. If used to satisfy one of those treatment requirements, the same facility shall not also be used to satisfy the oil control requirement, unless enhanced maintenance is assured. This is to prevent clogging of the filter by oil so that it will function for both suspended solids and phosphorus removal. Quarterly cleaning is required unless otherwise specified by the designer.

4.4 Phosphorus Treatment: Supplemental Information

4.4.1 Where Applied

The Phosphorus Treatment Menu (below) applies to projects within watersheds determined by local governments, the Department of Ecology, or the USEPA to be sensitive to phosphorus, and that are being managed to control phosphorus inputs from stormwater. This menu applies to stormwater conveyed to the lake by surface flow and to stormwater infiltrated within one-quarter mile of the lake in soils that do not meet soil suitability criteria described in Volume III, Chapter 3.

4.4.2 Performance Goal

The Phosphorus Menu facility choices are intended to achieve a goal of 50 percent total phosphorus removal for a range of influent concentrations of 0.1 – 0.5 mg/l total phosphorus. The choices are also intended to achieve the Basic Treatment performance goal. The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (offline treatment facilities), or can be passed through the facility (online treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate. Note that wet pool facilities are always designed to be online.

4.4.3 Phosphorus Treatment Menu

Any one of the following options may be chosen to satisfy the phosphorus treatment requirement.

- Infiltration with appropriate pretreatment:

  Infiltration treatment: If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (see Section 2.3 of Volume III and Volume V), a presettling basin or a basic treatment facility can serve for pretreatment.

  Infiltration preceded by Basic Treatment: If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a basic treatment facility unless the soil and site fit the description in the next option below.

  Infiltration preceded by Phosphorus Treatment: If the soils do not meet the soil suitability criteria *and* the infiltration site is within 1/4 mile of a phosphorus-sensitive receiving water, or a tributary to that water, treatment must be provided by one of the other treatment facility options listed below.

- **BMP MF.01** or **MF.02**: Large Sand Filter

- **BMP MF.01** or **MF.02**: Amended Sand Filter (sand filter amendment requires Drainage Manual Administrator acceptance from Thurston County)

Note: Processed steel fiber and crushed calcitic limestone are the only sand filter amendments for which Ecology has data that documents increased dissolved metals removal. The use of processed steel fiber has been reported to cause a number of maintenance problems as it oxidizes over time and decreases the design filtration rate.

- **BMP WP.02**: Large Wet Pond

- Media Filter targeted for phosphorus removal (Drainage Manual Administrator acceptance required)

- Two-Facility Treatment Trains – see Table 4-1.

Table 4-1 Treatment Trains for Phosphorus Removal

First Basic Treatment Facility	Second Treatment Facility
BMP BF.01 Biofiltration Swale	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP BF.04 Filter Strip	BMP MF.03 Linear Sand Filter (no presettling needed)
BMP MF.03 Linear Sand Filter	BMP BF.04 Filter Strip
BMP WP.02 Basic Wet Pond	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.03 Wet Vault	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.01 Stormwater Treatment Wetland	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.04 Basic Combined Detention and Wet Pool	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault

4.5 Enhanced Treatment: Supplemental Information

4.5.1 Performance Goal

The Enhanced Menu facility choices (below) are intended to provide a higher rate of removal of dissolved metals than Basic Treatment facilities. .

The choices are also intended to achieve the Basic Treatment performance goal. This performance goal assumes that the facility is treating stormwater with dissolved Copper typically ranging from 0.003 to 0.02 mg/l, and dissolved Zinc ranging from 0.02 to 0.3 mg/l.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities 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 wet pool facilities are always designed to be on-line.

4.5.2 Enhanced Treatment Menu

Any one of the following options may be chosen to satisfy the enhanced treatment requirement:

Note: If phosphorous treatment is also required, select a facility or facility train that meets both Enhanced and Phosphorous treatment.

- Infiltration with appropriate pretreatment (see Volume III and Volume V)

  Infiltration treatment: If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (see Volume III and Volume V), a presettling basin or a basic treatment facility can serve for pretreatment.

Infiltration preceded by Basic Treatment: If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a basic treatment facility unless the soil and site fit the description in the next option below.

Infiltration preceded by Enhanced Treatment: If the soils do not meet the soil suitability criteria **and** the infiltration site is within a designated well head protection area or within 1/4 mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, treatment must be provided by one of the other treatment facility options listed below.

- **BMP MF.01** or **BMP MF.02**: Large Sand Filter
- **BMP MF.01** or **BMP MF.02**: Amended Sand Filter (sand filter amendment requires Drainage Manual Administrator acceptance from Thurston County)
- **BMP WP.01**: Stormwater Treatment Wetland
- **BMP BF.04**: Compost-amended Filter Strip
- Compost Amended Biofiltration Swale
- Two Facility Treatment Trains – see Table 4-2

Table 4-2 Treatment Trains for Dissolved Metals Removal

First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Filter Strip	Linear Sand Filter with no pre-settling cell needed
Linear Sand Filter	Filter Strip
Basic Wet Pond	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Wet Vault	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Basic Combined Detention/Wet Pool	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Basic Sand Filter or Sand Filter Vault with a presettling cell if the filter isn't preceded by a detention facility	Media Filter [1]

[1] The media must be of a nature that has the capability to remove dissolved metals effectively based on at least limited data. Ecology includes Stormfilter's ™ leaf compost and zeolite media in this category.

- **BMP LID.08**: Bioretention Facility

Note: Any stormwater runoff that infiltrates through the imported soil mix will have received the equivalent of Enhanced Treatment. Where bioretention/rain gardens are intended to fully meet treatment requirements, they must be designed, using an approved continuous runoff model, to infiltrate 91 percent of the influent runoff file.

- **BMP MF.04**: Media Filter Drain

4.6 Basic Treatment: Supplemental Information

4.6.1 Applicability

The Basic Treatment Menu (below) is applied to:

- Project sites that discharge to the ground, *unless*:

The soil suitability criteria for infiltration treatment are met (see Section 2.3 of Volume III and Volume V), or

The project uses infiltration strictly for flow control – not treatment – and the discharge is within 1/4 mile of a phosphorus sensitive lake (use the Phosphorus Treatment Menu), or within 1/4 mile of a fish-bearing stream, or a lake (use the Enhanced Treatment Menu).

Facility is located within a designated Well Head Protection Area for a public water supply with 1,000 connections or greater (use the Enhanced Treatment Menu).

- Residential projects not otherwise needing phosphorus control as designated by the EPA, Ecology, or a local government.
- Project sites discharging directly to salt water or basic receiving waters
- Project sites that drain to streams that are not fish-bearing, or to waters not tributary to fish-bearing streams
- Landscaped areas of industrial, commercial, and multi-family project sites, and 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 developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area.

4.6.2 Performance Goal

The Basic Treatment Menu facility choices (below) are intended to remove 80 percent of TSS 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 facilities are intended to achieve an effluent goal of 20 mg/l TSS.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable. The goal also applies on an average annual basis to the entire annual discharge volume (treated plus bypassed). The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net TSS reduction is maintained. Ecology encourages the design and operation of treatment facilities 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. Wet pool facilities are always designed to be online. The performance goal assumes that the facility is treating stormwater with a typical particle size distribution. For a description of a typical particle size distribution, please refer to the stormwater monitoring protocol in “Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol - Ecology (TAPE)” on the Ecology website: <http://www.ecy.wa.gov/biblio/0210037.html>.

4.6.3 Basic Treatment Menu

Any one of the following options may be chosen to satisfy the basic treatment requirement:

- Infiltration (with adequate soils)
- Sand filters
- Biofiltration swales
- Filter strips
- Basic wet pond
- Wet vault
- Stormwater treatment wetland
- Combined detention and wet pool facilities
- Bioretention facilities

Note: For bioretention facilities, any stormwater runoff that infiltrates through the imported soil mix will have received the equivalent of Enhanced Treatment. Where bioretention/rain gardens are intended to fully meet treatment requirements, they must be designed, using an approved continuous runoff model, to infiltrate 91 percent of the influent runoff file.

- Media Filter Drain
- Alternative Technologies when accepted at the “General Use Level” under Ecology’s TAPE program: (for example: CONTECH Stormwater Management StormFilter with ZPGTM media – A canister-type filter with zeolite/perlite/granular activated carbon).

Note: A wet vault may be used for commercial, industrial, or road projects if there are space limitations. Thurston County discourages the use of wet vaults for residential projects. Combined detention/wet vaults are allowed. Any use of a wet vault for basic treatment requires specific authorization and acceptance by Thurston County based on site circumstances.

4.7 Other Treatment Facility Selection Factors

Selection of a treatment facility should be based on physical site factors and pollutants of concern. Requirements for using Enhanced Treatment or Phosphorus Treatment represent facility selection based on pollutants of concern. Even if the site is not subject to those requirements, try to choose a facility that has been shown to remove the types of pollutants generated on the site. The types of physical site factors that influence facility selection are summarized below.

4.7.1 Soil Type

The permeability of soil under a treatment facility has a profound influence on the facility's effectiveness. This is particularly true for infiltration treatment facilities that are best sited in sandy to loamy sand soils, and not generally appropriate for sites that have final infiltration rates of less than 0.5 inches per hour. Wet pond facilities situated on coarser soils will need a synthetic liner or soil amendment 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.

4.7.2 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 facility would typically be necessary.

4.7.3 Other Physical Factors

4.7.3.1 Slope

Steep slopes restrict the use of several BMPs. For example, biofiltration swales are usually situated on sites with slopes of less than 6 percent, although greater slopes can be considered. Infiltration BMPs are not suitable when the slope exceeds 15 percent.

4.7.3.2 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 seasonal high water table extends to within 5 feet of the bottom of an infiltration BMP, the site is seldom suitable.

4.7.3.3 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 5 feet below the bottom of the infiltration BMP, the site is seldom suitable. Similarly, pond BMPs are often not feasible if bedrock lies within the area that must be excavated.

4.7.3.4 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.

4.7.3.5 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.

Appendix I-A
Glossary

Appendix I-A – See Preface and Table of Contents.

Appendix I-B
Bond Quantities Worksheet

The Bond Quantity Worksheet is available for download as an Excel Spreadsheet on the Thurston County Drainage Design and Erosion Control Manual website at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html. If you need a paper copy, please contact Thurston County Water Resources Division at 360-754-4681.

Bond Quantities Worksheet

Appendix I-C
Engineer's Construction Inspection Report Form

The Engineer's Construction Inspection Report Form is available for download on the Thurston County Drainage Design and Erosion Control Manual website at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html. If you need a paper copy, please contact Thurston County Water Resources Division at 360-754-4681.

Engineer's Construction Inspection Report Form

Appendix I-D
Facility Summary Form

The Facility Summary Form is available for download on the Thurston County Drainage Design and Erosion Control Manual website at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html. If you need a paper copy, please contact Thurston County Water Resources Division at 360-754-4681.

Facility Summary Form

Appendix I-E
Maintenance Agreement Forms

The Maintenance Agreement Forms are available for download on the Thurston County Drainage Design and Erosion Control Manual website at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html. If you need a paper copy, please contact Thurston County Water Resources Division at 360-754-4681.

Commercial Stormwater Agreement to Maintain Template Microsoft Word version

Commercial Stormwater Pollution Prevention Source Control Plan Template (PDF) (For a Microsoft Word version, click here)

Stormwater Pollution Prevention Source Control Plan BMPs (Microsoft Word)

Residential Subdivision Agreement to Maintain Template Microsoft Word version

Single Family Residential Agreement to Maintain Template Microsoft Word version

Appendix I-F
Soils Report Forms

SOIL EVALUATION REPORT FORMS

INSTRUCTIONS

A geotechnical report and/or soils report is required for the majority of development projects. Specific requirements are described throughout the DDECM. Specific instances when a geotechnical report and/or soil report is required include:

- All projects for which a Drainage and Erosion Control Plan is required.
- To establish field-saturated percolation rates for stormwater facilities and the overall site.
- For characterizing the infiltration receptor when an infiltration facility is proposed for the project.
- For establishing parameters for the performance of a groundwater mounding analysis, if required.
- To support the design of structures, retaining walls and other site features associated with securing a building permit.
- To support the construction of roads, parking areas, etc. as part of the overall project design process.
- For sites with slopes greater than 15% to determine suitability for locating facilities and/or determining whether a landslide hazard exists and addressing the effects of seepage and potential for slope failure.
- As required for grading work per Thurston County Code Chapter 14.31, International Building Code Appendix *J, Grading*.

When completing a geotechnical/soils report, the forms in this Appendix shall be included in the report as follows:

- Form 1: General Site Information: One copy of this completed form will be included at the front of the report.
- Form 2: Soil Log Evaluation: One copy of Form 2 shall be completed and included for each soil location where testing has been done.

Where inadequate space is provided, reference attached supplemental documents or prepare separate report in format that includes each of the headings of Form 1

PREPARER:	PLEASE READ ALL INSTRUCTIONS FIRST.

STAFF USE ONLY

SOIL EVALUATION REPORT
FORM 1: GENERAL SITE INFORMATION

PROJECT TITLE: PROJECT NO.: PREPARED BY:	SHEET OF DATE:
1. SITE ADDRESS OR LEGAL DESCRIPTION:	
2. PROJECT DESCRIPTION:	
3. SITE DESCRIPTION:	
4. SUMMARY OF SOILS WORK PERFORMED:	
5. ADDITIONAL SOILS WORK RECOMMENDED:	
6. FINDINGS (Including pre-development site percolation rate):	
7. RECOMMENDATIONS:	
I hereby certify that I prepared this report and conducted or supervised the performance of related work. I certify that I am qualified to do this work. I represent my work to be complete and accurate within the bounds of uncertainty inherent to the practice of soil science and to be suitable for its intended use. SIGNED: ______________________________ DATE: ________________	

SOIL EVALUATION REPORT INSTRUCTIONS FOR COMPLETING FORM 1

Form 1 is the "cover page" for all projects that require a soil evaluation report. One copy of Form 1 must accompany all soil evaluation reports. Certain information may be omitted for soil evaluations completed for small projects (e.g., single-family residences, duplexes). The following instructions should give you the guidance needed to complete the form:

1. Provide project name and address or legal description. Attach a legible map on 8 ½" by 11" paper showing site and major landmarks (e.g., roadways and surface waters) within approximately one-quarter mile radius around site.

2. Provide acreage, parcel dimensions, type of development proposed, and approximate proposed coverage of impervious surfaces.

3. Describe site topography, geomorphology, terrain, and natural cover. Distinguish among areas of the site with significantly different characteristics.

4. Provide description and purpose of soils work done. List methods used to expose, sample, and test soils. Give number of test holes logged. Describe field and lab tests performed. Attach a scaled map of good accuracy on 8 ½" by 11" paper showing locations of soil logs. Except small projects, using soil log results, divide map area into sub-areas according to hydrologic group (A through D).

5. Describe soils work still needed. For example, more work may be needed to obtain accurate percolation or infiltration rates for stormwater facilities not yet constructed.

6. Describe results of soil logs and tests and compare with expected soils from NRCS Soils maps. **As appropriate for the project, give your best estimate of the (a) overall predeveloped site infiltration rate, (b) the saturated infiltration rate for the above-ground stormwater facility, or (c) the saturated percolation rate for the below ground stormwater trench or drywell.** Discuss soils factors related to erosion control, infiltration, percolation, and placement of buildings, as these vary on the site.

7. Describe the recommended general approach for managing stormwater on the site. For example, if stormwater can be infiltrated or percolated, indicate where and at what depth. If erosion, soil stability, or high ground water are problems, can these problems be avoided or mitigated?

Sign the form and affix relevant professional seal (e.g., P.E. ARCPACS, R.G.). The form becomes the cover page to one or more copies of Form 2, which has soil logs for each test hole evaluated.

PREPARER:	PLEASE READ ALL INSTRUCTIONS FIRST.

STAFF USE ONLY

SOIL EVALUATION REPORT
FORM 2: SOIL LOG INFORMATION

PROJECT TITLE: SHEET OF
PROJECT NO.: DATE:
PREPARED BY:

SOIL LOG:

LOCATION:

1. TYPE OF TEST DONE:	2. NRCS SOIL SERIES:	3. LAND FORM:
4. DEPOSITIOIN HISTORY:	5. HYDROLOGIC SOIL GROUP:	6. DEPTH TO SEASONAL HW:
7. CURRENT WATER DEPTH:	8. DEPTH TO IMPERV LAYER:	9. MISC:

POTENTIAL FOR:	EROSION	RUNOFF	PONDING

11. SOIL STRATA DESCRIPTION:

HORZ	DEPTH	COLOR	TEXTURE	%CL	%ORG	%CF	STR	MOT	IND	CEM	ROD	<X>	FSP

12. SITE PERCOLATION RATE:

13. FINDINGS & RECOMMENDATIONS:

SOIL EVALUATION REPORT INSTRUCTIONS FOR COMPLETING FORM 2

Form 2 is the detailed record of soil information obtained on the development site. One copy of Form 2 must be completed for <u>each soil location</u> where testing has been done. For tests other than soil logs for which the scientist wants to submit numerical results, please attach a separate sheet and briefly describe the results under "Findings and recommendations." The summary information that heads the sheet should be self-explanatory. Regarding location, reference the location to features that are permanent and static, such as roads or property lines.

1. State briefly tests that were done. Indicate whether tests were field, laboratory, or other.

2. Determine the soil series from the maps provided in the NRCS *Soil Survey of Thurston County*. Then, indicate what soil series was mapped as a result of the testing done.

3. Indicate land form (e.g., till plain)

4. Indicate depositional history (e.g., alluvial plain).

5. Indicate NRCS hydrologic soil group (e.g., letter designation A through D).

6. Indicate seasonal high water table depth based upon the presence of mottling, gleying, or other evidence. Indicate how you determined this value under "Findings…" section. If information available is inadequate, state value to be "greater than" bottom of hole depth.

7. Indicate current water table depth based upon observation. If saturated conditions are not observed, state value to be "greater than" bottom of hole depth.

8. Indicate depth to impervious layer (e.g., basal till). If information is inadequate, state value to be "greater than" bottom of hole depth.

9. Space for other miscellaneous observations regarding setting of site (e.g., concave, convex, swale, hillslope).

10. Indicate susceptibility of area to erosion, runoff, and ponding problems. The susceptibility should be rated based upon relevant physical characteristics and development operations planned for the area, such as shape of the area (e.g., concave, convex, flat) removal or addition of fill, time of year, existing and planned vegetative cover, degree of soil compaction, etc. For erosion, the K-factor for the soils series in question might help in assessing erodibility.

11. The profile description provides the <u>minimum</u> information on the physical attributes of the soil. Additional factors may be assessed at the option of the scientist, but data on these factors should be tabulated separately and summarized briefly in the "Findings and recommendations" section.

FORM 2 INSTRUCTIONS (CONTINUED)

All information provided for the profile shall utilize standard NRCS nomenclature and abbreviations. The following are the factors to be addressed, with brief examples of acceptable responses. Further information on most of these is provided in the NRCS *Soil Survey of Thurston County*.

a. Hor(izon): a layer of soil with distinct characteristics, labeled A, AB, B, C, Ccw, etc..

b. Depth: Starting at "0" (surface), depth and interval of horizon.

c. Color: Munsell code for hue, value, and chroma, such as 10 YR 3/4. Indicate whether color is wet or dry.

d. Textur(al class): Class that best describes relative percentages of sand, silt, and clay in horizon, such as sandy loam (SL).

e. %Cl(ay): Clay percentage is very useful as a guide to determining the drainage capability of a soil.

f. %Org(anic) M(atter): Organic matter percentage by volume is related to the infiltration as well as pollutant removal capability of soils.

g. %C(oarse)F(ragments): Coarse fragments percentage is relevant to drainage and other site management factors.

h. Str(ucture): Describes size and shape of soil "clods."

i. Mot(tling): Where present, describe using three-letter abbreviations to indicate abundance, size, and contrast, such as CFS (common, fine, distinct).

j. Ind(uration): Physical compaction of a layer such as a glacial till. Where present, describe as weak, mod(erate), or str(ong).

k. Cem(entation): Aggregation of soil particles due to chemical processes. Describe as in induration.

l. Roo(ts): Where present, describe using two-letter abbreviation to indicate abundance and size, such as CF (common, fine).

m. Generalized range of infiltration rates using NRCS Soil Survey <X>;

n. F(ield) S(aturated) P(ercolation rate): Using all available information, estimate field saturated percolation rate. This rate should be a <u>single number</u>, and may vary from that range (see previous column) published in the NRCS Soil Survey due to horizon-specific factors.

12. Provide overall site (location) field saturated percolation rate. Rate should reflect effects of the entire soil column. If soil test location is proposed for siting of an infiltration facility, use methods of Volume III and apply applicable correction factors to establish long-term, saturated infiltration rate for facility design.

13. Discuss results of tests done on soil. Indicate features of soil that most affect stormwater management <u>at this location.</u> Provide recommendations to the Project Engineer on soil-related factors such as problems and controls, and for additional work needed (if necessary).

Appendix I-G
Standard Stormwater Notes

See the Thurston County Drainage Design and Erosion Control website at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html for the current Standard Stormwater Notes. If you need a paper copy, please contact Thurston County Water Resources Division at 360-754-4681.

Standard Stormwater Notes

Thurston County Drainage Design and Erosion Control Manual

Volume II
Construction Stormwater Pollution Prevention

Prepared by
Thurston County Water Resources Division,
Department of Resource Stewardship

December 2016

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Acronyms

AKART	All known, available, and reasonable methods of prevention, control, and treatment.
ATB	Asphalt Treated Base
BFM	Bonded Fiber Matrix
BMPs	Best Management Practices
CESCL	Certified Erosion and Sediment Control Lead
CESCP	Contractor’s Erosion and Sediment Control Plan
CFR	Code of Federal Regulations
CPESC	Certified Professional in Erosion and Sediment Control
CWSGP	Construction Stormwater General Permit
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	The Federal Endangered Species Act
ESC	Erosion and Sediment Control
FCWA	Federal Clean Water Act
FEMA	Federal Emergency Management Agency
IECA	International Erosion Control Association
MBFM	Mechanically Bonded Fiber Matrix
Min.	Minimum
NOEC	No observed effects concentration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service (Formerly SCS, Soil Conservation Service)
NTU	Nephelometric Turbidity Unit
PAM	Polyacrylamide
RUSLE	Revised Universal Soil Loss Equation
SWPPP	Stormwater Pollution Prevention Plan
TESC	Temporary Erosion and Sediment Control
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
WSDOT	Washington State Department of Transportation

Chapter 1 - Introduction to Construction Stormwater Pollution Prevention

1.1 Purpose of this Volume

This volume of the *Drainage Design and Erosion Control Manual (DDECM*) explains how to prevent adverse stormwater impacts from construction activities on downstream resources and on-site stormwater facilities. It should be used in developing your Construction Stormwater Pollution Prevention Plan (SWPPP), which is a required component of your Drainage Design and Erosion Control Plan (see Volume I, Chapter 3).

Information in this Volume applies to your project if you are required to address Core Requirement # 2 (See Volume I). This includes any project with more than 2,000 square feet of new or replaced hard surface, disturbs greater than 7,000 sf of land, converts greater than 3/4 acre of vegetation to lawn or landscaping or that converts greater than 2 ½ acres of native vegetation to pasture. If your project has greater than 1-acre of land disturbing activity and discharges to surface water, you may also be required to obtain an NPDES Stormwater Permit from the Department of Ecology. Projects not meeting the above thresholds may still be required to prepare an Abbreviated Drainage Plan that shall include appropriate elements from this Volume to minimize downstream impacts of your project.

Construction may take place over multiple seasons or years. Therefore, all management practices and control facilities used during construction shall be designed and sized to ensure protection during the anticipated construction period, including the appropriate selection of design storms as shown Chapter 3 for each BMP.

IMPORTANT: Linear construction projects such as roadway construction and utility installations are special cases, and present their own unique set of stormwater protection challenges. You can adapt or modify many of the BMPs discussed in this volume to provide the controls needed to address these projects. You may also consider referring to the current edition of the WSDOT *Temporary Erosion and Sediment Control Manual* for additional guidance specific to linear projects. It may be advantageous to phase portions of long, linear projects and apply all necessary controls to individual phases.

1.2 How This Volume is Organized

Volume II is organized into three chapters that address key considerations and mechanics of construction stormwater BMPs:

Chapter 1 describes the 13 elements that must be considered when preparing a Stormwater Pollution Prevention Plan. It also includes additional regulatory requirements that may apply to construction sites and their stormwater discharges. This includes the Department of Ecology's (Ecology) National Pollutant Discharge Elimination System (NPDES) discharge permit and Washington's Water Quality Standards pertaining to construction stormwater and how they apply to field situations.

Chapter 2 explains additional requirements for construction erosion control, including seasonal limitations and required components of the SWPPP.

Chapter 3 describes best management practices (BMPs) for construction stormwater control and site management, including source control for construction-related activities, runoff, conveyance, and treatment. The third section presents practices specifically to protect low impact development (LID) BMPs during construction. These practices are required as part of Element #13 (discussed in the next section). You can use various combinations of these BMPs in the Construction SWPPP to satisfy each of the 13 elements described in Section 1.3. Design and facility sizing information is included within the applicable BMP sections.

1.3 13 Elements of Construction Stormwater Pollution Prevention

The project proponent or designated project engineer shall develop a Construction Stormwater Pollution Prevention Plan (SWPPP). The goal of a SWPPP is to avoid immediate and long-term environmental loss and degradation caused by poorly managed construction sites. Additional information on erosion and sedimentation processes and factors influencing erosion potential may be found in the latest edition of Ecology's *Stormwater Management Manual for Western Washington*.

The following 13 elements address water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources. Each element must be considered when developing the Construction SWPPP, unless site conditions make it unnecessary. If an element is unnecessary, the Construction SWPPP must justify the omission.

The 13 elements of a Construction SWPPP are:

1. Preserve Vegetation/Mark Clearing Limits
2. Establish Construction Access
3. Control Flow Rates
4. Install Sediment Controls
5. Stabilize Soils
6. Protect Slopes
7. Protect Drain Inlets
8. Stabilize Channels and Outlets
9. Control Pollutants
10. Control Dewatering
11. Maintain BMPs
12. Manage the Project
13. Protect Low Impact Development BMPs

Chapter 2 describes each element and its associated BMPs.

1.4 Water Quality Standards

Stormwater discharges from construction activity are subject to applicable state water quality standards. These discharges must not cause or contribute to violations of Washington State's surface water quality standards (Chapter 173-201A WAC), sediment management standards

(Chapter 173-204 WAC), ground water quality standards (Chapter 173-200 WAC), and human health based criteria in the National Toxics Rule (Federal Register, Vol. 57, No. 246, Dec. 22, 1992, pages 60848-60923).

A Site Development Permit does not authorize violation of these standards. Thurston County expects that the selection and implementation of appropriate BMPs outlined in this volume will result in compliance with water quality standards. Proper implementation and maintenance of BMPs is critical to adequately control adverse water quality impacts from construction activity. If observations reveal that installed BMPs do not adequately maintain flow and water quality standards, additional BMPs must be installed.

1.5 Other Applicable Regulations and Permits

In addition to Thurston County regulations, other regulations and permits may require the implementation of BMPs to control pollutants in construction site stormwater runoff. These include but are not limited to the following (principal permitting agency in parentheses):

- Construction General Permit under NPDES (Ecology)
- Total Maximum Daily Load (TMDLs) or Water Clean Up Plans (Ecology)
- Endangered Species Act – ESA (NOAA Fisheries or U.S. Fish & Wildlife)
- Hydraulic Project Approval Permits (WA Dept. of Fish & Wildlife)
- General provisions from the WSDOT (WA Dept. of Transportation)
- Contaminated site remediation agreements.

See the Introduction Section of this manual (preceding Volume I) for more information about these regulations and permits.

1.5.1 Enforcement Guidelines

The purpose of compliance monitoring is to ensure protection of water resources and stormwater infrastructure, not punish violators. Therefore, the initial and primary enforcement tool shall be a correction notice. Correction notices may be verbal or written. If the situation is not corrected within the timelines set in the correction notice, all construction work will be halted with a stop work order if necessary, until appropriate erosion prevention and sediment control BMPs are in place, and runoff meets applicable discharge and water quality standards.

If a timely and adequate response does not occur, or in cases of severe repeated violations, the County shall, at their discretion, issue infraction notices or citations carrying monetary penalties.

The Washington State Department of Ecology will also be contacted at this stage to help aid with enforcement under the responsible party’s individual NPDES Construction Permit.[1]

[1] Please see Thurston County Public Works Policy POL-820 on DDECM webpage at http://www.co.thurston.wa.us/stormwater/manual/manual-home.html

1.5.2 Compliance with Standards

Stormwater discharges from construction sites must not cause or contribute to violations of Washington State's surface water quality standards (WAC 173-201A), sediment management standards (WAC 173-204), and human health based criteria in the National Toxics Rule (40 CFR Part 131.36).

Before the site can discharge stormwater and non-stormwater to waters of the State, all known, available, and reasonable methods of prevention, control, and treatment (AKART) must be applied. This includes preparing and implementing a Construction SWPPP, with all appropriate BMPs installed and maintained in accordance with the SWPPP and the terms and conditions of the Construction Stormwater General Permit (if one is required).

In accordance with Chapter 90.48 RCW, compliance with water quality standards is presumed unless discharge monitoring data or other site specific information demonstrates otherwise, when the applicant fully:

- Complies with permit conditions for planning, sampling, monitoring, reporting and recordkeeping; and
- Implements the BMPs contained in this manual or BMPs that are demonstrably equivalent to BMPs contained in this manual, including the proper selection, implementation, and maintenance of all applicable and appropriate BMPs for on-site pollution control.

The following discharge standard applies:

Runoff leaving the construction site shall be free of settleable solids, as measured with an Imhoff Cone, turbidity meter or transparency tube and in accordance with Standard Methods for the Examination of Water and Wastewater, most recent addition, American Water Works Association. "Free of settleable solids" shall be defined as measuring less than 2.5 mg/L/hr. for storms up to the water quality design event. Generally, if turbidity is visible in runoff, it does not meet this standard.

Pollutants that might be expected in the discharge from construction sites are turbidity, pH, and petroleum products. The surface water quality standards for turbidity and pH for waters designated for salmon and trout spawning, core rearing, and migration use are:

Turbidity: For storms up to the water quality design event, turbidity downstream of a construction site may not increase more than 5 NTU, if upstream turbidity is 50 NTU or less, and may not increase more than 10 percent, if upstream turbidity is over 50 NTU. To the extent practicable, samples shall be taken far enough downstream so that the construction site discharge has been well-mixed with surface water.

pH: shall be within the range of 6.5 to 8.5 (freshwater) or 7.0 to 8.5 (marine water) with a human-caused variation within a range of less than 0.2 units. For Class A and lower water classifications, the permissible induced increase is 0.5 units.

Petroleum: Although there is no specific surface or ground water quality standard for petroleum products, narrative surface water quality criteria prohibits any visible sheen in a discharge to surface water.

Whenever inspection or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be fully resolved and implemented within 10 days of the inspection, Thurston County may approve additional time when an extension is requested within the initial 10-day response period.

Chapter 2 - Developing and Implementing a Construction Stormwater Pollution Prevention Plan

This chapter describes the important components and process necessary for developing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP).

Section 2.1 provides general guidelines for plan format and content, and ideas for creating an effective plan.

Section 2.2 lists the components to be submitted with the SWPPP.

Section 2.3 describes a step-by-step procedure for developing a Construction SWPPP, from data collection to finished product, to meet the 13 required elements. This section also includes a checklist for developing a construction SWPPP.

Section 2.4 lists drawing protocols for the SWPPP.

See Chapter 3 for design standards and specifications for BMPs referred to in this chapter.

2.1 General Guidelines

2.1.1 What is a Construction Stormwater Pollution Prevention Plan?

A Construction Stormwater Pollution Prevention Plan (SWPPP) means a written plan to implement measures to identify, prevent, and control the contamination of point source discharges of stormwater during construction. The Construction SWPPP explains and illustrates the measures, usually in the form of best management practices (BMPs), to take on a construction site to control potential pollution problems.

The Construction SWPPP consists of a Temporary Erosion and Sediment Control (TESC) Plan and a narrative that addresses the 13 required elements described in section 1.3 above. The TESC is a set of plan sheets showing BMP locations and other features such as topography and sensitive areas, and includes construction details for BMPs, construction notes and specifications.

The Narrative supplements the TESC and is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains site specific information about existing conditions, construction schedules, a description of the project, a description of how each of the 13 elements are addressed, and design calculations for specific BMPs including calculation of runoff volumes and flows for the design storm. See Section 2.2 for detailed submittal requirements for the TESC and Narrative.

A Construction SWPPP is required for projects that exceed the thresholds of Volume I, Chapter 2 and are subject to Core Requirement #2. For projects less than 1-acre and not meeting the above thresholds, and those that qualify for the Abbreviated Drainage Plan, a Short Form Construction SWPPP may be acceptable for erosion and sediment control purposes (see Appendix II-C).

A copy of the TESC drawings must always be kept on the construction site and the Construction SWPPP must be located either on the construction site or within reasonable access of construction and inspection personnel. As site work progresses, the plan must be modified to reflect changing site conditions.

The owner or lessee of the land being developed is responsible for preparing and submitting the Construction SWPPP to the County. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but the owner retains the ultimate responsibility for environmental protection at the site.

2.1.2 What is an "Adequate" Plan?

The Construction SWPPP must contain sufficient information to satisfy the County that sediment, erosion and pollution problems have been adequately addressed for the proposed project.

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, site specific, information about existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings show, on a site map, the specific BMPs which shall 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.

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. Each of the 13 elements (Section 2.3.2) must be included in the Construction SWPPP, unless an element is determined to not be applicable to the project and the exemption is justified in the narrative.

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.

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 action taken as a result of these inspections must be prepared and retained as part of the Construction SWPPP.

The step-by-step procedure outlined in Section 2.3 of this Volume is recommended for the development of the Construction SWPPP. The checklists in Section 2.5 may be helpful in preparing and reviewing the Construction SWPPP.

2.1.3 BMP Standards and Specifications

BMPs refer to schedules of activities; prohibitions of practices; maintenance procedures; and other physical, structural, and/or managerial practices to prevent or reduce the pollution of waters of the State. BMPs include treatment systems, operating procedures, and practices to control:

- Stormwater associated with construction activity
- Groundwater associated with construction activity
- Spillage or leaks
- Sludge or waste disposal
- Drainage from raw material storage

Chapter 3 contains standards and specifications for the BMPs referred to in this chapter. Wherever any BMPs are used on a site, reference the specific title and number of the BMP in the narrative and mark it on construction drawings.

The standards and specifications in Chapter 3 of this volume are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. If the BMPs in this chapter are not adequate to meet regulatory requirements, experimental management practices can be considered. Minor modifications to standard practices may also be employed. However, such practices must be pre-approved by both the County and Ecology before being used. All experimental management practices and modified standard practices are required to meet or exceed the performance of the BMPs listed in Chapter 3.

2.1.4 General Principles

The Construction SWPPP shall first consider the use of on-site practices to provide erosion and sediment control. On-site practices include design and construction practices that focus on preserving vegetation and native soils, minimizing impervious surfaces, and selecting construction materials and BMPs that mimic the natural hydrology of a site as much as possible.

NOTE: Projects incorporating on-site measures are not exempt from flow control and runoff treatment requirements and must be in compliance with applicable standards in this manual. For guidance on modeling hydrologic performance of on-site BMPs, see Volume III.

1. Minimize Clearing and Grading

Keep grading to a minimum by incorporating natural topographic depressions into the project and limiting the amount of cut and fill on those portions of the site with permeable soils. At a minimum, the following standards shall be used:

Preserve native soils and vegetation by retaining the duff layer, native topsoil, and natural vegetation in an undisturbed state to the maximum extent possible

Limit clearing to road, utility, building pad, lawn areas, and the minimum amount of extra land necessary to maneuver machinery (e.g., a 10-foot perimeter around a building). All other land outside these areas shall be protected with construction fencing to prevent intrusion and compaction by construction equipment or other types of vehicles.

Keep distances for overland flow short to promote sheet flow and minimize concentration of runoff.

Grading shall not increase angle or length of steep, continuous slopes.

Minimize the amount and time that graded areas are left exposed by completing construction and erosion control in one section of the site before beginning operation on the next.

Limit secondary excavations and heavy equipment use by shaping final lot grades and topographic features at the site development stage.

Reuse native topsoil elsewhere on the site to amend areas with sparse or nutrient-deficient topsoil.

Do *not* relocate topsoil or other material to critical areas where they can cover critical root zones, suffocate vegetation, or erode into adjacent streams.

Stockpile materials in areas designated for clearing and grading (such as parking areas and future roadways).

To prevent erosion, cover small stockpiles with weed barrier material that sheds moisture but allows air transmission. Large stockpiles may need to be seeded and/or mulched.

2. Incorporate Erosion Control Techniques

On-site best management practices to control erosion and sediment include the following:

Use effective revegetation methods to reduce erosion, including:

- Establish vegetation quickly, particularly during seasons that have the most rainfall.
- Use native plant species adapted to the local environment.
- Plant during seasons that provide the best opportunity for survival of vegetation (usually late fall, winter, or early spring months).
- Control excess surface water runoff to prevent erosion.
- Use proper seedbed preparation.
- Fertilize as needed and mulch to protect germinating plants.
- Protect areas designated for revegetation from soils compaction by restricting heavy equipment.
- Provide proper soil amendments where necessary (see BMP C120).
- Protect native topsoil during the construction phase. Native topsoil has a high organic content and native seed sources, which are excellent for reestablishing permanent vegetation.

- Limit clearing and grading during heavy rainfall seasons. Construction activities should begin during the season of lowest precipitation and end when conditions are favorable for the establishment of vegetation.
- Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.
- Direct runoff to areas of permeable soils or natural depressions to promote infiltration.
- Reduce runoff velocities to prevent channel erosion.
- Prevent offsite tracking of sediment.
- Reduce the number and width of construction access roads. Locate access roads where future roads and utility corridors will be placed.
- Perform preconstruction, routine, and post-construction inspections:
- Conduct a preconstruction inspection to determine that adequate barriers have been placed around vegetation retention areas and structural controls are properly implemented.
- Conduct routine inspections to verify that structural controls are being maintained and operating effectively throughout construction.
- Conduct a final inspection to verify that revegetation areas are stabilized and that stormwater management systems are in place and functioning properly.

3. Select Appropriate BMPs

In addition to the general erosion and sediment control BMPs for construction, on-site stormwater management principles to use in preparing your Construction SWPPP include:

- Prevent pollutant release. Select source control BMPs as a first line of defense. Prevent erosion rather than treat turbid runoff.
- Select BMPs depending on site characteristics (topography, drainage, soil type, ground cover, and critical areas) and the construction plan.
- Divert runoff away from exposed areas wherever possible. Keep clean water clean.
- Select appropriate BMPs for the control of non-sediment pollutants.
- Be realistic about the limitations of controls that you specify and the operation and maintenance of those controls. Anticipate what can go wrong, how to prevent it, and how to fix it.
- Monitor all construction BMPs for effectiveness and have a plan to address any failures, including lack of vegetative establishment.

2.2 Construction SWPPP Submittal Components

The Construction SWPPP is intended to be a stand-alone document that supplements other project documentation. The Construction SWPPP shall contain the components listed below. Some of these components may be derived from the Drainage and Erosion Control Report, Drainage Plans (drawings), Engineered Abbreviated Drainage Plan, or Abbreviated Drainage Plan prepared for the project.

1. Cover sheet
2. Project engineer's certification (where required)
3. Table of contents
4. Construction SWPPP Narrative
5. Construction SWPPP TESC Drawings including:
   - Coversheet and project information
   - TESC Plan
   - TESC Details
   - TESC Notes and Specifications
6. Inspection forms and inspection record.

Note that a Short Form Construction SWPPP can be submitted for projects that disturb less than 1- acre and require only an Abbreviated or Engineered Abbreviated Drainage Plan. See Appendix II-C for a template.

2.3 Step-By-Step Procedure

There are three basic steps in producing a Construction SWPPP:

Step 1: Document existing site conditions

Step 2: Select and design BMPs

Step 3: Develop and Implement Construction SWPPP.

2.3.1 Step 1 – Data Collection and Analysis

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP. Use collected data to visualize potential problems and limitation of the site. The applicant shall show the information gathered on the TESC drawings and detail it in the narrative. Give special consideration to those areas that have critical erosion hazards or erosion potential when evaluating existing site conditions. The following are some important factors to consider in data collection and analysis:

1. **Project Location**: Determine precise location of the construction site, adjacent roads and receiving waters:

    - Indicate locations on a Vicinity Map for inclusion in the narrative and on TESC drawings.
    - Describe project including locations in Project Description.

2. **Property Boundaries and Zoning**: Determine the legal property boundaries and zoning requirements for the site.

    - Indicate Legal Property Boundaries and Zoning on the TESC drawings.
    - Discuss zoning requirements in Existing Site Conditions section of the narrative.

3. **Topography**: Prepare a topographic drawing of the site to show existing contour elevations at intervals of 1 to 5 feet depending upon the slope of the terrain (see Section 2.4for drawing protocols). Evaluate topography for erosion potential. The primary topographic considerations are slope steepness and slope length. Because of the effect of runoff, the longer and steeper the slope, the greater the erosion potential. Erosion potential should be determined by a qualified engineer, soil professional, or certified erosion control specialist.

    - Show existing topography on the TESC drawings.
    - Discuss topographic considerations in the Existing Site Conditions section of the narrative.

4. **Ground Cover:** Label existing vegetation on the TESC drawing. Show features such as tree clusters, grassy areas, and unique or sensitive vegetation. Unique vegetation may include existing trees above a given diameter. Investigate requirements for tree preservation. (At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.) Also indicate existing denuded or exposed soil areas.

    Ground cover is the most important factor in erosion prevention. Existing vegetation that can be saved will usually prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider practices like phasing construction, temporary seeding, and mulching. Phasing of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

    - Show existing vegetation on TESC drawings.
    - Discuss vegetation in the Existing Site Conditions section of the narrative.

5. **Drainage**: Locate and clearly mark existing drainage swales and patterns on the TESC drawings, including existing storm drain pipe systems. The drawings should distinguish between natural and man-made drainage. Use natural drainage paths (e.g., overland flow, swales and **depressions**) to convey runoff through the site to avoid constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if not properly stabilized. 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 of saturated soil - areas where ground water may be encountered - and critical areas where drainage will concentrate. Preserve natural drainage patterns on the site.

   - Show existing Drainage on TESC drawings.
   - Discuss Drainage in Existing Site Conditions section of the narrative.

6. **Soils**: Identify and **label** soil type(s) and erodibility (slight, moderate, severe, very severe or an index value from the NRCS manual) on the drawings and in the narrative.

   Soils must be characterized for permeability, water holding capacity, percent organic matter, and effective depth by a qualified soil professional or engineer. Express these qualities in averaged or nominal terms for the subject site or project. This information is typically available in the published NRCS Soil Survey of Thurston County.

   - A sieve analysis of the soils
   - Permeability (in/hr)
   - Available water-holding capacity (in/in)
   - The percent of organic matter.

   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, and erodibility. Develop the Construction SWPPP based on known soil characteristics. Properly protect infiltration sites from clay and silt disturbed during construction activities, which reduce infiltration capacities.

   - Show soils information on TESC Plan Sheet and include soil descriptions on the TESC Notes sheet.
   - Discuss in Soils in the narrative.

7. **Critical Areas**: Delineate and describe critical areas adjacent to or within the site on the drawings and in the narrative. Critical areas that receive runoff from the site shall be described up to ¼ mile away. Describe special requirements for working near or within these areas. Show features **such** as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas. Delineate setbacks and buffer limits for these features on the TESC drawings. Other related jurisdictional boundaries, such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base

floodplain shall also be shown on the TESC drawings. Critical areas per Thurston County Critical Areas Ordinance (CAO) , may include aquifer recharge areas, geologic hazard areas, floodplains, streams, critical habitat and wetlands.

The existence of critical areas near the project exerts a strong influence on land development decisions. Critical areas and their buffers shall be delineated on drawings and clearly flagged in the field. 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 or their buffers, and will require special BMPs, permit restrictions, and mitigation plans.

- Show critical areas on the TESC Plan.
- Discuss critical area in the Critical Areas section of the narrative.

8. **Adjacent Areas:** Identify existing buildings, roads, and facilities adjacent to or within the project site on the TESC drawings. **Identify** existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings. An analysis of adjacent properties should focus on areas 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. Select erosion and sediment controls accordingly.

    - Show adjacent areas on the TESC Plan.
    - Discuss adjacent areas in the Adjacent Areas section of the narrative.

9. **Existing Encumbrances:** Identify wells, existing and abandoned septic drainfields, utilities, easements, setbacks, and site constraints.

    - Show existing encumbrances on the TESC Plan.
    - Discuss existing encumbrances in the Existing Encumbrances section of the narrative.

10. **Precipitation Records and Stormwater Design Flows**: see Volume III to determine the **required** rainfall records and the method of analysis for design of BMPs.

    - Include stormwater design flows for sediment control BMPs on the TESC Plan. Show basins for which the design flows are applicable.
    - Discuss rainfall data and stormwater design flows and volumes in the Engineering Calculations section of the Narrative.

11. **Timing of the Project**: Describe the construction schedule. An important consideration in selecting BMPs is the timing and duration of the project. 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.

- Describe design considerations based on timing in the Narrative.
- Prepare a construction schedule and include in the TESC drawings and the narrative.
- Include 13 elements in timeline as applicable.

2.3.2 Step 2 – Select and Design BMPs

After collecting and analyzing the data to determine the site limitations, BMPs can be selected and designed. **Each of the 13 elements below must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary.** Justification for exempting an element must be clearly explained in the narrative of the SWPPP.

On-site stormwater management general principles and BMPs should be given primary consideration when designing a SWPPP. On-site elements were already discussed under Section 2.1.4 – General Principles. In certain cases, the County may require written justification on why on-site techniques are not deemed practicable.

Element #1: Preserve Vegetation/Mark Clearing Limits

- Prior to 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. These shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts.
- Clearly visible plastic, metal, or stake wire fence may be used to mark the clearing limits.
- The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum degree practicable. If it is not practicable to retain the duff layer in place, stockpile it on-site, cover it to prevent erosion, and replace it immediately upon completion of the ground disturbing activities.

Suggested BMPs:

  - BMP C100: Preservation of Native Topsoil (On-site)
  - BMP C101: Preserving Natural Vegetation (On-site)
  - BMP C102: Buffer Zones
  - BMP C103: High Visibility Plastic Fence.
  - BMP C233: Silt Fence

Element #2: Establish Construction Access

- Limit construction vehicle access and exit to one route, if possible, or two for linear projects such as roadways where more than one access is necessary for large equipment maneuvering.

- Stabilize access points with a pad of quarry spalls or crushed rock, or equivalent BMP prior to traffic leaving the construction site to minimize the tracking of sediment onto public roads.
- Wheel wash or tire baths should be located on site, if the stabilized construction entrance is not effective in preventing sediment from being tracked on public roads.
- If sediment is tracked off site, clean the affected roadway thoroughly at the end of each day, or more frequently as necessary (for example during wet weather) to prevent sediment from entering waters of the state. Remove sediment from roads by shoveling or pickup sweeping and transport to a controlled sediment disposal area. Street washing is allowed only after sediment is removed in this manner.
- Control street wash wastewater by pumping back on site to an approved infiltration facility, or otherwise preventing it from discharging into systems tributary to the county municipal separated storm sewer system (MS4), wetlands, or waters of the State. Other options include discharge to the sanitary sewer, or discharge to an approved offsite treatment system. For discharges to the sanitary sewer, permits must be obtained from the local jurisdiction providing the sewer.

Suggested BMPs:

- o BMP C105: Stabilized Construction Entrance/Exit
- o BMP C106: Wheel Wash
- o BMP C107: Construction Road/Parking Area Stabilization.

Element #3: Control Flow Rates

- Protect properties and waterways downstream from development sites from erosion and the associated discharge of turbid waters due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.
- Downstream analysis is necessary if changes in offsite flows could impair or alter conveyance systems, stream banks, bed sediment, or aquatic habitat. See Volume I, Chapter 2, for potential offsite analysis requirements and guidelines (Core Requirement #11).
- Where necessary to comply with Core Requirement #7, construct stormwater retention/detention facilities as one of the first steps in grading. Ensure that detention facilities are functional prior to construction of site improvements (e.g., impervious surfaces).
- Outlet structures designed for permanent detention ponds are not appropriate for use during construction without modification. If used during construction, install an outlet structure that will allow for long-term storage of runoff and enable sediment to settle. Verify that the pond is sized appropriately for this purpose.

Restore ponds to their original design dimensions, remove sediment, and install a final outlet structure at completion of the project.

- Sites that must implement flow control (Core Requirement #7) for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from ½ of the 2-year flow through the 10-year flow as predicted by an approved continuous runoff model. Match the pre-developed condition to the land cover condition immediately prior to the development project.

- The County may require pond designs that provide additional or different stormwater flow control if necessary to address local conditions or to protect properties and waterways downstream from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.

- If permanent infiltration ponds are used for flow control during construction, protect them from siltation during the construction phase.

Suggested BMPs:

- BMP C203: Water Bars
- BMP C207: Check Dams
- BMP C209: Outlet Protection
- BMP C235: Wattles
- BMP C240: Sediment Trap
- BMP C241: Temporary Sediment Pond
- Refer to Volumes III and V for site suitability and sizing for infiltration facilities and for design of Detention and Infiltration Facilities for flow control.

Element #4: Install Sediment Controls

- Prior to leaving a construction site or prior to discharge to an infiltration facility, pass stormwater runoff from disturbed areas through a sediment pond or other appropriate sediment removal BMP.

- Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard of Element #3, the first bullet. Full stabilization means 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 County shall inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

- Construct sediment ponds, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment on site as one of the first steps in grading. Ensure that these BMPs are functional before other land disturbing activities take place.

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

- Seed and mulch earthen structures such as dams, dikes, and diversions according to the timing indicated in Element #5.

- 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, often during non-storm events, in response to rain event changes in stream elevation or wetted area.

- If installing a floating pump structure, include a stopper to prevent the pump basket from hitting the bottom of the pond.

Suggested BMPs:

- BMP C231: Brush Barrier
- BMP C232: Gravel Filter Berm
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip
- BMP C235: Wattles
- BMP C240: Sediment Trap
- BMP C241: Temporary Sediment Pond
- BMP C250: Construction Stormwater Chemical Treatment
- BMP C251: Construction Stormwater Filtration.

Element #5: Stabilize Soils

- Stabilize all exposed and un-worked soils by application of effective BMPs that prevent erosion; protect the soil from the erosive forces of raindrop impact, flowing water, and wind.

- Control stormwater volume and velocity within the site to minimize erosion; and 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.

- From October 1 through April 30, no soils shall remain exposed and un-worked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and un-worked for more than 7 days. This condition applies to all soils on site, whether at final grade or not. These time limits may be adjusted by the County if it can be shown that the average time between storm events justifies a different standard.

- Stabilize soils at the end of the shift before a holiday or weekend if the weather forecast calls for precipitation. Applicable practices 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.

- Soil stabilization measures 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.

- Soil stockpiles must be stabilized from erosion, protected with sediment trapping measures, and when possible, be located away from storm drain inlets, waterways and drainage channels.

- Minimize the amount of soil exposed during construction activity.

- Minimize the disturbance of steep slopes.

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

- Ensure that gravel base used for stabilization is clean and does not contain fines or sediment.

- Linear construction activities, including right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall be conducted to meet the soil stabilization requirements and time periods set forth above.

Suggested BMPs:

- o BMP C120: Temporary and Permanent Seeding
- o BMP C121: Mulching
- o BMP C122: Nets and Blankets
- o BMP C123: Plastic Covering
- o BMP C124: Sodding
- o BMP C125: Topsoiling/Composting
- o BMP C126: Polyacrylamide for Soil Erosion Protection
- o BMP C130: Surface Roughening
- o BMP C131: Gradient Terraces
- o BMP C140: Dust Control

Element #6: Protect Slopes

- Design and construct cut and fill slopes in a manner that will minimize erosion.
- Consider soil type and its potential for erosion.
- Reduce slope runoff velocities by reducing the length of continuous slope with terracing and diversions, reducing slope steepness, and roughening slope surface.
- Divert offsite stormwater (run-on) or ground water away from slopes and disturbed areas with interceptor dikes, pipes, and/or swales. Manage offsite stormwater separately from stormwater generated on the site.
- At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion.
- Design temporary pipe slope drains to handle the peak 10-minute velocity of flow from a 10-year, 24-hour event assuming a Type 1A rainfall distribution. Alternatively, the 10-year, 1 hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. If a 15-minute (or less) time step is used, no correction factor is required. The hydrologic analysis shall 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 shall 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 shall be modeled as "landscaped" area.
- Permanent pipe slope drains shall be sized for the 100-year, 24-hour event.
- Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.
- Place excavated material on the uphill side of trenches, consistent with safety and space considerations.
- Place check dams at regular intervals within channels that are cut down a slope.
- Stabilize soils on slopes, as specified in Element #5.
- BMP combinations are the most effective method of protecting slopes with disturbed soils. For example using both mulching and straw erosion control blankets in combination.

Suggested BMPs:

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

- BMP C123: Plastic Covering
- BMP C124: Sodding
- BMP C130: Surface Roughening
- BMP C131: Gradient Terraces
- BMP C200: Interceptor Dike and Swale
- BMP C201: Grass-Lined Channels
- BMP C203: Water Bars
- BMP C204: Pipe Slope Drains
- BMP C205: Subsurface Drains
- BMP C206: Level Spreader
- BMP C207: Check Dams
- BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam).

Element #7: Protect Drain Inlets

- 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.
- Keep all approach roads clean. Do not allow sediment and street wash water to enter storm drains without prior and adequate treatment unless treatment is provided before the storm drain discharges to waters of the state.
- Inspect inlets weekly at a minimum and daily during storm events. Clean inlet protection devices, or remove and replace when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

Suggested BMPs:

- BMP C220: Storm Drain Inlet Protection.

Element #8: Stabilize Channels and Outlets

- Design, construct, and stabilize all temporary on-site conveyance channels to prevent erosion from the expected peak 10 minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm. Alternatively, the 10-year, 1-hour time step flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. If a 15-minute (or less) time step is used, no correction factor is required. The hydrologic analysis shall 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 shall 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 shall be modeled as “landscaped” area.

- Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches at the outlets of all conveyance systems.

- The best method for stabilizing channels is to completely line the channel with a blanket product first, then add check dams as necessary to function as an anchor and to slow the flow of water.

Suggested BMPs:

  - BMP C122: Nets and Blankets
  - BMP C202: 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.

- Handle and dispose all pollutants, including waste materials and demolition debris that occur on-site, in a manner that does not cause contamination of stormwater. Woody debris may be chipped, ground, or chopped and spread on site.

- 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 shall 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.

- Use spill prevention and control measures when conducting fueling, maintenance and repair of heavy equipment and vehicles including oil changes, hydraulic system drain down, solvent and de-greasing 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.. 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.

- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as a closed-loop recirculation or upland land application, or to the sanitary sewer, with local sewer district approval.

- Apply agricultural chemicals, including fertilizers and pesticides, in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Follow manufacturers' recommendations for application rates and procedures shall be followed.

- Use BMPs to prevent or treat contamination of stormwater runoff by pH modifying sources. These acidic or basic sources include, but are not limited to, 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.

- Adjust the pH of stormwater if necessary to prevent violations of the water quality standards. Projects must obtain written approval from the Department of Ecology prior to using chemical treatment other than CO2 or dry ice to adjust pH.

- Washout of concrete trucks shall be performed off-site or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams. Do not dump excess concrete on site, except in designated concrete washout areas. Concrete spillage or concrete discharge to surface waters of the State if prohibited. Do not use upland land applications for discharging wastewater from concrete washout areas.

- Wheel wash or tire bath wastewater shall not be mixed with wastewater from concrete washout areas.

Suggested BMPs:

  - 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: High pH Neutralization Using CO2
  - BMP C253: pH Control for High pH Water.
  - See Volume IV – Source Control BMPs.

Element #10: Control De-Watering

- Discharge foundation, vault, and trench de-watering water, which have similar characteristics to stormwater runoff at the site, into a controlled conveyance system prior to discharge to a sediment trap or sediment pond. Channels must be stabilized, as specified in Element #8.

- Discharge clean, non-turbid de-watering water, such as well-point ground water, to systems tributary to, or directly into surface waters of the State, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters or interfere with operation of the system. Do not route these clean waters through stormwater sediment ponds. 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.

- Handle highly turbid or contaminated dewatering water from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, separately from stormwater.

- 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.

- Other treatment or disposal options, depending on site constraints, may include:
  - Infiltration
  - Transport offsite in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters
  - Ecology-approved on-site chemical treatment or other suitable treatment technologies
  - Sanitary sewer discharge with local sewer district approval, if there is no other option
  - Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Suggested BMPs:

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

Element #11: Maintain BMPs

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

- Remove all temporary erosion and sediment control BMPs not designed to remain in place following construction (e.g. compost socks), within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed.

Remove or stabilize trapped sediment on site. Permanently stabilize disturbed soil resulting from removal of BMPs or vegetation.

- Protect 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 condition. 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.

Suggested BMPs

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

Element #12: Manage the Project

Phasing of Construction:

- Phase development projects to the maximum extent practicable and take into account seasonal work limits in order to prevent soil erosion and, to reduce to the maximum extent practicable, the transport of sediment from the site during construction. Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities for any phase.
- Clearing and grading activities for developments are 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. When establishing these permitted clearing and grading areas, minimize the removal of existing trees and the disturbance/compaction of native soils except as needed for building purposes. Delineate the 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 the County, on the site plans and the development site.

Seasonal Work Limitations:

- From October 1 through April 30, clearing, grading, and other soil disturbing activities will not be permitted unless it is shown to the satisfaction of the County that silt-laden runoff will be prevented from leaving the site through a combination of the following:
    - o Site conditions including existing vegetative coverage, slope, soil type, and proximity to receiving waters; and
    - o Limitations on activities and the extent of disturbed areas; and
    - o Proposed erosion and sediment control measures.
- Based on the information provided and/or local weather conditions, the County may expand or restrict the seasonal limitation on site disturbance. The County

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 following activities are exempt from the seasonal clearing and grading limitations:
  - Routine maintenance and necessary repair of erosion and sediment control BMPs;
  - Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; and
  - Activities where there is 100 percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

Coordination 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.

Inspection and Monitoring:

- For construction sites that will disturb 1 acre or more a Certified Erosion and Sediment Control Lead (CESCL) shall be identified in the Construction SWPPP and shall 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.

- Project sites less than one acre (not part of a larger common plan of development or sale) may have a person without CESCL certification conduct inspections. The person shall be identified in the Construction SWPPP and shall be on-site or on-call at all times.

- All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections shall be conducted at least weekly and immediately following any substantial rainfall event by a person who is knowledgeable in the principles and practices of erosion and sediment control. The CESCL or inspector (project sites less than one acre) 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.

- 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.

- Implement appropriate BMPs or design changes 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.

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

  - Reviewing the SWPPP for compliance with the 13 construction SWPPP 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 and extension from the County within the initial 10-day response period.
  - Documenting BMP implementation and maintenance in the site log book (sites larger than 1-acre).
  - 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 temporarily stabilized, inactive sites to once every calendar month.

Maintaining an Updated Construction SWPPP:

- The Construction SWPPP shall be retained on-site or within reasonable access to the site.

- The SWPPP shall be modified 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 SWPPP shall be modified if, during inspections or investigations conducted by the owner/operator, Thurston County or a state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. The SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct problems identified. Revisions to the SWPPP shall be completed within seven (7) days following the inspection.

Suggested BMPs

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

Element #13: Protect Low Impact Development BMPs

- Protect all Bioretention and Rain Garden BMPs from sedimentation through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain into the Bioretention and/or Rain Garden BMPs.
- Restore Bioretention and Rain Garden BMPs to their fully functioning condition if they accumulate sediment during construction. Restoring the BMP includes removal of sediment and any sediment-laden Bioretention/Rain Garden soils, and replacing the removed soils with soils meeting the design specification.
- Prevent compaction of Bioretention, Rain Garden, and other infiltration BMPs by excluding construction equipment and foot traffic. Protect completed lawn and landscaped areas from compaction due to construction equipment.
- Protect surrounding land uses from erosion and manage to avoid introducing sediment onto permeable pavements. Do not allow muddy construction equipment on the base material or pavement. Do not allow sediment-lade runoff onto permeable pavements.
- Clean pavements fouled with sediments or no longer passing an initial infiltration test using procedures acceptable to the County or in accordance with manufacturer's procedures.
- Keep heavy equipment off of existing soils under LID facilities (Bioretention, Rain Gardens, Infiltration Ponds, Permeable Pavements, etc.) that have been excavated to final grade to retain the infiltration rate of the soils.

Suggested BMPs

- o BMP C102: Buffer Zone
- o BMP C103: High Visibility Fence
- o BMP C200: Interceptor Dike and Swale

- BMP C201: Grass-Lined Channels
- BMP C207: Check Dams
- BMP C208: Triangular Silt Dike (TSD) (Geotextile-Encased Check Dam).
- BMP C231: Brush Barrier
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip
- Additional Guidance: See Chapter 5: Precision Site Preparation and Construction in the LID Technical Guidance Manual for Puget Sound for more detail on protecting LID integrated management practices.

2.3.3 Step 3 – Development and Implementation of the Construction SWPPP

The Construction SWPPP must include all of the components specified in Construction SWPPP Submittal Requirements (Section 2.2) and the information required from Step 1 (Section 2.3.1). Refer to the checklist (Section 2.5).

A plan showing the overall project, clearly delineating phase boundaries, and estimating dates of construction, shall be part of any initial submittal. Phased projects shall be completed in accordance with approved plans and in accordance with phased development requirements placed upon the development by the County. Phasing of projects does not reduce drainage and erosion control requirements.

Submit three copies of the plan, bound, and 8.5 x 11 inches in size, with the exception of required engineered drawing sheets which shall meet the criteria established within this general Section 3.4.1. Where possible, sheets shall be folded or rolled as small as possible, but not smaller than 8.5 x 11 inches.

Number all pages.

Detailed Components of SWPPP Narrative

1. **Cover Sheet**: The Construction SWPPP narrative will include a cover sheet that includes:

   a) Project name

   b) Applicant, and owner’s name, address, and telephone number

   c) Project engineer's name, address and telephone number

   d) Date of submittal

   e) Contact's name, address, and telephone number

   f) Contractor’s name, address and telephone number.

2. **Table of Contents**: Show the page number for each section of the report. Show page numbers of appendices.

3. **Project Engineer's Certification**: For smaller projects, the SWPPP need not be developed by a professional engineer. However, for more complex projects where a Drainage Control Plan is also required or where the SWPPP involves engineering calculations, the SWPPP must be developed by a professional engineer licensed to practice in the State of Washington. For projects where a PE is required, all plans and specifications, calculations, certifications, "as-built" drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer's official seal and signature.

   The Construction SWPPP shall contain a page with the project engineer's seal with the following statement:

   > *"I hereby state that this Construction SWPPP for ______________________________________ (name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that Thurston County does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me."*

4. **Inspection Report:** All projects required to have a Construction SWPPP must conform to the inspection guidelines stated in Element 12: Manage **Project**. In summary, site inspections shall be conducted by a person who is knowledgeable in the principles and practices of ESC. For construction sites that will disturb 1 acre or more and that discharge stormwater to surface waters of the state, a Certified Erosion and Sediment Control Lead (CESCL) shall be identified in the Construction SWPPP and Construction SWPPP and shall be on-site or on-call at all times.

   In addition, for complex projects where a Stormwater Site Plan is required or where the SWPPP involves engineering calculations, the applicant shall have a professional engineer file with the County an Engineer's Inspection Report Form as shown in Appendix I-C before the project is accepted by the County as complete. The report will consist of a completed form and sufficient additional text to describe all factors relating to the construction and operation of the system to meet treatment, erosion control, detention/retention, flow control, and conveyance requirements.

5. **Narrative Discussion: Evaluate** the following subject areas for inclusion in the Construction SWPPP narrative.

   a) **General Information on the Existing Site and Project**

      1) Project description

2) Existing site conditions

3) Soils

4) Critical Areas

5) Adjacent Areas

6) Existing Encumbrances

b) **13 Elements:** Describe how the Construction SWPPP addresses each of the 13 required elements. Include the type and location of BMPs used to satisfy the required element. If an element is not applicable to a project, provide a written justification for why it is not necessary.

c) **Construction Schedule and Phasing:** Describe the construction schedule. If the schedule extends into the wet season, describe **activities** that 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.

d) **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.

e) **Engineering calculations:** Attach any calculations made for the design of such items as sediment ponds, diversions, 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.

f) **Certified Erosion and Sediment Control Lead (CESCL):** Identify along with their contact information and expiration of their CESCL certification.

2.4 Construction SWPPP TESC Drawing Protocols

Where applicable, TESC drawings for the SWPPP shall conform to the following drawing protocols:

2.4.1 Required Drawing Protocol

All sheets will have a north arrow, scale, a benchmark reference, the section, township, and range. Each set of drawings shall have a legend to define map symbols.

All lettering shall be one-tenth of an inch or greater. Existing spot elevations will be no smaller than one-twentieth of an inch or greater than one-tenth of an inch.

All submittals shall be stamped, signed, and dated by a licensed professional engineer prior to review by the County.

2.4.2 General Drawing Requirements

All drawings shall contain the following:

- Road alignments with 100-foot stationing, preferably increasing to the north or east and reading from left to right; stationing at points of curve, tangent, and intersection, with ties to section or quarter corners or other established and monumented survey control points to include at the intersection of any proposed road or roads and any existing county road or state highway. All lettering shall be right reading.
- Bearing on all centerlines.
- Curve data including radius, delta, and arc length on all horizontal lines.
- Right-of-way, easement, tract lines, and dimensions for all existing and proposed facilities, including proposed roads and intersecting roads. The plans shall show properly dimensioned lot lines and lot numbers, and locate and dimension all tract and easement areas.
- All topographic features within project limits and a sufficient area beyond (50-ft minimum), to resolve questions of setback, slope, drainage, access onto abutting property, and road continuations.
- Existing contours and drainage basins and the direction of flow for the different drainage areas. Contour intervals on the site plan shall be at a minimum as follows:

Slope (%)	Contour Interval (feet)
0 – 15	2
16 – 40	5
>40	10

- Topography must be field verified for drainage easements and conveyance systems. Contours shall extend a minimum of 50 feet beyond property lines and extend sufficiently to depict existing conditions. If survey is restricted to the project site due to lack of legal access, contours shall be provided by other means; i.e., Thurston County Geodata, USGS, etc.
- All ditch flow lines, all drainage structures with invert elevations, utility locations, fences, structures, existing curbing and approaches, pertinent trees and shrubbery, and other appurtenances which would affect the construction of the project.

- Identification of all existing public roads and adjoining subdivisions when it is pertinent to the scope of the project.
- Scale: 1 inch = 20 feet or 1 inch = 50 feet (1 inch = 100 feet may be used with prior county approval) for public facilities and roads to be dedicated to the County.
- Scale: 1 inch = 50 feet for plats, 1 inch = 20 feet, 30 feet, or 40 feet for all others.
- North arrow shall point to the top or to the left of the sheet.
- Existing features will be ghosted or shaded.
- A legend.

2.4.3 Cover Sheet

Any drawing sets submitted for review and acceptance by the County containing three or more sheets shall have a cover sheet.

The cover sheet shall be sheet one of the drawing set and contain the following information:

- A simple vicinity map, with north arrow oriented to the top of the sheet, showing project site, existing public road system, receiving waters and any other pertinent information. Minimum scale shall be 4 inches = 1 mile.
- An overall site plan or location map showing the project site(s). Road and stormwater drainage system network including its connection to an existing public road or state highway. This does not have to be to scale.
- The applicant and project engineer’s, firm, name, address, and telephone numbers, current owner, and parcel numbers.
- An index table of drawings.
- Title block descriptive of project.

2.4.4 General Drawing Site and/or Grading Plan Sheets

In addition to the general drawing requirements the site and/or grading plan sheets shall show the features below. The site and/or grading plan sheet 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 and bearings).
- Proposed storm drainage and easements, tracts, drainage facilities, all buffer and screening areas, offsite and on-site existing drainage courses, delineated wetlands,

and associated buffers, FEMA base flood boundaries, and Shoreline Management boundaries.

- Soil logs and soil log locations.
- Wells – existing and proposed.
- Topographic information including contour lines of the property in its existing condition. County or U.S. Geological Survey (USGS) topographic mapping must be field verified and supplemented with additional field topographic information when necessary to provide an accurate depiction of the property. Contour intervals shall be as follows:

–	0 percent	< 15 percent	2-foot contour interval
–	15 percent	- 40 percent slope	5-foot contour interval
–	40 percent	+ slope	10-foot contour interval.

- The boundaries of and labels indicating different soil types and areas of potential erosion problems.
- Final and interim grade contours as appropriate, drainage basins, and flow arrows designating the direction of stormwater flow during and upon completion of construction.
- Areas of soil disturbance, including all areas affected by clearing, grading and excavation.
- Locations where stormwater discharges to surface water 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.
- Property lines, parcel numbers and ownership.
- Conveyance systems: Show on the site map the following temporary and permanent conveyance features:

    1) Locations for temporary and permanent swales, interceptor trenches, or ditches.

    2) Drainage pipes, ditches, or cut-off trenches associated with erosion and sediment control and stormwater management.

3) Temporary and permanent pipe inverts and minimum slopes and cover.

4) Grades, dimensions, and direction of flow in all ditches, swales, culverts, and pipes.

5) Details for bypassing off-site runoff around disturbed areas.

6) Locations and outlets of any dewatering systems.

- 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 applicable).

- 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:

1) The location of sediment pond(s), pipes and structures.

2) Dimension pond berm widths and inside and outside pond slopes.

3) The trap/pond storage required and the depth, length, and width dimensions.

4) Spacing for rock check dams as required.

5) Location of silt fence

6) Construction entrance location.

2.4.5 Plan and Profile Sheets (Roadway Projects)

Show the following:

- Original ground line at 100-foot stations and at significant ground breaks and topographic features, with accuracy to within 0.1 feet on unpaved surface and 0.01 feet on paved surfaces.

- Typical roadway/storm drainage cross-sections when applicable.

- Existing and proposed drainage features, indicating direction of flow, size, and kind of each drainage channel, pipe and structure. The status of existing drainage structures must be clarified as either, “existing-abandon” or “existing-remove.”

- Final surface and storm drain profile with stationing the same as the site/grading plan sheets. Preferably reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevations to 0.01 feet.

- Surface grade and vertical curve data; roads to be measured at centerline.

- Datum and all bench mark information shall use established U.S.C. and G.S. control or county bench marks when there is an existing bench mark within one-half mile of the project.

- Vertical scale 1 inch = 5 feet. Clarifying details may be drawn to a convenient scale. Use 1 inch = 10 feet for vertical scale when horizontal scale is at 1 inch = 100 feet.

- When roads end at a property line, the existing ground profile shall be continued a minimum of 200 feet to show the proposed vertical alignment is reasonable.

- When intersecting road profile grades have a difference of 1 percent or less, a vertical curve is not required. All other vertical grade intersections will require a minimum 50-foot vertical curve.

- Storm drainage text to be shown in profile only to avoid duplication of text. Number of structure will be shown in the plan and profile views. The following information shall be shown in the profile view:
    - Type of structure
    - Structure number
    - Stationing/offsets (coordinates to be shown in the plan view)
    - Rim elevation
    - Invert elevations (in)
    - Invert elevations (out)
    - Pipe length, pipe size, material and slope (percent).

2.4.6 Detail Sheets and Cross-Sections

Include the following, as applicable on the detail sheets:

- All applicable standard notes (Appendix II-A). Notes addressing construction phasing and scheduling must be included on the drawings.

- A minimum of two cross-sections of each retention/detention pond and sediment pond/trap showing original property lines, slope catch points, and all other pertinent information to adequately construct the pond.

- Typical details of gravel cone and standpipe, and/or other filtering devices.

- Stabilization technique details for inlets and outlets.
- Control/restrictor device details.
- Rock specifications and details for rock check dam, if used.
- Front and side sections of rock check dams.
- Details for silt fence.
- Details for construction entrance.
- Standard open conveyance system cross-sections, if applicable.
- Detailed drawings: Any structural control practices used that are not referenced in this manual must be explained and illustrated with detailed drawings.
- Right-of-way cross-sections as required by the County.
- Construction recommendations from a soils report, if applicable.

2.4.7 Required Drawing Size

Drawings shall be 22x34 inches. Original sheets shall be Mylar or photo Mylar.

2.4.8 Plans and Specifications

The most recently adopted editions of standard specifications and standard plans (see Glossary in Volume I, Appendix I-A) shall be the standards for all design and construction of drainage facilities not explicitly described herein. In the event of a conflict between the standard specifications, standard plans, and the manual, this manual shall prevail. When required by the County, standard specifications and general provisions for construction must be submitted with any road construction plans.

2.5 Construction SWPPP Checklist

The checklists on the following pages can be used in the preparation of the Construction SWPPP to ensure that all required information is provided or addressed. Section I of the checklist addresses the preparation of the Construction SWPPP narrative; Section II of the checklist addresses the preparation of the Construction SWPPP Temporary Erosion and Sediment Control (TESC) Plan.

Section I – Construction SWPPP Narrative

Construction Stormwater Pollution Prevention Elements

1. ____ Describe how each of the Construction Stormwater Pollution Prevention Elements has been addressed through the Construction SWPPP.
2. ____ Identify the type and location of BMPs used to satisfy the required element.
3. ____ Provide written justification identifying the reason an element is not applicable to the proposal.

Thirteen Required Elements – Construction SWPPP

1. ____ Mark Clearing Limits
2. ____ Establish Construction Access
3. ____ Control Flow Rates
4. ____ Install Sediment Controls
5. ____ Stabilize Soils
6. ____ Protect Slopes
7. ____ Protect Drain Inlets
8. ____ Stabilize Channels and Outlets
9. ____ Control Pollutants
10. ____ Control De-Watering
11. ____ Maintain BMPs
12. ____ Manage the Project
13. ____ Protect Low Impact Development BMPs

Project Description

1. ____ Total project area
2. ____ Total proposed impervious area
3. ____ Total proposed area to be disturbed, including off-site borrow and fill areas
4. ____ Total volumes of proposed cut and fill

Existing Site Conditions

1. ____ Description of the existing topography
2. ____ Description of the existing vegetation
3. ____ Description of the existing drainage

Adjacent Areas

1. ____ Description of adjacent areas which may be affected by site disturbance or drain to project site.
   a. ____ Streams
   b. ____ Lakes
   c. ____ Wetlands

d. ____ Residential Areas
e. ____ Roads
f. ____ Other

2. ____ Description of the downstream path leading from the site to the receiving body of water. (Minimum distance of 400 yards.)

Critical Areas

1. ____ Description of critical areas that are on or adjacent to the site.
2. ____ Description of special requirements for working in or near critical areas.

Soils

1. Description of on-site soils.
   a. ____ Soil name(s)
   b. ____ Soil mapping unit
   c. ____ Erodibility
   d. ____ Settleability
   e. ____ Permeability
   f. ____ Depth
   g. ____ Texture
   h. ____ Soil structure

Erosion Problem Areas

1. ____ Description of potential erosion problems on site.

Construction Phasing

1. ____ Construction sequence
2. ____ Construction phasing (if proposed)

Construction Schedule

1. ____ Provide a proposed construction schedule.
2. ____ Wet season construction activities
   a. ____ Proposed wet season construction activities.
   b. ____ Proposed wet season construction restraints for environmentally sensitive/critical areas.

Financial/Ownership Responsibilities

1. ____ Identify the property owner responsible for the initiation of bonds and/or other financial securities.
2. ____ Describe bonds and/or other evidence of financial responsibility for liability associated with erosion and sedimentation impacts.

Engineering Calculations

1. ____ Provide design calculations
    a. ____ Sediment ponds/traps
    b. ____ Diversions
    c. ____ Waterways
    d. ____ Runoff/Stormwater detention calculations

Section II – Temporary Erosion and Sediment Control Plans

General

1. ____ Vicinity map
2. ____ Thurston County clearing and grading approval block
3. ____ Erosion and Sediment Control Notes

Site Plan

1. ____ Note legal description of subject property.
2. ____ Show north arrow.
3. ____ Indicate boundaries of existing vegetation, e.g. tree lines, pasture areas, etc.
4. ____ Identify and label areas of potential erosion problems.
5. ____ Identify on-site/adjacent surface waters, critical areas and associated buffers.
6. ____ Identify FEMA base flood boundaries and Shoreline Management boundaries.
7. ____ Show existing and proposed contours.
8. ____ Indicate drainage basins and direction of flow for individual drainage areas.
9. ____ Label final grade contours and identify developed condition drainage basins.
10. ____ Delineate areas that are to be cleared and graded.
11. ____ Show all cut and fill slopes indicating top and bottom of slope catch lines.

Conveyance Systems

1. ____ Designate locations for swales, interceptor trenches, or ditches.
2. ____ Show all temporary and permanent drainage pipes, ditches, or cut-off trenches required for erosion and sediment control.
3. ____ Provide minimum slope and cover for all temporary pipes or call out pipe inverts.
4. ____ Show grades, dimensions, and direction of flow in all ditches, swales, culverts and pipes.
5. ____ Provide details for bypassing off-site runoff around disturbed areas.
6. ____ Indicate locations and outlets of any dewatering systems.

Location of Detention BMPs

1. ____ Identify location of detention BMPs.

Erosion and Sediment Control Facilities

1. ____ Show the location of sediment trap(s), pond(s), pipes and structures.
2. ____ Dimension pond berm widths and inside and outside pond slopes.
3. ____ Indicate trap/pond storage required and the depth, length, and width dimensions.
4. ____ Provide typical section views through pond and outlet structure.
5. ____ Provide typical details of gravel cone and standpipe, and/or other filtering devices.
6. ____ Detail stabilization techniques for outlet/inlet.
7. ____ Detail control/restrictor device location and details.
8. ____ Specify mulch and/or recommended cover of berms and slopes.
9. ____ Provide rock specifications and detail for rock check dam(s), if applicable.
10. ____ Specify spacing for rock check dams as required.
11. ____ Provide front and side sections of typical rock check dams.
12. ____ Indicate the locations and provide details and specifications for silt fabric.
13. ____ Locate the construction entrance and provide detail.

Detailed Drawings

1. ____ Any structural practices used that are not referenced in the Thurston County Drainage Design and Erosion Control Manual should be explained and illustrated with detailed drawings.

Other Pollutant BMPs

1. ____ Indicate on the site plan the location of BMPs to be used for the control of pollutants other than sediment, e.g. concrete wash water.

Monitoring Locations

1. ____ Indicate on the site plan the water quality sampling locations to be used for monitoring water quality on the construction site, if applicable.

Chapter 3 - Standards and Specifications for Best Management Practices

Best Management Practices (BMPs) are activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices that, prevent or reduce the release of pollutants to the waters of Washington State. This chapter contains standards and specifications for temporary BMPs for use during the construction phase of a project. Often using BMPs in combination is the best method to meet Construction Stormwater Pollution Prevention Plan (SWPPP) requirements.

None of the BMPs listed below will work successfully through 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.

Section 3.1 contains the standards and specifications for source control BMPs.

Section 3.2 contains the standards and specifications for runoff conveyance and treatment BMPs.

Standards for each BMP are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards

Note that "Conditions of Use" always refers to site conditions. As site conditions change, BMPs must change to remain in compliance.

Information on streambank stabilization is available in the *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2003, or as updated/amended.

Section 3.3 contains required practices to protect LID BMPs during construction, per Core Requirement #2, Element #13.

3.1 Source Control BMPs

This section contains the standards and specifications for Source Control BMPs. Table 3-1, below, shows the relationship of the BMPs in Section 3.1 to the Construction Stormwater Pollution Prevention Plan (SWPPP) Elements described in Section 2.3.2. Elements not shown on Table 3.1.1 are not satisfied through installation of Source Controls.

Table 3-1. Source Control BMPs by SWPPP Element

BMP or Element Name	Element #1 Preserve Vegetation/Mark Clearing Limits	Element #2 Establish Construction Access	Element #5 Stabilize Soils	Element #6 Protect Slopes	Element #9 Control Pollutants	Element #11 Maintain BMPs	Element #12 Manage the Project	Element #13 Protect LID BMPs
BMP C101: Preserving Natural Vegetation	✓							
BMP C102: Buffer Zones	✓							✓
BMP C103: High Visibility Plastic or Metal Entrance/Exit	✓							✓
BMP C105: Stabilized Construction Entrance / Exit		✓						
BMP C106: Wheel Wash		✓						
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 for Soil Erosion Protection			✓					
BMP C130: Surface Roughening			✓	✓				
BMP C131: Gradient Terraces			✓	✓				
BMP C140: Dust Control			✓					
BMP C150: Materials On Hand						✓	✓	
BMP C 151: Concrete Handling					✓			
BMP C152: Sawcutting and Surfacing Pollution Prevention					✓			
BMP C153: Material Delivery, Storage and Containment					✓			
BMP C154: Concrete Washout Area					✓			
BMP C160: Certified Erosion and Sediment Control Lead						✓	✓	
BMP C162: Scheduling							✓	

BMP C101: Preserving Natural Vegetation

Purpose

Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers hold up to 50 percent of all rain that falls on them during a storm, with the size of the storm playing a large factor. As much as 30 percent of rain, on average, may never reach the ground but is taken up by the tree or evaporates. The rain held in the tree is released slowly to the ground after the storm.

Preserving natural vegetation is an important LID technique. It can help protect water quality and preserve the natural hydrology of a site by maintaining the infiltration capacity of soils, reducing impervious surfaces, and reducing fertilizer and irrigation requirements required to establish new vegetation.

Conditions of Use

- Preserve natural vegetation on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- Where established native plants or ground cover are present, or where underlying soils have good infiltrative properties (Natural Resource Conservation Service Hydrologic Group A or B) they should be preserved to the maximum extent possible.
- At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.
- 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.
- Fence or clearly mark areas around trees to be saved. Keep ground disturbance at least outside the tree’s dripline and preferably outside the critical root zone, see Figure 3.1.

Take the following steps to protect vegetation during construction:

- Map natural resource protection areas on all plans and delineate these areas on the site with silt, construction, or other appropriate fencing to protect soils and vegetation from construction damage.

- Meet and walk property with equipment operators to clarify construction boundaries and limits of disturbance.

- Protect drainage areas during construction. If an area has any type of channel or drainage swale that provides a hydrologic connection to vegetation protection area(s), the channel must also be protected throughout the construction phase by fencing and erosion control measures to prevent untreated runoff from the construction site to flow into the channel.

- Install signs and fences to identify and protect natural resource protection areas.

- Protect trees and tree root systems using the following methods:

    - Reduce soil compaction during the construction phase by protecting critical tree root zones that extend beyond the trees canopy or drip line. Determine the critical tree root zone using the tree's diameter breast height (6-inch diameter breast height = 8-foot radius; 10-inch diameter breast height = 10-foot radius, 30-inch diameter breast height = 45-foot radius) (see Figure 3.1).

    - Prohibit excavation within the critical tree root zone.

    - Prohibit stockpiling or disposal of excavated or construction materials in vegetation retention areas to prevent contaminants from damaging vegetation and soils.

    - Changing the natural grade level around a tree affects the tree's ability to obtain the necessary air, water and minerals. Avoid excavation or grade changes near trees designated for protection. If raising the grade level around a tree, a dry rock wall or rock well shall be constructed around the tree. The wall or well shall be placed at least outside of the dripline of tree canopy plus 5 feet and preferably outside of the critical root zone.

    - When there are fills more than 3 inches, it is necessary to supply air to the roots of trees. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a drywell around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

    - When there are cuts required around trees, keep the cut at least outside of the drip line plus 5 feet and preferably outside the critical root zone. Use retaining walls if necessary to retain as much of the natural grade as possible.

- Restrict trenching in critical tree root zone areas. Where possible, the trenches should be routed around trees and large shrubs. If this is not possible, it is best to tunnel under them. Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots. If it is not possible to route the trench around plants to be saved or tunnel beneath them, then the following should be observed:
    - Cut as few roots as possible. When you have to cut, cut clean. Cover exposed roots with a heavy, wet material, such as burlap, and keep it moist. Remove material before backfilling the trench.
    - When roots will be exposed for more than an hour, wrap all exposed roots over 1.5 inches in diameter with a heavy, wet material, such as burlap, and keep moist until backfilling the trench. Remove material before backfilling.
    - Backfill the trench as soon as possible.
- Prevent wounds to tree trunks and limbs during the construction phase.
- Prohibit installation of impervious surfaces in critical root zone areas (see Figure 3.1). Where road or sidewalk surfaces are needed under a tree canopy, use un-mortared porous pavers or flagstone (rather than concrete or asphalt) or bridging techniques.

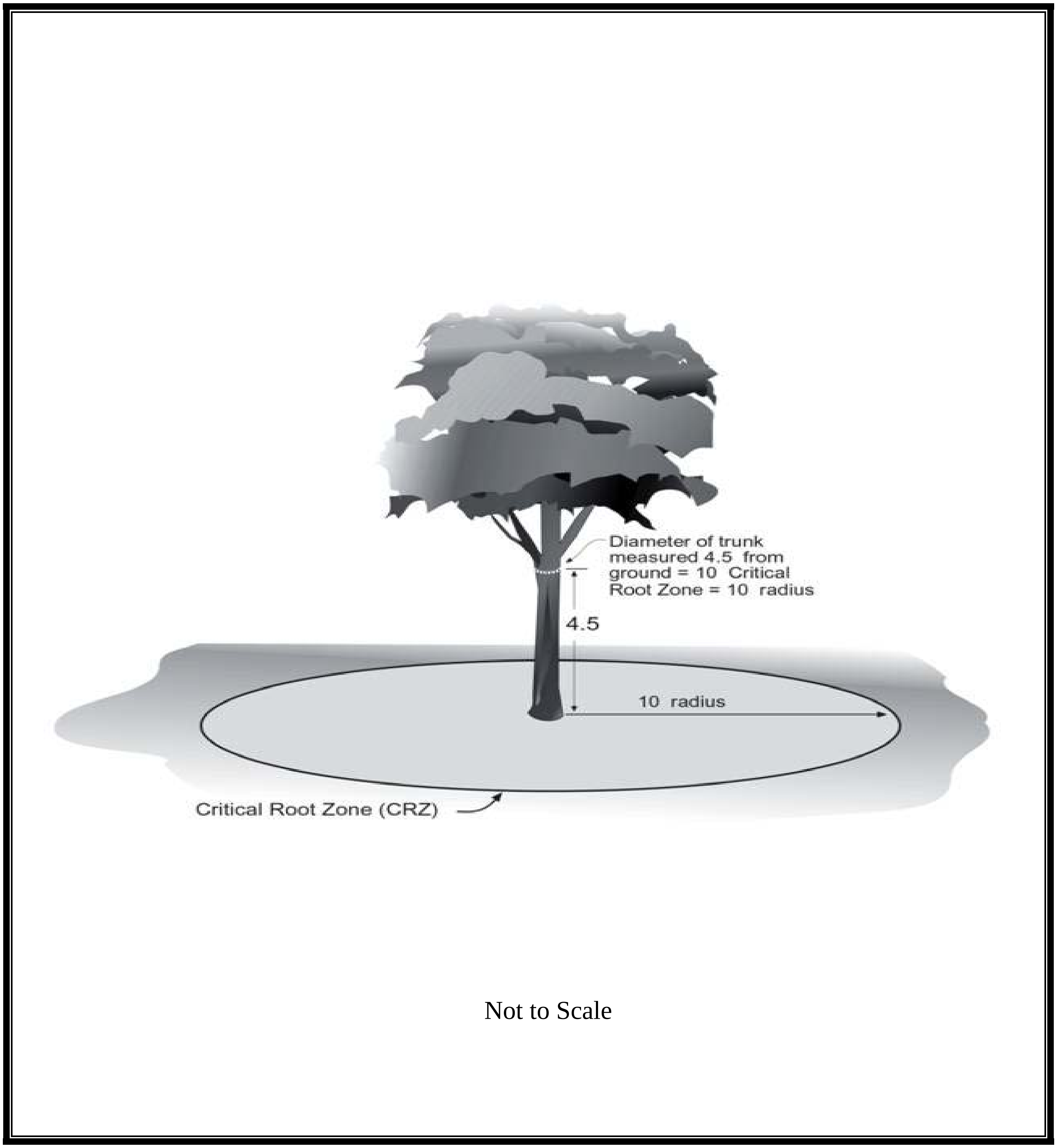


Figure 3-1. Critical Root Zone (CRZ), in feet

- Prepare tree conservation areas to better withstand the stresses of the construction phase by fertilizing (if necessary), watering, pruning, and mulching around them well in advance of construction activities. Mulch with a thin layer of compost to add nutrients and organic matter to the soil. Water areas around trees during and after construction to reduce stress and enhance recovery.

Problems that can be encountered with a few specific trees include:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment, so take special care 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 that can infiltrate and block sewer lines, drain fields, and infiltration systems. However, these trees 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 re-cover 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 or preservation of an undisturbed area or strip of natural vegetation to provide a living filter to reduce soil erosion and runoff velocities.

Conditions of Use

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

Do not use critical-areas buffer zones as sediment treatment areas. These areas shall remain completely undisturbed. The County may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

Design and Installation Specifications

- Preserving natural vegetation or plantings in clumps, blocks, or strips is 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 in protecting sensitive areas and buffers. High visibility plastic fencing and 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 from burying and smothering.
- Vegetative buffer zones for streams, lakes or other waterways are established by the County or other state or federal permits or approvals.

Maintenance Standards

Inspect the area frequently to make sure fencing or flagging remains in place and the area remains undisturbed. Replace all damaged fencing or flagging immediately.

BMP C103: High Visibility Fence

Purpose

Fencing is intended to:

1. Restrict clearing to approved limits
2. Prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed.
3. Limit construction traffic to designated construction entrances, exits or internal roads.
4. Protect areas where survey tape markers 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 4 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 6 inches with a polyethylene tie. 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 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 Entrance / Exit

Purpose

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

Conditions of Use

Construction entrances shall be stabilized wherever traffic will enter or leave a construction site if paved roads or other paved areas are within 1,000 feet of the site.

For residential construction, such as within a subdivision, provide stabilized construction entrances 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/configuration.

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances 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 3.2 for details. Note: the 100 foot minimum length of the entrance shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100 feet).

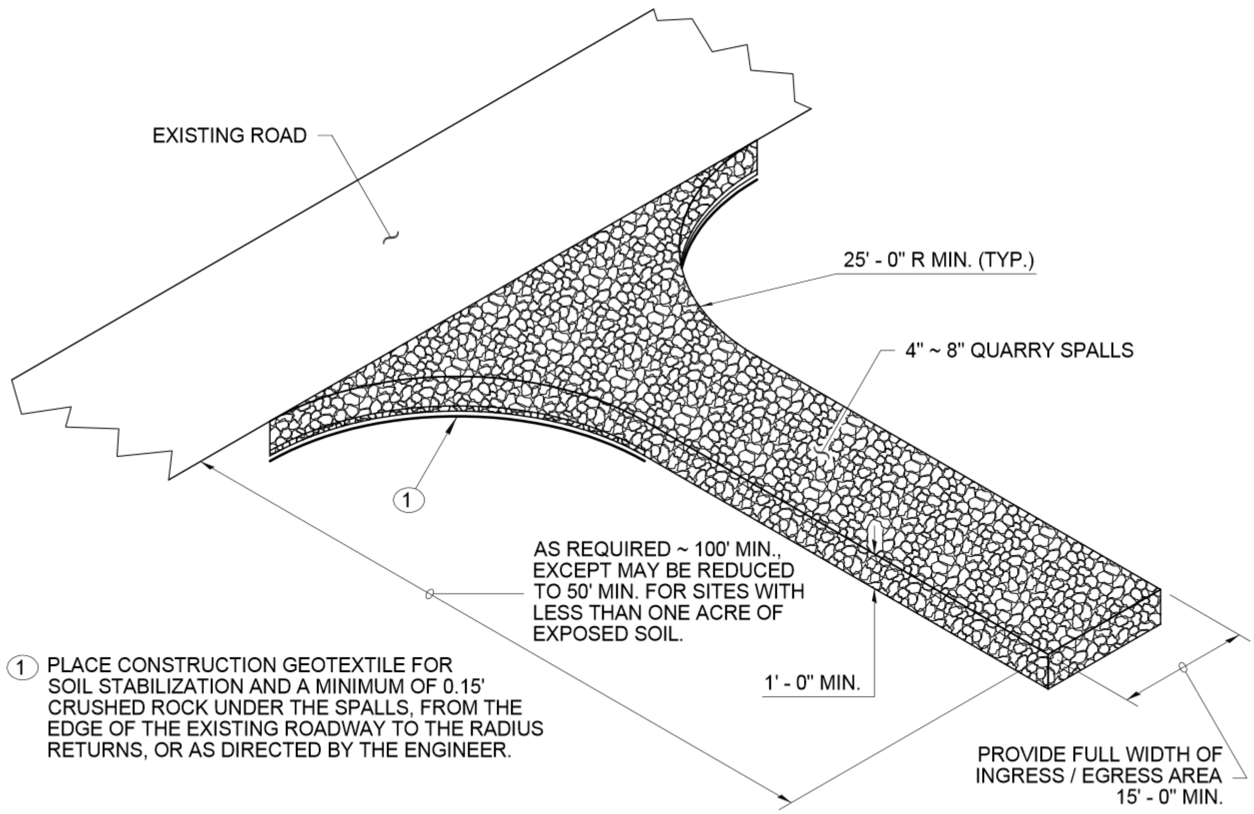


Figure 3.2. Stabilized Construction Entrance.
(Drawing courtesy of WSDOT Standard Plans)

Construct stabilized construction entrances 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 entrance stabilization because these products raise pH levels in stormwater and concrete discharge to surface 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 following standards:

- Grab Tensile Strength (ASTM D4751): 200 psi min.
- Grab Tensile Elongation (ASTM D4632): 30% max.

- Mullen Burst Strength (ASTM D3786-80a): 400 psi min.
- AOS (ASTM D4751): 20-45 (U.S. standard sieve size).

- Fencing (see BMP C103) shall be installed as necessary to restrict traffic to the construction entrance.

- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

- Consider early installation of the first lift of asphalt in areas that will be paved; this can be used as a stabilized entrance. Also consider the installation of excess concrete as a stabilized entrance. During large concrete pours, excess concrete is often available for this purpose.

- Construction entrances should avoid crossing existing sidewalks and back of walk drains. If a construction entrance 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.

Products Approved as Equivalent

Products approved by Ecology as equivalent to meet the requirements of BMP C105 are acceptable for use in Thurston County. The approved products are available for review on Ecology's website at:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html.

Maintenance Standards

Quarry spalls shall be added if the pad is no longer in accordance with the specifications.

- A volume of quarry spalls equal to 5% of the surface area X the depth must be kept on site for maintenance purposes.

- If the entrance 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 entrance or the installation of a 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 sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, construct a small sump to contain the wash water if possible. Wash the sediment 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 loosened from the pad, that end up on the roadway shall be removed immediately.

- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see BMP C103) 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.

BMP C106: Wheel Wash

Purpose

To reduce the amount of sediment transported onto paved roads by motor vehicles.

Conditions of Use

When a stabilized construction entrance (see BMP C105) is not preventing sediment from being tracked onto pavement.

- Wheel washing is an effective BMP when installed with careful attention to topography. However, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where water from the dripping truck can run unimpeded into the street, for example.
- 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.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as a closed-loop recirculation or upland land application or to the sanitary sewer with local sewer district approval.
- Wheel wash or tire bath wastewater should not include wastewater from concrete washout areas.

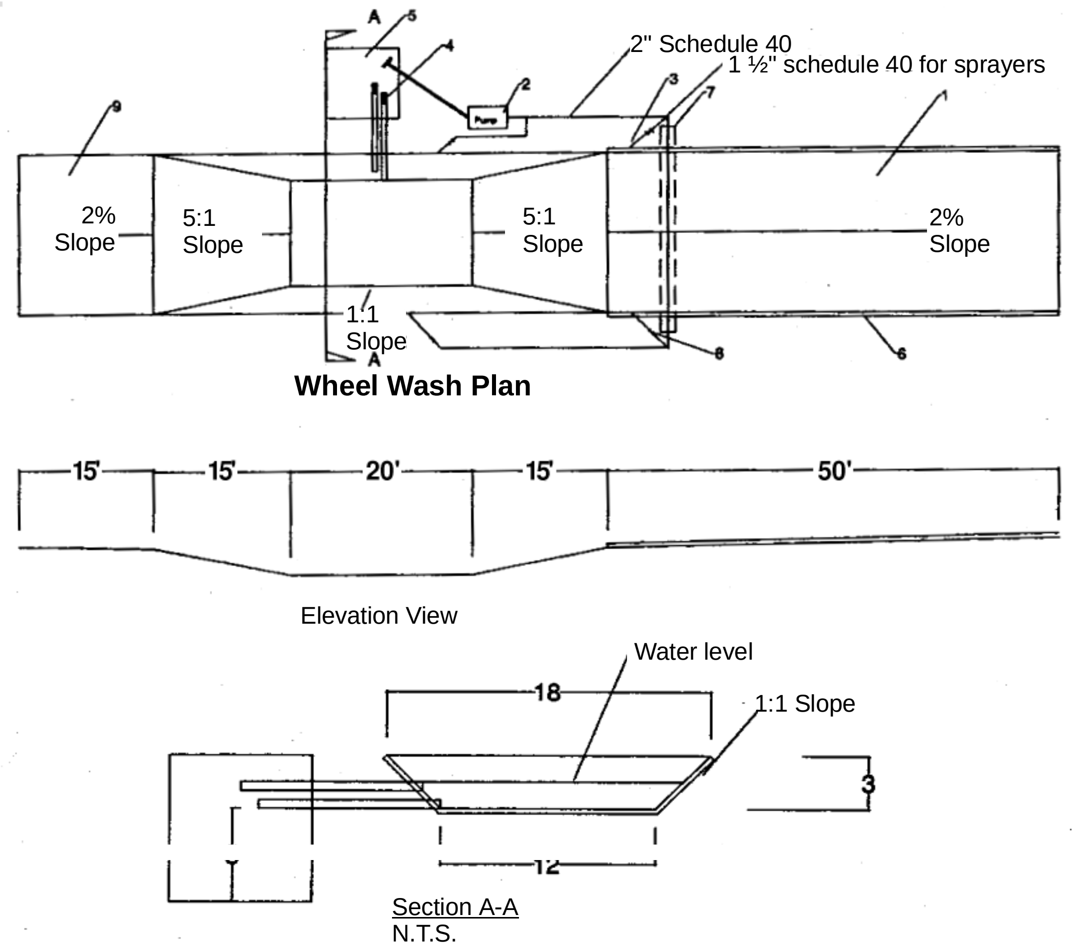
Design and Installation Specifications

- Suggested details are shown in Figure 3.3. 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 wheel wash clearance 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.
- Design wheel wash systems 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. Install a drainpipe with a 2- to 3-foot riser 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 each day with fresh water.
- Change the wash water a minimum of once per day. On large earthwork jobs where more than 10 to 20 trucks per hour are expected, the wash water will need to be changed more often.



Notes:

1. Asphalt construction entrance 6 in. asphalt treated base (ATB).
2. 3-inch trash pump with floats on the suction hose.
3. Midpoint spray nozzles, if needed.
4. 6-inch sewer pipe with butterfly valves. Bottom one is a drain. Locate top pipe's invert 1 foot above bottom of wheel wash.
5. 8 foot x 8 foot sump with 5 feet of catch. Build so can be cleaned with trackhoe.
6. Asphalt curb on the low road side to direct water back to pond.
7. 6-inch sleeve under road.
8. Ball valves.
9. 15 foot. ATB apron to protect ground from splashing water.

Figure 3.3. Wheel Wash.

BMP C107: Construction Road/Parking Area Stabilization

Purpose

To reduce erosion caused by construction traffic or runoff by stabilizing subdivision roads, parking areas, and other on-site vehicle transportation routes immediately after grading.

Conditions of Use

Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.

High Visibility Fencing (see BMP C103) 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, 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 road base stabilization, pH monitoring and BMPs (BMP C252 and C253) are 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 sheet-flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation, then it is 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 sheet flow 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 storm drain system (see BMP C220).

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

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

Conditions of Use

- Seeding shall be used throughout the project on disturbed areas that have reached final grade or that will remain un-worked for more than 30 days.
- Install channels that will be vegetated before major earthwork and hydroseed them with a bonded fiber matrix. The vegetation should be well established before water is allowed to flow in the ditch. With channels that will have high flows, install erosion control blankets over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod shall be installed in the bottom of the ditch over hydromulch and blankets.
- Retention/detention ponds shall be seeded as required.
- 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. Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier, along with the seed and fertilizer. See BMP C121: Mulching for specifications. Tackifier shall be plant-based (such as guar or alpha plantago) or chemical-based (such as polyacrylamide or polymers). Any mulch or tackifier product used shall be installed per manufacturer’s instructions.
- All disturbed areas shall be reviewed in late August to early September and all seeding should be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.
- At final site stabilization, all disturbed areas not otherwise vegetated or stabilized shall be seeded and mulched. 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.

Design and Installation Specifications

Seeding should be done during those seasons most conducive to growth and will vary with the climate conditions of the region. Local experience should be used to determine the appropriate seeding periods.

The optimum seeding windows for western Washington are April 1 through May 15 and September 1 through October 1. Seeding that occurs between June 1 and August 30 requires irrigation until 75 percent grass cover is established. Seeding that occurs between October 1 and March 30 will require a mulch with straw, hydromulch, or an erosion control blanket until 75 percent grass cover is established.

To prevent seed from being washed away, confirm that all required surface water control measures have been installed. 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 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 hydromulch and erosion control blankets.

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 or use BMP LID.02 - Post-Construction Soil Quality and Depth on the disturbed soil surface before application.

Roughening and Rototilling

- The seedbed should be firm and rough. All soil shall be roughened regardless of slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.

- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use BMP LID.02 - Post-Construction Soil Quality and Depth to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches, perform the rototilling process in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.

Fertilizers

- Organic matter is the most appropriate form of “fertilizer” because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2 to 10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.

- In general, 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow-release coating is destroyed. Do not use fertilizers in areas that have been amended with compost or used BMP LID.02 - Post-Construction Soil Quality and Depth.

- There are numerous products available on the market 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 is 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. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer’s instructions. Most products require 24 to 36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40 to 50 pound bags and include all necessary ingredients except for seed and fertilizer.

BFMs and MBFMs have some advantages over blankets, including:

- No surface preparation required
- Can be installed via helicopter in remote areas
- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety
- BFMs and MBFMs are at least $1,000 per acre cheaper to install.

In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

Seeding and Seed Mixtures

When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. One way to overcome this is to increase seed quantities by up to 50 percent.

Vegetation establishment can also be enhanced by dividing the hydromulch operation into two phases:

- Phase 1 – Install all seed and fertilizer with 25 to 30 percent mulch and tackifier onto soil in the first lift;
- Phase 2 – Install the rest of the mulch and tackifier over the first lift.

An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800 to 1,000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

- Irrigation
- Reapplication of mulch
- Repair of failed slope surfaces.

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

Areas to be permanently landscaped shall provide a healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation. This is required for most project and shall be completed in accordance with the requirements of BMP LID.02: Post – Construction Soil Quality and Depth (Volume V of DDECM).

Seed installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets.

The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Consult local suppliers or the Thurston County Conservation District for recommendations because 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 County may be used.

- Table 3-2represents the standard mix for those areas where just a temporary vegetative cover is required.

Table 3-2. Temporary Erosion Control Seed Mix

	% Weight	% Purity	% Germination
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

Table 3-3 Provides just one recommended possibility for landscaping seed.

Table 3-3. Landscaping Seed Mix

	% Weight	% Purity	% Germination
Perennial rye blend *Lolium perenne*	70	98	90
Chewings and red fescue blend *Festuca rubra var. commutata* or Festuca *rubra*	30	98	90

- This turf seed mix in Table 3-4 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

Table 3-4. Low-Growing Turf Seed Mix

	% Weight	% Purity	% Germination
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

- Table 3-5 presents a mix recommended for bioswales and other intermittently wet areas.

Table 3-5. Bioswale Seed Mix[a]

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	75-80	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	92	85
Redtop bentgrass *Agrostis alba* or *Agrostis gigantea*	5-10	90	80

[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

- The seed mix shown in Table 3-6is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Other mixes may be appropriate, depending on the soil type and hydrology of the area. Recent research suggests that bentgrass (*agrostis* sp.) should be emphasized in wet-area seed mixes. Apply this mixture at a rate of 60 pounds per acre.

Table 3-6. Wet Area Seed Mix

	% Weight	% Purity	% Germination
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

[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

- The meadow seed mix in Table 3-7 is recommended for areas that will be maintained infrequently or not at all and where native plant colonization is desired. 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. The appropriateness of clover in the mix may need to be considered, as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

Table 3-7. Meadow Seed Mix

	% Weight	% Purity	% Germination
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

Maintenance Standards

- Reseed any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows).

- If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets shall be used.

- If winter weather prevents adequate grass growth, time limits may be relaxed at the discretion of the County when sensitive areas would otherwise be protected.
- After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes runoff.

Products Approved as Equivalent

Products approved by Ecology as equivalent to meet the requirements of BMP C120 are acceptable for use in Thurston County. The approved products are available for review on Ecology's website at:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html.

BMP C121: Mulching

Purpose

To provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture and holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches, but only the most common types are discussed in this section.

Conditions of Use

As a temporary cover measure, use mulch:

- On disturbed areas that require cover measures for less than 30 days.
- At all times for seeded areas, especially during the wet season and 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 from wood, recycled cellulose, hemp, kenaf; compost; or blends of these. Tackifier shall be plant-based, such a guar or alpha plantago, or chemical-based such as polyacrylamide or polymers. Any mulch or tackifier product used shall be installed per manufacturer’s instructions. Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 3-8. Always use a 2-inch minimum mulch thickness; increase the thickness until the ground is 95% covered (i.e. not visible under the mulch layer). Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

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 with WDFW as part of the Hydraulic Project Approval for mulch mixes allowed, if applicable.

Where the option of “Compost” is selected, it should be a coarse compost that meets the following size gradations when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” (TMECC) Test Method 02.02-B.

Coarse Compost

Minimum Percent passing 3” sieve openings 100%

Minimum Percent passing 1” sieve openings 90%

Minimum Percent passing ¾” sieve openings 70%

Minimum Percent passing ¼” sieve openings 40%

Maintenance Standards

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be re-mulched 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 re-mulched.

Table 3-8. Mulch Standards and Guidelines

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2 to 3 inches thick; 5 bales per 1,000 sf or 2 to 3 tons per acre	Cost-effective when applied with adequate thickness. Hand-application requires greater thickness than blown straw. Straw thickness 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 since light winds will blow it away. Straw, however, has several deficiencies to consider when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and has no significant long-term benefits. Use straw only if mulches with long-term benefits are unavailable. It also shall not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 25-30 lbs per 1,000 sf or 1,500-2,000 lbs per acre	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 to 1 inch clog hydromulch equipment. Keep fibers to less than 3/4 inch.
Composted Mulch and Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt) and produced in accordance with WAC 173-350.	2-in thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	Increase thickness to 3 inches to improve effectiveness. Excellent mulch for protecting final grades until landscaping, because it can be directly seeded or tilled into soil as an amendment. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use composted mulch near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2-in thick min.	A cost-effective way to dispose of debris from clearing and grubbing, and eliminates problems associated with burning. Should not be used on slopes above about 10 percent because of its tendency to be transported by runoff. Not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch or Wood Straw	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.	2-in. thick min.; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	Often called "hog or hogged 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).

Mulch Material	Quality Standards	Application Rates	Remarks
Wood Strand Mulch	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.	2-in. thick min.	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 3/8-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. (WSDOT specification 9-14.4(4))

BMP C122: Nets and Blankets

Purpose

To prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. Some nets and blankets can 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 form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). Blankets 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

Use erosion control nets and blankets:

- 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). Using netting or blankets in drainage ditches and swales can protect bare soil from channelized runoff until vegetation is established. Nets and blankets can also capture a large amount of sediment due to their open, porous structure. Nets and blankets can permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches can be easily reused as temporary ditch liners.

Disadvantages of blankets include:

- Surface preparation required
- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety
- They cost at least $4,000 to 6,000 per acre installed.

Advantages of blankets include:

- Can be installed without mobilizing special equipment
- Can be installed by anyone with minimal training
- Can be installed in stages or phases as the project progresses
- Seed and fertilizer can be hand-placed by the installers as they progress down the slope

- Can be installed in any weather

There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

Design and Installation Specifications

See Figure 3.2 and Figure 3.3 (and WSDOT *Standard Plans)* for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed using 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.

- Installing 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 blanket into the small trench and staple approximately every 18 inches. Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are available.

    5. Roll the blanket slowly down the slope as installer walks backwards. The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. Do not allow the blanket to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, do not walk on the blanket after it is in place.

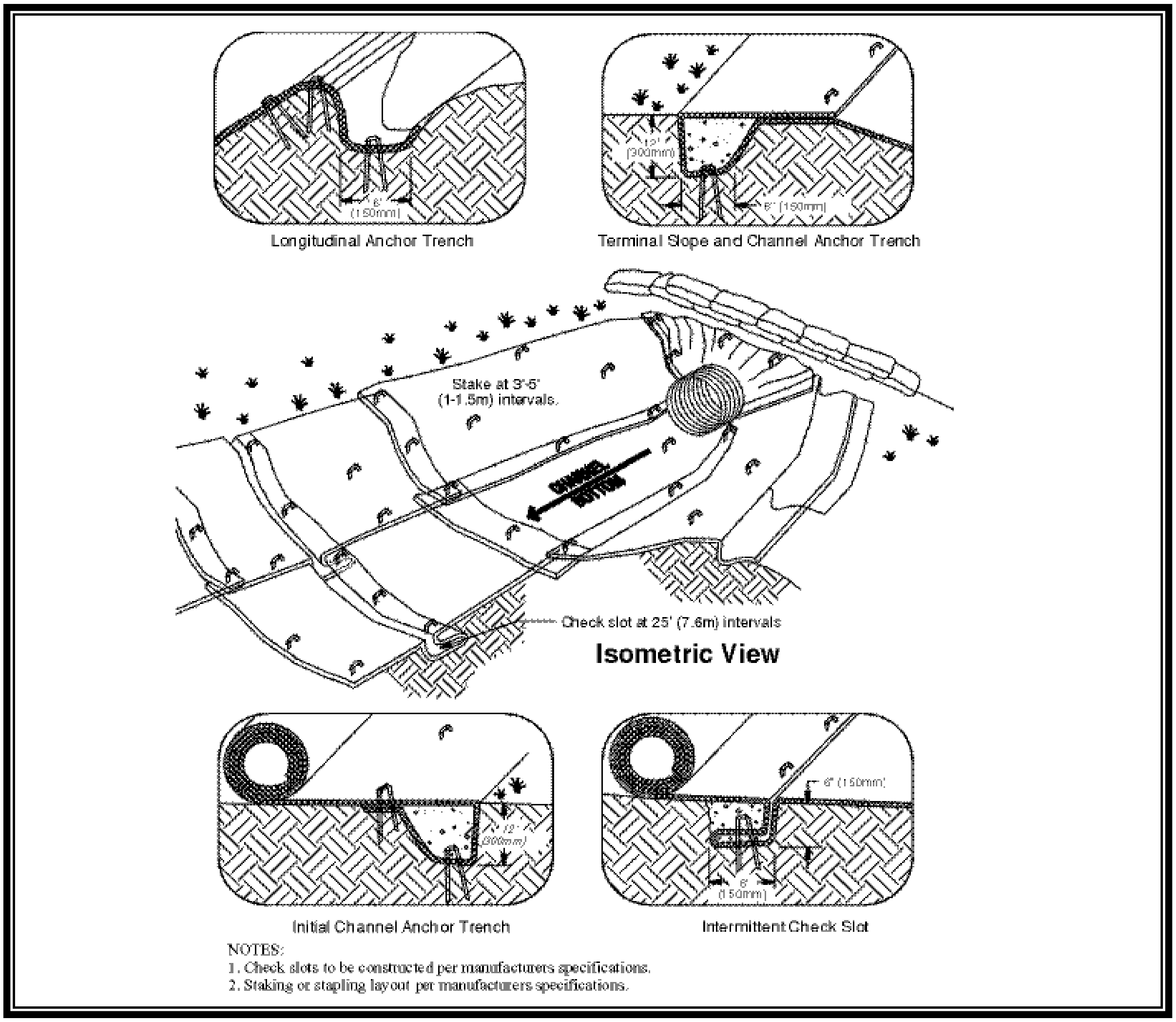


Figure 3.2. Channel Installation.

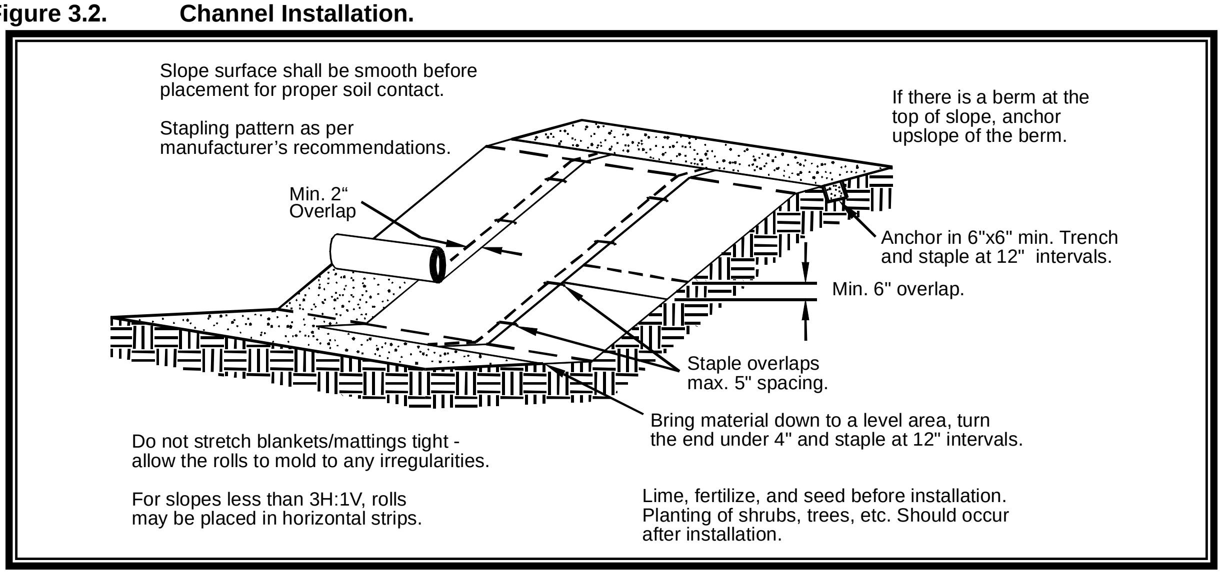


Figure 3-3. Slope Installation

6. If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket shall overlap the leading edge of the lower blanket and be stapled. On steeper slopes, install this overlap in a small trench, staple it, and cover it with soil.

- A wide variety of products is available. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to ensure that the product specified is appropriate. Information is also available at the following web sites:

  - WSDOT: http://www.wsdot.wa.gov/NR/rdonlyres/3B41E087-FA86-4717-932D-D7A8556CCD57/0/ErosionTrainingManual.pdf

  - Texas Transportation Institute: http://www.txdot.gov/business/doing_business/product_evaluation/erosion_control.htm

- Jute matting must be used in conjunction with mulch (BMP C121). 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 require mulch in order to prevent erosion because of their open structure. Blankets typically do not require mulch because they normally provide complete protection of the surface.

- Extremely steep, unstable, wet, or rocky slopes are often appropriate locations for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, hydromulch the soil 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 can last up to a year.

- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

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.

BMP C123: Plastic Covering

Purpose

To provide immediate, short-term erosion protection of 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, but the rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than 6 months) applications.
- Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- Plastic sheeting requires close monitoring and frequent maintenance to ensure proper performance. Water quality standards must be met at all times.
- While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to $1.50-2.00 per square yard.
- Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to covey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.
- Other uses for plastic include:
    1. Temporary ditch liner
    2. Pond liner in temporary sediment pond
    3. Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored
    4. Emergency slope protection during heavy rains
    5. 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 slope, not across slope

2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet
3. Minimum of 8-inch overlap at seams
4. Tape all seams on long or wide slopes, or slopes subject to wind
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 and pound a wooden stake through each 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 if the plastic begins to deteriorate due to ultraviolet radiation.
- Completely remove the plastic when it is no longer needed.

BMP C124: Sodding

Purpose

To establish permanent turf for immediate erosion protection and stabilize drainage ways 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:

- Shape and smooth the surface to final grade in accordance with the approved grading plan. The swale needs to be overexcavated 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. See http://www.ecy.wa.gov/programs/swfa/organics/soil.html for further information.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer into the top 1 to 2 inches of the soil, and smooth the surface.[2]
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- Roll the sodded area and irrigate.

[2] Lime and fertilizer shall only be applied if necessary as determined by a soil test on the amended soil.

- 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

To provide a suitable growth medium for final site stabilization with vegetation.

While not a permanent cover practice, topsoiling and composting are an integral component of providing permanent cover in areas with an unsuitable soil surface for plant growth. Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding.

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

- Leave native soils and the duff layer undisturbed as much as possible. Restore native soils disturbed during clearing and grading as much as possible, to a condition where moisture-holding capacity is equal to or better than the original site conditions. This criterion can be met by using on-site native topsoil, incorporating amendments into on-site soil, or importing blended topsoil.

- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.

- Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly it shall be preserved in its undisturbed and uncompacted condition.

- Depending on where the topsoil comes from, or what vegetation was 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.

Design and Installation Specifications

See BMP LID.02, Chapter 5 of Volume V of this manual for post construction soil requirements.

- 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- 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.

- 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. Stockpiled topsoil is to be reapplied 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 stockpiles.
  - Within 2 days complete erosion control seeding, or cover stockpiles with clear plastic, or other mulching materials.

- Between May 1 and September 30:
  - An interceptor dike with gravel outlet and silt fence shall be installed 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 cover stockpiles with clear plastic, or other mulching materials.

- When native topsoil is to be stockpiled and reused the following apply to ensure 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, truck traffic (including pickup trucks, parking, material storage, 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.

BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection

Purpose

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

Applying PAM to bare soil in advance of rain significantly reduces erosion and controls sediment in two ways. First, PAM increases the soil's available pore volume, thus increasing infiltration through flocculation 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 only be applied with prior acceptance by the County, and shall not be directly applied to water or allowed to enter a water body. Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products should be used, as noted in the following paragraph.

The specific PAM copolymer formulation must be anionic. **Cationic PAM shall not be used in any application because of known aquatic toxicity problems**. Only the highest drinking water grade PAM, certified for compliance with ANSI/NSF Standard 60 for drinking water treatment, will be used for soil applications. 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 County. The Washington State Department of Transportation (WSDOT) has listed approved PAM products on their web page.

In areas that drain to a sediment pond, PAM can be applied to bare soil in the following locations and 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, use PAM together with mulch.

Design and Installation Specifications

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

PAM is to be applied at a maximum rate of 2/3 pound PAM per 1,000 gallons water (80 mg/L) per 1 acre of bare soil. Table 3.8 can be used to determine the PAM and water application rate for a disturbed soil area. Higher concentrations of PAM **do not** provide any additional effectiveness.

Table 3-9. 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

The Preferred Method:

- Pre-measure the area where PAM is to be applied and calculate the amount of product and water necessary to provide coverage at the specified application rate (2/3 pound PAM/1,000 gallons/acre).
- PAM has high 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.
- Pre-fill the water truck about 1/8 full with water. The water does not have to be potable, but it must have relatively low turbidity – in the range of 20 NTU or less.
- Add PAM /Water mixture to the truck

- Completely fill the water truck to specified volume.
- Spray PAM/Water mixture onto dry soil until the soil surface is uniformly and completely wetted.

An Alternate Method:

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

The following shall be used for application of powdered PAM:

- PAM shall be used in conjunction with other BMPs and not in place of other BMPs.
- Do not use PAM on a slope that flows directly into a stream or wetland. The stormwater runoff shall pass through a sediment control BMP prior to discharging to surface waters.
- Do not add PAM to water discharging from 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 a minimum of three check dams per acre. The total number of check dams used shall be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site. Each check dam shall be spaced evenly in the drainage channel through which stormwater flows are discharged offsite.
- On all sites, the use of silt fence shall be maximized to limit the discharges 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.
- Keep the granular PAM supply out of the sun. Granular PAM loses its effectiveness in three months after exposure to sunlight and air.
- Proper application and re-application plans are necessary to ensure total effectiveness of PAM usage.

- PAM, combined with water, is very slippery and can be a safety hazard. Care must be taken to prevent spills of PAM powder onto paved surfaces. During an application of PAM, prevent over-spray from reaching pavement as pavement will become slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water-this only makes cleanup messier and take longer.

- Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products shall be used.

- 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 to 30 percent; a value of 18 percent is typical. Studies conducted by the United States Department of Agriculture (USDA)/ARS demonstrated that soil stabilization was optimized by using very high molecular weight (12 to 15 mg/mole), highly anionic (>20 percent hydrolysis) PAM.

- PAM tackifiers are available and being used in place of guar and alpha plantago. Typically, PAM tackifiers should be used at a rate of no more than 0.5 to 1 lb. per 1,000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 to 5 lbs. per acre, which can be too much. In addition, pump problems can occur at higher 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 2 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.

BMP C130: Surface Roughening

Purpose

To aid in the establishment of vegetative cover, reduce runoff velocity, increase infiltration, and provide 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.

Conditions for Use

Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding.

- All slopes steeper than 3:1 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 3.4 for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each “step” catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment. Stair steps must be on contour or gullies will form on the slope.
- Areas that will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.

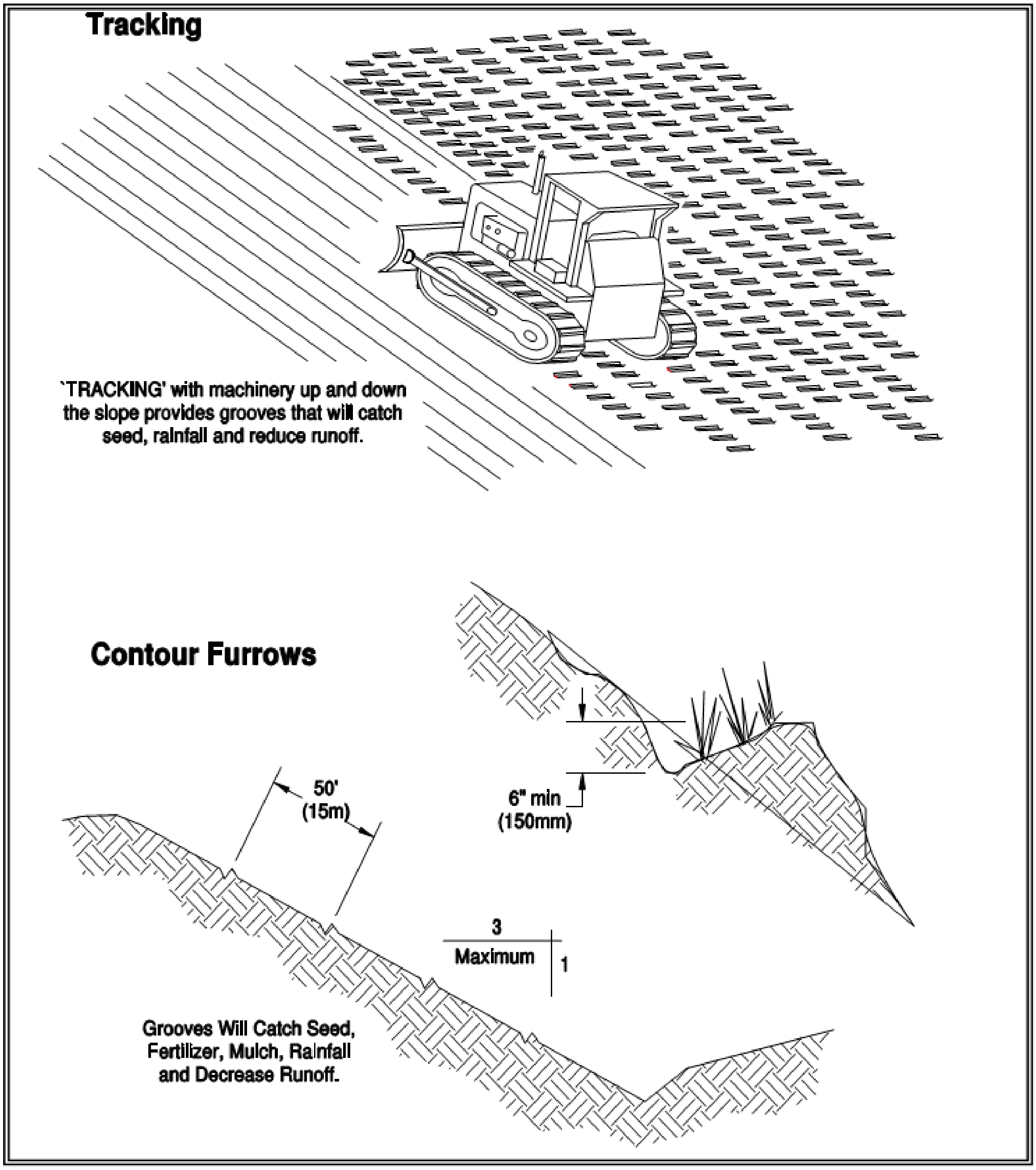


Figure 3-4. Surface Roughening by Tracking and Contour Furrows

- Graded areas with slopes greater than 3:1 but less than 2:1 shall 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

- Seed areas graded in this manner as quickly as possible.
- Regular inspections should be made of the area. If rills appear, re-grade and re-seed immediately.

BMP C131: Gradient Terraces

Purpose

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity.

Conditions of Use

Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available. See Figure 3.5 for gradient terraces.

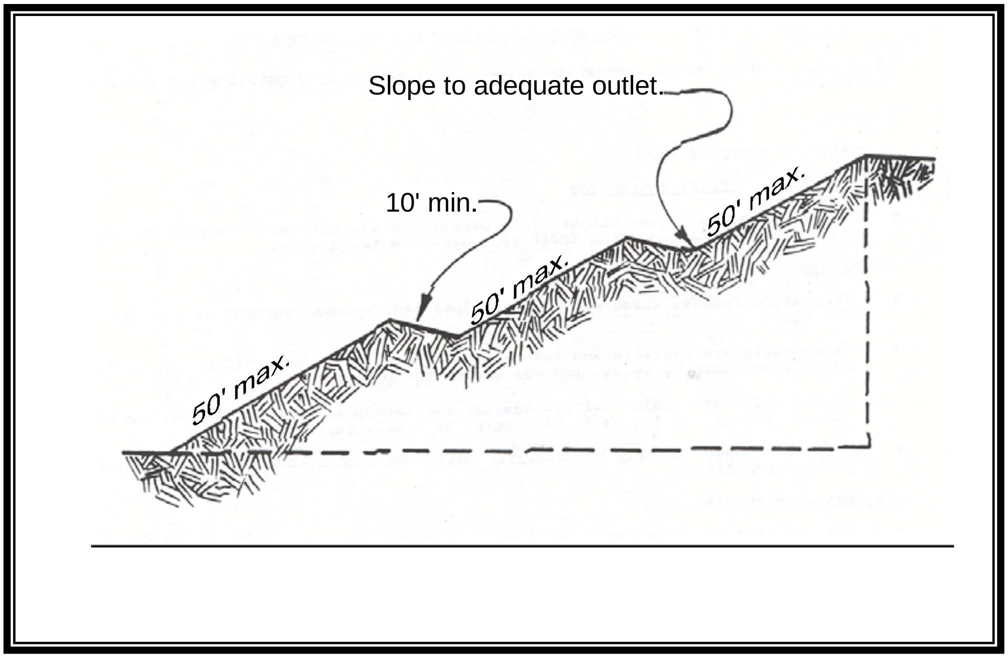


Figure 3-5. Gradient Terraces

Design andInstallation Specifications

- Determine the maximum spacing of gradient terraces using the following formula:

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 (1-1/2 tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section shall meet the design dimensions.
- The top of the constructed ridge shall 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 shall 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 shall not exceed that which is non-erosive for the soil type with the planned treatment.
- All gradient terraces shall 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. Use vegetative cover in the outlet channel.
- The design elevation of the water surface of the terrace shall 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 shall not exceed the area that would be drained by a terrace with normal spacing.
- The terrace shall 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 shall have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel shall be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

Maintenance Standards

Performance maintenance as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

BMP C140: Dust Control

Purpose

To prevent wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

Dust control must be used in areas (including roadways) subject to surface and air movement of dust, where on-site and 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, if stable. Maintain the original ground cover as long as practical.

- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.

- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, see Stabilized Construction Entrance (BMP C105).

- Irrigation water can be used for dust control. Install irrigation systems as a first step on sites where dust control is a concern.

- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Oil based products are prohibited from use as a dust suppressant. The County may approve other dust palliatives such as calcium chloride or PAM.

- PAM (BMP C126) added to water at a rate of 0.5 lbs. per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control. PAM has also shown to be relatively affordable and thus an extremely cost-effective dust control method.

- 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.

  - Restrict roadway use by tracked vehicles and heavy trucks to prevent damage to road surface and base.

  - Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.

  - Pave unpaved permanent roads and other trafficked areas.

  - Use vacuum street sweepers.

  - Remove mud and other dirt promptly so it does not dry and then turn into dust.

  - Limit dust-causing work on windy days.

- Contact the Olympic Region Clean Air Agency (ORCAA) for guidance and training on other dust control measures. Compliance with the ORCAA constitutes compliance with this BMP.

Maintenance Standards

Respray area as necessary to keep dust to a minimum.

BMP C150: Materials on Hand

Purpose

Quantities of erosion prevention and sediment control materials can be kept on the project site at all times for emergency situations such as unexpected heavy summer rains. Having these materials on-site reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements.

Conditions of Use

- Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric, and steel “T” posts.

- Materials are stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or developer could keep a stockpile of materials that are available to be used on several projects.

- If storage space at the project site is at a premium, the contractor could maintain the materials at 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 that will cover numerous situations includes:

Table 3-10. Materials on Hand

Material	Measure	Quantity
Clear Plastic, 6 mil	100 foot roll	1-2
Drainpipe, 6- or 8-inch diameter	25 foot section	4-6
Sandbags, filled	each	25-50
Straw Bales for mulching,	approx. 50# each	10-20
Quarry Spalls	ton	2-4
Washed Gravel	cubic yard	2-4
Geotextile Fabric	100 foot roll	1-2
Catch Basin Inserts	each	2-4
Steel “T” Posts	each	12-24
Silt fence material	Lineal feet	200
Straw Wattles	Lineal feet	100

Maintenance Standards

All materials with the exception of the quarry spalls, steel "T" posts, and gravel should be kept covered and out of both sun and rain. Re-stock materials used as needed.

BMP C151: Concrete Handling

Purpose

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; these management practices shall be utilized, since 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 surface waters of the State is prohibited.

Concrete construction projects include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways.

Design and Installation Specifications

- Concrete truck chutes, pumps, and internals shall be washed out only into formed areas awaiting installation of concrete. Assure that washout of concrete trucks is performed off-site or in designated concrete washout areas. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams. Refer to BMP C154 for information on concrete washout areas.

- Unused concrete remaining in the truck and pump shall be returned to the originating batch plant for recycling, as feasible. Do not dump excess concrete on site, except in designated concrete washout areas.

- Hand tools including, but not limited to, screeds, shovels, rakes, floats, and trowels shall be washed off only into formed areas awaiting installation of concrete.

- Equipment that cannot be easily moved, such as concrete pavers, shall only be washed in areas that do not directly drain to natural or constructed stormwater conveyances.
- Do not allow washdown from areas such as concrete aggregate driveways to drain directly to natural or constructed stormwater conveyances.
- When no formed areas are available, contain washwater and leftover product in a lined container. Lining shall be a minimum of 10-mil polyethylene sheeting and shall be free of holes, tears, or other defects that compromise the impermeability of the material. Dispose contained concrete in a manner that does not violate groundwater or surface water quality standards.
- Always use forms or solid barriers for concrete pours, such as pilings, within 15-feet of surface waters.
- Refer to BMPs C252 and C253 for pH adjustment requirements.
- If the project is subject to a Construction Stormwater General Permit, or if required by the Administrator, pH monitoring may be required if the project involves one of the following activities:
    - Significant concrete work (greater than 1,000 cubic yards poured concrete or recycled concrete used over the life of a project).
    - The use of engineered soils amended with (but not limited to) Portland cement-treated base, cement kiln dust or fly ash.
    - Discharging stormwater to segments of water bodies on the 303(d) list (Category 5) for high pH.

Maintenance Standards

Check containers for holes in the liner daily during concrete pours and repaired the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

To minimize and eliminate process water and slurry from entering waters of the State.

Conditions of Use

Anytime sawcutting or surfacing operations take place, these management practices shall be utilized, since 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 surface waters of the State is prohibited.

Sawcutting and surfacing operations include, but are not limited to, the following:

- 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 collected slurry and cuttings in a manner that does not violate groundwater or surface water quality standards.
- Do not allow process water that is generated during hydro-demolition, surface roughening or similar operations to drain to any natural or constructed drainage conveyance including stormwater systems and dispose it in a manner that does not violate groundwater or surface water quality standards.
- Handle and dispose cleaning waste material and demolition debris in a manner that does not cause contamination of water. If the area is swept with a pick-up sweeper, haul the material out of the area to an appropriate disposal site.

Maintenance Standards

Continually monitor operations to determine whether slurry, cuttings, or process water could enter waters of the state. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventive measures such as berms, barriers, secondary containment, and vacuum trucks.

BMP C153: Material Delivery, Storage and Containment

Purpose

To prevent, reduce, or eliminate the discharge of pollutants to the stormwater system or water courses from material delivery and storage by minimizing on-site hazardous materials storage, storing materials in a designated area, and installing secondary containment.

Conditions of Use

These procedures are suitable for use at all construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil and grease
- Soil stabilizers and binders (e.g., Polyacrylamide)
- Fertilizers, pesticides and herbicides
- Detergents
- Asphalt and concrete compounds
- Hazardous chemicals such as acids, lime, adhesives, paints, solvents and curing compounds
- Any other material that may be detrimental if released to the environment.

Design and Installation Specifications

To minimize risk, do the following:

- Locate temporary storage area away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Supply Material Safety Data Sheets (MSDS) for all stored materials. Chemicals should be kept in their original labeled containers.
- Minimize on-site hazardous material storage.
- Handle hazardous materials as infrequently as possible.
- During the wet weather season (October 1 – April 30), store materials in a covered area when possible.
- Store materials in secondary containments such as an earthen dike, a 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, in 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.

Material Storage Areas and Secondary Containment Practices:

- 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 precipitation from a 25-year, 24-hour storm event, plus 10 percent of the total enclosed container volume of all containers, or 110 percent of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, 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.
- Provide sufficient separation between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (October 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” x 19”

- 1-Pair Splash Resistant Goggles
- 3-Pair Nitrile Gloves
- 10-Disposable Bags with Ties
- Instructions.

BMP C154: Concrete Washout Area

Purpose

To prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout off-site, or performing on-site washout in a designated area to prevent pollutants from entering surface waters or groundwater.

Conditions of Use

Concrete washout area best management practices 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 trucks, pumpers, or other concrete coated equipment are washed on-site.

Note: If less than 10 concrete trucks or pumpers need to be washed out on-site, the washwater may be disposed of in a formed area awaiting concrete or an upland disposal site where it will not contaminate surface or groundwater. The upland disposal site shall be at least 50 feet from sensitive areas such as storm drains, open ditches, or water bodies, including wetlands.

Design and Installation Specifications

Implementation

The following steps will help reduce stormwater pollution from concrete wastes:

- Perform washout of concrete trucks off-site or in designated concrete washout areas only.
- Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped on-site, except in designated concrete washout areas.
- Concrete washout areas may be pre-fabricated concrete washout containers, or self-installed structures (above-grade or below-grade).
- Pre-fabricated 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.

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 contractor's superintendent or Certified Erosion and Sediment Control Lead (CESCL) to oversee and enforce concrete waste management procedures.
- A sign shall be installed adjacent to each temporary concrete washout facility to inform concrete equipment operators to utilize the proper facilities.

Contracts

Incorporate requirements for concrete waste management into concrete supplier and subcontractor agreements.

Location and Placement

- Locate washout area at least 50 feet from sensitive areas such as storm drains, open ditches, or water bodies, including wetlands.
- Allow convenient access for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access washout, prevent track-out with a pad of rock or quarry). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.
- The number of facilities you install should be dependent on the expected demand for storage capacity.
- On large sites with extensive concrete work, washouts should be placed in multiple locations for ease of use by concrete truck drivers.

On-site Temporary Concrete Washout Facility, Transit Truck Washout Procedures:

- Temporary concrete washout facilities shall be located a minimum of 50 feet from sensitive areas including storm drain inlets, open drainage facilities, and watercourses. See Figure 3-6, Figure 3-7, and Figure 3-8.

- Construct, and maintain concrete washout facilities in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.
- Approximately 7 gallons of wash water are used to wash one truck chute.
- Approximately 50 gallons are used to wash out the hopper of a concrete pump truck.
- Perform washout of concrete trucks in designated areas only.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated washout area or properly disposed of off-site.
- Once concrete wastes are washed into the designated 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.
- Temporary Above-Grade Concrete Washout Facility
    - Temporary concrete washout facility (type above-grade) should be constructed as shown on the details below, with a recommended minimum width of 10 feet, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
    - Plastic lining material shall 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.
- Temporary Below-Grade Concrete Washout Facility
    - Temporary concrete washout facilities (type below-grade) should be constructed as shown on the details below, with a recommended minimum length and minimum width of 10 feet. The quantity and volume should be sufficient to contain all liquid and concrete waste generated by washout operations.
    - Lath and flagging should be commercial type.
    - Plastic lining material shall 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.
    - 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.

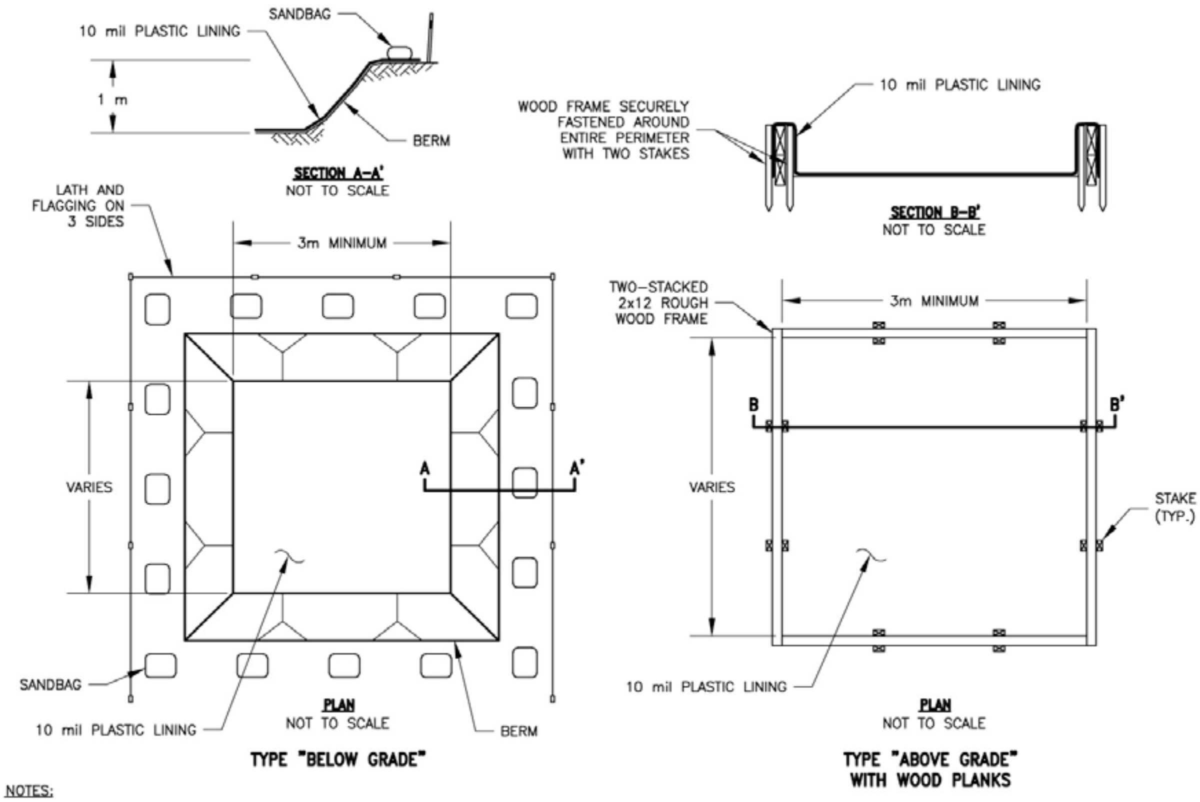
Maintenance Standards

Inspection and Maintenance

- Inspect and verify that concrete washout BMPs are in place prior to the commencement of concrete work.
- During periods of concrete work, inspect daily to verify continued performance.
    - Check overall condition and performance.
    - Check remaining capacity (% full).
    - If using self-installed washout facilities, verify plastic liners are intact and sidewalls are not damaged.
    - If using prefabricated containers, check for leaks.
- Washout facilities shall be maintained to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.
- If the washout is nearing capacity, vacuum and dispose of the waste material in an approved manner.
    - Do not discharge liquid or slurry to waterways, storm drains, or directly onto the ground.
    - Do not use sanitary sewer without local sewer service provider approval.
    - Place a secure, non-collapsing, non-water collecting cover over the concrete washout facility prior to predicted wet weather to prevent accumulation and overflow of precipitation.
    - Remove and dispose of hardened concrete and return the structure to a functional condition. Concrete may be reused on-site or hauled away for disposal or recycling.
- When you remove materials from the self-installed concrete washout, build a new structure; or, if the previous structure is still intact, inspect for signs of weakening or damage, and make any necessary repairs. Re-line the structure with new plastic after each cleaning.

Removal of Temporary Concrete Washout Facilities

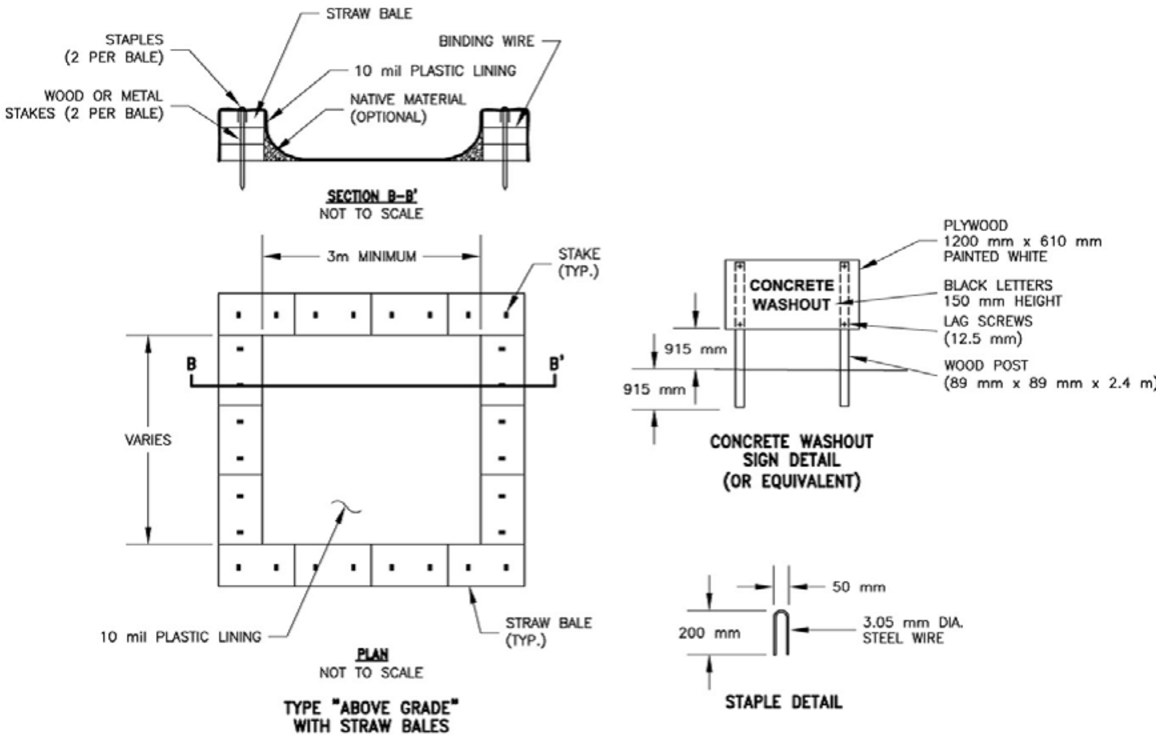
- When temporary concrete washout facilities are no longer required for the work, the hardened concrete, slurries and liquids shall be removed and properly disposed of.
- Materials used to construct temporary concrete washout facilities shall be removed from the site of the work and disposed of or recycled.
- Holes, depressions or other ground disturbance caused by the removal of the temporary concrete washout facilities shall be backfilled, repaired, and stabilized to prevent erosion.



NOTES:

1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN (SEE PAGE 6) SHALL BE INSTALLED WITHIN 10 m OF THE TEMPORARY CONCRETE WASHOUT FACILITY.

Figure 3-6. Concrete Washout Area



NOTES:

1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN (SEE FIG. 4–15) SHALL BE INSTALLED WITHIN 10 m OF THE TEMPORARY CONCRETE WASHOUT FACILITIY.

CALTRANS/FIG4–14.DWG SAC 8–14–02

Figure 3-7. Concrete Washout Area

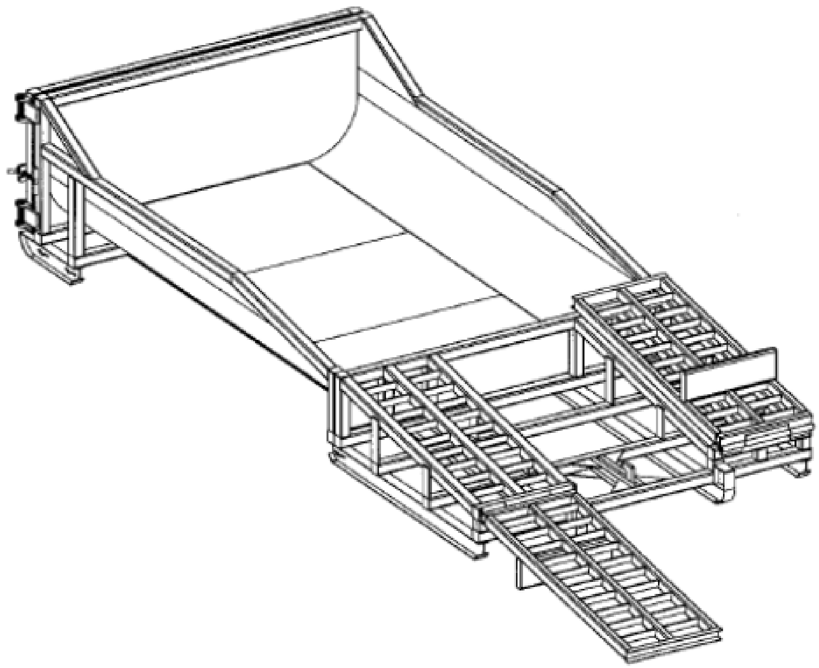


Figure 3-8. Prefabricated Concrete Washout Container w/Ramp

BMP C160: Certified Erosion and Sediment Control Lead

Purpose

To ensure compliance with all local, state, and federal erosion and sediment control and water quality requirements by designating at least one person as the responsible representative in charge of erosion and sediment control (ESC), and water quality protection. The designated person shall be the Certified Erosion and Sediment Control Lead (CESCL).

Conditions of Use

A CESCL shall be made available on projects disturbing ground 1 acre or larger and that discharge stormwater to surface waters of the state. Sites less than one acre may have a person without CESCL certification conduct inspections; sampling is not required on sites that disturb less than an acre.

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 (see Ecology's 2012 Stormwater Management Manual for Western Washington for details).

  Ecology will maintain a list of ESC training and certification providers at: http://www.ecy.wa.gov/programs/wq/stormwater/cescl.html.

OR

- Be a Certified Professional in Erosion and Sediment Control (CPESC); for additional information go to: www.cpesc.net.

Specifications

- Certification shall remain valid for 3 years.
- The CESCL shall have authority to act on behalf of the contractor or developer 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.
- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region.

Duties and responsibilities of the CESCL shall include, but are not limited to the following:

- Maintaining permit file on site at all times which includes the SWPPP and any associated permits and plans.
- Directing BMP installation, inspection, maintenance, modification, and removal.
- Updating all project drawings and the Construction SWPPP with changes made.
- Completing any sampling requirements including reporting results.
- Keeping daily logs, and inspection reports. Inspection reports shall include:

    a. Inspection date/time.

    b. Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.

    c. A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:

        – Locations of BMPs inspected
        – Locations of BMPs that need maintenance
        – Locations of BMPs that failed to operate as designed or intended
        – Locations of where additional or different BMPs are required.

    d. 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.

    e. Any water quality monitoring performed during inspection.

    f. General comments and notes, including a brief description of any BMP repairs, maintenance or installations made as a result of the inspection.

- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

BMP C162: Scheduling

Purpose

To reduce the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking by sequencing a construction project.

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 surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

Design Considerations

- Avoid 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.

3.2 Runoff Conveyance and Treatment BMPs

This section contains the standards and specifications for Runoff Conveyance and Treatment BMPS. Table 3-11, below, shows the relationship of the BMPs in Section 3.2 to the Construction Stormwater Pollution Prevention Plan (SWPPP) Elements described in Section 2.3.3.

Table 3-11. Runoff Conveyance and Treatment BMPs by SWPPP Element

BMP or Element Name	Element #3 Control Flow Rates	Element #4 Install Sediment Controls	Element #6 Protect Slopes	Element #7 Protect Drain Inlets	Element #8 Stabilize Channels and Outlets	Element #9 Control Pollutants	Element #10 Control De-Watering	Element #13 Protect LID BMPs
BMP C200: Interceptor Dike and Swale			✓					✓
BMP C201: Grass-Lined Channels			✓					✓
BMP C202: 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 (Geotextile-Encased Check Dam)			✓					✓
BMP C209: Outlet Protection	✓				✓			
BMP C220: Storm Drain Inlet Protection				✓				
BMP C231: Brush Barrier		✓						✓
BMP C232: Gravel Filter Berm		✓						
BMP C233: Silt Fence		✓						✓
BMP C234: Vegetated Strip		✓						✓
BMP C235: Wattles	✓	✓						
BMP C236: Vegetated Spray Fields							✓	
BMP C240: Sediment Trap	✓	✓						
BMP C241: Temporary Sediment Pond	✓	✓						
BMP C250: Construction Stormwater Chemical Treatment		✓				✓		
BMP C251: Construction Stormwater Filtration		✓				✓		
BMP C252: High pH Neutralization Using CO_2						✓		
BMP C253: pH Control for High pH Water						✓		

BMP C200: Interceptor Dike and Swale

Purpose

To intercept and convey stormwater runoff from unprotected areas and direct it to areas where erosion can be controlled by creating a ridge of compacted soil, or a ridge with an upslope swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area.

Conditions of Use

Use the dike or swale to intercept runoff from undisturbed areas before it enters exposed soils to prevent the clean runoff from becoming sediment laden or to intercept runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area and sediment-laden runoff from leaving the construction site.

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely contain the stormwater:

- Locate upslope of a construction site to prevent runoff from entering disturbed area.
- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.
- Locate downslope to collect runoff from a disturbed area and direct it to a sediment basin.

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.
- Channel requires a positive grade for drainage; steeper grades require channel protection and check dams.
- Review construction for areas where overtopping may occur.
- Can be used at top of new fill before vegetation is established.
- May be used as a permanent diversion channel to carry the runoff.
- Sub-basin tributary area shall be 1 acre or less.
- Design capacity for the peak flow from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution, for temporary facilities. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model. If a 15-minute (or less) time step is used, no correction factor is required.

For conveyance systems that will also serve on a permanent basis see design standards in Volume III, Chapter 3.

Interceptor dikes shall meet the following criteria:

-Top Width:	2 feet minimum
-Height:	1.5 feet minimum on berm
-Side Slope:	2:1 or flatter
-Grade:	Depends on topography, however, dike system minimum is 0.5% and maximum is 1%
-Compaction:	Minimum of 90 percent ASTM D698 standard proctor.

Horizontal Spacing of Interceptor Dikes:

Table 3-12. Horizontal Spacing of Interceptor Dikes

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach:

-Slopes <5%:	Seed and mulch applied within 5 days of dike construction (*see BMP C121, Mulching*).
-Slopes 5 to 40%:	Dependent on runoff velocities and dike materials. Stabilization shall 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.

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 a sediment pond)
-Stabilization:	Seed as per BMP C120, Temporary and Permanent Seeding, or BMP C202, Channel Lining, 12 inches thick of 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. See Figure 3-9 for typical grass-lined channels.

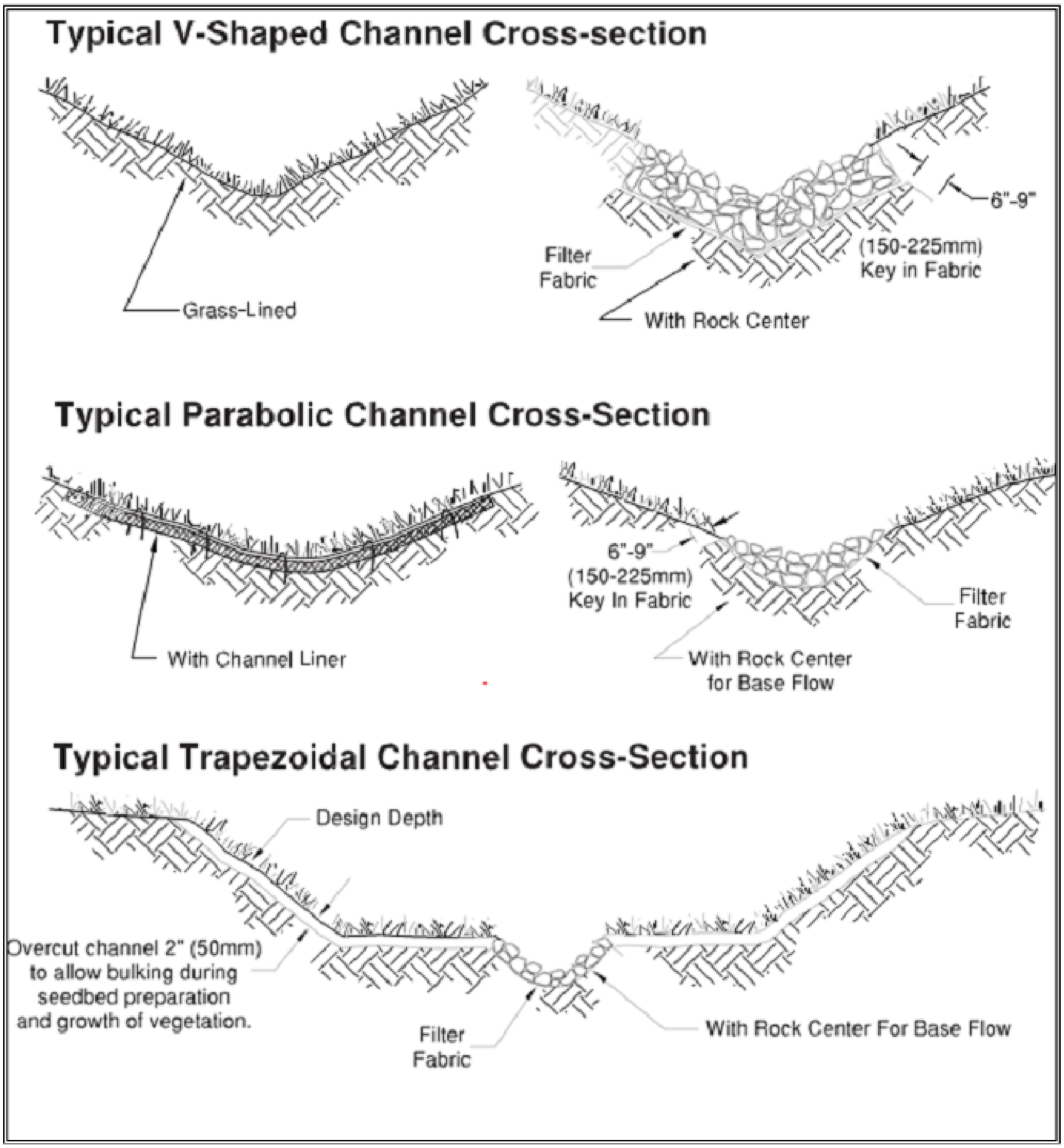


Figure 3-9. Typical Grass-Lined Channels

Conditions of Use

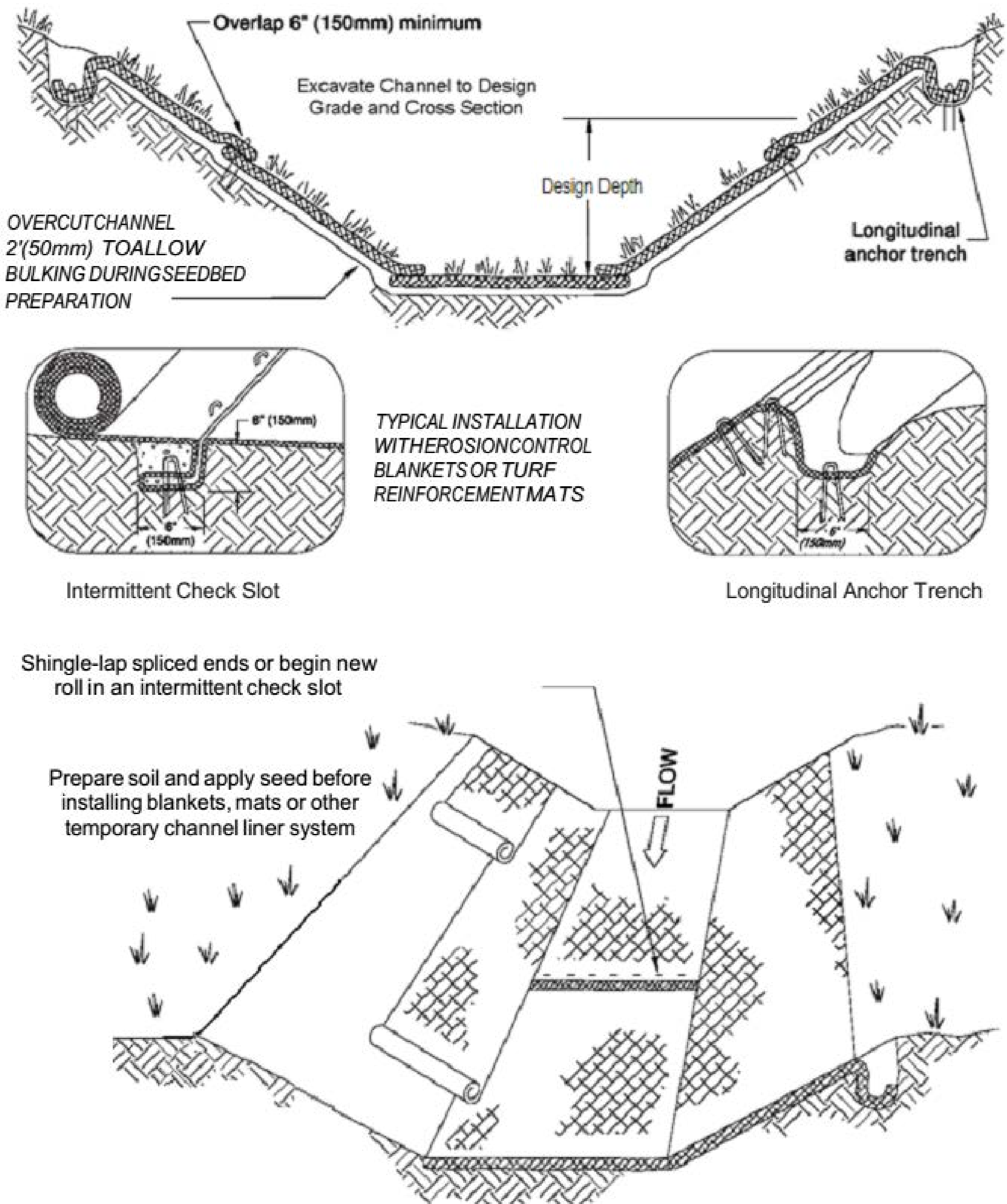
This practice applies to construction sites where concentrated runoff needs to be contained to prevent erosion or flooding.

- 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.
- Install channels to be vegetated before major earthwork and hydroseed with a bonded fiber matrix (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, install erosion control blankets over the hydroseed. (See WSDOT Standard Plan I-60.20-01) If vegetation cannot be established from seed before water is allowed in the ditch, install sod in the bottom of the ditch in lieu of hydromulch and blankets.

Design and Installation Specifications

- Locate the channel where it can conform to the topography and other features such as roads.
- Locate them to use natural 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 times shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak runoff from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model to determine a flow rate which the channel must contain. . If a 15-minute (or less) time step is used, no correction factor is required.
- Where the grass-lined channel will also function as a permanent stormwater conveyance facility the channel must meet the conveyance requirements defined in Volume III, Chapter 3.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets.

- If design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. Geotextile or mulch protection such as fiberglass roving or straw and netting should be used to provide stability until the vegetation is fully established. See Figure 3-10.



NOTES:

1 Design velocities exceeding 2 ft/sec (0.5m/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 (2m/sec) should include turf reinforcement mats.

Figure 3-10. Temporary Channel Liners

- Remove temporary check dams when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. Seed and mulch the area beneath the check dams immediately after dam removal.

- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.

- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.

- V-shaped grass channels generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross-section is least desirable because it is difficult to stabilize the bottom where velocities may be high.

- Trapezoidal grass channels are used where runoff volumes are large and slope is low so that velocities are non-erosive 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, shall 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. Make repairs immediately.

- It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.

- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

BMP C202: Channel Lining

Purpose

To protect erodable channels by providing a channel liner using blankets or riprap.

Conditions of Use

- Channel lining must be used when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.

- When a permanent ditch or pipe system is to be installed and a temporary measure is needed.

- In almost all cases, synthetic and organic coconut blankets are more effective than riprap for protecting channels from erosion. Blankets can be used with and without vegetation. Blanketed channels can be designed to handle any expected flow and longevity requirement. Some synthetic blankets have a predicted life span of 50 years or more, even in sunlight.

- Other reasons why blankets are better than rock include the availability of blankets over rock. In many areas of the state, rock is not easily obtainable or is very expensive to haul to a site. Blankets can be delivered anywhere. Rock requires the use of dump trucks to haul and heavy equipment to place. Blankets usually only require laborers with hand tools, and sometimes a backhoe.

- The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 lbs/ft^2.

Design and Installation Specifications

- See BMP C122 for information on blankets.

- Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.

- Disturbance of areas where riprap is to be placed should be undertaken 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 children 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.

- Place a lining of engineering filter fabric (geotextile) between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Key the geotextile in at the top of the bank.

- Do not use filter fabric on slopes greater than 1-1/2H:1V as slippage may occur. Use it in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

BMP C203: Water Bars

Purpose

To divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch by constructing a small ditch or ridge of material diagonally across a road or right-of-way. See Figure 3-11

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.

- Base width of ridge: 6-inch minimum.

- Locate them to use natural drainage systems and to discharge into well vegetated stable areas.

- Guideline for Spacing:

Table 3-13. Water Bar Spacing

Slope %	Spacing (ft)
< 5	125
5 - 10	100
10 - 20	75
20 - 35	50
> 35	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope less than 2 percent.
- Install as soon as the clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.
- Compact the ridge when installed.
- Stabilize, seed and mulch the portions that are not subject to traffic. Gravel the areas crossed by vehicles.

Maintenance Standards

- Periodically inspect right-of-way diversions for wear and after every heavy rainfall for erosion damage.
- Immediately remove sediment from the flow area and repair the dike.
- Check outlet areas and make timely repairs as needed.
- When permanent road drainage is established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dikes and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

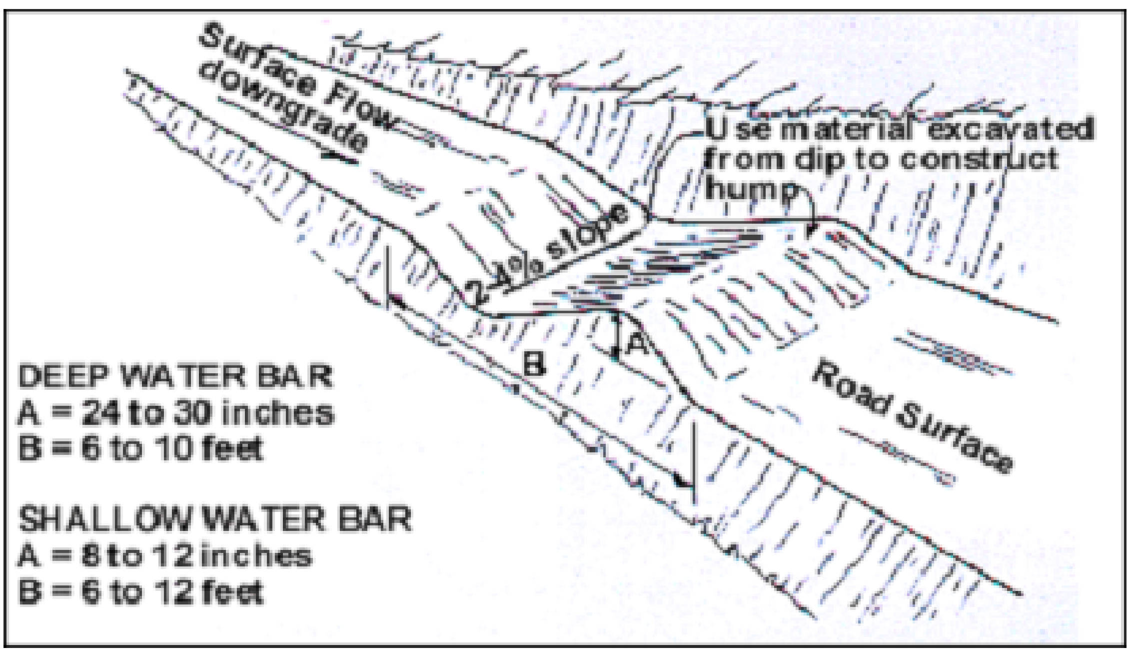


Figure 3-11. Water Bar
(Figure courtesy of SWMMWW)

BMP C204: Pipe Slope Drains

Purpose

To use a pipe to convey stormwater when diverting water away from (or over) bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use

Use pipe slope drains when a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion (Figure 3-12).

On highway projects, use pipe slope drains at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. These can be designed into a project and included as bid items. Another use on road projects is to collect runoff from pavement and pipe it away from side slopes. These are 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.

Water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

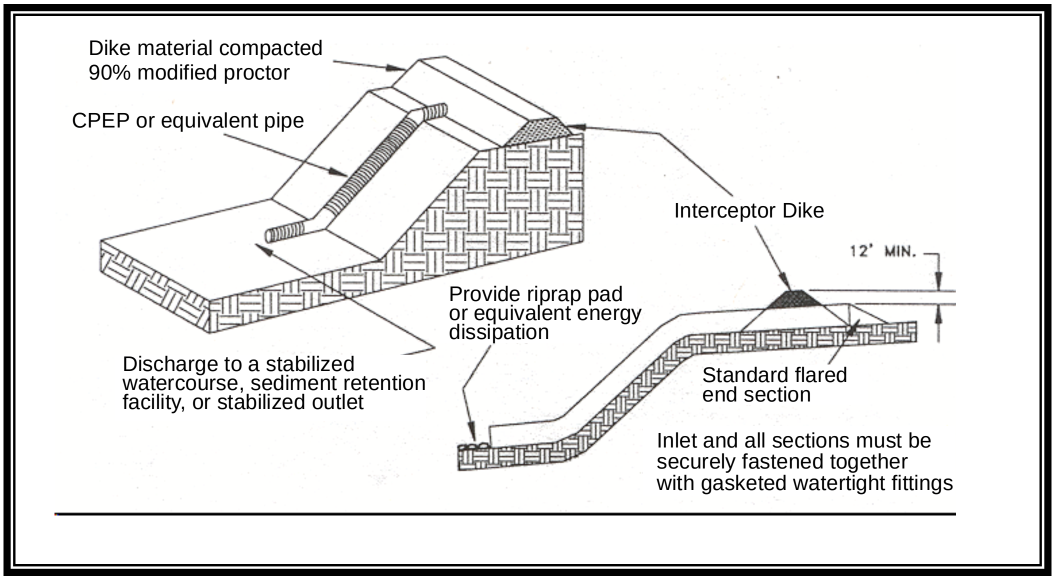


Figure 3-12. Pipe Slope Drain

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed;
- Used to drain water collected from aquifers exposed on cut slopes and take it to the base of the slope;
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil;
- Installed in conjunction with silt fence to drain collected water to a controlled area;
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement; and,
- Connected to existing down spouts and roof drains and used to divert water away from work areas during building renovation, demolition, and construction projects.

There are now several commercially available collectors that are attached to the pipe inlet and help prevent erosion at the inlet.

Design and Installation Specifications

- Size the pipe to convey the flow. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10-year, 24-hour storm event, assuming a Type 1A rainfall distribution. Alternatively, use 1.6 times the 10-year, 1-hour time-step flow indicated by an approved continuous runoff model. If a 15-minute (or less) time step is used, no correction factor is required. See Volume III, Chapter 3 for sizing requirements for 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 diversion dikes or swales to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Dike material shall be compacted to 90 percent modified proctor to prevent piping of water through the berm. The entrance area is a common failure location.
- 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.
- Install thrust blocks anytime 90 degree bends are used. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “t” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “t” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. Do this approximately every 10 to 20 feet of pipe length, depending on the size of the pipe and quantity of water to be diverted.
- Interceptor dikes shall be used to direct runoff into a 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 with a riprap apron (see BMP C209 Outlet Protection, for the appropriate outlet material).

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Materials specifications for any permanent piped system are listed in Volume III, Section 3.7.3 and shall be acceptable to the County.

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, reinforce the headwall with compacted earth or sand bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe, however, debris may become lodged in the pipe. Remove debris immediately.

BMP C205: Subsurface Drains

Purpose

To intercept, collect, and convey ground water to a satisfactory outlet, using a perforated pipe or conduit below the ground surface. Subsurface drains are also known as "french drains". The perforated pipe provides a dewatering mechanism to drain excessively wet soils, provide a stable base for construction, improve stability of structures with shallow foundations, and to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

Use when you must remove excessive water 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

- **Relief drains** are used either to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.
  - They are installed along a slope and drain in the direction of the slope.
  - They can be installed in a grid pattern, a herringbone pattern, or a random pattern.
- **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.
  - They are installed perpendicular to a slope and drain to the side of the slope.
  - They usually consist of a single pipe or series of single pipes instead of a patterned layout.
- **Depth and spacing of interceptor drains –** The depth of an interceptor drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer. For practical reasons, the maximum depth is usually limited to 6 feet, with a minimum cover of 2 feet to protect the conduit.
- The soil should have depth and sufficient permeability to permit installation of an effective drainage system at a depth of 2 to 6 feet.
- An adequate outlet for the drainage system must be available either by gravity or by pumping.
- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).

- This standard does not apply to subsurface drains for building foundations or deep excavations.
- The capacity of an interceptor drain is determined by calculating the maximum rate of ground water flow to be intercepted. Therefore, it is good practice to make complete subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.
- Size of drain – Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity required to prevent silting is 1.4 ft./sec. The line shall be graded 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 shall surround the drain to a minimum of 3-inch thickness.
- The outlet of the subsurface drain shall empty into a sediment pond 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.
- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the 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.
- Outlet – Ensure that the outlet of a 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

- Check subsurface drains periodically to ensure that they are free-flowing and not clogged with sediment or roots.
- Keep the outlet clean and free of debris.
- Keep the surface inlets open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Plan drain placement to minimize this problem.
- Where drains are crossed by heavy vehicles use steel plate or boards to prevent the lines from being crushed. After work is complete the line shall be checked to ensure that it was not crushed.

BMP C206: Level Spreader

Purpose

To provide a temporary outlet for dikes and diversions, and to convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Conditions of Use

- A level spreader consists of an excavated depression constructed at zero grade across a slope. It is used when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.
- Items to consider are:
    1. What is the risk of erosion or damage if the flow may become concentrated?
    2. Is an easement required if discharged to adjoining property?
    3. Most of the flow should be as ground water and not as surface flow.
    4. Is there an unstable area downstream that cannot accept additional ground water?
- Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Design and Installation Specifications

- Use above undisturbed areas that are stabilized by existing vegetation.
- If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.
- Discharge area below the outlet must be uniform with a slope of less than 5H:1V.
- Construct the outlet level in a stable, undisturbed soil profile (not on fill).
- Do not allow the runoff to re-concentrate after release unless intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- Place a 6-inch high gravel berm across the level lip consisting of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.

- The spreader length shall be determined by estimating the peak flow expected from the 10-year, 24-hour design storm. The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall be 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 spreader shall be at least 6 feet.

- The depth of the spreader as measured from the lip shall be at least 6 inches and it should be uniform across the entire length.

- Level spreaders shall be setback 100 feet minimum from the property line unless there is an easement for flow or the flow is directed to a natural drainage course.

- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sand bags, lumber, plastic lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figure 3-13 and Figure 3-14 provide a cross-section and a detail of a level spreader. A capped perforated pipe can also be used as a spreader.

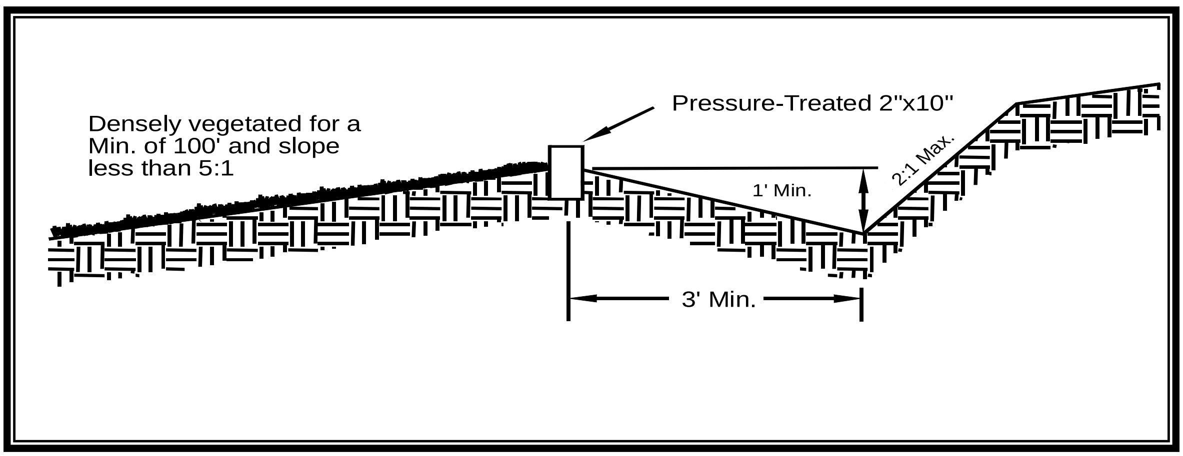


Figure 3-13. Cross-Section of Level Spreader

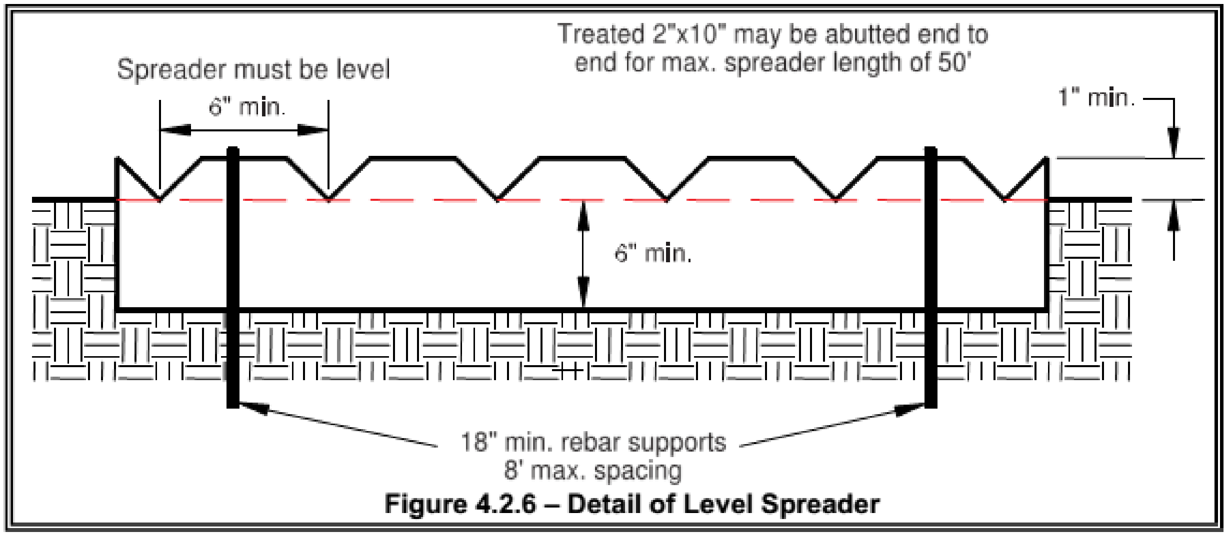


Figure 3-14. Detail of Level Spreader

Maintenance Standards

- Inspect the spreader after every runoff event to ensure that it is functioning correctly.
- The contractor should avoid the placement of any material on the structure and should prevent construction traffic from crossing over the structure.
- If the spreader is damaged by construction traffic, it shall be immediately repaired.

BMP C207: Check Dams

Purpose

Check dams are used to reduce the velocity of concentrated flow and dissipate energy.

Conditions of Use

- Use check dams where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, and velocity checks are required.
- 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 Thurston County and/or another applicable 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

- Whatever material is used, the dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the dam rather than falling directly onto the ditch bottom.
- 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 in association with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. Provide a deep sump 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.
- Construct rock check dams with appropriately sized rock. Place the rock by hand or by mechanical means (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.
- 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 maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Keep the maximum height at 2 feet at the center of the dam.
- Keep the center of the check dam at least 12 inches lower than the outer edges at natural ground elevation.
- Keep the side slopes of the check dam at 2:1 or flatter.
- Key the stone into the ditch banks and extend it beyond the abutments a minimum of 18 inches to avoid washouts from overflow around the dam.
- Use filter fabric foundation under a rock or sand bag check dam. If a blanket ditch liner is used, this is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- In the case of grass-lined ditches and swales, 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. Figure 3-15 depicts a typical rock check dam.

Maintenance Standards

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. 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.

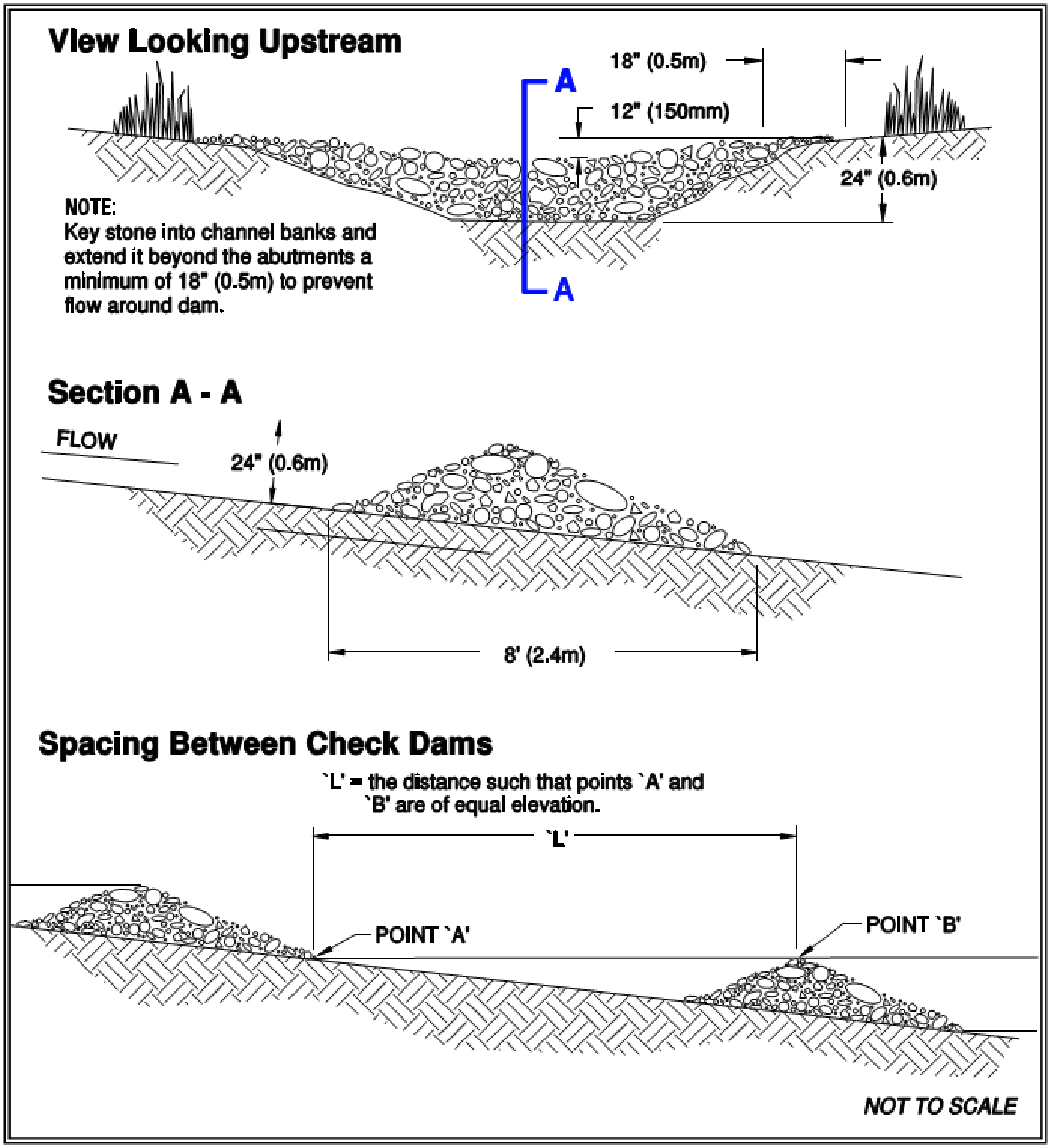


Figure 3-15. Check Dams

BMP C208: Triangular Silt Dike (TSD) (Geotextile-Encased Check Dam)

Purpose

Triangular silt dikes may be used as check dams for perimeter protection, temporary soil stockpile protection, drop inlet protection, or as a temporary interceptor dike.

Conditions of Use

- May be used on soil or pavement with adhesive or staples.
- TSDs have been used to build temporary:
  1. sediment ponds;
  2. diversion ditches;
  3. concrete wash out facilities;
  4. curbing;
  5. water bars;
  6. level spreaders; and
  7. berms.

Design and Installation Specifications

- Silt dikes are typically made of urethane foam sewn into a woven geosynthetic fabric.
- It is triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2–foot apron extends beyond both sides of the triangle along its standard

section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.

- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples shall be No. 11 gauge wire and shall be 200 mm to 300 mm (8 in to 12 in) 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.
- Locate and install check dams as soon as construction will allow.
- Place check dams perpendicular to the flow of water.
- When used as check dams, the leading edge 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

- Triangular silt dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the height of the dam.
- Anticipate submergence and deposition above the triangular silt dam and erosion from high flows around the edges of the dam. Immediately repair any damage or any undercutting of the dam.

BMP C209: Outlet Protection

Purpose

To prevent scour at conveyance outlets and minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of Use

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or man-made drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

- The receiving channel at the outlet of a culvert shall be protected from erosion by rock 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 large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.

- Standard wingwalls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection. (See WSDOT Hydraulic Manual, available through WSDOT Engineering Publications, or on-line.)

- Organic or synthetic erosion blankets, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.

- With low flows, vegetation (including sod) can be effective.

- The following guidelines shall be used for riprap outlet protection:

    1. If the discharge velocity at the outlet is less than 5 fps (pipe slope less than 1 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1 foot.

    2. For 5 to 10 fps discharge velocity at the outlet (pipe slope less than 3 percent), use 24-inch to 4-foot riprap. Minimum thickness is 2 feet.

    3. For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used.

- Filter fabric or erosion control blankets shall always be used under riprap to prevent scour and channel erosion.

- 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 dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a HPA from WDFW. See Volume III for more information on outfall system design.

Maintenance Standards

- Inspect and repair as needed.

- Add rock as needed to maintain the intended function.

- Clean energy dissipater if sediment builds up.

BMP C220: Storm Drain Inlet Protection

Purpose

Inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of a disturbed area.

Conditions of Use

Use this BMP where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.

Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters in new home construction 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 3-14lists several options for inlet protection. All of the methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance. Limit drainage areas to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Table 3-14. 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 will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large Area Requirement: 30' X 30'/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		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 a 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			18 month expected life.

Design and Installation Specifications

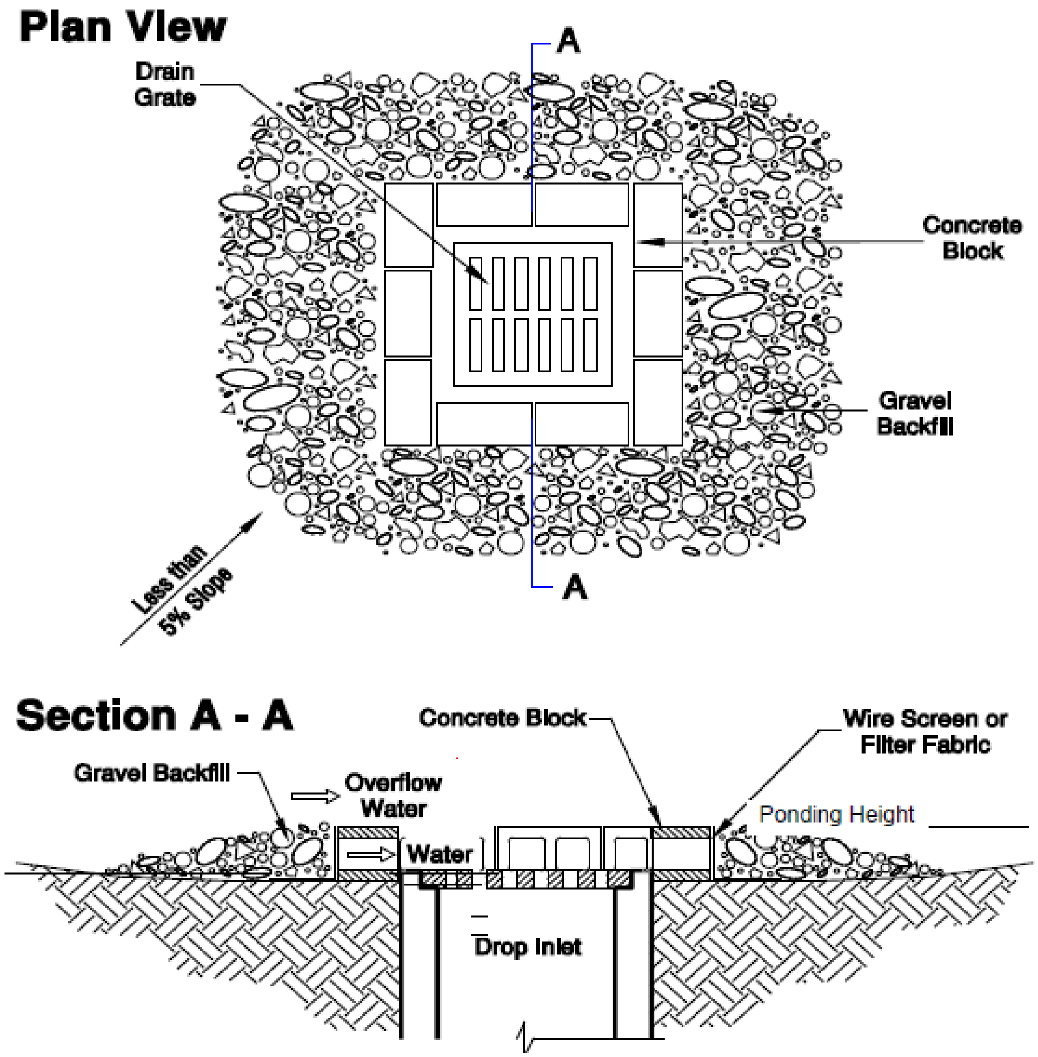
Excavated Drop Inlet Protection – An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

- Depth 1 to 2 feet as measured from the crest of the inlet structure.
- Side Slopes of excavation no steeper than 2H:1V.
- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.

- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

Block and Gravel Drop Inlet Protection – A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See Figure 3-16.

- Provide a height of 1 to 2 feet above inlet.
- Recess the first row 2-inches into the ground for stability.
- Support subsequent courses by placing a 2x4 through the block opening.
- Do not use mortar
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of 2H:1V or flatter.
- An alternative design is a gravel donut.
- Provide an inlet slope of 3H:1V.
- Provide an outlet slope of 2H:1V.
- Provide a 1-foot wide level stone area between the structure and the inlet.
- Use inlet slope stones 3 inches in diameter or larger.
- Use gravel ½ - to ¾-inch at a minimum thickness of 1-foot for the outlet slope.



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.

Figure 3-16. Block and Gravel Filter

Gravel and Wire Mesh Filter- A gravel barrier placed over the top of the inlet. This structure does not provide an overflow.

- Use a hardware cloth or comparable wire mesh with ½-inch openings.
- Use course aggregate.

- 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 course aggregate over the wire mesh.
- Provide at least a 12-inch depth of coarse aggregate over the entire inlet opening and extend at least 18-inches on all sides.

Catchbasin Filters – Use inserts 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 catchbasin 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.

- 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 catchbasin filter in the catchbasin just below the grating.

Curb Inlet Protection with Wooden Weir – Barrier formed around a curb inlet with a wooden frame and gravel.

- Wire mesh with 1/2-inch openings.
- Extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against wire/fabric.
- Place weight on frame anchors.
- See Figure 3-17

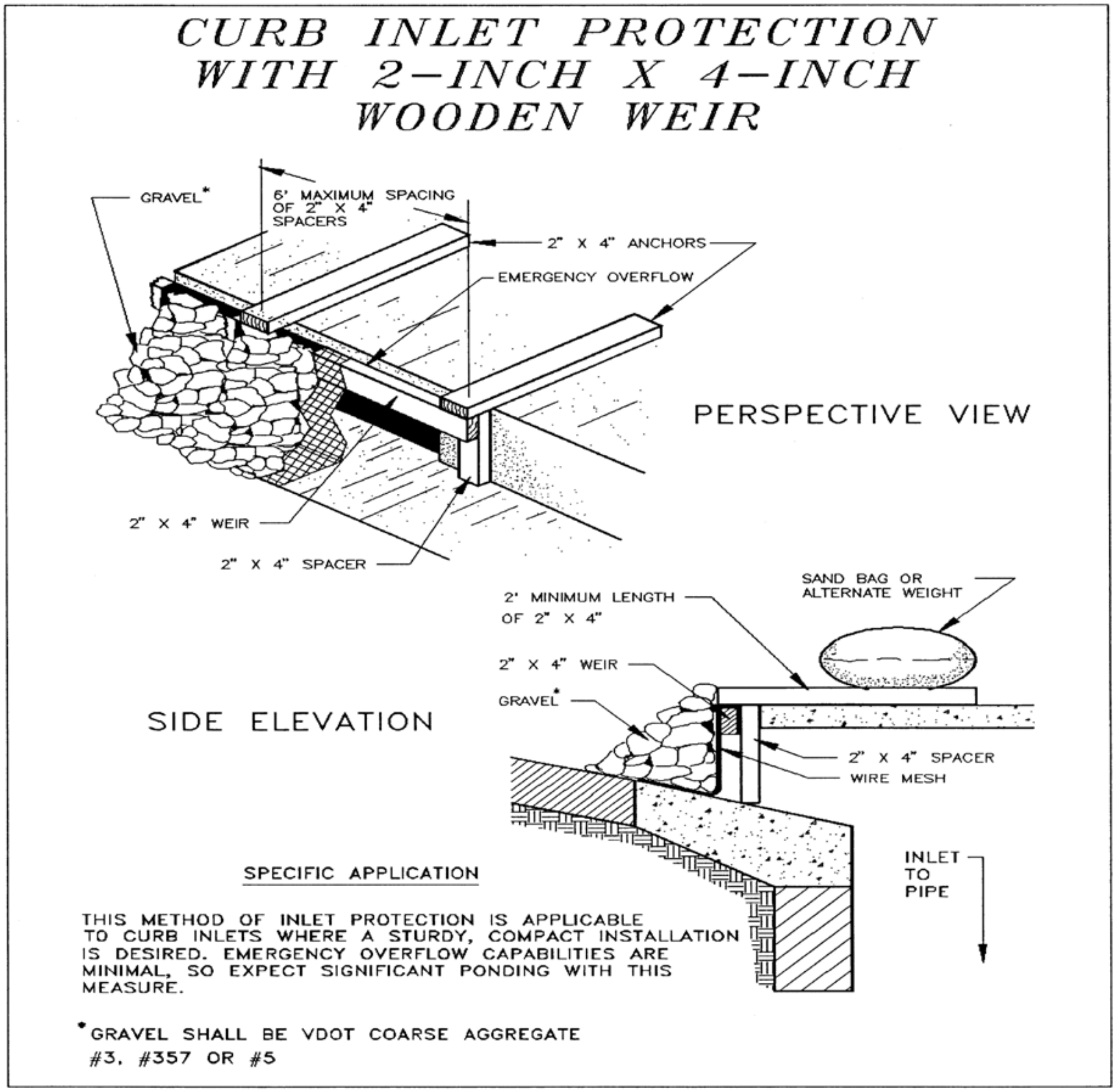


Figure 3-17. Curb Inlet with Wooden Weir
(Figure courtesy of Maryland Standards and Specifications for Soil Erosion and Sediment Control)

Block and Gravel Curb Inlet Protection – Barrier formed around a curb inlet with concrete blocks and gravel. See Figure 3-18.

- 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 course aggregate against the wire to the top of the barrier.

Curb and Gutter Sediment Barrier – Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 3-19.

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.

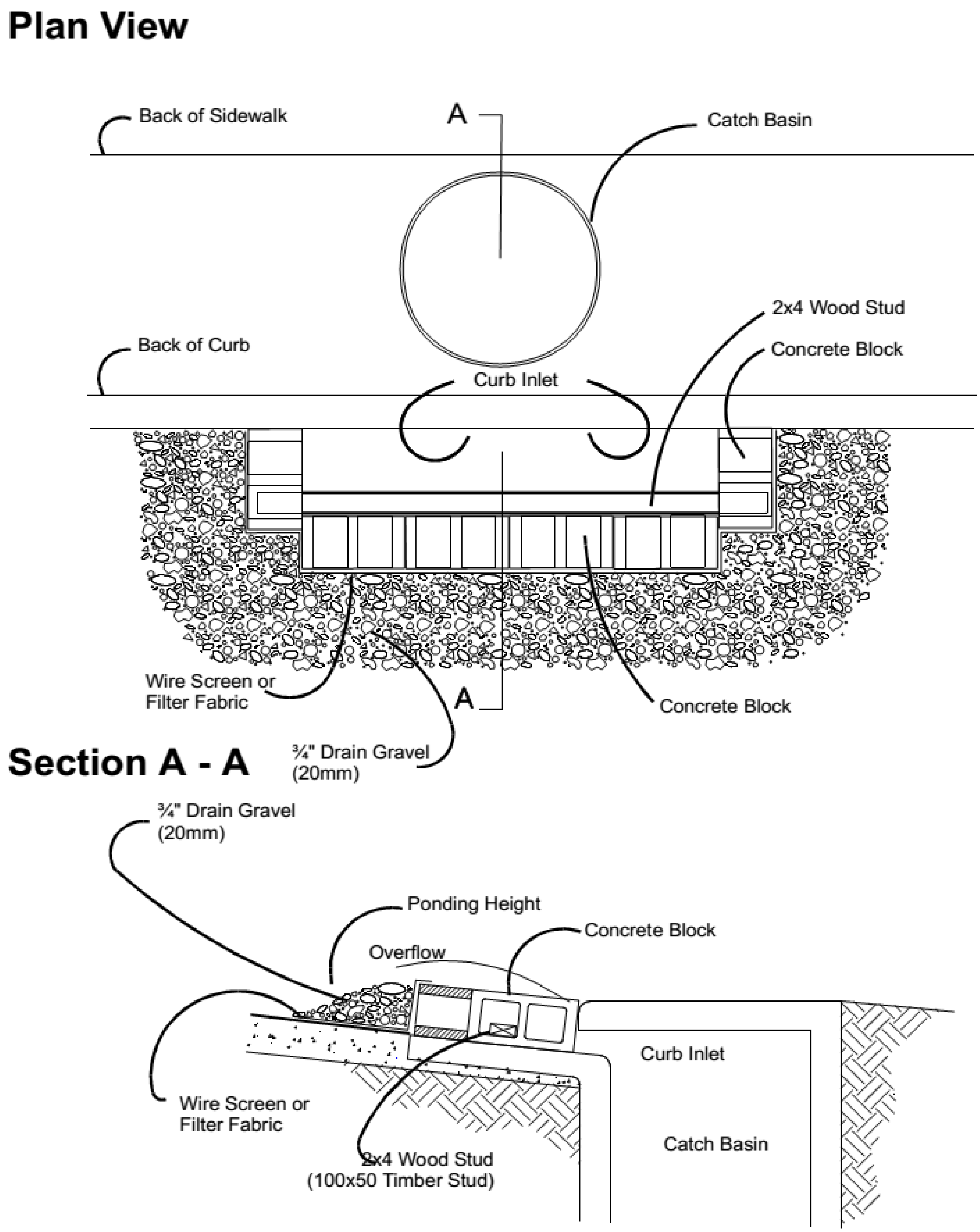
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.

Maintenance Standards

- Inspect catch basin filters frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.

- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

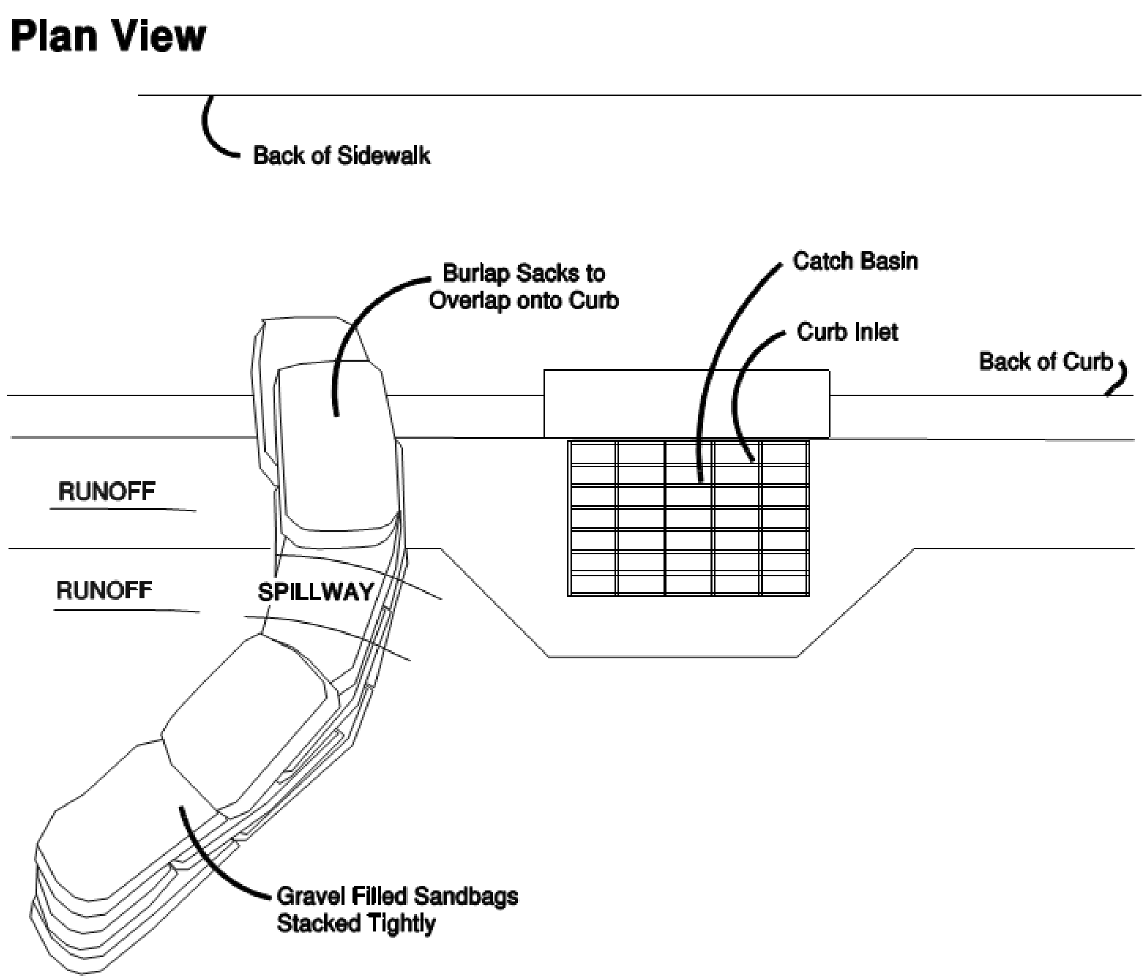
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.



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.

Figure 3-18. Block and Gravel Curb Inlet Protection



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.

Figure 3-19. Curb and Gutter Barrier

BMP C231: Brush Barrier

Purpose

To reduce the transport of course 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 all disturbed area of less than one-quarter acre.
- Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a brush barrier, rather than a sediment pond, 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) can be used to construct brush barriers.
- A 100 percent biodegradable installation can be constructed using 10-ounce burlap held in place by wooden stakes. Figure 3-20 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.

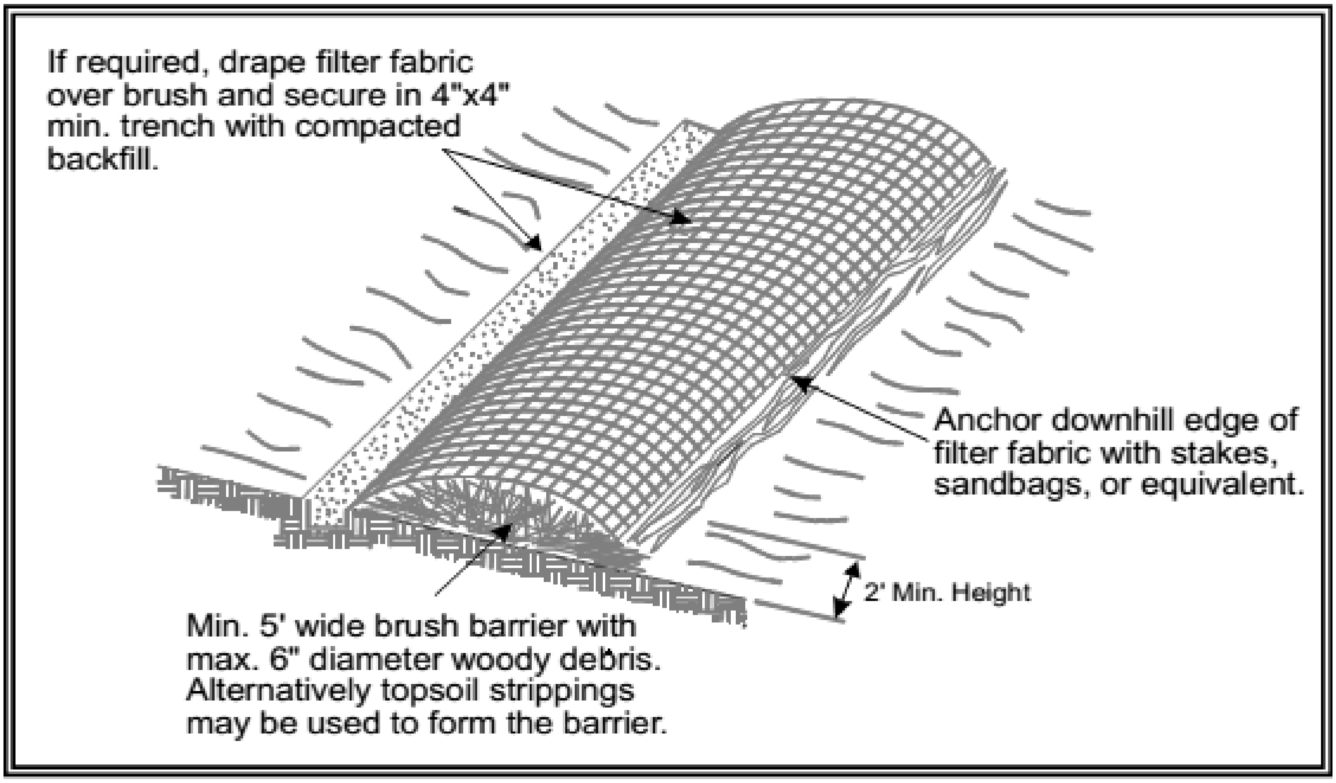


Figure 3-20. Brush Barrier

BMP C232: Gravel Filter Berm

Purpose

To retain sediment within a construction site by using a filter berm of gravel or crushed rock constructed on rights-of-way or traffic areas.

Conditions of Use

- Where temporary measures are needed to retain sediment from rights-of-way or in traffic areas on construction sites.

Design and Installation Specifications

- Berm material shall be ¾ to 3 inches in size, washed well-graded gravel or crushed rock with less than 5 percent fines (% passing the 200 sieve).
- 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.

Maintenance Standards

- Regular inspection is required.
- Sediment shall be removed and filter material replaced as needed.

BMP C233: Silt Fence

Purpose

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. See Figure 3-21 for details on silt fence construction.

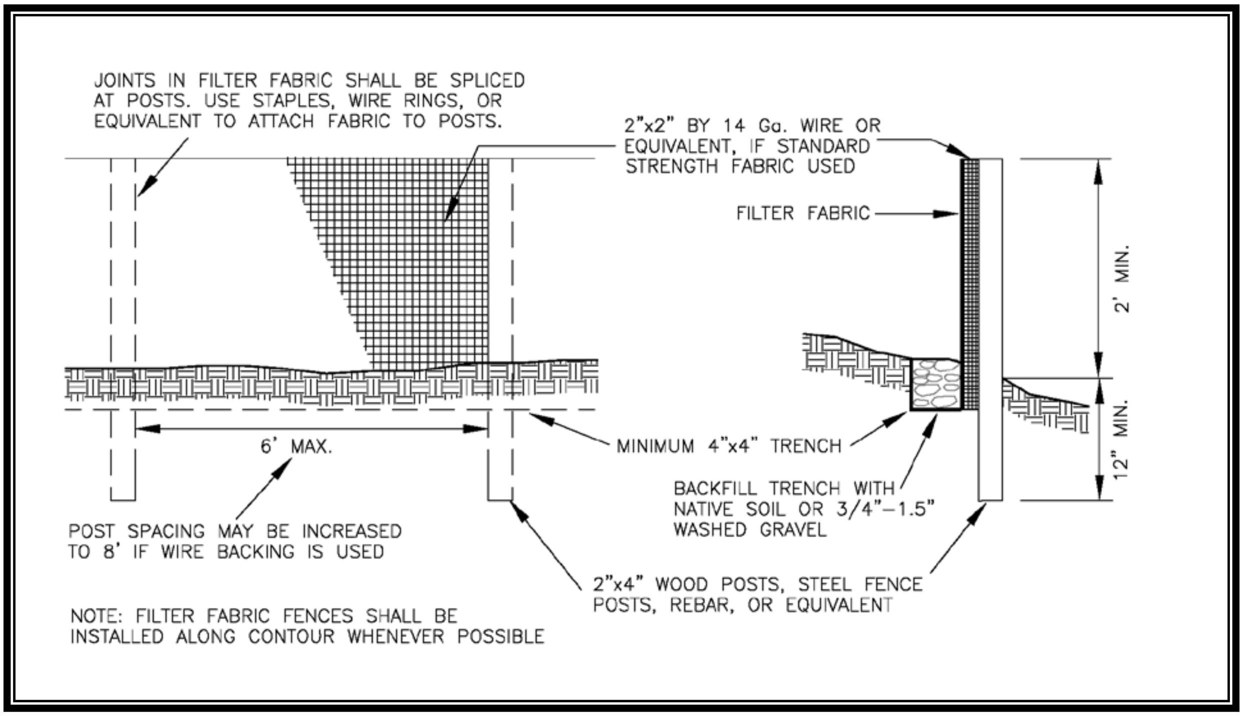


Figure 3.21 Silt Fence

- Silt fence may be used downslope of all disturbed areas.
- Silt fence shall prevent soil carried by runoff water 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 pond.
- Silt fences should not be constructed in streams or use in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

Design and Installation Specifications

- Use in combination with sediment basins or other BMPs.

- Maximum slope steepness (normal (perpendicular) to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- No flows greater than 0.5 cfs.
- The geotextile used for filter fabric shall meet 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 3-15):

Table 3-15. Geotextile Standards

Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film wovens (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Support standard strength fabrics with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.
- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.
- 100 percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed..
- Include the following Standard Notes for silt fence on construction plans and specifications. Refer to Figure 3.16 for standard silt fence details.

    1. The contractor shall install and maintain temporary silt fences at the locations shown in the Plans.
    2. Silt fences shall be constructed in the areas of clearing, grading, or drainage prior to starting those activities.
    3. The silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.

4. The minimum height of the top of silt fence shall be 2 feet and the maximum height shall be 2-1/2 feet above the original ground surface.

5. The geotextile shall be sewn together at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths as required. All sewn seams shall be located at a support post. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.

6. The geotextile shall be attached on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. The geotextile shall be attached to the posts in a manner that reduces the potential for geotextile tearing at the staples, wire, or other connection device.

7. Silt fence back-up support for the geotextile in the form of a wire or plastic mesh is dependent on the properties of the geotextile selected for use. If wire or plastic back-up mesh is used, the mesh shall be fastened securely to the up-slope side of the posts with the geotextile being up-slope of the mesh back-up support.

8. 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 filter fabric it supports.

9. The geotextile at the bottom of the fence shall be buried in a trench to a minimum depth of 4 inches below the ground surface. The trench shall be backfilled and the soil tamped in place over the buried portion of the geotextile, such that no flow can pass beneath the fence and scouring cannot occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches.

10. Drive or place the fence posts a minimum of 18 inches into the ground. A minimum depth of 12 inches is allowed if topsoil or other soft subgrade soil is not present and a minimum depth of 18 inches cannot be reached. Fence post depths shall be increased 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.

11. Silt fences shall be located 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, gravel check dams placed perpendicular to the back of the fence shall be used to minimize concentrated flow and erosion along the back of the fence.

- The gravel check dams shall be approximately 1 foot deep at the back of the fence. It 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.
- The gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. The gravel check dams shall be located every 10 feet along the fence where the fence must cross contours.
- The slope of the fence line where contours must be crossed shall not be steeper than 3:1.

13. Wood, steel or equivalent posts shall be used. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of either:

- Wood posts with minimum dimensions of 2 inches by 2 inches and 3 feet minimum length. Wood posts shall be free of defects such as knots, splits, or gouges.
- No. 6 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.

14. Other steel posts having equivalent strength and bending resistance to the post sizes listed. Fence back-up 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 ultraviolet radiation as the geotextile it supports.

- Silt fence installation using the slicing method specification details follow. Refer to Figure 3-22 for slicing method details.

1. The base of both end posts must be at least 2 to 4 inches above the top of the silt fence 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 fabric, enabling posts to support the fabric from upstream water pressure.

4. Install posts with the nipples facing away from the silt fence fabric.

5. Attach the filter 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. In addition, position each tie to hang on a post nipple when tightening to prevent sagging.

6. Wrap approximately 6 inches of fabric around the end posts and secure with three ties.

7. No more than 24 inches of a 36-inch fabric is allowed above ground level.

- The installation should be checked and corrected for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

- Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence 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.

Maintenance Standards

- Any damage shall be repaired immediately.

- If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment pond.

- It is important to check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.

- Sediment deposits shall either be removed when the deposit reaches approximately one-third the height of the silt fence, or a second silt fence shall be installed.

- If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, it shall be replaced.

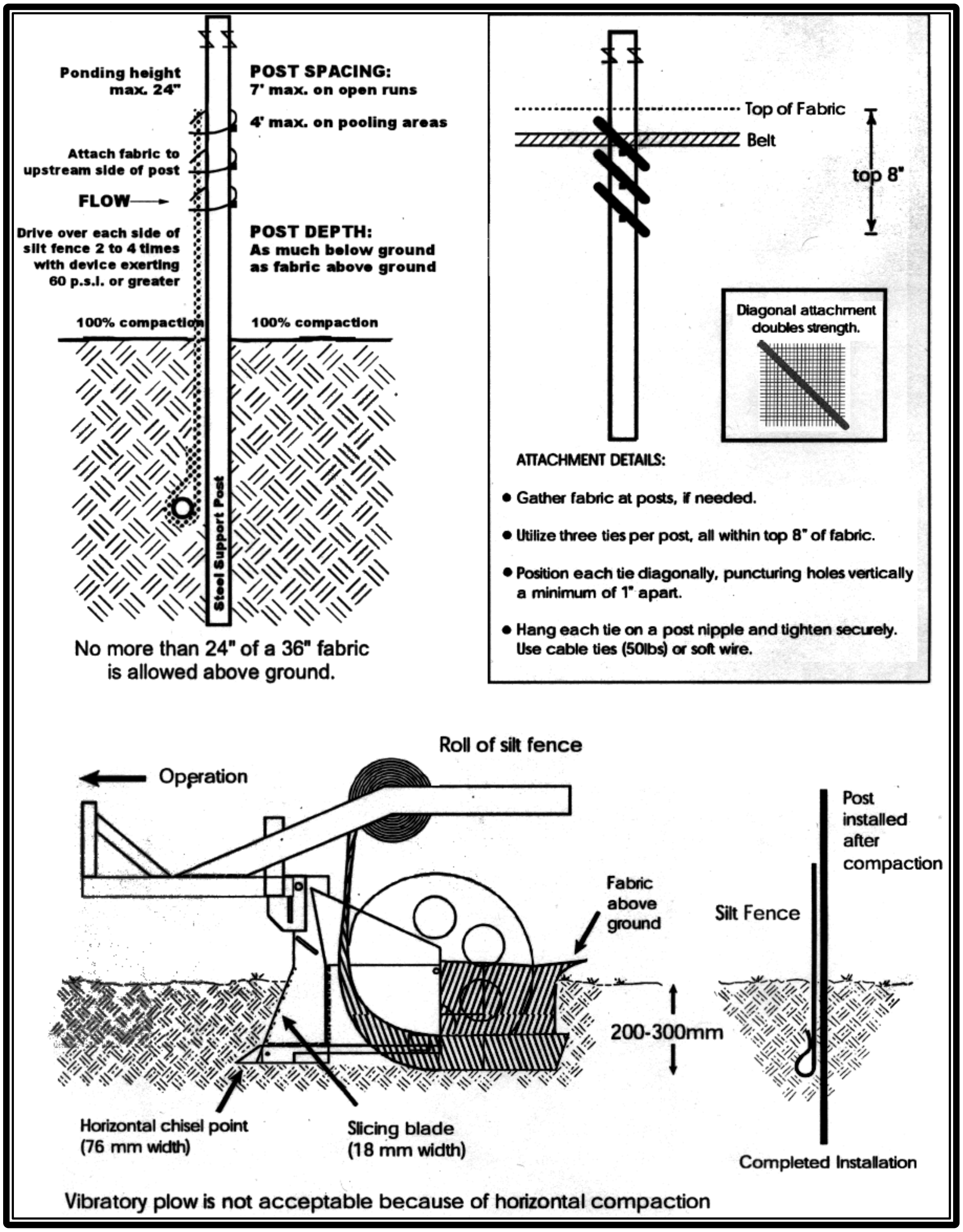


Figure 3-22 - Silt Fence Installation by Slicing Method

BMP C234: Vegetated Strip

Purpose

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

- 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 a sediment pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment pond, is when the criteria shown in Table 3-16 are met.

Table 3-16. Vegetated Strips

Average Slope of Contributing Area	Slope Percent	Contributing Flowpath Length
1.5H:1V or less	67% or less	100 feet
2H:1V or less	50% or less	115 feet
4H:1V or less	25% or less	150 feet
6H:1V or less	16.7% or less	200 feet
10H:1V or less	10% or less	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a continuous strip of dense vegetation with topsoil and have a minimum 25-foot long 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 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 buffer, surface water controls must be installed to reduce the flows entering the buffer, or additional perimeter protection must be installed.

BMP C235: Straw Wattles

Purpose

To reduce the velocity and spread the flow of rill and sheet runoff, and to capture and retain sediment.

Straw wattles are temporary erosion and sediment control barriers consisting of straw, compost, or other material that is wrapped in biodegradable tubular plastic or similar encasing material. They are typically 8 to 10 inches in diameter and 25 to 30 feet in length. The wattles are placed in shallow trenches and staked along the contour of disturbed or newly constructed slopes. See Figure 3-23 for typical construction details. WSDOT Standard Plan I-30.30-00 also provides information on Wattles (http://www.wsdot.wa.gov/Design/Standards/Plans.htm#SectionI)

Conditions of Use

- Use Wattles:
    1. In disturbed areas that require immediate erosion protection.
    2. 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. Wattles are typically effective for one to two wet seasons.
- If conditions are appropriate, wattles can be staked to the ground using willow cuttings for added revegetation.

- Prevent rilling beneath wattles by properly entrenching and abutting wattles together to prevent water from passing between them.

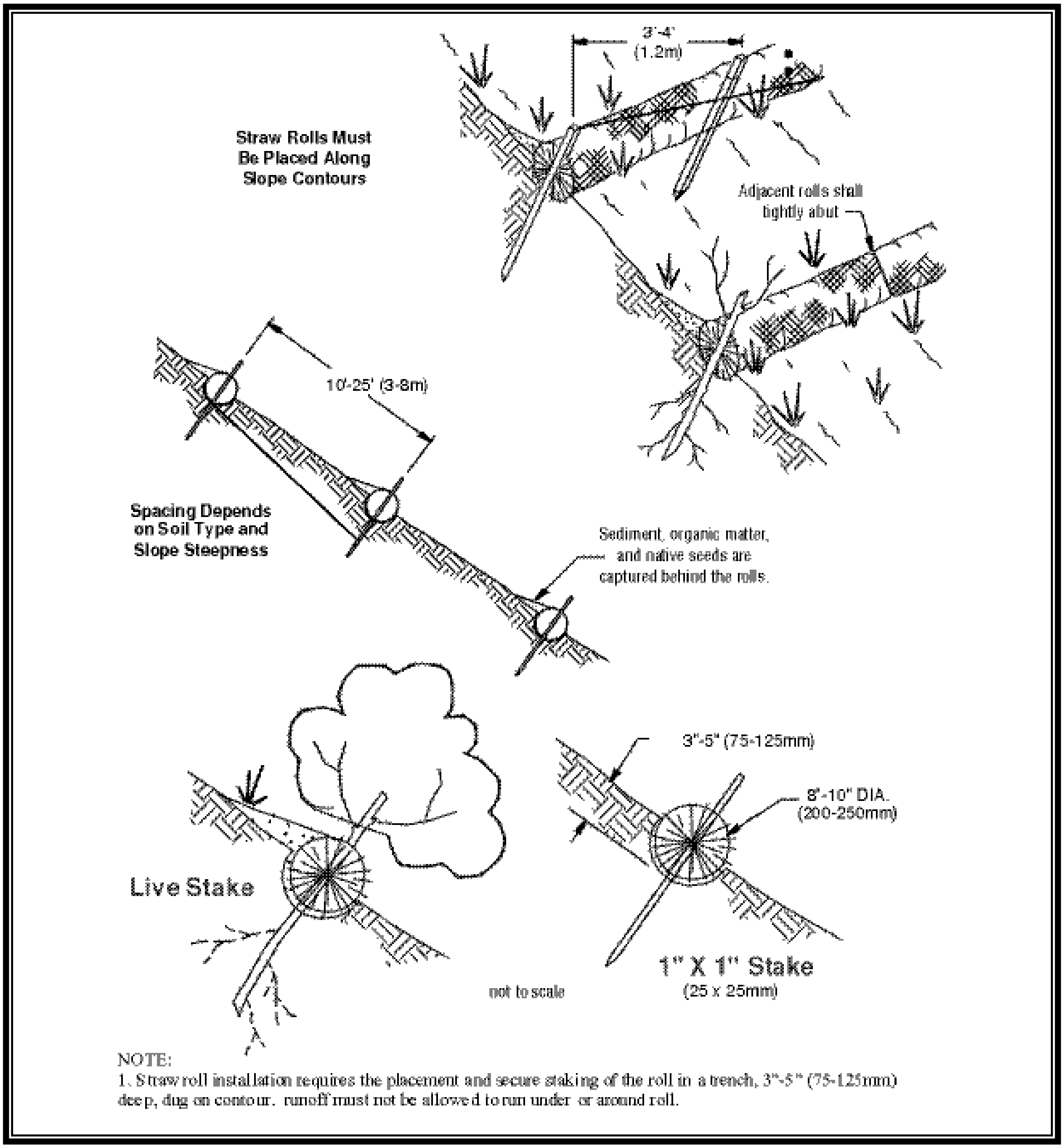


Figure 3-23. Straw Wattles

Design Criteria

- Install wattles perpendicular to the flow direction and parallel to the slope contour.

- Install wattles in 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, install wattles in trenches to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material evenly along the uphill slope and compact using hand tamping or other methods.
- Construct trenches on contours at intervals of 10 to 40-feet depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches need to be. See Table 3-17 for spacing information.
- Install the wattles snugly into the trenches and abut tightly end to end. Do not overlap the ends.
- 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 shall be approximately 3/4 x 3/4 x 24 inches. 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.

Table 3-17 Wattle Spacing Table

8” Diameter Wattle Spacing Table	
Slope	Maximum Spacing
1H:1V	10’-0”
2H:1V	20’-0”
3H:1V	30’-0”
4H:1V	40’-0”

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.

BMP C236: Vegetative Filtration

Purpose

To improve turbidity levels of stormwater discharges by filtering through existing vegetation where undisturbed forest floor duff layer or established lawn with thatch layer are present or to infiltrate dewatering wastewater from foundations, vaults, and trenches as long as runoff does not occur. Vegetative Filtration may be used in conjunction with BMP C241, *Temporary Sediment Ponds,* BMP C206, *Level Spreader* and a pumping system with surface intake.

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. See Table 3-18for flowpath length requirements based on vegetative filtration area.
- 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 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 needed for this BMP.
- Stop distributing water into the vegetated area if standing water or erosion results.

Design Criteria

- Find land adjacent to the project that has a vegetated field, preferably a farm field, or wooded area.
- If the project 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 (many 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" schedule 20, swaged-fit common septic tight-lined sewer line, or 6" fire hose, which can convey the turbid water out to various sections of the field. See Figure 3-24.

- Determine the branch length based on the field area geography and number of branches. Typically, branches stretch from 200-feet to several thousand feet. Always lay branches on contour with the slope.

- On uneven ground, sprinklers perform well. Space sprinkler heads so the 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. Pipe should be placed with the holes up to allow for a gentle weeping of stormwater evenly out all holes. Leveling the pipe by staking and using sandbags may be required.

- To prevent the over saturation of the field area, rotate the use of branches or spray heads. Do this as needed based on monitoring the spray field.

Table 3-18. Flowpath Guidelines for Vegetative Filtration

Average Slope of Vegetated Area	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

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.

- Since the operator is handling contaminated water, physically monitor the vegetated spray field all the way down to the nearest surface water, or furthest spray area to ensure that the water has not caused overland or concentrated flows, and has not created erosion around the spray nozzle.

- Monitoring usually needs to take place 3 to 5 times per day to ensure sheet-flow into state waters. Do not exceed water quality standards for turbidity.

- A separate inspection log shall be developed, maintained and kept with the existing site logbook to aid the operator conducting inspections. This separate "Field Filtration Logbook" can also aid the facility in demonstrating compliance with permit conditions.

- Inspect the spray nozzles daily, at a minimum, for leaks and plugging from sediment particles.

- If erosion, concentrated flows, or over saturation of the field occurs, rotate the use of branches or spray heads or move the branches to a new field location.

- Check all branches and the manifold for unintended leaks.

Figure 3-24. Manifold and Branches in wooded, vegetated spray field

BMP C240: Sediment Trap

Purpose

To collect and store sediment from sites cleared and/or graded during construction.

A sediment trap is a small temporary ponding area using a gravel outlet. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

- Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or trap or other appropriate sediment removal best management practice.

- Non-engineered sediment traps may be used on-site prior to an engineered sediment trap or sediment pond to provide additional sediment removal capacity.

- 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 6 months or less.

- The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by 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.

- Whenever possible, sediment-laden water shall be discharged into on-site, relatively level, vegetated areas (see BMP C234 – Vegetated Strip). This is the only way to effectively remove fine particles from runoff unless chemical treatment or filtration is used. This can be particularly useful after initial treatment in a sediment trap. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose.

- Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it, because of the possibility of pump failure or runoff volume in excess of pump capacity.

- All projects that are constructing permanent facilities for runoff quantity control should use the rough-graded or final-graded permanent facilities for traps. This includes combined facilities and infiltration facilities. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to no more than of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized.

- When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap or pond must be met. If the surface area requirements are larger than the surface area of the permanent facility, the trap or pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds.

- Either a permanent control structure or the temporary control structure (described in BMP C241, Temporary Sediment Pond) can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond. A shut-off valve may be added to the control structure to allow complete retention of stormwater in emergency situations. In this case, an emergency overflow weir must be added.

- A skimmer may be used for the sediment trap outlet.

Design and Installation Specifications

- See Figure 3-25 and Figure 3-26 for details.

- If permanent runoff control facilities are part of the project, use them for sediment retention (see Conditions of Use provisions above).

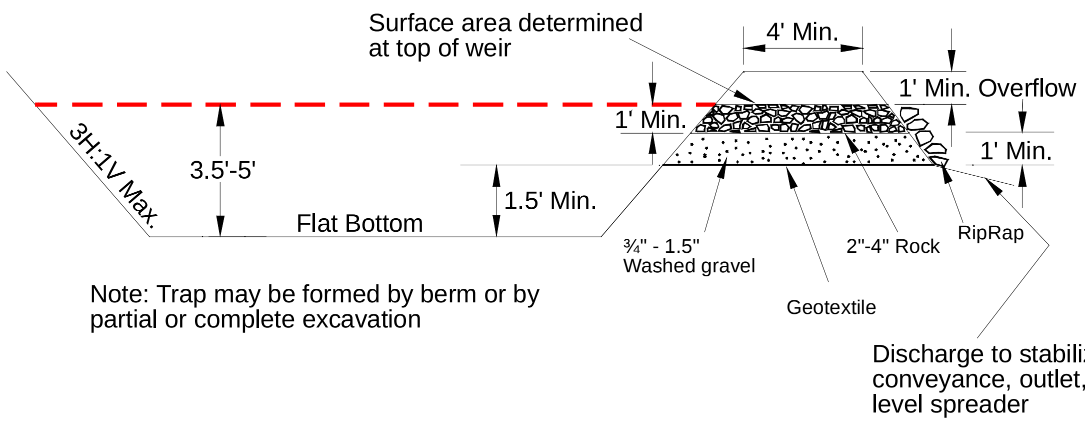


Figure 3-25. Cross Section of Sediment Trap

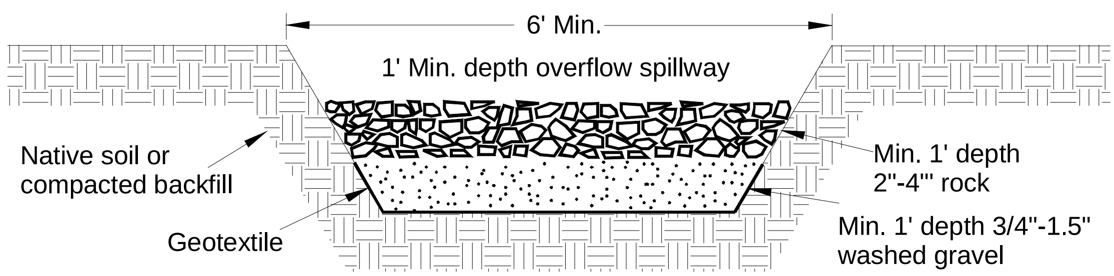


Figure 3-26. Sediment Trap Outlet

- 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 = Design inflow (cfs) based on the peak discharge from the developed 2-year runoff event from the contributing drainage area as computed in the hydrologic analysis. The 10-year recurrence interval peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

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/cm^3 has been selected as the particle of interest and has a settling velocity (V_s) of 0.00096 ft/sec.

FS A safety factor of 2 to account for non-ideal settling.

Therefore, the equation for computing surface area becomes:

$SA = 2 \times Q_2/0.00096$

OR

2,080 square feet per cfs of inflow

Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent labeled mark for each 1-foot interval above the bottom of the trap.
- 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.

Maintenance Standards

- Sediment shall be removed from the trap when it reaches 1 foot in depth.
- Any damage to the pond embankments or slopes shall be repaired.

BMP C241: Temporary Sediment Pond

Purpose

To remove sediment from runoff originating from disturbed areas of the site.

Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they may reduce turbidity only slightly.

Conditions of Use

- Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or other appropriate sediment removal best management practice.
- A sediment pond shall be used where the contributing drainage area is 3 acres or more. Ponds must be used in conjunction with erosion control practices to reduce the amount of sediment flowing into the basin.

Design and Installation Specifications

- Sediment ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities.
- Sediment traps and ponds are attractive to children and can be very dangerous. If fencing of the pond is planned, the type of fence and its location shall be shown on the ESC plan.
- Structures having a maximum storage capacity at the top of the dam of 10 acre-ft (435,600 ft3) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).
- See Figure 3-27, Figure 3-28, and Figure 3-29 for details.
- If permanent runoff control facilities are part of the project, use them for sediment retention. The surface area requirements of the sediment pond must be met. This may require temporarily enlarging the permanent pond to comply with the surface area requirements. The permanent control structure must be temporarily replaced with a control structure that only allows water to leave the pond from the surface or by pumping. The permanent control structure must be installed after the site is fully stabilized.
- Use of infiltration facilities for sedimentation ponds during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to no more than 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. The

infiltration pretreatment facility should be fully constructed and used with the sedimentation pond to help prevent clogging.

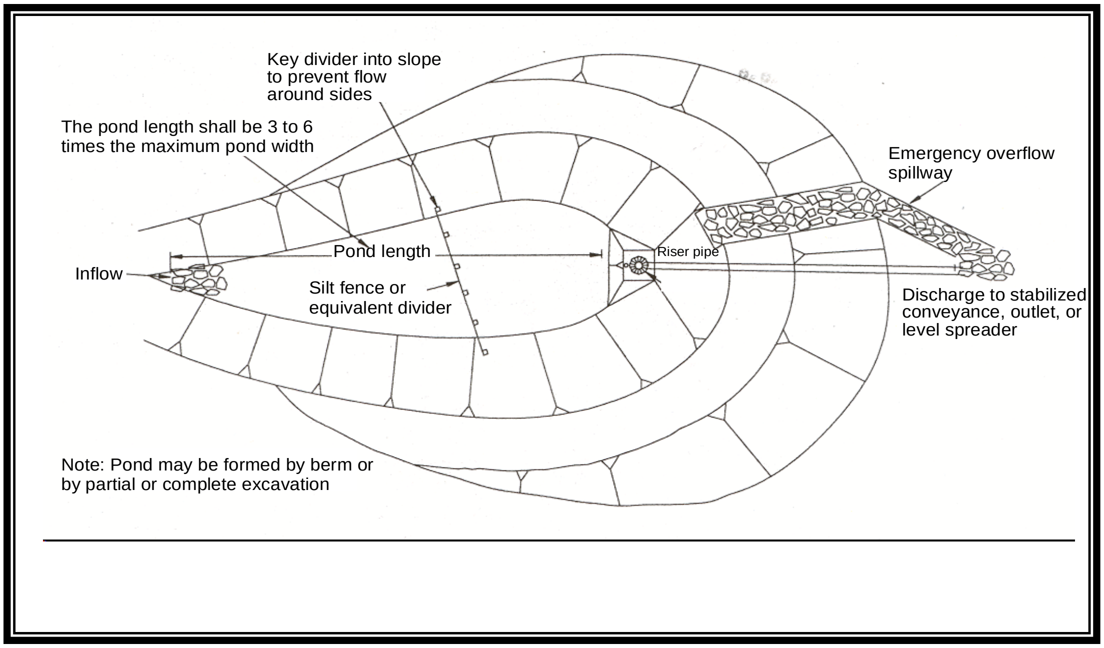


Figure 3-27. Sediment Pond Plan View

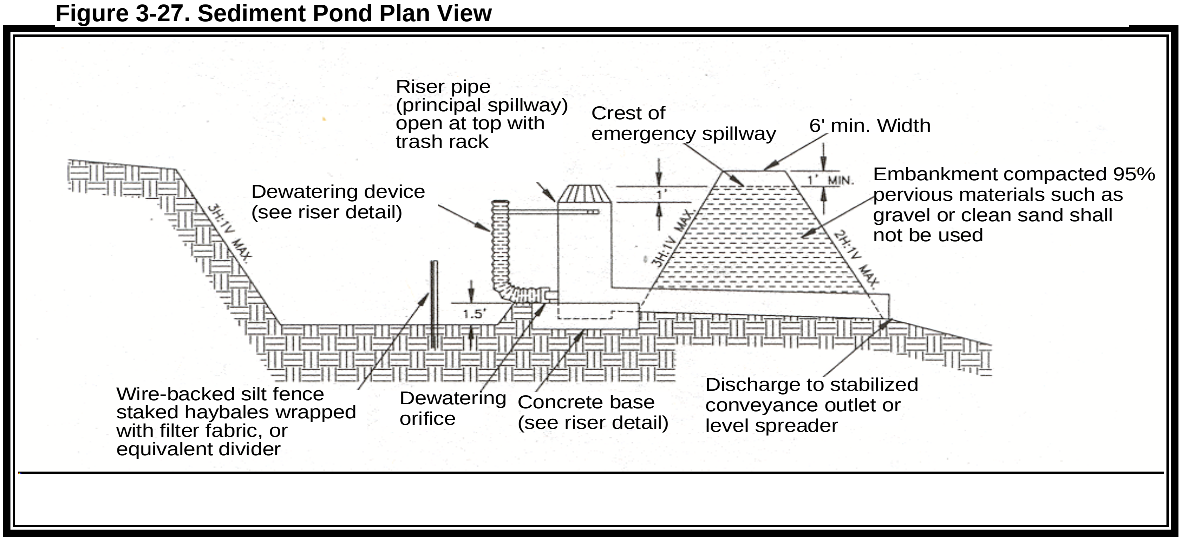


Figure 3-28. Sediment Pond Cross-Section

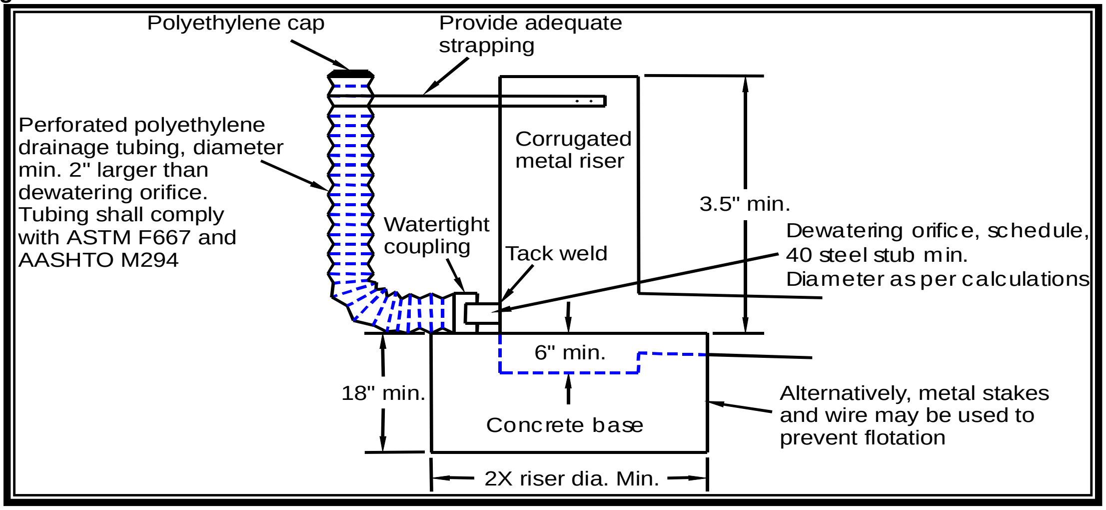


Figure 3-29. Sediment Pond Riser Detail

Determining Pond Geometry:

1. Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year recurrence interval runoff event (Q_2). The 10-year recurrence interval peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

2. Determine the required surface area at the top of the riser pipe with the equation:

   $SA = 2 \text{ x } Q_2/0.00096$

   OR

   2,080 square feet per cfs of inflow

   See BMP C240 for more information on the derivation of the surface area calculation.

3. The basic geometry of the pond can now be determined using the following design criteria:

   - Required surface area SA (from Step 2 above) at top of riser.
   - Minimum 3.5-foot depth from top of riser to bottom of pond.
   - Maximum 3H:1V interior side slopes and maximum 2H:1V exterior slopes. The interior slopes can be increased to a maximum of 2H:1V if fencing is provided at or above the maximum water surface.
   - One foot of freeboard between the top of the riser and the crest of the emergency spillway.
   - Flat bottom.
   - Minimum 1-foot deep spillway.
   - Length-to-width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms:

- The outlet for the 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 recurrence interval storm. If, due to site conditions and pond geometry, a separate emergency spill-way is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year recurrence interval storm. However, an attempt to provide a separate emergency spillway shall always be made.
- The runoff calculations shall be based on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the

100-year recurrence interval storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

- The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak rate of runoff. However, the riser outlet design will not adequately control the pond discharge to the predevelopment discharge limitations as stated in Core Requirement #7: Flow Control. However, if the basin for a permanent stormwater detention pond is used for a temporary sedimentation pond, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations.

- The size of the pond, the expected life of the construction project, the anticipated downstream effects and the anticipated weather conditions during construction, should be considered to determine the need of additional discharge control. See Figure 3.24 for riser inflow curves.

- Principal Spillway: Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the site's 15-minute, 10-year flowrate. If using the Western Washington Hydrology Model (WWHM), design flow is the 10-year flow for the developed (unmitigated) site using a 15-minute time step. Use Figure 3-30. Riser Inflow Curves to determine this diameter (h = 1-foot). Note: A permanent control structure may be used instead of a temporary riser.

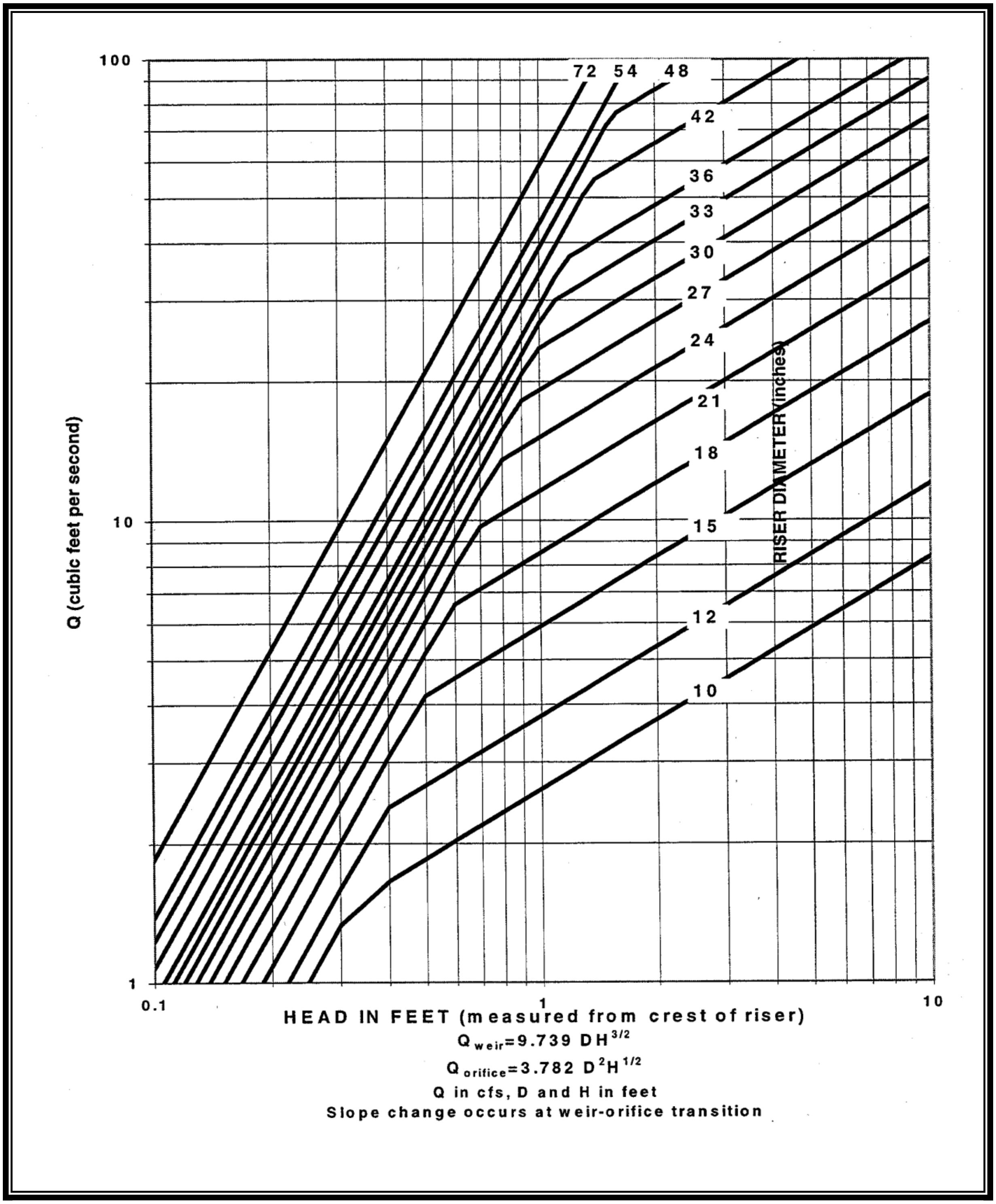


Figure 3-30. Riser Inflow Curves

- **Emergency Overflow Spillway:** Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow indicated by an approved continuous runoff model using a 15-minute time step

- **Dewatering Orifice:** Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s (2h)^{0.5}}{0.6 \text{x} 3600 T g^{0.5}}$$

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 required surface area to the required diameter D of the orifice:

$$D = 24\text{x}\sqrt{\frac{A_o}{\pi}} = 13.54\text{x}\sqrt{A_o}$$

The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. Make the size and number of perforations in the tubing so that the tubing does not restrict flow. The orifice should control the flow rate.

- **Additional Sediment Pond Design Specifications:**

  - The **pond shall be divided** into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells.

  - The divider shall be at least one-half the height of the riser and a minimum of 1 foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by treated 4"x4"s can be used as a divider. Alternatively, staked straw bales wrapped with filter fabric (geotextile) may be used.

  - If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

  - To aid in determining sediment depth, **1-foot intervals** above the pond bottom shall be prominently marked on the riser or a staff gauge.

- If an **embankment** of more than 6 feet is proposed, the pond must comply with the criteria contained in Volume V regarding dam safety for detention BMPs.

- The most common structural failure of sedimentation 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 sequences to prevent piping will be:

1. Tight connections between riser and barrel and other pipe connections.

2. Adequate anchoring of riser.

3. Proper soil compaction of the embankment and riser footing.

4. Proper construction of anti-seep devices.

Maintenance Standards

- Sediment shall be removed from the pond when it reaches 1 foot in depth.

- Any damage to the pond embankments or slopes shall be repaired.

BMP C250: Construction Stormwater Chemical Treatment

Purpose

This BMP applies when using stormwater chemicals in batch treatment or flow-through treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Chemical treatment may be used to reduce the turbidity of stormwater runoff.

Conditions of Use

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Chemical treatment may be required to meet turbidity stormwater discharge requirements and protect streams from the impact of turbid stormwater discharges, especially when construction is to proceed through the wet season.

Formal written approval from Ecology and acceptance by the County is required for the use of chemical treatment regardless of site size. The intention to use Chemical Treatment shall be indicated on the Notice of Intent for coverage under the General Construction Permit. Chemical treatment systems should be designed as part of the Construction SWPPP, not after the fact. Chemical treatment may be used to correct problem sites in limited circumstances with formal written approval from Ecology and acceptance by the County.

The intention to use chemical treatment should be included in the SEPA documentation for the project. The SEPA review authority (typically Thurston County) must be notified at the application phase of the project review (or the time that the SEPA determination on the project is performed) that chemical treatment is proposed. If it is added after this stage, an addendum may be necessary and may result in project approval delay.

Design and Installation Specifications

- See Appendix II-B for background information on chemical treatment.

- **Criteria for Chemical Treatment Product Use:** Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol (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: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>.

- **Treatment System Design Considerations:** The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It is important to recognize the following:

    - Only Ecology approved chemicals may be used and must follow approved dose rates.

    - The pH of the stormwater must be in the proper range for the polymers to be effective, which is typically 6.5 to 8.5.

    - The coagulant must be mixed rapidly into the water to ensure proper dispersion.

    - A flocculation step is important to increase the rate of settling, to produce the lowest turbidity, and to keep the dosage rate as low as possible.

    - Too little energy input into the water during the flocculation phase results in flocs that are too small and/or insufficiently dense. Too much energy can rapidly destroy floc as it is formed.

    - Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. Discharge from a batch treatment system shall be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge. Currently, flow-through systems always discharge through the chemically enhanced sand filtration system.

    - System discharge rates must take into account downstream conveyance integrity.

- **Polymer Batch Treatment Process Description:**

System Components: A batch chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

Treatment Cells: The batch treatment system shall use a minimum of two lined treatment cells in addition to the untreated stormwater storage pond. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than 6 feet high require special engineering analyses. The Ecology Dam Safety Section has specific design criteria for dams in Washington State (see http://www.ecy.wa.gov/programs/wr/dams/guidanceDocs.html).

Conveyance and Storage Pond: 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.

pH Adjustment: The first step in the treatment sequence is to check the pH of the stormwater in the untreated stormwater storage pond. The pH is adjusted by the application of carbon dioxide or a base until the stormwater in the storage pond is within the desired pH range, 6.5 to 8.5. When used, carbon dioxide is added immediately downstream of the transfer pump. Typically sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the untreated stormwater storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Initial pH adjustments should be based on daily bench tests. Further pH adjustments can be made at any point in the process.

Polymer Addition: Once the stormwater is within the desired pH range (dependent on polymer being used), the stormwater is pumped from the untreated stormwater storage pond to a treatment cell as polymer is added. The polymer is added upstream of the pump to facilitate rapid mixing.

Clarification: After polymer addition, the water is kept in a lined treatment cell for clarification of the sediment-floc. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge, samples are withdrawn for analysis of pH, flocculent chemical concentration, and turbidity. If all are acceptable, the treated water is discharged.

Discharge of Treated Water: Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety: 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.

- **Polymer Flow-Through Treatment Process Description:**

System Components: At a minimum, a flow-through chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, and the chemically enhanced sand filtration system.

Conveyance and Storage Pond: 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.

Treatment and Discharge: Stormwater is then pumped from the untreated stormwater storage pond to the chemically enhanced sand filtration system where polymer is added. Adjustments to pH may be necessary before chemical addition. The sand filtration system continually monitors the stormwater for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is recycled to the untreated stormwater pond where it can be retreated.

- **For batch treatment and flow-through treatment, the following equipment should be located in a lockable shed:**
    - The chemical injector.
    - Secondary non-corrosive containment for acid, caustic, buffering compound, and treatment chemical.
    - Emergency shower and eyewash.
- Monitoring equipment which consists of a pH meter and turbidimeter.
- **System Sizing**

Certain sites are required to implement flow control for the developed sites. These sites must also control stormwater release rates during construction. Generally, these are sites that discharge stormwater directly, or indirectly, through a conveyance system, into a fresh water. System sizing is dependent on flow control requirements.

- **Sizing Criteria for Batch Treatment Systems for Flow Control Exempt Water Bodies**
    1. The total volume of the untreated stormwater storage pond and treatment ponds or tanks must be large enough to treat the volume of stormwater that is produced during multiple day storm events. It is recommended that at a minimum the untreated stormwater

storage pond be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass shall be provided around the chemical treatment system to accommodate extreme storm events.

2. Runoff volume shall be calculated using the methods presented in Volume III. Worst-case land cover conditions (i.e., producing the most runoff) shall be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).

3. Primary settling should be encouraged in the untreated stormwater storage pond. A forebay with access for maintenance may be beneficial.

4. 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 times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.

5. If the discharge is directly to a lake, flow control exempt receiving water listed in Volume I, or to an infiltration system, there is no discharge flow limit.

6. Ponds sized for flow control water bodies must at a minimum meet the sizing criteria for flow control exempt waters.

- **Sizing Criteria for Flow-Through Treatment Systems for Flow Control Exempt Water Bodies:**

1. When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies, the treatment system capacity should be a factor. The untreated stormwater storage pond or tank shall be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period.

2. For a chitosan-enhanced sand filtration system, the treatment system flowrate shall be sized using a hydraulic loading rate between 6 to 8 gpm/ft^2. Other hydraulic loading rates may be more appropriate for other systems.

3. Bypass shall be provided around the chemical treatment system to accommodate extreme storms.

4. Runoff volume shall be calculated using the methods presented in Volume III. Worst-case land cover conditions (i.e., producing the most runoff) shall be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).

- **Sizing Criteria for Flow Control Water Bodies**

1. Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from 50 percent of the 2-year recurrence interval flow through the 10-year flow as predicted by an approved continuous runoff model.

2. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond and treatment cells.

3. The following is how WWHM can be used to determine the release rates from the chemical treatment systems:

   a. Determine the pre-developed flow durations to be matched by entering the land use area under the “Pre-developed” scenario in WWHM. The default flow range is from 50 percent of the 2-year recurrence interval flow through the 10-year flow.

   b. Enter the post developed land use area in the “Developed Unmitigated” scenario in WWHM.

   c. Copy the land use information from the “Developed Unmitigated” to “Developed Mitigated” scenario.

   d. While in the “Developed Mitigated” scenario, add a pond element under the basin element containing the post-developed land use areas. This pond element represents information on the available untreated stormwater storage and discharge from the chemical treatment system. In cases where the discharge from the chemical treatment system is controlled by a pump, a stage/storage/ discharge (SSD) table representing the pond must be generated outside WWHM and imported into WWHM. WWHM can route the runoff from the post-developed condition through this SSD table (the pond) and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial SSD table proved to be inadequate, the designer would have to modify the SSD table outside WWHM and re-import in WWHM and route the runoff through it again. The iteration will continue until a pond that complies with the flow duration standard is correctly sized.

e. Notes on SSD table characteristics:

i. The pump discharge rate would likely be initially set at just below 50 percent of the 2-year recurrence interval flow from the pre-developed condition.

ii. As runoff coming into the untreated stormwater storage pond increases and the available untreated stormwater storage volume gets used up, it would be necessary to increase the pump discharge rate above 50 percent of the 2-year recurrence interval flow. The increase(s) above 50 percent of the 2-year recurrence interval flow must be such that they provide some relief to the untreated stormwater storage needs but at the same time will not cause violations of the flow duration standard at the higher flows.

iii. The final design SSD table will identify the appropriate pumping rates and the corresponding stage and storages.

iv. When building such a flow control system, the design must ensure that any automatic adjustments to the pumping rates will be as a result of changes to the available storage in accordance with the final design SSD table.

4. It should be noted that the above procedures would be used to meet the flow control requirements. The chemical treatment system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of 50 percent of the 2-year recurrence interval or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

5. If the discharge 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. If the municipal storm drainage system discharges to a water body not on the flow control exempt list, the project site is subject to flow control requirements.

6. If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirement. In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt water bodies described earlier except all discharge (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond.

7. If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater storage pond and the post-treatment 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 post-treatment flow control pond's revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

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:

<u>Operational Monitoring:</u>

1. Total volume treated and discharged
2. Flow must be continuously monitored and recorded at not greater than 15-minute intervals
3. Type and amount of chemical used for pH adjustment, if any
4. Quantity of chemical used for treatment
5. Settling time.

Compliance Monitoring:

1. Influent and effluent pH, flocculent chemical concentration, and turbidity must be continuously monitored and recorded at not greater than 15-minute intervals.

2. pH and turbidity of the receiving water.

Biomonitoring:

- o Treated stormwater must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemical content. Frequency of biomonitoring will be determined by Ecology.
- o Residual chemical tests must be approved by Ecology prior to their use.
- o 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.

- **Discharge Compliance:**
  - o **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. The pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard units.
  - o Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge.
  - o 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 contractor who intends to use chemical treatment shall be trained by an experienced contractor on an active site. Each site using chemical treatment must have an operator trained and certified by an organization approved by Ecology.
- **Standard BMPs:** Surface stabilization BMPs should be implemented on site to prevent significant erosion. All sites shall use a truck wheel wash to prevent tracking of sediment off site.

- **Sediment Removal and Disposal:**
  - Sediment shall be removed from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells.
  - Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.
  - Sediment that is known to be non-toxic may be incorporated into the site away from drainages.

BMP C251: Construction Stormwater Filtration

Purpose

To remove sediment from runoff originating from disturbed areas of the site using filtration.

Conditions of Use

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 µm). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may achieve compliance with the water quality standard for turbidity.

The use of construction stormwater filtration does not require prior approval from Ecology or Thurston County as long as treatment chemicals are not used. Filtration in conjunction with polymer treatment requires testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from the appropriate regional Ecology office and acceptance by Thurston County must be obtained at each site where polymers use is proposed prior to use. For more guidance on stormwater chemical treatment see BMP C250.

Design and Installation Specifications

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow. Rapid sand filters are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gpm/sf, because they have automatic backwash systems to remove accumulated solids. In contrast, slow sand filters have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems. To date, slow sand filtration has generally been used to treat stormwater. Slow sand filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

- **Filtration Equipment.** Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm. Sequence filters from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

- **Treatment Process Description.** Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The untreated stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid sand filtration system. Slow sand filtration systems are designed as flow through systems using gravity.

Sizing Criteria for Flow-Through Treatment Systems for Flow Control

- **Exempt Water Bodies:**
  - When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies the treatment system capacity should be a factor.
  - The untreated stormwater storage pond or tank shall be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period.
  - For a chitosan-enhanced sand filtration system, the treatment system flowrate shall be sized using a hydraulic loading rate between 6 to 8 gpm/ft^2.
  - Other hydraulic loading rates may be more appropriate for other systems.
  - Bypass shall be provided around the chemical treatment system to accommodate extreme storms.
  - Runoff volume shall be calculated using the methods presented in Volume III. Worst-case conditions (i.e., producing the most runoff) shall be used for analyses (most likely conditions present prior to final landscaping).
- **Sizing Criteria for Flow Control Water Bodies:**
  - Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from 50 percent of the 2-year recurrence interval flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond, the filtration system, and the flow rate through the filter system.
  - The following is how WWHM can be used to determine the release rates from the filtration systems:
    1. Determine the pre-developed flow durations to be matched by entering the land use area under the “Pre-developed” scenario in WWHM. The default flow range is from 50 percent of the 2-year recurrence interval flow through the 10-year flow.
    2. Enter the post developed land use area in the “Developed Unmitigated” scenario in WWHM.

3. Copy the land use information from the “Developed Unmitigated” to “Developed Mitigated” scenario.

4. There are two possible ways to model stormwater filtration systems:

    a. The stormwater filtration system uses an untreated stormwater storage pond/tank and the discharge from this pond/tank is pumped to one or more filters. In-line filtration chemicals would be added to the flow right after the pond/tank and before the filter(s). Because the discharge is pumped, WWHM cannot generate a stage/storage/discharge (SSD) table for this system. This system is modeled the same way as described in BMP C250.

    b. The stormwater filtration system uses a storage pond/tank and the discharge from this pond/tank gravity flows to the filter. This is usually a slow sand filter system and it is possible to model it in WWHM as a Filter element or as a combination of Pond and Filter element placed in series. The stage/storage/ discharge table(s) may then be generated within WWHM as follows:

        i. While in the “Developed Mitigated” scenario, add a Filter element under the basin element containing the post-developed land use areas. The length and width of this filter element would have to be the same as the bottom length and width of the upstream untreated stormwater storage pond/tank.

        ii. In cases where the length and width of the filter is not the same as those for the bottom of the upstream untreated stormwater storage tank/pond, the treatment system may be modeled as a Pond element followed by a Filter element. By having these two elements, WWHM would then generate a SSD table for the storage pond which then gravity flows to the Filter element. The Filter element downstream of the untreated stormwater storage pond would have a storage component through the media, and an overflow component for when the filtration capacity is exceeded.

            WWHM can route the runoff from the post-developed condition through the treatment systems in 4b and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial sizing estimates for the treatment system proved to be inadequate, the designer would have to modify the system and route the runoff through it again. The iteration would continue until compliance with the flow duration standard is achieved.

5. It should be noted that the above procedures would be used to meet the flow control requirements. The filtration system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of 50 percent of the 2-year recurrence interval flow or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

- If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirements.

  In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt water bodies described earlier except all discharges (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond.

- If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater discharge pond and the post-treatment 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 post-treatment flow control pond’s revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

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 stormwater stored in the holding pond or tank, backwash return to the pond or tank may be appropriate. However, land application or another 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.

BMP C252: High pH Neutralization Using CO_2

Purpose

Description

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, this process is called pH neutralization. The pH neutralization involves the use of solid or compressed carbon dioxide gas in water requiring neutralization.

Neutralized stormwater may be discharged to surface waters under the General Construction NPDES Permit but neutralized process water must be managed to prevent discharge to surface waters. Process wastewater includes any stormwater contaminated during concrete work such as concrete truck wash-out, hydro-demolition, or saw-cutting slurry.

Reason for pH Neutralization

A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH 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.

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.

The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

Conditions of Use

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).

Advantages of CO_2 Sparging

- Rapidly neutralizes high pH water
- Cost effective and safer to handle than acid compounds
- CO_2 is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

The Chemical Process

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:

$CO_2 + H_2O \longleftrightarrow H_2C0_3 \longleftrightarrow H^+ + HCO_3^-$

The free proton is a weak acid that can lower the pH. Water temperature has an effect on the reaction as well. The colder the water temperature is the slower the reaction occurs and the warmer the water temperature is the quicker the reaction occurs. Most construction applications in Washington State have water temperatures in the 50°F or higher range so the reaction is almost simultaneous.

Design and Installation Specifications

Treatment Procedures

- High pH water may be treated using continuous treatment, continuous discharge systems. These manufactured systems continuously monitor influent and effluent pH to ensure that pH values are within an acceptable range before being discharged.
- All systems must have fail safe automatic shut off switches in the event that pH is not within the acceptable discharge range.
- Only trained operators may operate manufactured systems. System manufacturers often provide trained operators or training on their devices.
- The following procedure may be used when not using a continuous discharge system:
    - Prior to treatment, Thurston County must be notified.
    - Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater on-site.
    - Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to treatment.
    - Transfer water to be treated to the treatment structure. Ensure that treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill tank completely, allow at least 2 feet of freeboard.
    - The operator samples the water for pH and notes the clarity of the water. As a rule of thumb, less CO_2 is necessary for clearer water. This information shall be recorded.
    - In the pH adjustment structure, add CO_2 until the pH falls in the range of 6.9 to 7.1. Remember that pH water quality standards apply so adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near the bottom of the tank; this will allow carbon dioxide to bubble up through the water and diffuse more evenly.

    - Slowly discharge the water making sure water does not get stirred up in the process. Release about 80 percent of the water from the structure leaving any sludge behind.
    - Discharge treated water through a pond or drainage system.
    - Excess sludge needs to be disposed of properly as concrete waste. If several batches of water are undergoing pH treatment, sludge can be left in the treatment structure for the next batch treatment. Dispose of sludge when it fills 50 percent of tank volume.

- Sites that must implement flow control for the developed site must also control stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

Maintenance Standards

Safety and Materials Handling

- All equipment should be handled in accordance with OSHA rules and regulations
- Follow manufacturer guidelines for materials handling.

Operator Records

- Each operator should provide:
    - A diagram of the monitoring and treatment equipment
    - A description of the pumping rates and capacity the treatment equipment is capable of treating.
- Each operator shall keep a written record of the following:
    - Client name and phone number.
    - Date of treatment.
    - Weather conditions.
    - Project name and location.
    - Volume of water treated.
    - pH of untreated water.
    - Amount of CO_2 needed to adjust water to a pH range of 6.9 to 7.1.
    - pH of treated water.
    - Discharge point location and description.
- A copy of this record shall be given to the client/contractor who shall retain the record for 3 years.

BMP C253: pH Control for 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; this process is called pH neutralization. Stormwater with pH levels exceeding water quality standards may be treated by infiltration, dispersion in vegetation or compost, pumping to a sanitary sewer, disposal at a permitted concrete batch plant with pH neutralization capabilities, or carbon dioxide sparging. BMP C252 gives guidelines for carbon dioxide sparging, the other methods are presented below.

Reason for pH Neutralization

A pH level between 6.5 and 8.5 is typical for most natural watercourses, and this 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

Causes of High pH

High pH levels at construction sites are 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).

Design and Installation Specifications

Disposal Methods

Infiltration

- Infiltration is only allowed if soil type allows all water to infiltrate (no surface runoff) without causing or contributing to a violation of surface or groundwater quality standards.
- Infiltration techniques should be consistent with Volume V, Chapter 3.

Dispersion

- Use Volume V, Chapter 2, BMP LID.11Full Dispersion.

Sanitary Sewer Disposal

- Thurston County approval is required prior to disposal via the sanitary sewer.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water
- Facility should be contacted before treatment to ensure they can accept the high pH water.

Stormwater Discharge

Any pH treatment options that generate treated water that must be discharged off site are subject to flow control requirements. Sites that must implement flow control for the developed site must also control stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

3.3 Low Impact Development BMPs

3.3.1 Introduction

To ensure that LID stormwater facilities and BMPs will be fully functional after construction, it is important to protect these BMPs during construction activities. Protecting native soil and vegetation, minimizing soil compaction, and retaining the

hydrologic function of LID BMPs during the site preparation and construction phases are some of the most important practices during the development process.

The purpose of this section is to provide designers, builders, and inspectors with guidance and tools for meeting Core Requirement #2, Element #13 – Protect Low Impact Development BMPs. This section does not provide guidance on construction or design of LID BMPs (see Volume III, V, and VI), or cover all Construction SWPPP practices (see Sections 3.1 and 3.2), but rather focuses on how to most efficiently reduce impacts on LID BMPs specifically during construction. The practices specified in Section 3.3 must be applied to protect LID BMPs, unless the given practice does not apply to the project site conditions or activities.

General

3.3.2 Erosion and Sediment Control BMPs Applicable to LID

Overall Construction Stormwater Pollution Prevention Plan (SWPPP) requirements are specified in Volume I, Core Requirement #2 and Volume II. In general, Construction SWPPP BMPs limit the impact of site disturbance, erosion, and sediment deposition during construction. Some Construction SWPPP BMPs (presented in more detail in Sections 3.1 and 3.2) focus on providing a physical barrier or deterrent to help minimize construction-related site disturbance and/or erosion, while other Construction SWPPP BMPs help protect the site from concentrated (i.e., erosive) flows. General Construction SWPPP BMPs and their application for protection of LID BMPs are summarized below. These BMPs must be considered for projects subject to Core Requirement #2 that are proposing to construct LID BMPs.

Table 3-19. LID Construction BMPs

Construction SWPPP BMP	Application	Section Reference
BMP C103: High Visibility Fence	Use fencing to limit clearing; prevent disturbance of sensitive areas, their buffers, and other areas; limit construction traffic; and protect areas where marking with flagging may not provide adequate protection	3.1
BMP C200: Interceptor Dike and Swale	Use an interceptor dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled	3.2
BMP C201: GrassLined Channels	Use grass lined channels where concentrated runoff may cause erosion and flooding of the site	3.2
BMP C207: Check Dams	Use check dams in swales or ditches to reduce the velocity and dissipate concentrated flow	3.2
BMP C208: Triangular Silt Dike	(TSD) (Geotextile Encased Check Dam) Use triangular silt dikes as check dams, for perimeter protection, temporary soil stockpile protection, drop inlet protection, or as a temporary interceptor dike	3.2
BMP C231: Brush Barrier	Use brush barriers to decrease flow velocities and reduce transport of coarse sediment from overland flow	3.2
BMP C233: Silt Fence	Use silt fences to decrease flow velocities and reduce transport of sediment from overland flow	3.2
BMP C234: Vegetated Strip	Use vegetated strips to decrease flow velocities and reduce transport of sediment from overland flow	3.2

3.3.3 Additional Construction Techniques for LID BMPs

In addition to the general Construction SWPPP BMPs presented in Section 3.3.2, this section outlines construction-phase techniques to protect LID BMPs. LID BMP protection is still a somewhat new and evolving practice, therefore the specific LID BMP protection measures outlined below are not explicitly called out in Sections 3.1 and 3.2. Rather, the techniques presented in this section supplement the Construction SWPPP BMPs presented above and in Sections 3.1 and 3.2. (Note: these techniques can be applied to any site, not just those incorporating LID, but these techniques are particularly important for LID BMP protection.)

3.3.4 Construction Site Planning and Sequencing

Construction site planning and sequencing is a procedural BMP that is critical to successful installation and long-term operation of LID BMPs. Proper site planning and construction sequencing will minimize the impact of construction on permanent stormwater facilities by reducing the potential for soil erosion and compaction. Site planning and sequencing techniques to be used as practicable for protection of LID BMPs include:

Table 3-20. Construction Sequencing

Construction Site Planning and Sequencing Requirements	Construction Site Planning and Sequencing Techniques
Limit clearing and grading activities	• Keep grading to a minimum by incorporating natural topographic depressions into the development. • Shape final lot grades and topographic features early (i.e., at the site development stage) where feasible. • Limit the amount of cut and fill in areas with permeable soils. • Limit clearing to road, utility, building pad, lawn areas, and the minimum amount of extra land necessary to maneuver machinery (e.g., a 10-foot perimeter around a building).
Limit construction activity in areas designated for LID	• Clearly document – and plan to meet and walk through the site with equipment operators prior to construction – to clarify construction boundaries, limits of disturbance, and construction activities in the vicinity of LID BMPs. • General/primary contractor must inform other subcontractors of applicable LID BMP protection requirements. This is particularly important when working around permeable pavement.

Construction Site Planning and Sequencing Requirements	Construction Site Planning and Sequencing Techniques
Limit clearing and grading during heavy rainfall seasons	• Time construction activities to start during the summer (lowest precipitation) and end in the fall (when conditions are favorable for the establishment of vegetation), if feasible.
Minimize the amount and time that graded areas are left exposed	• Complete construction and erosion control activities in one section of the site before beginning activity in another section.
Utilize permeable and nutrient rich soils	• Preserve any portion of the site with permeable soils to promote infiltration of stormwater runoff. • Leave areas of rich topsoil in place, or if excavated, utilize elsewhere on the site to amend areas with sparse or nutrient deficient topsoil.
Reduce impact of construction access roads	• Reduce the number and size (width/length) of construction access roads. • Locate construction access roads in areas where future roads and utility corridors will be placed (unless utilizing permeable pavement).
Promote sheet flow and minimize concentrated runoff	• Avoid grading that results in steep, continuous slopes, especially in areas contributing runoff to LID BMPs.
LID BMP activation	• LID BMPs shall not begin operation until all erosion causing project improvements (including use of access roads that may contribute sediment) are completed and all exposed ground surfaces are stabilized by revegetation or landscaping in upland areas potentially contributing runoff to the BMP.

3.3.5 Activities During Construction

Many common construction-phase activities pose a risk to LID BMPs. The following techniques will help minimize these impacts. Techniques to be used for protection of LID BMPs include:

Table 3-21. LID Erosion Control Requirements

Erosion Control Requirements	Erosion Control Techniques
Protect native topsoil during the construction phase, and reuse on-site	• Where practicable, protect areas of rich topsoil. If excavation is necessary, stockpile native soils that can be used on the site after construction. • Stockpile materials in areas designated for clearing and grading (such as parking areas and future impervious roadways) and away from infiltration and other stormwater facilities. • Cover small stockpiles with weed barrier material that sheds moisture yet allows air transmission. Large stockpiles may need to be seeded and/or mulched. • Do not relocate topsoil or other material to areas where they can cover critical root zones, suffocate vegetation, or erode into adjacent streams.
Use effective revegetation methods	• Use native plant species adapted to the local environment. • Plant during late fall, winter, or early spring months when vegetation is likely to establish quickly and survive. • Utilize proper seedbed preparation. • Fertilize and mulch to protect germinating plants. Apply 1 inch of compost topped with 2 inches of mulch. • Protect areas designated for revegetation from soil compaction by restricting heavy equipment. • Provide proper soil amendments where necessary (refer to Volume III, Section 3.1). • During storage, plants should be protected by solar screens when possible to prevent overexposure and excessive drying.
Perform preconstruction, routine, and post-construction inspections	• Conduct a preconstruction inspection to verify that adequate barriers have been placed around vegetation retention areas, infiltration facilities (as needed), and structural controls are implemented properly. • Conduct routine inspections to verify that structural controls are being maintained and effectively protecting LID BMPs throughout construction. • Conduct a final inspection to verify that revegetation areas are stabilized and that permanent LID BMPs are in place and functioning properly.

3.3.6 BMP-specific Construction Techniques

This section outlines construction-phase BMP protection techniques specific to categories of LID BMPs (e.g., infiltration and dispersion) as well as specific LID BMPs (permeable pavement, bioretention areas/rain gardens, and vegetated roofs). The BMP protection techniques presented previously in Section 3.3.3 are applicable to the overall construction site to help protect LID BMPs. The techniques outlined in this section are based on the specific BMP functions, targeting typical construction activities that pose a risk to individual BMPs.

3.3.7 Infiltration and Dispersion Facility Construction Techniques

It is critical that appropriate methods are used to protect infiltration and dispersion BMPs from compaction and sediment loading during construction. For infiltration facilities in particular, the subgrade soils must be protected from clogging and over-compaction to maintain the soil permeability and ensure BMP performance. Techniques for protection of infiltration and dispersion BMPs during various stages of construction are summarized below.

Table 3-22. Techniques for Protecting Infiltration and Dispersion Facilities

Construction Stage	Techniques for Protecting Infiltration and Dispersion Facilities
Prior to construction	• The infiltration/dispersion area shall be clearly identified (e.g., using flagging or high visibility fencing) and protected prior to construction to prevent compaction of underlying soils by vehicle traffic. • Develop a soil and vegetation management plan showing areas to be protected and restoration methods for disturbed areas before land clearing starts. • The Construction SWPPP sheets must outline construction sequencing that will protect the infiltration/dispersion area during construction. • Construction SWPPP BMPs and protection techniques identified in Sections 3.3.2 and 3.3.3 shall be implemented as applicable. In particular, be sure to stabilize upslope construction areas (e.g., using silt fences, berms, mulch, or other Construction SWPPP BMPs) and minimize overland flow distances.
Excavation	• Excavation of infiltration/dispersion areas shall be performed by machinery operating adjacent to the BMP. No heavy equipment with narrow tracks, narrow tires, or large lugged high pressure tires shall be allowed on the infiltration/dispersion area footprint. • Where feasible, excavate infiltration/dispersion areas to final grade only after all disturbed areas in the up-gradient project drainage area have been permanently stabilized. (If infiltration areas must be excavated before permanent site stabilization, initial excavation must be conducted to no less than 6 inches of the final elevation of the facility floor.) • Excavation of infiltration areas shall not be allowed during wet or saturated conditions. • The use of draglines and trackhoes should be considered for constructing infiltration and dispersion areas. • The sidewalls and bottom of an infiltration facility excavation must be raked or scarified to a minimum depth of 3 inches after final excavation to restore infiltration rates. • Scarify soil along the dispersion flow path if disturbed during construction.
Sediment control	• Bioretention, rain garden, and permeable pavement BMPs shall not be used as sediment control facilities, and all drainage shall be directed away from the BMP location after initial rough grading. • Direct construction site flow away from the infiltration/dispersion area using applicable Construction SWPPP BMPs (e.g., temporary diversion swales)

3.3.8 Permeable Pavement

There are many potential applications and site scenarios where permeable pavement can be applied. The following techniques highlight the most broadly applicable techniques to be used to protect permeable pavement BMPs during construction. Refer to the previous section for construction protection methods that are applicable to all infiltration BMPs, as well as Section 3.3.2 and 3.3.3 for general site protection measures. In addition to those techniques, the following techniques apply specifically for protection of permeable pavement during construction:

- Use procedural BMPs to plan construction. For example, phase construction to minimize compaction, sedimentation, or structural damage to the permeable pavement.
- Use physical Construction SWPPP BMPs and/or grade the site to avoid sediment laden runoff from reaching permeable pavements.
- Place protective surfaces (e.g., waterproof tarps and steel plates) over any permeable pavement areas used for construction staging.
- Do not drive sediment-laden construction equipment on the base material or pavement. Do not allow sediment-laden runoff on permeable pavements or base materials.
- Once the pavement is finished and set, cover the pavement surface with plastic and geotextile to protect from other construction activities. Close and protect the pavement area until the site is permanently stabilized.
- Incorporate measures to protect road subgrade from over compaction and sedimentation if permeable pavement roads are used for construction access.
    - Cover the aggregate base or pavement surface with protective geotextile fabric and protect fabric with steel plates or gravel. Gravel should only be used to protect the fabric placed over aggregate base.
    - Once construction is complete and the site is permanently stabilized, remove protective geotextile, clean, and complete pavement installation.

Refer to the detailed permeable pavement BMP information in Volume III, Section 3.5 for general permeable pavement construction criteria.

3.3.9 Bioretention Areas and Rain Gardens

As with permeable pavements, there are many potential applications and site scenarios where bioretention and rain garden BMPs can be applied. The following techniques highlight the most broadly applicable techniques to be used to protect bioretention and rain garden BMPs during construction. Refer to the beginning of this section for construction protection methods that are applicable to all infiltration BMPs, as well as Section 3.3.2 and 3.3.3 for general site protection measures. In addition to those techniques, the following techniques apply specifically for protection of bioretention and rain garden BMPs during construction:

- Excavation:
  - If machinery must operate in the bioretention area for excavation, use lightweight, low ground-contact pressure equipment and rip the base at completion to scarify soil to a minimum of 12 inches.
- Protect bioretention soil mix from compaction during construction
  - Do not place bioretention soil mix if saturated or during wet periods.
  - Check for compaction prior to planting. If compaction occurs, aerate the bioretention soil and then proceed to plant.

Refer to the detailed bioretention and rain garden BMP information in Volume V, Section 2.2.5 ~~III, Section 3.4 and 3.8~~ for general bioretention and rain garden construction criteria.

3.3.10 Vegetated Roofs

The following additional techniques apply for protection of vegetated roof facilities during construction:

- Because of their location and complexity, vegetated roofs typically require more planning and coordination effort relative to ground-level landscaping. For new construction, a critical path approach is highly recommended to establish the sequence of tasks for construction of the vegetated roof system.
- During construction, it is vitally important that the waterproof membrane be protected once installed. The waterproofing should be tested prior to placement of the growth media and other subsequent vegetated roof materials.

Refer to the detailed vegetated roof BMP information in Volume V ~~III~~ for general construction criteria.

Typo correction 01/05/2017

Resource Materials

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Clark County Conservation District, Erosion and Runoff Control, January 1981.

King County Conservation District, Construction and Erosion Control, December 1981.

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King County Surface Water Design Manual, September 1998.

Maryland Erosion and Sedimentation Control Manual, 1983.

Michigan State Guidebook for Erosion and Sediment Control, 1975.

Snohomish County Addendum to the 1992 Ecology Stormwater Management Manual for the Puget Sound Basin, September 1998.

University of Washington, by Loren Reinelt, Construction Site Erosion and Sediment Control Inspector Training Manual, Center for Urban Water Resources Management, October 1991.

University of Washington, by Loren Reinelt, Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity, Center for Urban Water Resources Management, October 1991.

Virginia Erosion and Sediment Control Handbook, 2nd Edition, 1980.

Appendix II-A
Recommended Standard Notes for Construction Stormwater Pollution Prevention Plans

The following standard notes are suggested for use in the erosion control plan prepared as part of the construction stormwater pollution prevention plan (SWPPP). The County has other mandatory notes for construction plans that may be applicable, see Volume I Appendix I-G. Plans should also identify with phone numbers the person or firm responsible for the preparation of and maintenance of the erosion control plan.

Standard Notes

1. Acceptance of this erosion/sediment control (ESC) plan by Thurston County does not constitute an acceptance of permanent road or drainage design (e.g., size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).

2. The implementation of this ESC plan and the construction, maintenance, replacement, and upgrading of ESC facilities is the responsibility of the owner and contractor until all construction is completed and approved and vegetation/landscaping is established.

3. The boundaries of the clearing limits shown on this plan shall be clearly flagged 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/contractor for the duration of construction.

4. The ESC facilities shown on this plan must be constructed in conjunction with all clearing and grading activities, and in such a manner as to insure that sediment and sediment laden water does not enter the drainage system, roadways, or violate applicable water standards.

5. The ESC facilities shown on this plan are the core requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and to ensure that sediment and sediment-laden water do not leave the site.

6. The ESC facilities shall be inspected daily by the applicant/contractor and maintained as necessary to ensure their continued functioning.

7. The ESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within the 48 hours following a major storm event (>1” in 24 hours).

8. At no time shall more than 1 foot or 1/3 of the sump volume, whichever is less, of sediment be allowed to accumulate within a trapped catch basin. 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.

9. Stabilized construction entrances shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures may be required to insure that all paved areas are kept clean for the duration of the project.

Appendix II-B
Background Information on Chemical Treatment

Coagulation and *flocculation* have been used for over a century to treat water. Both are used less frequently for the treatment of wastewater, and their use for treating stormwater is a very recent application. Experience with water and wastewater treatment has resulted in a basic understanding of the process, especially factors that affect performance. This experience can provide insights on 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. Because of these two factors, small size and negative charge, fine particles tend to stay in suspension for extended periods of time, making removal by gravity settling impractical. These are called stable suspensions. Polymers and inorganic chemicals such as alum speed the process of clarification by destabilizing the suspension and causing the smaller particles to agglomerate. This process consists of three steps: coagulation, flocculation, and settling or clarification. Each step is explained below as well as the factors that affect the efficiency of the process.

1. **Coagulation**: Coagulation is the process of disrupting negative charges on the fine particles that prevent their agglomeration. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals 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 not readily separated by clarification until flocculation occurs.

2. **Flocculation**: Flocculation occurs when fine particles that have been destabilized bind together to form larger, rapidly settling particles. Flocculation begins naturally following coagulation but is enhanced by gentle mixing of the destabilized suspension. Mixing helps to bring particles in contact with one another so that they bind and continually grow to form "flocs." As the size of the flocs increases, they become heavier and tend to settle more rapidly.

3. **Clarification**: The final step is the settling of the particles. 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 water treatment. 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.

> 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 effective performance as many of these factors become less important in comparison to typical sedimentation basins. One source of currents that is likely important in batch systems is movement of the water leaving the clarifier unit. Since flocs are small and light, the exit velocity of the water must be as low as possible. Sediment on the bottom of the basin can be resuspended and removed by moderate velocities.

<u>Coagulants:</u> Polymers are large organic molecules 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.

Cationic polymers can be used as coagulants to destabilize negatively charged turbidity particles present in natural waters, wastewater and stormwater. Aluminum sulfate (alum) can also be used as this chemical becomes positively charged when dispersed in water. In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or on-site testing.

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.

<u>Application Considerations:</u> 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 polymer 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 polymers 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. Again, the result is higher residual turbidity than that with the optimum dose.

Mixing in Coagulation/Flocculation: 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.

Design engineers wishing to review more detailed presentations on this subject are referred to the following textbooks.

- Fair, G., J. Geyer and D. Okun, Water and Wastewater Engineering, Wiley and Sons, NY, 1968.

- American Water Works Association, Water Quality and Treatment, McGraw-Hill, NY, 1990.

- Weber, W.J., Physiochemical Processes for Water Quality Control, Wiley and Sons, NY, 1972.

Adjustment of the pH and Alkalinity: The pH must be in the proper range for the polymers to be effective, which is 6.5 to 8.5 for Calgon CatFloc 2953, the most commonly used polymer. 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, it may 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 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.

Appendix II-C
Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) Template

Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) Template

This Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) may be used for projects less than 1-acre that require submittal of only an Abbreviated or Engineered Abbreviated Drainage Plan.

Section 1 – Project and Contact Information

Project Name/Description ____
Contact/Owner ______________________ Phone number _____________
Erosion Control Supervisor _________________ Phone number _____________
Emergency (after hour) contact _________________ Phone number _____________

Section 2 – Site Information

Site address ____
Parcel # ____
Soil type ____
(Soil type A, B, C, or D & Soil series per SCS Soil survey)

To find parcel number:
http://www.geodata.org/parcelsrch.asp

For soil information, see
http://websoilsurvey.nrcs.usda.gov/app/

For County Use Only:

County Permit No. _____________________________ Review Date ____________________
Reviewer _____________ __________________________

Section 3 – Eligibility for Abbreviated Drainage Plan/ Short Form SWPPP

Have you reviewed Volume I, Chapter 3 to confirm that your project is eligible to use the Abbreviated Drainage Plan? **YES** **NO**

Section 4 – Project Narrative

This narrative must be completed as part of the Construction SWPPP. Any information described as part of the narrative shall be shown on the site plan.

Note: From October 1 thru April 30, clearing, grading, and other soil disturbing activities are not permitted unless it can be demonstrated that no silt laden water will discharge from the site and except with authorization from Thurston County Development Services.

Project Description (check all that apply)

Project Type

Subdivision, Type	
Single Family Residential Project (building permit)	
Large Lot (>2.5 acres)	
Grading Permit	
Commercial Development	
Land Clearing	
Conversion of native vegetation to landscaping or pasture	
Other	

Project Areas

Total site area		SF
What is the area of land disturbance?		SF
Area of existing impervious surfaces		SF
Area of new impervious surfaces		SF
Total area of new, replaced, and existing impervious surface after project improvements		SF
Area of existing native vegetation to be converted to landscaping or pasture		SF
Will there be stormwater runoff or sediment discharges to adjoining properties or waters of the U.S. from the site?	YES	NO
If a grading permit is required, what is the total volume of grading?		CY

Additional Project Information (attach additional sheets if necessary)

____

____

____

____

____

Existing Site Conditions

1. What existing vegetation is present on the site? (check all that apply)

Description	**EXIST? (Y/N)**	**% of Total Area**
Forest		
Pasture/prairie grass		
Pavement		
Lawn/landscaping		
Brush		
Deciduous Trees		
Other		

2. How does surface water drainage flows across/from the site? (check all that apply)

Sheet flow/dispersion (with runoff from site)	
Sheet flow/dispersion (no runoff from site)	
Infiltration – no surface drainage leaving site	
Ditch/swale	
Stream	
Storm Sewer/catch basin or inlet	
Other	

3. Which of the following site condition(s) or other features of note are present on the site (indicate their location on site map)?

Steep slopes (>20%)	
Large depression	
Underground tanks	
Springs/Seeps	
Easements	
Existing structures	
Existing utilities	
Existing roadways	
Waters of the State (pond, stream, creek, river, etc.)	
Other	

Adjacent Areas

1. Which of the following adjacent areas could be impacted by site disturbance?

Streams*	
Lakes*	
Wetlands*	
Steep slopes*	
Residential Areas	
Roads	
Ditches, pipes, culverts	
Marine Bluff*	
Other	

*Note: If site is on or adjacent to a critical area, Thurston County may require additional information, engineering, and other permits to be submitted with this short-form.

2. Describe the downstream drainage path leading from the site to the receiving body of water. (Minimum distance of ¼-mile (1,320 feet)) {e.g., water flows from site, into curb-line to catch basin at intersection of X and Y streets. A 10-inch pipe system conveys water another 1,000 feet to a ravine/wetland.} (attach additional sheets if necessary)

____

____

____

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Section 5 – Abbreviated Erosion Control Plan

Enter estimated start/end dates for the following construction activities/milestones.

Construction Schedule	Estimated Start/End Date
1. Permit obtained (start date)	____________________
2. Mark clearing limits	____________________
3. Establish construction access	____________________
4. Install sediment controls	____________________
5. Demolition	____________________
6. Grading	____________________
7. Utility construction	____________________
8. Building or structure construction	____________________
9. Landscaping/final site stabilization	____________________

Complete Checklist for all Projects

Element/ Description	Requirement	Applicable BMP(s)[1]	Confirmation
Preserve Vegetation//Mark Clearing Limits	Prior to beginning land-disturbing activities, mark clearing limits and delineate sensitive areas and their buffers with high visibility fence. Retain the native top soil and duff layer or stockpile it on-site for replacement at completion of the project.	BMP C100: Preservation of Native Topsoil (On-site) BMP C101: Preserving Natural Vegetation BMP C102: Buffer Zones BMP C103: High Visibility Plastic Fence BMP C233: Silt Fence	Will comply ☐ N/A (explain):
Establish Construction Access	Provide stabilized construction entrance (e.g., quarry spalls or crushed rock); clean public roads if any sediment is transported off site. If an existing driveway will be used for construction access, describe condition and show on Site Plan. If stabilized construction entrance in not effective use wheel wash or tire baths located on site.	BMP C105: Stabilized Construction Entrance BMP C106: Wheel Wash BMP C107: Construction Road/Parking Area Stabilization.	Will comply ☐ N/A (explain):
Control Flow Rates	Protect downstream properties and waterways from discharge of turbid water. Provide flow control if required (MR #7).	BMP C203: Water Bars BMP C207: Check Dams BMP C209: Outlet Protection BMP C235: Wattles BMP C240: Sediment Trap Volumes III & V for sizing infiltration and detention facilities.	Will comply ☐ N/A (explain):
Install Sediment Controls	Provide suitable sediment control BMPs to prevent sediment from leaving site.	BMP C231: Brush Barrier BMP C232: Gravel Filter Berm BMP C233: Silt Fence BMP C234: Vegetated Strip BMP C235: Wattles BMP C240: Sediment Trap	Will comply ☐ N/A (explain):

Element/ Description	Requirement	Applicable BMP(s)[1]	Confirmation
Stabilize Soils	Stabilize all unworked and exposed soils to prevent erosion. From October 1 through April 30, no soils shall remain exposed and un-worked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and un-worked for more than 7 days.	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 C130: Surface Roughening BMP C131: Gradient Terraces BMP C140: Dust Control	Will comply ☐ N/A (explain):
Protect Slopes	Design and construct cut and fill slopes to minimize erosion.	BMP C120: Temporary and Permanent Seeding BMP C121: Mulching BMP C122: Nets and Blankets BMP C130: Surface Roughening BMP C200: Interceptor Dike and Swale	Will comply ☐ N/A (explain):
Protect Drain Inlets	Protect conveyance system from sediment by providing filtration of stormwater prior to entering inlets.	BMP C220: Storm Drain Inlet Protection	Will comply ☐ N/A (explain):
Stabilize Channels and Outlets	Stabilize channels and outlets to prevent erosion.	BMP C202: Channel Lining BMP C207: Check Dams BMP C209: Outlet Protection	Will comply ☐ N/A (explain):
Control Pollutants	Handle and dispose of construction debris in dumpster or by hauling to waste transfer station so that it does not contaminate stormwater.	BMP C151: Concrete Handling BMP C152: Sawcutting and Surfacing Pollution Prevention BMP C153: Material Delivery, Storage and Containment BMP C154: Concrete Washout Area	Will comply ☐ N/A (explain):
Control Dewatering	Manage dewatering water from construction activities to prevent sediment discharge from site. Manage highly turbid dewatering water separate from stormwater.	BMP C203: Water Bars BMP C236: Vegetative Filtration	Will comply ☐ N/A (explain):

Element/ Description	Requirement	Applicable BMP(s)[1]	Confirmation
Maintain BMPs	Maintain BMPs to insure continued function.	BMP C150: Materials On Hand BMP C160: Certified Erosion and Sediment Control Lead	Will comply ☐ N/A (explain):
Manage the Project	Phase the project to avoid soil disturbance from Oct. 1 through April 30 if possible. Modify BMPs if not effective or to meet changed conditions.	BMP C150: Materials On Hand BMP C160: Certified Erosion and Sediment Control lead BMP C162: Scheduling	Will comply ☐ N/A (explain):
Protect Low Impact Development BMPs	Protect all bioretention, rain garden, and porous pavement BMPs from sedimentation through installation and maintenance of erosion and sediment control BMPs for areas that drain to the bioretention, rain garden or porous pavement BMPs.	BMP C102: Buffer Zone BMP C103: High Visibility Fence BMP C200: Interceptor Dike and Swale BMP C201: Grass Lined Channels BMP C207: Check Dams BMP C208: Triangular Silt Dike BMP C231: Brush Barrier BMP C233: Silt Fence BMP C2234: Vegetated Strip	Will comply ☐ N/A (explain):

[1] Descriptions of BMPs designated can be found in Volume II of this manual.

Section 6 – Site Plan (see attached example)

A site plan, to scale, shall be included with this checklist that shows the following items:

Item	Complete
Address, Parcel Number, and Street names*	
North Arrow	
Indicate boundaries of existing vegetation (e.g., tree lines, grassy areas, pasture areas, fields, etc.)*	
Identify any on-site or adjacent critical areas and associated buffers (e.g., wetlands, steep slopes, streams, etc.).	
Identify any FEMA base flood boundaries and Shoreline Management boundaries. *	
Show existing and proposed contours. *	
Delineate areas that are to be cleared and graded.	
Show all cut and fill slopes, indicating top and bottom of slope catch lines	
Indicate existing surface water flow direction(s).	
Label final grade contours and indicate proposed surface water flow direction and surface water conveyance systems (e.g., pipes, catch basins, ditches, etc.).	
Show grades, dimensions, and direction of flow in all (existing and proposed) ditches, swales, culverts, and pipes.	
Indicate locations and outlets of any dewatering systems (usually to sediment trap).	
Identify and locate all erosion control techniques to be used during and after construction.	

* For GIS information on these items, see Thurston County Geodata at www.geodata.org

Thurston County
Drainage Design and Erosion Control Manual

Volume III
Hydrologic Analysis and Stormwater Conveyance

Prepared by:
Thurston County Department of Resource Stewardship
Water Resources Division

December 2016

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Table of Contents

Tables

Figures

Chapter 1 - Introduction to Volume III

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* describes hydrologic analysis techniques and general design criteria for flow control and water quality Best Management Practices (BMPs). Design details and requirements for specific flow control and water quality BMPs are provided in Volume V. This volume also includes hydrologic analysis techniques, design criteria and specifications for stormwater conveyance systems including pipes, open channels, outfalls and other stormwater conveyance structures.

This volume is intended to prescribe approved methods and requirements for calculating infiltration rates, runoff flow volumes and rates to be used in sizing water quality treatment and flow control BMPs to minimize or eliminate impacts on downstream properties and natural resources. The County recognizes that it is not always possible to fully prevent any downstream impacts; in these cases, the County may require the project to provide off-site mitigation.

These regulations and criteria are based on fundamental principles of drainage, hydraulics, and hydrology, environmental considerations, and publications, manuals, and texts accepted by the professional engineering community. The project design engineer is responsible for being knowledgeable of and proficient with necessary design methodologies identified in this manual. The following is a partial list of publications which may be used as reference documents:

- The Washington State Department of Ecology *Stormwater Management Manual For Western Washington*
- Any Washington State Department of Ecology Approved Stormwater Management Manual, such as one produced by an NPDES Phase I community
- The Low Impact Development Technical Guidance Manual for Puget Sound (Washington State University Extension and the Puget Sound Partnership)
- Washington State Department of Transportation *Highway Runoff Manual.*
- *Applied Handbook of Hydrology*, by V.T. Chow
- *Handbook of Hydraulics*, by E.G. Brater and H.W. King
- Washington State Department of Transportation *Hydraulics Manual*
- *Soil Survey of Thurston County, Washington*, published by the Natural Resource Conservation Service, U.S. Department of Agriculture
- Washington State Department of Transportation *Standard Plans for Road, Bridge and Municipal Construction*
- *Thurston County Road Standards*, or the latest amendment

The most current edition of all publications shall be used.

1.2 How This Volume is Organized

Volume III is organized into three chapters and three appendices:

- **Chapter 1**: Introduction

- **Chapter 2**: Hydrologic design standards and acceptable analysis methods, including the use of hydrograph methods for BMP design, an overview of computerized modeling methods, analysis of closed depressions, and evaluation of the feasibility and sizing of infiltration facilities.

- **Chapter 3**: Natural and constructed conveyance systems and acceptable analysis methods. This chapter also discusses hydraulic structures linking conveyance systems to runoff treatment and flow control facilities.

- **Appendix A**: Infiltration testing procedures. This appendix also includes the USDA soil textural triangle, used for alternative methods of determining infiltration rates.

- **Appendix B**: SBUH/SCS computer models and charts and tables useful in designing conveyance systems with event-based hydrologic models. This includes: design storm rainfall totals, isopluvial maps for western Washington, common Thurston County Soil types, and hydrologic groupings, SCS curve numbers, and hydraulic roughness coefficients.

- **Appendix C**: Nomographs useful for culvert sizing.

- **Appendix D:** summarizes the feasibility criteria that can be used to determine if various on-site stormwater management BMPs in the List #1 or List #2 option of Core Requirement #5 can or cannot be used on the site. This information is also presented under the description of each BMP, but is summarized in Appendix D as a quick reference point.

1.3 How Do I Get Started?

First, consult Chapter 2 of Volume I to determine which Core Requirements apply to your project and to select BMPs. After determining the Core Requirements for your project and selecting BMPs, use Volume III (this volume) to determine the methods of estimating design volume or flow rates for those BMPs. Design guidelines for stormwater BMPs are included in Volume V. These facilities can then be included in any required stormwater submittals (see Volume I, Chapter 3). Chapter 3 of this volume also includes information on the design of stormwater conveyance systems.

Chapter 2 - Hydrologic Analysis and Design Standards

Hydrology is the study of the source, properties, distribution, and laws of water as it moves through its closed cycle (the hydrologic cycle). In this manual, however, the term "hydrologic analysis" addresses and quantifies only a small portion of this cycle, the relatively short-term movement of water over land resulting from precipitation, called surface water or stormwater runoff. Localized and long-term ground water movement is also a concern for successful stormwater management, but only as this relates to the movement of water on or near the surface, such as stream base flow or shallow groundwater effects on stormwater infiltration systems.

This chapter defines the minimum computational standards for conducting hydrologic analysis and how to apply these standards. It also explains the hydrologic design process, including flow routing through on-site stormwater management facilities.

Due to the relationship between stormwater runoff quantity (both flow and volume) and quality, it is critical to consider runoff treatment when designing for flow control and vice versa. Runoff treatment and flow control goals can often be accomplished in one facility. For example, wet ponds can be designed to provide both runoff treatment and flow control by providing for live storage volume above the permanent pool.

Site planning and layout play an important role in the amount of stormwater runoff generated by a project site. Reductions in impervious areas result in smaller runoff treatment and flow control facilities, thereby reducing stormwater management costs. Low Impact Development (LID) directly addresses this idea by limiting runoff and creating more aesthetically appealing sites. LID is discussed in Chapter 2 of Volume V.

Some of the things that must be considered during site planning and layout include: minimizing creating hard and impervious surfaces, clustering buildings and preserving larger areas of open space, minimizing directly connected hard and impervious areas (try to separate impervious surfaces with areas of turf, or other vegetation or gravel), incorporation of low maintenance landscaping that doesn't need frequent applications of fertilizers, herbicides and pesticides and minimizing the impact area and soil compaction during construction.

2.1 Minimum Computational Standards

Minimum computational standards depend on the type of information required and the size of the drainage area to be analyzed, as follows:

When designing runoff treatment and flow control BMPs, use a continuous simulation hydrologic model based on the EPA's Hydrologic Simulation Program-Fortran (HSPF) program (i.e., Ecology's Western Washington Hydrology Model (WWHM) or WSDOT's MGS Flood model) to calculate runoff and determine flow rates and volumes. Continuous models simulate rainfall and runoff over a long period of time, usually years, encompassing many storm events. Additional design standards applicable for selection and sizing of specific runoff treatment and flow control BMPs are found in Volume V.

- For conveyance system design, the designer may use a single event hydrologic model, a continuous simulation model, or the Rational Method to determine peak flow rate. For conveyance facilities that are also designed as water quality or flow control BMPs a continuous simulation runoff model shall be used to design the facility to meet the water quality or flow control requirements and the methodologies of this chapter shall be used to design the same facility for conveyance of stormwater. A single event hydrologic model may be used to determine the peak flow rate. The peak flow rate from a continuous runoff model will vary depending on the time step used in the model. Therefore, the length of the time step must be sufficiently short relative to the time of concentration of the watershed to provide for reasonable conveyance system design flows. For most situations in Thurston County, a 15-minute (maximum) time step will be sufficient for conveyance system design. If the project is in a predominantly urbanized watershed with a time of concentration less than about 15 minutes (roughly 10 acres in size), the conveyance design must either use a 5-minute time step (if available), or use an event-based model for conveyance sizing.

Conveyance design is discussed in detail in Chapter 3 of this Volume.

Circumstances where different methodologies apply are summarized in Table 2.1 Summary of Applicable Hydrologic Design Methodologies for Design of Stormwater Best Management Practices in Thurston County Table 2.1 below.

Table 2.1 Summary of Applicable Hydrologic Design Methodologies for Design of Stormwater Best Management Practices in Thurston County

Method	Runoff Treatment	Flow Control	Conveyance
Continuous Runoff Models: (WWHM or MGS Flood)	Method applies to all BMPs	Method applies to all BMPs	Method applies with appropriate time step based on time of concentration
SCSUH/SBUH (Soil Conservation Service Unit Hydrograph/Santa Barbara Urban Hydrograph)	Not Applicable[a]	Not Applicable	Method applies
Rational Method	Not Applicable	Not Applicable	Method applies for some conveyance design

[a] can be used for biofiltration BMPs (BF.01 – BF.05)

By default, the Department of Ecology's WWHM uses rainfall/runoff relationships originally developed for specific basins in the Puget Sound region for all parts of western Washington. These default parameters may be replaced with basin-specific rainfall/runoff data established by extensive field monitoring approved by the County where such data will improve the model's accuracy.

Free WWHM 2012 software and documentation can be found at the Department of Ecology website: http://www.ecy.wa.gov/programs/wq/stormwater/wwhmtraining/index.html.

A professional version of WWHM with expanded capabilities can be purchased from Clear Creek Solutions, Inc. at http://www.clearcreeksolutions.com/.

Use of continuous simulation runoff models other than WWHM 2012 or MGS Flood must be approved by the County before being used as a computational standard.

For large, master-planned developments, the County may require a basin-specific calibration of HSPF rather than default parameters. Basin-specific calibrations may be required for projects that encompass more than 320 acres.

Hydrologic Analysis of LID and Flow Control BMPs

There are three flow-related standards stated in Volume I of this manual: Core Requirement #5: On-site Stormwater Management; Core Requirement #7: Flow Control; and Core Requirement #8: Wetlands Protection.

The LID performance and flow control standards (Core Requirements #5 and #7) must be met using an approved continuous runoff model. Core Requirement #5 allows the user to demonstrate compliance with the LID Performance Standard of matching developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8 percent of the 2-year peak flow to 50 percent of the 2-year peak flow. If the post development duration values exceed any of the predevelopment flow levels between 8 percent and 50 percent of the 2-year predevelopment peak flow values, then the LID performance standard has not been met.[1]

The standard flow control requirement is summarized below:

- Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50 percent 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 available that indicates the site was prairie prior to settlement (modeled as “pasture” in the Western Washington Hydrology Model); or

Core Requirement #8 specifies that total discharge to a wetland must not deviate by more than 20 percent on a single event basis, and must not deviate by more than 15 percent on a monthly basis. Flow components feeding the wetland under both pre- and post-development scenarios are assumed to be the sum of the surface, interflow, and groundwater flows from the project site. Ecology has added the capability to model flows to wetlands and analyze the daily and monthly flow deviations (per these requirements) to WWHM2012.

See the documentation for WWHM (or alternate model) for instructions on how to use the model to meet these standards.

If off-site drainage combines with site runoff, these off-site flows must be included in the flow control BMP sizing analysis. See Chapter 3 for conveyance requirements for off-site drainage.

[1]Core Requirement #5 can be met by using the menu of BMPs as outlined in Volume I, Section 2.4.6 or the LID Performance Standard.

Hydrologic Analysis of Runoff Treatment BMPs

Water Quality Design Storm Volume

The 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model shall be used as the water quality design storm volume.

Water Quality Design Flow Rate

Downstream of detention facilities: The full 2-year recurrence interval release rate from a detention facility (using an approved continuous runoff model) designed to meet the flow duration standard shall be used as the design flow rate.

Preceding detention facilities or when detention facilities are not required: The flow rate at or below which 91 percent of the runoff volume, as estimated by an approved continuous runoff model, is routed through the treatment facility shall be used as the design flow rate. The 91 percent volume for treatment facilities is designed to achieve the applicable performance goal at the water quality design flow rate (e.g., 80 percent total suspended solids removal).

- *Offline facilities*: When runoff flow rates exceed the water quality design flow rate and treatment facilities are not preceded by an equalization or storage basin, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the portion of flow rates that exceed the water quality design flow may be bypassed around a treatment facility.

  Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of an approved continuous runoff model is treated to the applicable performance goals (e.g., 80 percent total suspended solids removal at the water quality design flow rate and 80 percent total suspended solids removal on an annual average basis).

- *Online facilities*: Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained.

Treatment facilities that are located downstream of detention facilities shall only be designed as on-line facilities.

Hydrologic Analysis of Conveyance Systems

For design of storm drainage conveyance systems, several design storms may have to be used to adequately assess the project and any downstream impact. The design of conveyance systems can be performed using the flow rates generated by an approved continuous simulation model per Section 2.1 or by one of two other methods, either the single event hydrograph method (SCS, SBUH) or the Rational Method (for small projects).

Single Event Storms – Hydrograph

Hydrograph analysis uses a plot of runoff flow versus time for a given single design storm event, allowing the key runoff characteristics like peak discharge, volume, and timing to be considered in drainage facility design. All storm event hydrograph methods require parameters that describe physical drainage basin characteristics. These parameters provide the basis of development of the runoff hydrograph. Because single event methods are only used in this manual to size conveyance systems and flow-through treatment facilities (biofiltration swales), discussion of design storms, curve numbers and peak runoff calculation is limited (see Appendix III-B).

For conveyance design, the preferred single event method is the Santa Barbara Urban Hydrograph Method or, if unavailable, the SCS Unit Hydrograph Method.

Rational Method

The rational method is a simple method used to estimate peak flows, and may be used for conveyance sizing on sites 25 acres or less in size, and having a time of concentration of less than 100 minutes. See Appendix III-B for details on the method.

2.2 Closed Depression Analysis

Closed depressions (potholes, kettles) represent a "dead end" for surface water flows and generally facilitate infiltration of runoff. If a closed depression is classified as a wetland or the discharge path flows through a wetland, then Core Requirement #8 for wetlands applies. If there is an outflow from this depression to a surface water (such as a creek), then the flow must also meet Core Requirement #7 for flow control.

A calibrated continuous simulation runoff 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 WWHM or an approved continuous runoff model.

Analysis and Design Criteria

The infiltration rates used in the analysis of closed depressions must be determined according to the procedures of Section 2.3. For closed depressions containing standing water, soil texture tests must be performed on dry land adjacent to, and on opposite sides of the standing water (as practicable). The elevation of the testing surface at the bottom of the test pit must be one foot above the standing water elevation. A minimum of four tests must be performed to estimate an average surface infiltration rate.

The criteria which must be met for discharge to a closed depression depend upon the location, whether the proponent has control of, or a right to discharge to the closed depression and the results of a hydrologic analysis of the closed depression.

Closed Depression Located On-Site or with a Legal Right to Discharge to Closed Depression

For a closed depression entirely on the subject property, or a closed depression to which the Proponent has acquired a legal right to discharge, analyze the closed depression using hydrologic methods described in Section 2.1. Infiltration must be addressed where appropriate. In assessing the impacts of the proposed project on the performance of the closed depression, there are two cases that dictate different approaches to meeting Core Requirement #7 – *Flow Control.*

Case 1

The 100-year recurrence interval storm runoff from an approved continuous simulation program, flowing from the TDA to the closed depression, is routed into the closed depression using only infiltration as outflow. If predevelopment runoff does not overflow the closed depression, then no runoff may leave the closed depression at the 100-year recurrence interval storm runoff following development of the proposed project. This may be accomplished by excavating additional storage volume in the closed depression, subject to all applicable requirements (for example, providing a defined overflow system).

Case 2

The 100-year recurrence interval storm runoff from an approved continuous simulation program, from the TDA to the closed depression, is routed into the closed depression using only infiltration as outflow, and overflow occurs in both the existing and the proposed conditions. The closed depression must then be analyzed as a detention/infiltration pond. The required performance, therefore, is to meet the runoff duration standard specified in Core Requirement 7 – *Flow Control*, using an adequately calibrated continuous simulation model. This will require a control structure, emergency overflow spillway, access road, and other design criteria and may require excavating additional storage volume in the closed depression. Also depending on who will maintain the system, it will require placing the closed depression in a tract dedicated to the responsible party.

Closed Depression Located Off-Site

For a closed depression shared with, or entirely on other properties, absent a legal agreement to the contrary, the peak water elevation for the 100-year recurrence interval storm runoff from an approved continuous simulation program, from the Threshold Discharge Area to the closed depression shall not cause an increase in water levels exceeding:

- 0.1 feet above the base, if available information indicates that the base is to be dry at all times, or
- 0.1 feet above the current peak water elevation, if this elevation can be clearly demonstrated.

In all cases, discharge to a closed depression shall be allowed only if the Project Engineer can satisfactorily demonstrate that no significant public health, safety, welfare, or property damage issues are present.

2.3 Site Suitability and Hydrologic Analysis of Infiltration Facilities

Infiltration is the percolation of surface water into the ground, and is an effective way to meet the flow control requirements of Core Requirement #7. While other flow control facilities, such as detention ponds, just reduce peak flow rates associated with developed areas, infiltration facilities reduce the total volume of surface runoff as well as peak flow rates. When properly sited and designed, infiltration facilities can help recharge groundwater and protect downstream receiving waters. In some cases, infiltration facilities can be used to meet the runoff treatment requirements of Core Requirement #6 also (see Section 2.3.1 below).

Infiltration Facilities for Runoff Treatment

Infiltration facilities can be designed for runoff treatment within Thurston County. The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants.

- Measured (initial) soil infiltration rate should be 9 inches per hour, or less. This infiltration rate is also typical for soil textures that possess sufficient physical and chemical properties for adequate treatment, particularly for soluble pollutant removal. It is comparable to the textures represented by Hydrologic Group B and C. Design (long-term) infiltration rates up to 3.0 inches per hour can also be used with approval by Thurston County, 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 considered suitable for treatment (see description later in this section) to control target pollutants.

- Cation exchange capacity (CEC) of the treatment soil must be ≥5 milliequivalents CEC/100 g dry soil (USEPA Method 9081). Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of >5 meq/100g are expected in loamy sands, according to Rawls et al. Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is accepted by Thurston County.

- Depth of suitable treatment soil used for infiltration treatment must be a minimum of 18 inches. If native soils cannot meet the treatment criteria of this section, soils may be amended or an engineered soil (minimum depth of 18 inches) may be used. See BMP LID.08 Bioretention in Volume V for an acceptable engineered soil for runoff treatment.

- Organic content of the treatment soil (ASTM D 2974): Organic matter can increase the sorptive capacity of the soil for many pollutants. The site professional shall evaluate whether the organic matter content is sufficient for control of the target pollutant(s). A minimum organic content of 1.0% is necessary.

- Waste fill materials shall not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.

- Engineered soils may be used to meet infiltration BMP design criteria in Volume V and the performance goals in Core Requirement #6 (Runoff Treatment; Volume I). BMP LID.08 Bioretention provides an acceptable engineered soil specification for runoff treatment. Use of alternate engineered soils must be accepted by the County, and requires field performance evaluation(s), using acceptable protocols, to determine effectiveness, feasibility, and acceptability.

Also note that although infiltration is one of the preferred methods for disposing of excess stormwater, and may be required to meet Core Requirement #7 **–** *Flow Control*, infiltration may be regulated by the Department of Ecology and the Underground Injection Control (UIC) Program (WAC 173-218) if an injection device, such as a dry well or trench with distribution pipe is used. Additional information and requirements on UIC and how it applies to infiltration and stormwater management is included in Volume V, Section 3.1.3.

Site Suitability and Analysis Procedures

The following procedures must be followed when considering and designing an infiltration facility. Each step is outlined in more detail in the subsequent sections. Figure 2.1 illustrates the process of analyzing and sizing infiltration facilities.

Step 1 – Conduct general site reconnaissance, and review survey and other information to identify existing drinking water wells or aquifers, designated well head protection areas for public water systems, existing and proposed buildings, steep slopes, and septic systems in the vicinity of the proposed facility.

Step 2 – Evaluate Core Requirements for infiltration facilities to determine whether infiltration is feasible for the site.

Step 3 – Infiltration Receptor Characterization. Estimate depth to groundwater from the bottom of proposed infiltration facility. If estimated depth to groundwater is less than 50 feet, installation of groundwater monitoring wells and characterization of the infiltration receptor will be required. If less than 6 feet to groundwater, then a mounding analysis will be required.

Step 4 – Determine whether the simple or detailed method of analysis will be used to establish a design infiltration rate. Consultation with Thurston County is required at this stage to obtain acceptance of the proposed method of analysis (simple or detailed).

Step 5 – Complete simple analysis or detailed analysis, as determined in Step 4 and described in Sections 2.3.3 and 2.3.5. Prepare geotechnical report.

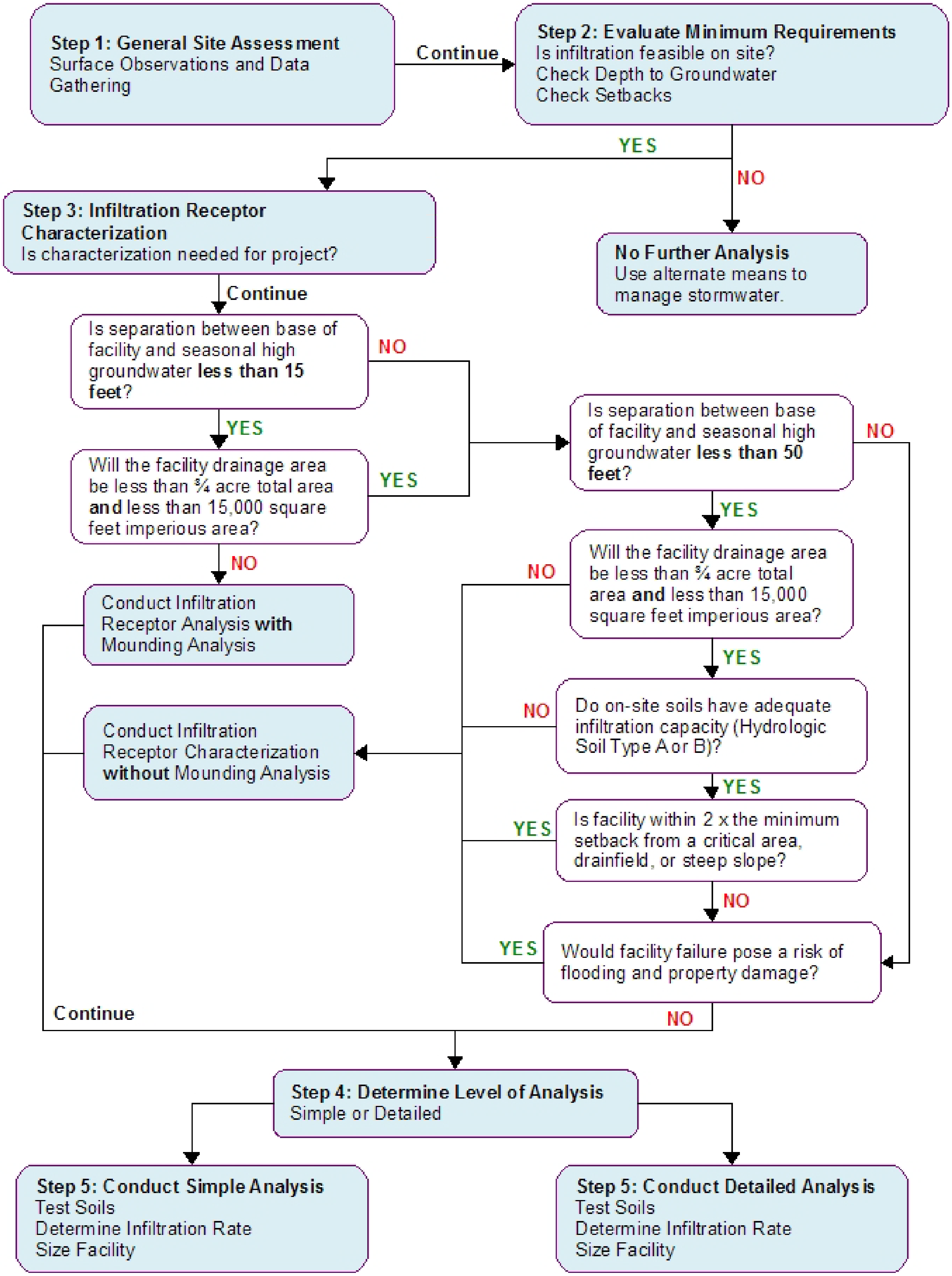

Figure 2.1 Infiltration Analysis and Sizing Flow Chart

Details of these five steps are provided in the sections below.

Step 1: General Surface Characterization

The first step in designing an infiltration facility is to select a location and assess the site's suitability. The information to be reviewed as part of this initial site characterization varies by site, but may include:

- Topography within 500 feet of the proposed facility
- Anticipated site use (street/highway, residential, commercial, high-use site)
- Location of water supply wells within 500 feet of proposed facility
- Location of project relative to any designated well head protection areas for public water systems and/or 1-, 5-, and 10-year time of travel zones for municipal well protection areas2. (Enhanced treatment required prior to infiltration if located within a designated WHPA). Location of steep slopes (>15%) or landslide hazard areas
- Location of septic systems in the vicinity of the proposed facility
- A description of local site geology, including soil or rock units likely to be encountered, the groundwater regime, and geologic history of the site.
- Analysis of site borings and soil testing and review of any available existing soils information for the site or adjacent sites.
- Analyze any existing runoff flowing into and out of the site. Speculate on possible flows generated by greater than the 100-year event. Check the proximity of other stormwater facilities on adjacent properties.
- Location of any high groundwater hazard areas or wetlands per the Thurston County Critical Areas Ordinance, TCC Title 17 and Title 24.

This information, along with additional geotechnical information necessary to design the facility, shall be summarized in the geotechnical report prepared in Step 5.

Step 2: Evaluate Core Requirements for Infiltration Facilities

Infiltration is not permitted unless all of the Depth to Seasonal High Groundwater and Setbacks criteria below are met. Note: not all sites that meet the following criteria will be suitable for infiltration – these are **Core Requirement**s only.

[2] Infiltration facilities of drinking water supplies and within 1, 5, and 10-year time of travel zones must comply with Health Dept. requirements (Washington State Wellhead Protection Program Guidance Document, DOH, 6/2010).

Depth to Seasonal High Groundwater

The base of all infiltration basins or trench systems shall be a minimum of 3 feet above seasonal high groundwater levels, bedrock (or hardpan), or any other low permeability layer. Small bioretention (BMP LID.08) facilities with less than 10,000 square feet of impervious area contributing to the facility may be designed with a reduced vertical separation of 1 foot minimum.

Seasonal high groundwater level is the upper level at which the groundwater table normally is located during the season of the year when such levels are at their highest (typically December 1 through April 30). This level is determined using a test pit (reviewed by a soil analyst for soil color patterns in the soil profile) or using groundwater monitoring data gathered through a minimum of one wet period (December through April). See Step 3 for additional criteria related to groundwater depth.

Setbacks

Infiltration basins may not be constructed within a floodplain area or high groundwater flood hazard area as defined in Thurston County Code, Title 17 and Title 24. Additional setbacks are summarized in Appendix V-E.

Step 3: Infiltration Receptor Characterization

An Infiltration receptor characterization consists of monitoring and analysis of groundwater, and (in some cases) a mounding analysis. This characterization must be conducted if any of the following conditions are present:

- Proposed facility would pose a risk of flooding or property damage if failure were to occur.
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND tributary drainage area contains more than 15,000 square feet impervious surface or ¾ acre total area.
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND on-site soils may not have adequate infiltration capacity (Hydrologic Soil Group C or D [till soils]).
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND there is less than 2 times the minimum setback to a critical area, drainfield, or steep slope (>15%).

In addition, mounding analysis must be conducted if BOTH of the following conditions are present:

- Separation between base of facility and seasonal high groundwater is less than 15 feet, AND

- Tributary drainage area is greater than 3/4 acre or there is greater than 15,000 square feet of impervious surface contributing to the facility.

A mounding analysis may also be required by the Administrator for conditions other than those listed above if any of the following conditions are present:

- Hydrologic Soil Group C or D soils with an estimated infiltration rate of less than 0.5 inches/hour.
- The potential impact to downstream properties and/or critical areas is high as a result of a facility failure.
- Urban environment (> 4 units per acre).
- Facility is within 100-feet of a steep slope (>15%) with soils having less than a 1 inch/hour infiltration rate.
- When soils work indicates there may be a perched low permeability layer above the water table.

An exemption from the mounding analysis may be granted if the geotechnical professional can demonstrate to the satisfaction of the Administrator that it is not necessary. This demonstration shall be based on site specific information that in the judgment of the geotechnical professional mitigates against the requirement to conduct a mounding analysis. Examples of circumstances that the Administrator will consider in granting an exemption include:

- Soils are classified as outwash with an estimated design infiltration rate of greater than 5 in/hr.
- Soils are uniform and easily characterized as outwash. Risk of low permeability lenses is low.
- Site topography, etc. indicates no substantial risk to slopes, wetlands, structures etc. in the event groundwater breaches the surface.
- Other studies of groundwater mounding for the same or adjacent sites indicate that mounding would not be a concern.

If it is determined that an Infiltration Receptor Characterization is not required for a project, continue to Step 4.

Monitor Groundwater Levels

A minimum of three groundwater monitoring wells shall be installed per infiltration facility that will establish a three-dimensional relationship for the groundwater table. Seasonal groundwater levels must be monitored at the site through at least one wet season (December 1 through April 30). Where longer term groundwater monitoring information is available, normalize the single wet season observations to historic groundwater records in the region.

Monitoring wells shall be installed and monitored in accordance with the following requirements:

- Well shall be screened across the water table.
- Maximum screen and sand pack length of 15 feet.
- Weekly water level monitoring resulting in a minimum of 16 measurements over 4 months.

Document Characterization

A geotechnical report will be developed in Step 5. This report shall include the following information to characterize the infiltration receptor (unsaturated and saturated soil receiving the stormwater):

- Depth to groundwater and to bedrock/impermeable layers.
- Seasonal variation of groundwater table based on well water levels and observed mottling of soils. Provide an estimated seasonal high groundwater level and an estimated maximum high groundwater level taking into account historical and seasonal groundwater table fluctuations.
- Existing groundwater flow direction and gradient
- Volumetric water holding capacity of the infiltration receptor soils. The volumetric water holding capacity is the storage volume in the soil layer directly below the infiltration facility and above the seasonal high groundwater mark, bedrock, hardpan, or other low permeability layer.
- Consider the potential for both unconfined and confined aquifers, or confining units, at the site that may influence the proposed infiltration facility as well as the groundwater gradient.
- Determine ambient ground water quality, if that is a concern.
- Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water
- Approximation of the lateral extent of infiltration receptor
- Impact of the infiltration rate and proposed added volume from the project site on local groundwater mounding, flow direction, and water table; and the discharge point or area of the infiltrating water determined by hydrogeologic methods.
- Location of the project within the Salmon Creek Basin requires specific groundwater characterization elements be met and reference to the Salmon Creek

Basin Plan and Interim Site Development Standards for New Development in Salmon Creek Basin should be referred to for specific requirements.

- State whether location is suitable for infiltration and recommend a method for estimating the design infiltration rate (simple or detailed, in-situ or gradation based).

Mounding Analysis

If a mounding analysis is required, the geotechnical professional shall develop an approach and obtain its acceptance from Thurston County prior to initiating the study. Simple, conservative methods of estimating groundwater mounding are available and may be acceptable with the use of conservative parameters to demonstrate that risks from groundwater mounding are acceptable. The methodology, approach, software program, input data, calibration requirements and output format for the mounding analysis shall be proposed by the geotechnical professional in the geotechnical report for acceptance by Thurston County.

The purpose of the mounding analysis is to identify the impact of groundwater mounding on the estimated design infiltration rate, the seasonal high groundwater elevation at the property boundary and at any on-site or off-site structures, critical areas, or other site features that might be impacted by groundwater mounding.

The results of the mounding analysis will be reported by the geotechnical professional as part of the Infiltration Receptor Characterization and shall include the following determinations:

- A minimum separation of at least 3-feet to seasonal high groundwater will be maintained from the bottom of the facility with mounding.

- There will be no breakout of groundwater to the surface in the vicinity of the project as a result of mounding.

- That a minimum separation to groundwater from the estimated lowest elevation of any basement, building foundation, road, or other structure will be at least 3-feet.

- That there will be no intrusion of the groundwater mound into any existing or proposed drainfield or reserve area and that there will be no greater than a 6-inch increase in groundwater elevation beneath any septic drainfield or reserve area as a result of groundwater mounding.

- That the increase in groundwater elevation at the property boundaries of the project will not result in impacts to adjacent property owners. Generally demonstrating that the increase in groundwater level at the property boundary is less than 1-foot due to mounding would meet this criterion unless there are special circumstances.

Step 4: Determine Method of Analysis

Thurston County requires consideration of infiltration facilities for sites where conditions are appropriate. Some sites may not be appropriate for infiltration due to soil characteristics, groundwater levels, steep slopes, or other constraints.

The design infiltration rate for a proposed infiltration facility shall be calculated based on either the Simple Method or Detailed Method as described in this section.

Simple Method

The Simple Method was derived from high ground water and shallow pond sites in western Washington, and in general will produce conservative designs. The Simple Method (Section 2.3.3) should be considered a suitable method of calculating design infiltration rates in the following circumstances:

- When determining the trial geometry of the infiltration facility,
- For small or low impact facilities
- For facilities where a more conservative design is acceptable.
- High infiltration capacity soils (NRCS [SCS] soil types A or B)
- For small facilities serving short plats or commercial developments with less than one acre of contributing area
- Where other infiltration facilities are performing successfully at nearby locations
- Low risk of flooding and property damage in the event of clogging or other failure of the infiltration system

Where the combination of depth to ground water/low permeability layer and soil type results in the possibility of groundwater mounding effects the Simple Method should not be applied. The suitability of the Simple Method should be discussed in the geotechnical report.

Detailed Method

The detailed method of analysis is more suitable when it is unclear if a site is well-suited to infiltration and in cases where failure of an infiltration facility would create a high risk of flooding and/or property damage. The detailed method of analysis, described in Section 2.3.4, includes more intensive field testing and soils investigation and analyses than the Simple Method and takes into account the depth to groundwater. Sites that have **ANY** of the following conditions should be considered for use of the detailed method:

- Low infiltration capacity soils (NRCS [SCS] soil types C or D)
- History of unsuccessful infiltration facility performance, or no history of successful infiltration performance at nearby locations

- A large contributing drainage area (greater than 1-acre)
- Shallow groundwater levels (Less than 50 feet to seasonal high groundwater)
- High risk of flooding and property damage in the event of clogging or other failure.

The County may allow the Simple Method in circumstances that might warrant the detailed method if it is demonstrated that the infiltration facility could be converted to a detention facility of adequate size if the infiltration facility were to fail.

Step 5: Conduct Simple or Detailed Analysis

Based on the results of Step 3 and 4, conduct a simple analysis (Section 2.3.3), or a detailed analysis (Section 2.3.4).

Simple Analysis Procedures

All proposed infiltration projects must evaluate soils, determine the design infiltration rate, prepare a geotechnical report, and estimate the volume of stormwater to be infiltrated.

The Simple Method of calculating a design infiltration rates includes several alternative methods as follows:

- Field Testing by In-Situ Methods (must incorporate safety factors) including:
    - Split Double Ring Infiltrometer
    - Ecology Pilot Infiltration Test (PIT)
    - Single Ring Falling Head Infiltration Method (US EPA 1980) as Modified by Thurston County.
- USDA Soil Textural Classification
- ASTM Gradation Testing

Soil Testing

Test holes or test pits must be dug according to the following guidelines (see Table 2.2):

- Test hole or test pit explorations shall be conducted during mid to late in the wet season (with the wet season defined as December 1 through April 30).
- Collect representative samples from each soil type and/or unit to a depth of 6 feet below the proposed base of the infiltration facility or 2.5 times the estimated depth of the infiltration pond, whichever is greater. See Table 2.2 for required number of test pits or test holes by facility type.

- 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).

    - Textural class (USDA).

    - Percent clay content (include type of clay, if known).

    - Color/mottling.

    - Variations and nature of stratification.

    - Cation exchange capacity (CEC) and organic matter content (if facility may be considered to provide treatment as well as flow control).

- For small-scale infiltration facilities (contributing drainage area is less than 7,500 square feet), only one testing location is required.

- The required number of test pits/test holes may be modified by the Administrator or designee if provided adequate evidence of consistent subsurface conditions.

- 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 the depth, soil descriptions, depth to water, evidence of seasonal high groundwater elevation, existing ground surface elevation, proposed pond bottom elevation, and presence of stratification that may impact the infiltration design. Elevations shall be referenced to a vertical datum such as NGVD 29. Use the soil evaluation report forms in Appendix I-F.

Table 2.2 Required Number of Test Pits, Test Holes, and In-Situ Testing Locations for infiltration Facilities

Contributing Drainage Area	BMP Type	Number of Test Pits/Test Holes per BMP	Number of In-Situ Infiltration Testing Locations per BMP (If Using In-Situ Testing Method of Simple Method)[a]
SFR or Commercial, less than 7,500 square feet	All Infiltration BMPs	1	1
Greater than 7,500 square feet or other land use type	Infiltration trench (BMP IN.02) or linear configuration of other Infiltration BMP	1 per 200 linear feet (2 minimum)	1 per 500 linear feet (2 minimum) [a,b]
Greater than 7,500 square feet or other land use type	Bioretention Area (BMP LID.08), Infiltration Pond (BMP IN.01), or Alternative Pavement (BMP LID.09)	1 per 5,000 square feet (2 minimum)	1 per 10,000 square feet (2 minimum) [a,b]

BMP: best management practice
SFR: single family residential
[a] In-Situ testing only required if applicant intends to use In-Situ Method for Estimating Design Infiltration Rate. Test pits are still required to characterize subsurface. For small scale in-situ methods, a minimum of three tests are required at each location. Small scale in-situ testing includes ASTM D3385 Method (DRI) and Single-Ring Falling Head Infiltration method.
[b] Tests must be conducted at the test pits with the least permeable soils, as determined by observation of grain size gradation.

Note: The required number of test pits/test holes may be modified by the Administrator or designee if provided adequate evidence of consistent subsurface conditions

Determine Design Infiltration Rate

There are two ways of estimating design infiltration rates: in-situ testing or using relationships between soil properties and infiltration rates.

Note: It should be recognized that there is a distinction between infiltration rate and hydraulic conductivity. These two parameters are related by Darcy's equation where:

$f = Ki$ where f = infiltration rate, i = hydraulic gradient (head in ft/ft) and K = hydraulic conductivity.

In cases where water percolates under free draining conditions the hydraulic gradient is 1.0 and the infiltration rate equals the hydraulic conductivity. However, in circumstances where groundwater mounding or pond depth creates a hydraulic gradient, the infiltration rate and hydraulic conductivity would not be equal. In the simple methods, it is likely that the hydraulic gradient is close to 1.0 and therefore the infiltration rate and hydraulic conductivity are close to equal. The design professionals should keep these distinctions in mind and account for the differences as appropriate to the circumstances.

Prescriptive BMP sizing methods can be used in lieu of estimating an infiltration rate for downspout infiltration (BMP LID.04) when the following conditions apply:

- Contributing drainage area is less than 7,500 square feet.

- Property is a single family residential lot or commercial development.
- Soils are characterized by a soils professional (including a septic system designer) as one of the soil types used to establish the design criteria of BMP LID.04 (e.g., infiltration trenches limited to loam, sandy loam, etc.).
- For prescriptive drywells sized using Table 2.2 of Volume V the project must either be located outside of the Thurston County Phase II NPDES permit boundary or not be subject to Flow Control (MR#7).

These prescriptive methods are included in the BMP descriptions in Volume V.

The two following general methods of estimating the design infiltration rate can be used:

Method 1 – In-Situ Testing Methods

- Ecology Pilot Infiltration Test (PIT) is a large-scale test of infiltration. The PIT (described in Appendix III-A) is the preferred method of determining infiltration rate in Thurston County, and can be used for any infiltration BMP. The PIT method requires a substantial amount of water, which may not be available at some sites. If the test is not feasible for this reason, the alternative methods described below can be used.
- Single-Ring Falling-Head Infiltration method (US EPA 1980), as modified in Appendix III-A or as modified by Clark County (2015) is an acceptable in-situ method when the PIT method cannot be conducted due to site constraints, or the availability of sufficient water.
- Small-Scale (PIT). This test applies to infiltration facilities with drainage areas less than one acre and may be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Core Requirement #5.
- Double-Ring Infiltrometer method (ASTM D3385) is an acceptable in-situ method when the PIT method cannot be conducted due to site constraints, or the availability of sufficient water.

Method 2 – Soil Property Relationships

- USDA Soil Textural Classification method (USDA 1993). This method is applicable to sites with soils classified as loam, sandy loam, loamy sand, sand, sandy gravel or gravelly sand, and is described in Appendix III-A. This method only applies to projects sites that trigger Core Requirement #1 through #5 (not #1 through #10). This method may not be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Core Requirement #5.
- ASTM Gradation Testing method (ASTM D422). This method is applicable to sites with soils classified as sand or sandy gravel, and is described in Appendix

III-A. This method may not be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Core Requirement #5.

If conducting in-situ testing of infiltration rates, see Table 2.3 for guidelines on the frequency of in-situ infiltration tests.

Determine Infiltration Rate of Engineered Treatment Soils

If the Bioretention Soil Mix (BSM) (Section 2.2.5.6.6, *Bioretention Soil Mix*, of Volume V) is used, assume a default short term infiltration rate of 12 inches per hour and apply appropriate correction factors to obtain a design infiltration rate. The applied correction factor shall be 2 or 4 depending upon the drainage area. Use a factor of 2 as the applied correction factor if the contributing area has less than 5,000 square feet of pollution generating impervious surface and less than 10,000 square feet of impervious surface; otherwise a correction factor of 4 shall be applied (i.e. multiply the short term infiltration rate by a factor of 0.25 or 0.5). If custom engineered soils other than the BSM are used for the treatment soils the following procedure will be used to determine the design infiltration rate for the facility and inputs for hydrologic modeling (WWHM). For other engineered soils the long term infiltration rate shall be determined as follows:

1. The infiltration rate used for hydrologic modeling and facility sizing shall be the lower of the long-term infiltration rate of the engineered soils or the short term infiltration rate of the underlying soils.

2. The long term infiltration rate of the engineered soils can be assumed to be 6 inches per hour with an applied correction factor of 2 or 4 depending upon the drainage area if the engineered soils meet the soil specifications for a bioretention facility as described in Section 2.2.5.6.6, *Bioretention Soil Mix*, of Volume V. For other engineered soils the long term infiltration rate will be based on ASTM 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 85 percent of maximum density using ASTM 1557 Test Method (Modified Proctor) with an applied correction factor of 2 or 4 depending upon the drainage area. (see above).

3. The short term rate for the underlying soils will be based on the calculated rate as determined by the methods described in this Chapter without application of the adjustment factor for clogging of the soils. This is based on the assumption that the treatment soil layer removes the silt and sediment that would have resulted in clogging of the underlying soils.

4. Use the lower infiltration rate of the two determined above in the hydrologic model and use an infiltration reduction factor of 1.

Prepare Geotechnical Report

A geotechnical report shall be prepared by or under the direct supervision of, and stamped by either a professional engineer with geotechnical expertise, or a licensed geologist, engineering geologist, or hydrogeologist. The report must summarize site characteristics and demonstrates that sufficient permeable soil for infiltration exists. In addition to the information required by Step 3 – *Infiltration Receptor Characterization* (as applicable), at a minimum, the report must contain the following:

- Figure showing the following:
    - Topography within 500 feet of the proposed facility
    - Locations of any water supply wells within 500 feet of the proposed facility
    - Location of groundwater protection areas, aquifer recharge areas, or 1-, 5-, and 10-year times of travel zones for designated wellhead protection areas.
    - Location of high groundwater hazard or flood plain areas in the project vicinity.
    - Locations of test pits or test holes.
- Results of soils tests including but not limited to: detailed soil logs, visual grain size analysis, grain-size distribution (required if using the grain size analysis method to estimate infiltration rates), percent clay content (include type of clay, if known), color/ mottling, variations and nature of stratification
- Description of local site geology, including soil or rock units likely to be encountered at soil sampling depths, the seasonal high groundwater elevation, and an estimate of the maximum historical groundwater elevation.
- Detailed documentation of the design infiltration rate determination, as specified above
- State whether location is suitable for infiltration and recommend a design infiltration rate.

Estimate Volume of Stormwater

Use the Western Washington Hydrologic Model (WWHM), MGSFlood, or other approved continuous simulation runoff model to generate a runoff inflow file that will be used to size the infiltration facility. The facility must either:

- Infiltrate all of the flow volume as specified by the inflow file without any overflow, or
- Infiltrate a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Core Requirement #7 – Flow Control, or

- Be designed as a combined infiltration/detention facility such that any discharge to surface water from the facility meets the flow duration standards in Core Requirement #7 – Flow Control.

In addition, the overflow/bypass must meet the LID performance standard if it is the option chosen to meet Core Requirement #5.

If the facility is designed to meet runoff treatment requirements of Core Requirement #6, it must infiltrate the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

For downspout infiltration (BMP LID.04) a simplified sizing table can be used if the facility meets soils requirements and contributing drainage area thresholds. Simplified sizing methods are presented in the corresponding BMP description in Volume V.

Detailed Analysis Procedure

This detailed approach was obtained from Massmann (2003). Procedures for the detailed approach are as follows (see Figure 2.2):

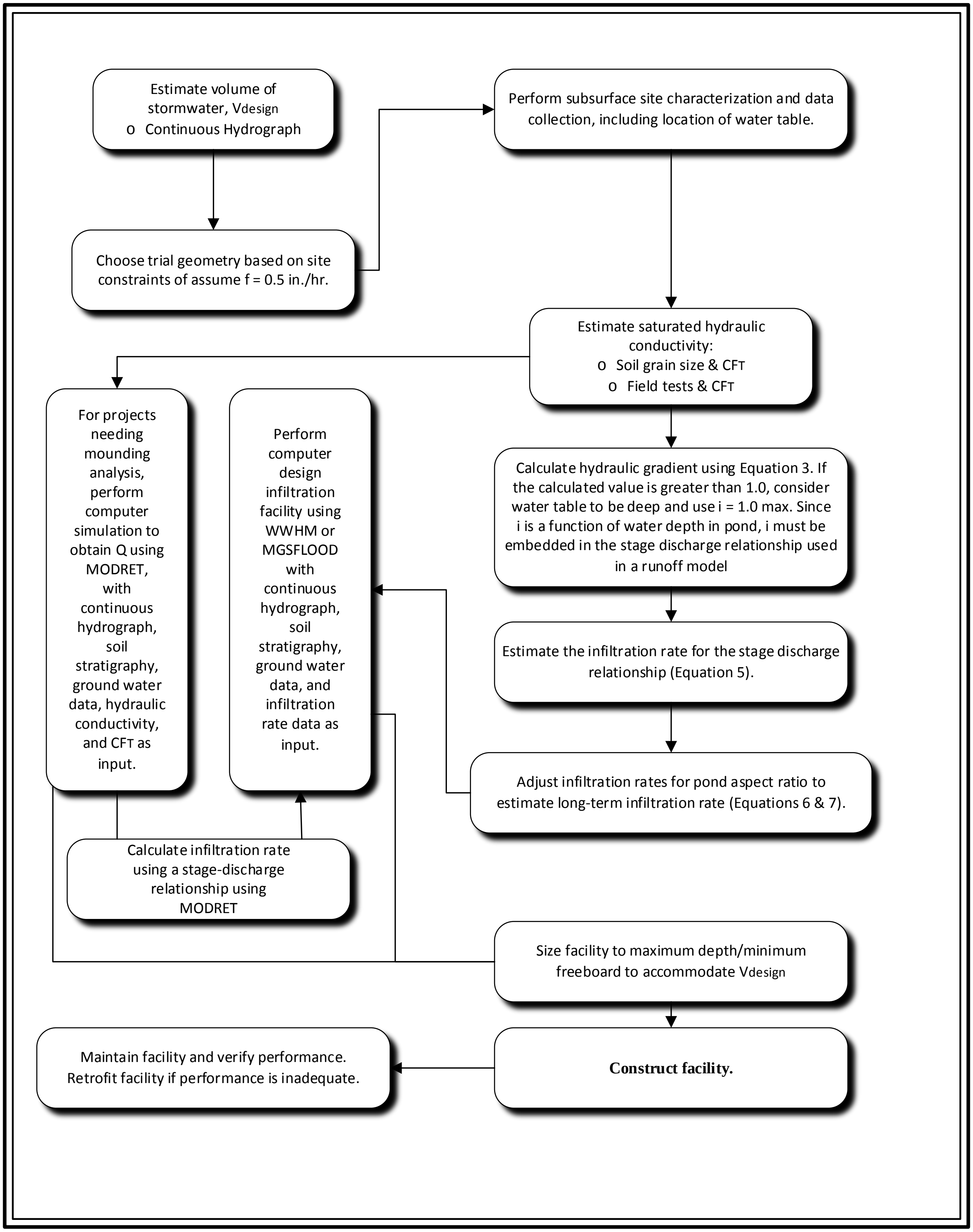

Figure 2.2 Engineering Design Steps for Final Design of Infiltration Facilities Using the Detailed Method (from Ecology [2012])

Develop a Trial Infiltration Facility Geometry Based on Length, Width, and Depth

To accomplish this, either assume an infiltration rate based on previously available data, or use a default infiltration rate of 0.5 inches/hour. Use this trial geometry to help locate the facility, and for planning purposes in developing the geotechnical subsurface investigation plan.

Conduct a Geotechnical Investigation

A geotechnical investigation must be conducted to evaluate the site's suitability for infiltration, to establish the infiltration rate for design, and to evaluate slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the facility. Geotechnical investigation requirements are provided below.

The depth, number of test holes or test pits, and sampling described below should be increased if a licensed engineer with geotechnical expertise (P.E.), or a licensed geologist or hydrogeologist judges that conditions are highly variable and make it necessary to increase the depth or the number of explorations to accurately estimate the infiltration system's performance. The exploration program described below may be decreased if the licensed professional judges that conditions are relatively uniform, or design parameters are known to be conservative based on site specific data or experience, and the borings/test pits omitted will not influence the design or successful operation of the facility.

- For infiltration basins (ponds), at least one test pit or test hole per 5,000 ft^2 of basin infiltrating surface (two minimum).

- For infiltration trenches, at least one test pit or test hole per 200 feet of trench length (two minimum).

- Subsurface explorations (test holes or test pits) to a depth below the base of the infiltration facility of at least 5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone (whichever is less).

- Continuous sampling to a depth below the base of the infiltration facility of 2.5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone, but not less than 6 feet. Samples obtained must be adequate for the purpose of soil gradation/classification testing. For large infiltration facilities 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).

- Conduct Infiltration Receptor Characterization as described in Step 3 if required.

- Laboratory testing as necessary to establish the soil gradation characteristics and other properties as necessary, to complete the infiltration facility design. At a minimum, one-grain size analysis per soil stratum in each test hole must be conducted within 2.5 times the maximum design water depth, but not less than 6 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 facility, requiring soil gradation/classification testing for layers deeper than indicated above.

Prepare Geotechnical Report

A report must be prepared by or under the direction supervision of and stamped by either a professional engineer with geotechnical expertise, or a licensed geologist, engineering geologist, or hydrogeologist The report must summarize site characteristics and demonstrate that sufficient permeable soil for infiltration exists. In addition to information required in Step 3 – *Infiltration Receptor Characterization* (as applicable), at a minimum, the report must contain the following:

- Figure showing the following:
    - Topography within 500 feet of the proposed facility
    - Locations of any water supply wells within 500 feet of the proposed facility
    - Location of groundwater protection areas, aquifer recharge areas, or 1-, 5-, and 10-year times of travel zones for designated wellhead protection areas
    - Location of high groundwater hazard areas and flood plains in the vicinity of the project
    - Locations of test pits or test holes
- Results of soils tests, including detailed soil logs, visual grain size analysis, grain-size distribution (required if using the grain size analysis method to estimate infiltration rates), percent clay content (include type of clay, if known), color/ mottling, variations and nature of stratification
- Description of local site geology, including soil or rock units likely to be encountered at soil sampling depths, the seasonal high groundwater elevation, and an estimate of the maximum groundwater depth
- Detailed documentation of the design infiltration rate determination, as specified in this Chapter
- State whether location is suitable for infiltration and recommend a design infiltration rate
- The stratification of the soil/rock below the infiltration facility, including the soil gradation (and plasticity, if any) characteristics of each stratum
- The depth to the ground water table and to any bedrock/ impermeable layers

- Seasonal variation of the ground water table
- The existing ground water flow direction and gradient
- The hydraulic conductivity or the infiltration rate for the soil/rock at the infiltration facility
- The porosity of the soil below the infiltration facility but above the water table
- The lateral extent of the infiltration receptor
- Impact of the infiltration rate and volume on flow direction and water table at the project site, and the potential discharge point or area of the infiltrating water.

Determine Design Infiltration Rate

Procedures for determining the design infiltration rate of the site soils are included in Appendix III-A.

As with the simple analysis described above, if engineered soils are used for the treatment soils, the lower of the long-term infiltration rate of the engineered soils and the short term infiltration rate of the underlying soils shall be used for facility sizing.

Sizing of Infiltration Facilities

Design Criteria – Sizing Facilities

- The size of the infiltration facility can be determined using a continuous runoff model by routing the inflow runoff file through the proposed infiltration facility. In general, an infiltration facility would have two discharge modes. The primary mode of discharge from an infiltration facility is infiltration into the ground. However, when the infiltration capacity of the facility is reached, additional runoff to the facility will cause the facility to overflow. If a project is subject to Core Requirement #7 (Flow Control), overflows from an infiltration facility must comply with the flow control standard. Infiltration facilities designed to meet Core Requirement #6 (Runoff Treatment) must not overflow more than 9 percent of the total volume of runoff in the inflow runoff file. However, if the facility is an infiltration basin (BMP IN.01) configured as an off-line facility, it must be sized as follows: ***Off-line, upstream of detention facility (or without detention facility):*** A flow splitter shall be designed to send all flows at or below the 15-minute water quality flow rate, as predicted by an approved continuous runoff model to the treatment facility. Within the WWHM, the flow splitter icon is placed ahead of the pond icon which represents the infiltration basin. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).
- ***Off-line, downstream of detention facility:*** A flow splitter shall be designed to send all flows at or below the 2-year flow frequency from the detention pond, as

predicted by an approved continuous runoff model, to the infiltration basin. Within the WWHM, the flow splitter icon is placed ahead of the pond icon which represents the infiltration basin. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

For infiltration facilities designed for runoff treatment, document that the 91st percentile, 24-hour runoff volume (indicated by WWHM or MGS Flood) can infiltrate through the infiltration basin surface within 48 hours (using the long-term infiltration rate). This can be calculated using a horizontal projection of the infiltration basin mid-depth dimensions and the estimated long-term infiltration rate. 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.

In order to determine compliance with the flow control requirements, the Western Washington Hydrology Model (WWHM), or an appropriately calibrated continuous simulation runoff model based on HSPF, must be used. When using WWHM for simulating flow through an infiltrating facility, the facility is represented by using the Pond Icon and entering the pre-determined infiltration rates. Below are the procedures for sizing a pond to completely infiltrate 100 percent of runoff.

For 100 Percent Infiltration

- Input dimensions of your infiltration pond.
- Input infiltration rate and safety (rate reduction) factor. In general, the rate reduction factor is 1 if the design infiltration rate is used with the applicable adjustment factors described in Appendix III-A. If amended soils or engineered soils are used for treatment in the bottom of the facility, an adjustment factor would be applied to the infiltration rate as described in Volume V.
- Input a riser height and diameter (any flow through the riser indicates that you have less than 100 percent infiltration and must increase your infiltration pond dimensions).
- Run only HSPF for Developed Mitigated Scenario (if that is where you put the infiltration pond). It is not necessary to run duration.
- Go back to your infiltration pond and look at the Percentage Infiltrated at the bottom right. If less than 100 percent infiltrated, increase pond dimension until you get 100 percent.

Chapter 3 - Conveyance Systems and Hydraulic Structures

3.1 Overview

This chapter presents acceptable methods for analysis and design of conveyance systems. It also discusses hydraulic structures linking the conveyance system to runoff treatment and flow control facilities. The chapter is organized as follows:

- Design and analysis methods (Sections 3.2 through 3.6)
- Pipe systems (Section 3.7)
- Outfalls (Section 3.8)
- Flow spreaders
- Culverts (Section 3.9)
- Open conveyances (Section 3.10)
- Private Drainage Systems (Section 3.11)
- Floodplains/floodways (covered in TCC 17.15 and TCC 24).

Where space and topography permit, open conveyances are the preferred means of collecting and conveying stormwater.

3.2 Design Event Storm Frequency

Ideally, every conveyance system and hydraulic structure would be designed for the largest possible amount of flow. Since this would require unusually large structures and be too costly, hydraulic structure designs are analyzed using a specific storm frequency. When selecting a storm frequency, consideration is given to potential adjacent property damage, potential hazard and inconvenience to the public, the number of users, and initial construction cost of the conveyance system or hydraulic structure.

The design event recurrence interval is related to the probability that such an event will occur in any one-year period. For example, a peak flow having a 25-year recurrence interval has a 4 percent probability of being equaled or exceeded in any future year (100/25 = 4). A peak flow having a 2-year recurrence interval has a 50 percent probability of being equaled or exceeded in any future year (100/2 = 50). The greater the recurrence interval, the lower the probability that the event will occur in any given year.

Conveyance systems shall be designed to convey the peak flows from the following storm events:

- The project's internal piped conveyance system shall be designed for a 25-year, 24-hour storm event. In areas where the County determines there is a high risk of damage or vital service interruption, a backwater analysis of the peak flows from the 100-year, 24-hour storm events shall be conducted.

- All open channel conveyance systems shall be designed for the 100-year, 24-hour storm event.

- Piped conveyance under public roads and arterials shall convey a 25-year, 24-hour storm event under fully developed basin conditions. Additional criteria:

  - In the urban area inside of the long-term urban growth management boundary (boundary is depicted on current zoning maps available at the County) the outside driving lane of public roads and streets must not have water over more than 50 percent of the lane for a design event of a 25-year, 24-hour storm.

  - In the area outside of the long-term urban growth management boundary, the design event shall be the 100-year, 24-hour storm.

  - In areas where the County determines there is a high risk of damage or vital service interruption (e.g., more than 6 inches of standing water in the streets), the Administrator or designee may specify up to the 100-year, 24-hour event as the design event.

- Natural channel bridges and culverts shall be designed to convey at least the 100-year, 24-hour storm event under fully developed drainage basin conditions based on the tributary area zoning. Culvert and bridge designs must also meet applicable fish passage and scour criteria.

3.3 Determination of Design Flows

All existing and proposed conveyance systems shall be analyzed and designed using peak flows from hydrographs developed through single event storm hydrologic analyses described in Section 2.1.3 or from a continuous simulation hydrologic model using 15 minute time steps. See Chapter 2 and Appendix III-B for more information.

EXCEPTION: For drainage subbasins 25 acres or less, and having a time of concentration of less than 100 minutes, peak flows for analyzing the capacity of conveyance elements may be determined using the Rational Method (see Chapter 2 and Appendix III-B).

3.4 Open Channel Flow – Hydraulic Analysis

Two hydraulic analysis methods are used to analyze and design conveyance systems:

- The Uniform Flow Analysis Method (Section 3.4.1 below), commonly referred to as the Manning's equation, is used for the design of open conveyances (Section

3.10) and new pipe systems (Section 3.7), as well as for analysis of existing pipe systems. Manning's equation is only valid for pipe flow when the pipe is flowing less than full. If the pipe is surcharged, the backwater method must be used.

- The Backwater Analysis Method (Section 3.4.2 below), is used to analyze the capacity of both proposed and existing pipe systems when a pipe is surcharged. If the County determines that, as a result of the project, runoff for any event up to and including the 100-year, 24-hour event would exceed the pipes' un-surcharged capacity, a backwater (pressure sewer) analysis shall be required. Results shall be submitted in tabular and graphic format showing hydraulic and energy gradient.

Uniform Flow Analysis - Manning's Equation

Manning's equation can be used for open channel flow or for a pipe that is flowing less than full. Manning's equation is expressed as:

$$V = \frac{1.486}{n} \times R^{0.67} \times S^{0.5}$$

Where:

V = velocity (feet per second),

n = Manning's roughness factor (-)

R = hydraulic radius (area/wetted perimeter; feet), and

S = Channel slope (feet/foot)

Manning's equation can also be expressed in terms of discharge (Q):

$$Q = \frac{1.486}{n} \times A \times R^{0.67} \times S^{0.5}$$

Where A = cross-sectional area of flow (square feet).

Manning's roughness factors (n) for open channels are shown in Table 3.1, and for piped conveyances in Table 3.2. A more extensive table of Manning's roughness factors can be found in Table B-3 in Appendix III-B.

Table 3.1 Manning's Roughness Factors for Open Channel Conveyances

Channel Lining	Manning's Roughness Factor (n)
Concrete	0.012
Short grass	0.030
Stony bottom and weedy grass	0.035
Cobble bottom and grass banks	0.040
Dense weeds as high as flow	0.080
Dense woody brush as high as flow	0.120
Biofiltration swale	see Volume V

Table 3.2. Manning's Roughness Factors for Pipe Conveyances

Table 3.2 Manning's Roughness Factors for Pipe Conveyances

	Analysis Method	
Type of Pipe Material	**Backwater Flow**	**Manning's Equation Flow [a]**
A. Concrete pipe	0.013	0.015
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2-2/3" x 1/2" corrugation (riveted)	0.024	0.028
2. 3" x 1" corrugation	0.027	0.031
3. 6" x 2" corrugation (field bolted)	0.030	0.035
C. Helical 2-2/3" x 1/2" corrugation	0.024	0.028
D. Spiral rib metal pipe	0.016	0.018
E. Ductile iron pipe cement lined	0.013	0.015
F. Plastic	0.010	0.012

[a] The roughness values for this method are 15 percent higher in order to account for entrance, exit, junction, and bend head losses

Backwater Analysis

When a backwater calculation is required for a pipe conveyance, the design engineer shall analyze for the 100-year, 24-hour design storm event against the following criteria:

- For the 100-year event, overtopping of the pipe conveyance system may occur; however, the additional flow shall not extend beyond half the lane width of the outside lane of the traveled way and shall not exceed 4 inches in depth at its deepest point.

- Off-channel storage on private property is allowed with recording of the proper easements (see Section 3.6). The additional flow shall be analyzed by open channel flow methods.

A backwater profile analysis computer program such as the King County Backwater (KCBW) computer program prepared by the King County Department of Natural Resources and Parks, Water and Land Resources Division is recommended over manual calculations. The BPIPE subroutine of KCBW may be used for quick computation of backwater profiles, given a range of flows through the existing or proposed pipe system. This program is available free of charge from King County.

3.5 Conveyance System Route Design and Off-Site Drainage

All pipe shall be located under the pavement flow line or lie outside of the pavement. Perpendicular crossings and cul-de-sacs are exempted from this requirement. New conveyance system alignments that are not in dedicated tracts or right-of-way shall be located in drainage easements that are adjacent and parallel to property lines. The width of the permanent easement will be completely within a single parcel or tract. Topography and existing conditions are the only conditions under which a drainage easement that is not adjacent and parallel to a property line may be placed. Requirements for conveyance system tracts and easements are discussed in Section 3.6 below.

EXCEPTION: Streams and natural drainage channels cannot be relocated to meet this routing requirement.

Development projects are required to handle off-site drainage in the same manner as exists in the predeveloped condition. In other words, after development of the subject site, off-site flows shall be infiltrated within or passed through the project site in the same proportion as occurred prior to development. The area and existing use of the off-site land area should be included in any modeling performed to design new facilities. If the adjacent site is undeveloped, model the off-site land area as if it were developed with a detention facility discharging per the Core Requirements of this manual and factor the future flow into the design of the facilities. To avoid this analysis, it would be preferable to collect and bypass off-site drainage around the site or infiltrate it prior to the flow being combined with on-site drainage. If the off-site drainage is to be infiltrated on site, the infiltration facilities shall be sized to accommodate the correct proportion of off-site flows.

Off-site pass-through flows shall be routed separately across the development site. They shall not be routed through the project’s conveyance, runoff treatment, or flow control systems. Storage and treatment of off-site pass-through flows is not required.

However, if the Project Engineer and the Administrator or designee agree that separate handling of off-site flows is impracticable, then off-site flows may be routed through the project’s stormwater management systems. Those systems affected by the off-site flows shall be sized as if the off-site flows were generated within the development project’s boundaries.

3.6 Easements, Access, and Dedicated Tracts

All man-made drainage facilities and conveyances, and all natural channels (on the project site) used for conveyance of altered flows due to development shall be located within easements or dedicated tracts as required by the County. Easements shall contain the natural features and facilities and shall allow County access for purposes of inspection, maintenance, repair or replacement, flood control, water quality monitoring, and other activities permitted by law.

The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100-ft along the length of the easement. Contact Thurston County Water Resources Division for additional information on easement marker requirements.

Maintenance Access to Stormwater Facilities

All drainage facilities such as detention or wet ponds or infiltration systems whether privately maintained or maintained by the County shall be located in separate tracts. Conveyance systems and dedicated stormwater dispersion areas can be in easements with County acceptance.

The dedicated tract for a stormwater facility shall include a minimum 20-foot wide access from a public street or right-of-way. If the development is served by private roads or is gated, then the Proponent shall provide for County access through the gate or private roads to access stormwater facilities. This may include providing a pass code to the Administrator or other means acceptable to the County.

An easement shall be granted through the tract for access to the stormwater facility and shall not be included as part of any individual lots within a subdivision. Access easements across individual lots for access to a stormwater facility are discouraged and shall only be allowed with specific acceptance of Thurston County (including the Administrator or designee) and only upon demonstration that measures are in place to ensure that the easement will not be encroached upon by the lot owner.

The access shall be surfaced with a minimum 12-foot width of crushed rock or other approved surface to allow year-round equipment access to the facility and delineated by a gate, fencing or some other measure to indicate to adjacent property owners that an easement exists. See individual BMP descriptions in Volume V for additional stormwater facility access requirements.

Drainage facilities that are designed to function as multi-use recreational facilities shall be located in separate tracts or in designated open space and shall be privately maintained and owned, unless accepted by and dedicated to the County.

Maintenance vehicle access, i.e., vactor truck, must be provided for all manholes, catch basins, vaults, or other underground drainage facilities. Maintenance shall be through an access easement (see requirements above) or dedicated tract. Drainage structures for conveyance, other than open channels, must have vehicular access.

Access to Conveyance Systems

All publicly and privately maintained conveyance systems shall be located in dedicated tracts, drainage easements, or public rights-of-way in accordance with this manual. Exception: Roof downspout, minor yard, and footing drains unless they serve other adjacent properties.

Conveyance systems to be maintained and operated by Thurston County must be located in a dedicated tract or drainage easement granted to the County. Any new conveyance system on private property conveying drainage from other private properties must be located in a dedicated tract or private drainage easement granted to the stormwater contributors.

Any easement for access to a conveyance system shall include measures to ensure that the easement will not be encroached upon by adjacent lot owners such as delineation by a gate, fencing, signage or some other measure to indicate to adjacent property owners that an easement exists.

All drainage tracts and easements must have a minimum width of 20 feet. All pipes and channels must be located within the easement in accordance with Table 3.3. If circumstances require the location of the pipe or channel within the easement to differ from the requirements of Table 3.3, then, at a minimum each pipe face or top channel edge shall be no closer than 5 feet from its adjacent easement boundary. Easements or Tract widths shown in Table 3.3 are minimums for drainage facilities and may be increased depending on pipe/channel size, depth or other factors.

Table 3.3 Minimum Easement Widths for Conveyance Systems for Access, Inspection and Maintenance

Conveyance Width	Easement/Tract Width
Channels ≤ 30 feet wide	Channel Width + 20 feet from top, one side
Channels > 30 feet wide	Channel Width + 20 feet from top, both sides
Pipes/Outfalls ≤ 36 inches	20 feet centered on pipe
Pipes/Outfalls ≤ 60 inches	20 feet centered on pipe*
Pipes/Outfalls > 60 inches	30 feet centered on pipe*

* May be greater, depending on depth and number of pipes in easement.

Discharge to Private Property

When the proposed project site discharges to an adjacent property where no public drainage facility or no defined drainage course exists (e.g., a natural channel such as a Department of Natural Resources (DNR) Type “Ns” rated stream), the Proponent shall obtain an easement from the adjacent property owner(s) to establish a drainage way to connect to a defined drainage system. In the absence of such an easement, the discharge from stormwater management facilities shall be distributed along the property line in approximately the same flow pattern as before development. A quantitative downstream analysis shall be conducted to determine any potential impacts of the distributed flow to downstream property.

The Administrator or designee may, under highly unusual circumstances, excuse the Proponent from requirements of this section (e.g., adjacent property is a wetland and is not a closed basin, and discharge to the wetland would not significantly alter the hydrology, degrade wetland functions and values, or reduce the value of the property).

3.7 Pipe System Design Criteria

Pipe systems are networks of storm drain pipes, catch basins, manholes, and inlets designed and constructed to convey storm and surface water. The hydraulic design of new storm drain pipes is limited to gravity flow; however, in analyzing existing systems, it may be necessary to address pressurized conditions.

Analysis Methods

Two methods of hydraulic analysis (using Manning's Equation) are used for pipe system analysis (see Section 3.4):

- Uniform Flow Analysis Method (Section 3.4.1), commonly referred to as the Manning's Equation.
- Backwater Analysis Method (Section 3.4.2).

When using the Manning's Equation for design, each pipe within the system shall be sized and sloped so that its barrel capacity at normal full flow is equal or greater than the required conveyance capacity as identified in Section 3.2. Pipes should not be designed to surcharge.

Nomographs may also be used for sizing the pipes. For pipes flowing partially full, the actual velocity may be estimated from engineering nomographs by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow). Appendix III-C includes several nomographs that may be useful for culvert sizing.

Acceptable Pipe Sizes

Storm drainage pipe are subject to the following minimum diameters:

- Private drainage system ≥8 inches for pipes other than French drains, foundation drains and downspout drains. See the Uniform Plumbing Code for minimum sizes and cleanout locations for other pipes such as French drains and downspout pipes,
- Public right-of-way = 12 inches

The Administrator or designee may waive these minimums in cases where topography and existing drainage systems make it impractical to meet the standard. For culverts, see Section 3.10.

Pipe Materials

All storm drainage pipe, except as otherwise provided for in these standards, shall be as per current WSDOT Standard Specifications 9-05. When extreme slope conditions or other unusual topographic conditions exist, pipe materials and methods such as, but not limited to, PVC, HDPE, or ductile iron pipe should be used. See the WSDOT Hydraulics Manual for minimum and maximum depth of cover criteria.

Pipe Slope and Velocity

Minimum velocity is 2 feet per second at design flow. The County may waive these minimums when topography and existing drainage systems make it impractical.

Maximum slopes, velocities, and anchor spacings are shown in Table 3.4. If velocities exceed 15 feet per second for the conveyance system design event, provide anchors at bends and junctions.

Table 3.4 Maximum Pipe Slopes and Velocities

Pipe Material	Pipe Slope Above Which Pipe Anchors Required	Max. Slope Allowed	Max. Velocity @ Full Flow
PVC(1), CPEP-singlewall(1) Corrugated Metal Pipe(1)	20% (1 anchor per 100 LF of pipe)	30% (3)	30 fps
Concrete(1) or CPEP-smooth interior(1)	10% (1 anchor per 50 LF of pipe)	20% (3)	30 fps
Ductile Iron (4)	40% (1 anchor per pipe section)	None	None
HDPE (2)	50% (1 anchor per 100 LF of pipe – cross slope installations may be allowed with additional anchoring and analysis)	None	None

NOTES:

(1) Not allowed in landslide hazard areas.

(2) Butt-fused pipe joints required. Above ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

(3) Maximum slope of 20% allowed for these pipe materials with no joints (one section) if structures are provided at each end and the pipes are properly grouted or otherwise restrained to the structures.

(4) Restrained joints required on slopes greater than 25%. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes:

KEY:

PVC = Polyvinyl chloride pipe
HDPE = High density polyethylene
fps = Feet per second

Downsizing of pipes is only allowed under special conditions (i.e. no hydraulic jump can occur; downstream pipe slope is significantly greater than the upstream slope; velocities remain in the 3 to 8 feet per second range, etc.).

Downsizing of downstream culverts within a closed system with culverts 18 inches in diameter or smaller will not be permitted.

Pipes on Steep Slopes

Steep slopes (greater than 30 percent) shall require all drainage to be piped from the top to the bottom in HDPE pipe (butt fused) or ductile iron pipe welded or mechanically restrained. Pipes may be installed in trenches with standard bedding on slopes up to 20 percent. In order to minimize disturbance to slopes greater than 20 percent, it is recommended that pipes be placed at grade with proper pipe anchorage and support. If slopes exceed 40 percent, then pipe shall be installed above ground and anchored (see Table 3.4). Additional anchoring design may be required for these pipes.

Pipe System Layout Criteria

Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction (except for HDPE and ductile iron with flanged restrained mechanical joint bends, not greater than 30°, on steep slopes).

A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on private roof/footing/yard drain systems on pipes 8 inches in diameter, or less, with clean-outs upstream of each wye or tee.

Provide 6 inches minimum vertical and 3 feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits. Development Standards for Water and Sewer Systems, Thurston County will apply for crossings of or parallel runs with Thurston County sewer lines and for crossings of water lines. Additional requirements for crossings of septic transport lines or water supply lines may apply. Contact the Thurston County Environmental Health Division or the local water purveyor for these requirements. Contact the Environmental Health Division of the Thurston County Department of Public Health and Social Services at 360-867-2673 for more information.

Suitable pipe cover over storm pipes in road rights-of-way shall be calculated for HS-20 loading by the Project Engineer. Pipe cover is measured from the finished grade elevation to the top of the outside surface of the pipe. Pipe manufacturer recommendations are acceptable, if verified by the Project Engineer.

Except as indicated above, pipes or conveyances that traverse the marine intertidal zone and connect to outfalls should be buried at 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 pipe, such material should be covered with at least 3 feet of native bed material or equivalent

PVC SDR 35 minimum cover shall be 3 feet in areas subject to vehicular traffic; maximum cover shall be 30 feet or per the manufacturer's recommendations and as verified with calculations from the Project Engineer.

Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to a 1 foot minimum.

Access barriers are required on all pipes 18 inches and larger exiting a closed pipe system. Debris barriers (trash racks) are required on all pipes entering a pipe system.

Where a minimal fall is necessary between inlet and outlet pipes in a structure, pipes must be aligned vertically by one of the following in order of preference:

- Match pipe crowns
- Match 80 percent diameters of pipes
- Match pipe inverts

Where inlet pipes are higher than outlet pipes, drop manhole connections may be required or increased durability in the structure floor may be required.

High Density Polyethylene (HDPE) pipe systems longer than 100 feet must be anchored at the upstream end if the slope exceeds 25 percent and the downstream end placed in a minimum 4 foot long section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of the pipe material. These sleeve connections should be located as close to the discharge end of the outfall system as is practical.

Pipe Structure Criteria

Catch Basins and Manholes

All catch basins and manholes shall meet current WSDOT Standard Specifications and Plans. The following criteria shall be used when designing a conveyance system which uses catch basins or manholes.

Unless otherwise required by the County, Type 1 catch basins shall be used at the following locations or for the following situations:

- When overall structure height does not exceed 8 feet, or when invert does not exceed 5 feet.
- When pipe sizes do not exceed 18 inches and connect at right angles to the long side of the structure; or 12 inches connecting to the short side.
- When all pipes tying into the structure connect at or very near to right angles.

Unless otherwise required by the County, Type 1L catch basins must be used at the following locations or for the following situations:

- When overall structure height does not exceed 8 feet or when invert does not exceed 5 feet.
- When any pipes tying into the structure exceed 18 inches connecting to the long side, or 15 inches connecting to the short side at or very near to right angles.

Unless otherwise required by the County, Type 2 (48-inch minimum diameter) catch basins shall be used at the following locations or for the following situations:

- When overall structure height does not exceed 15 feet.
- When all pipes tying into the structure do not exceed the limits set forth by the manufacturers. Type 2 catch basins over 4 feet in height shall have standard ladders. Ladders shall not cover inlet or outlet pipes.

Where an approved connection of a private storm drainage system into a County system occurs, a minimum of a Type 1 catch basin shall be used in Thurston County.

Maximum spacing on main storm sewers between access structures, whether catch basins or manholes, shall be 300 feet (Table 3.5).

Table 3.5 Maximum Surface Runs Between Inlet Structures on the Paved Roadway Surface in Thurston County

Roadway Slope (%)	Thurston County Max. Spacing (ft)
0.5 to 1.0	150
1.0 to 3.0	200
>3.0	300

Catch basin (or manhole) diameter shall be determined by pipe diameter and orientation at the junction structure. A plan view of the junction structure, drawn to scale, is required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must insure a minimum distance (of solid concrete wall) between pipe openings of 8 inches for 48-inch and 54-inch diameter catch basins and 12 inches for 72-inch and 96-inch diameter catch basins.

Catch basin evaluation of structural integrity for H-20 loading will be required for multiple junction catch basins and other structures which exceed the recommendations of the manufacturers.

The WSDOT Hydraulics Manual can be used to determine inlet grate capacity when capacity is of concern. When verifying capacity, assume grate areas on slopes are 80 percent free of debris, and “vaned” grates are 95 percent free. In sags or low spots, assume grates are 50 percent free of debris, and “vaned” grates are 75 percent free.

The maximum slope of the ground surface shall be 3:1 for a radius of 5 feet around a catch basin grate.

Catch basins shall be provided within 50 feet of the entrance to a pipe system to provide for silt and debris removal.

Maximum spacing of structures for storm drainage conveyance lines running within an easement area shall be 300 feet for pipe grades greater than 0.3 percent and 200 feet for grades less than 0.3 percent. Structures not acting as points of entry for stormwater shall have locking lids and have solid covers.

Locking lids will be installed on all structures containing restrictor or flow devices. Locking lids shall use WSDOT Standard Plan B-30.70-01 with the lettering of “STORM” or other county pre-approved design.

A metal frame and grate for catch basin and inlet, WSDOT Standard Plan B-30.10 and B-30.30-01or pre-approved county standard grate that is deemed bicycle safe, shall be used for all structures collecting drainage from the paved roadway surface.

When the road profile equals or exceeds 6 percent between structures, an asphalt berm shall be installed around the inlet of the structure or the catch basin may be recessed into the curb per Figure 3.1 and Figure 3.2.

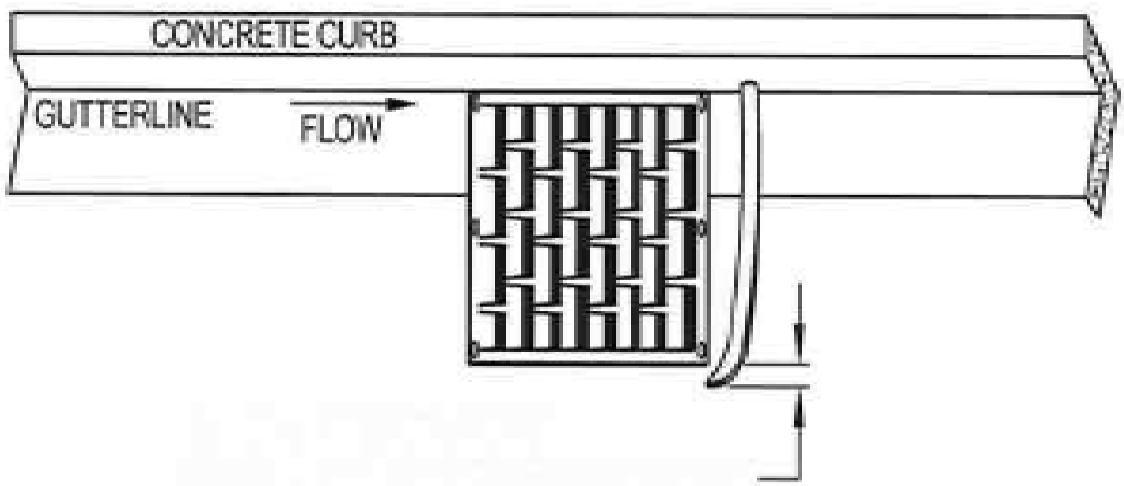

Figure 3.1 Asphalt Inlet Berm

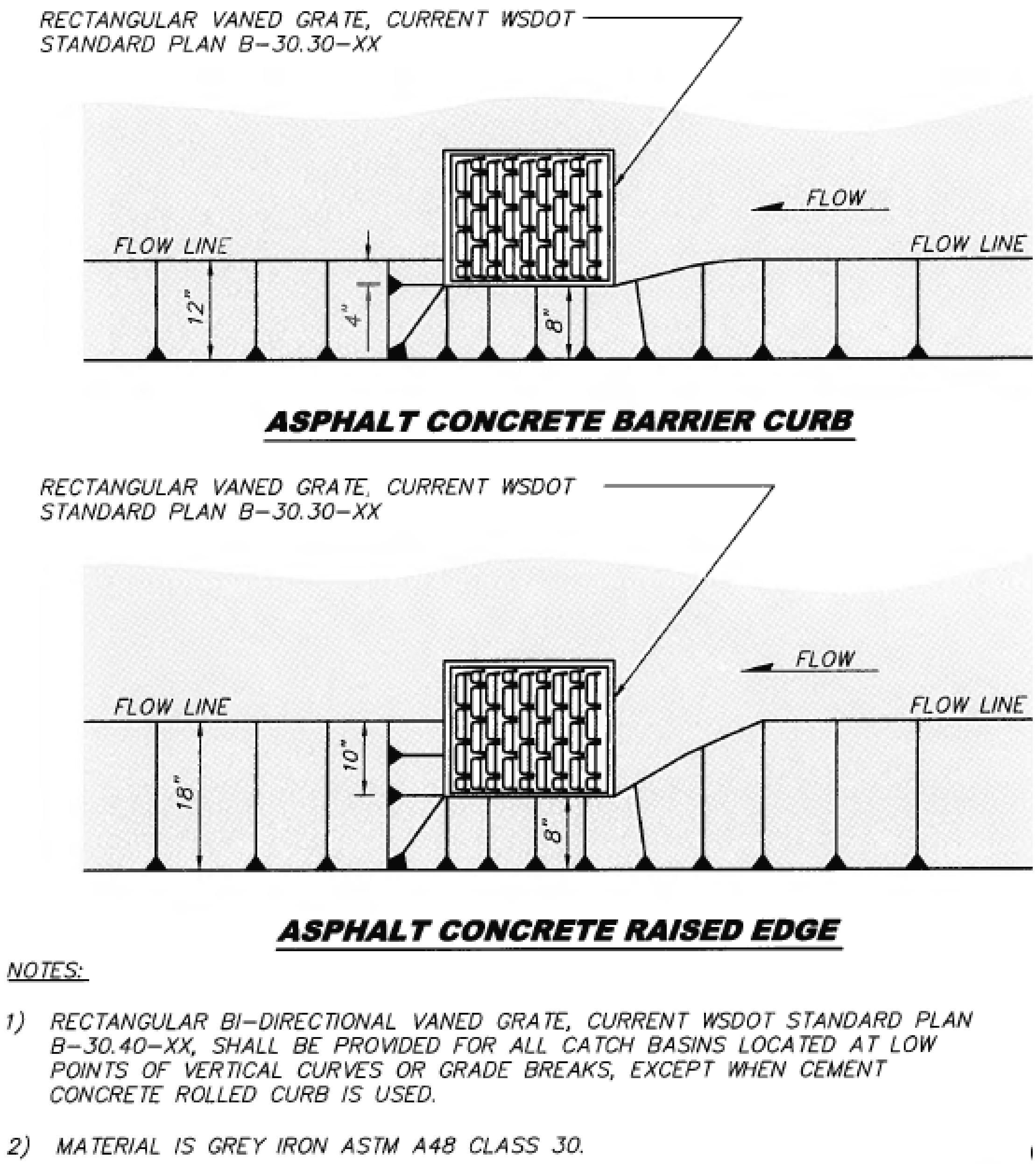

Figure 3.2 Recessed Curb Inlet (From Pierce County Standard Plan 10.0)

Table 3.6 presents the allowable structures and pipe sizes allowed by size of structure. All catch basins, inlets, etc., shall be marked as shown in Volume IV, Figure 4.24.

Table 3.6 Allowable Structure and Pipe Sizes

	Maximum Pipe Diameter	
Catch Basin Type (1)	Spiral Rib CPEP, HDPE, PVC (2) (Inches)	Concrete and Ductile Iron (Inches)
Inlet (4)	12	12
Type 1 (3)	15	15
Type IL (3)	18	18
Type 2-48-inch dia.	30	24
Type 2-54-inch dia.	36	30
Type 2-72-inch dia.	54	48
Type 2-96-inch dia.	72	72

(1) Catch basins, including manhole steps, ladder, and handholds shall conform to the WSDOT Standard Plans or an approved equal based upon submittal for approval.

(2) Maintain the minimum side wall thickness per WSDOT standards.

(3) Maximum 5 vertical feet allowed between grate and invert elevation.

(4) Normally allowed only for use in privately maintained drainage systems and must discharge to a catch basin immediately downstream.

NOTE: The applicant shall check with the County to determine the allowable pipe materials.

Flow Splitter Designs

Many runoff treatment facilities can be designed as flow-through or on-line systems with flows above the water quality design flow or volume simply passing through the facility at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to runoff treatment facilities and bypass the remaining higher flows around them through off-line facilities. This can be accomplished by splitting flows in excess of the water quality design flow upstream of the facility 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 a designer’s choice whether runoff treatment facilities 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 treatment facility 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 facility under high flow conditions. Flow splitters may be used for purposes other than diverting flows to runoff treatment facilities. However, the following discussion is generally focused on using flow splitters in association with runoff treatment facilities.

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." Two possible design options for flow splitters are shown in Figure 3.3 and Figure 3.4. Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the facility are also acceptable.

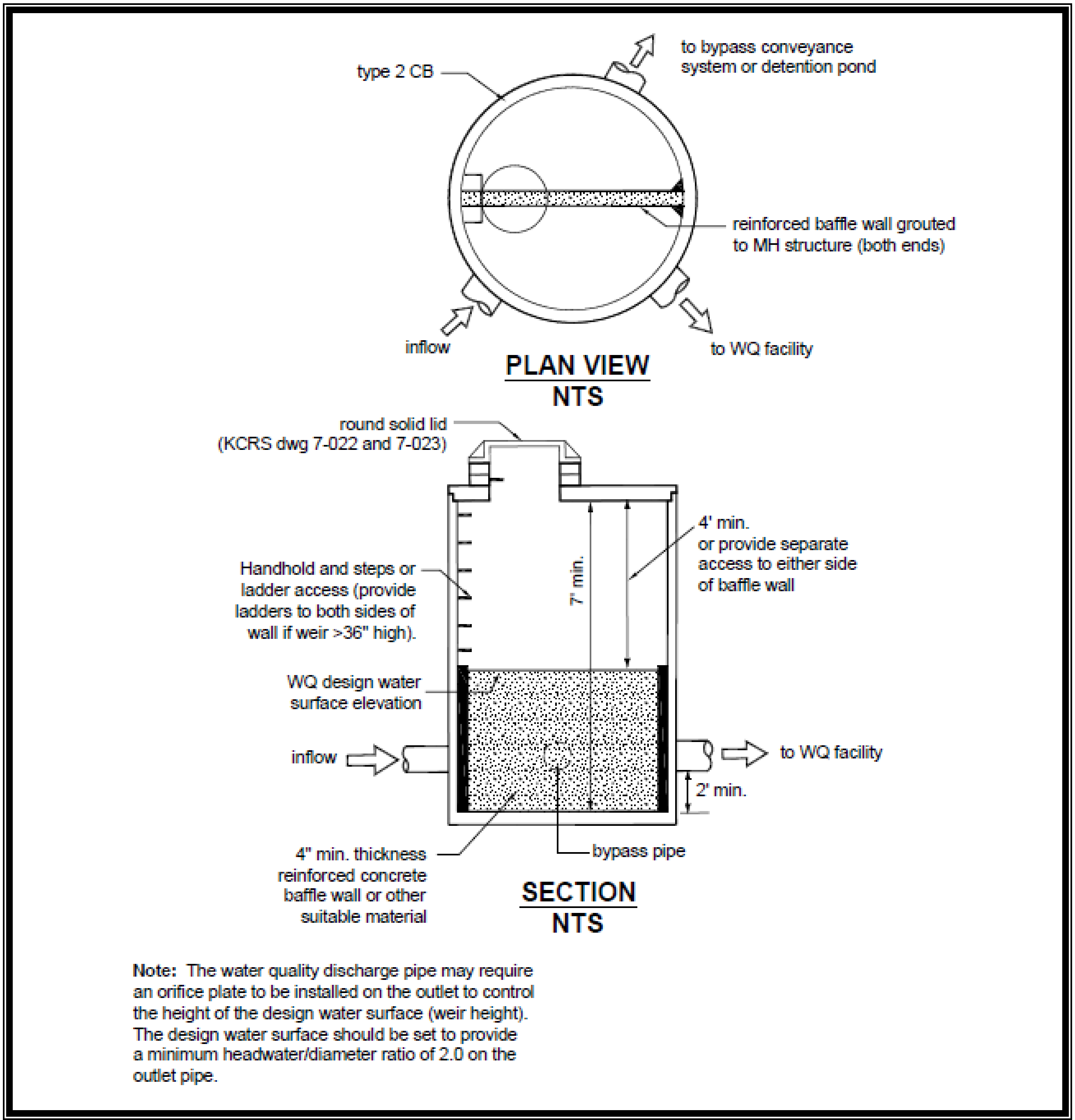

Figure 3.3 Flow Splitter, Option A. (Source, King County Surface Water Design Manual)

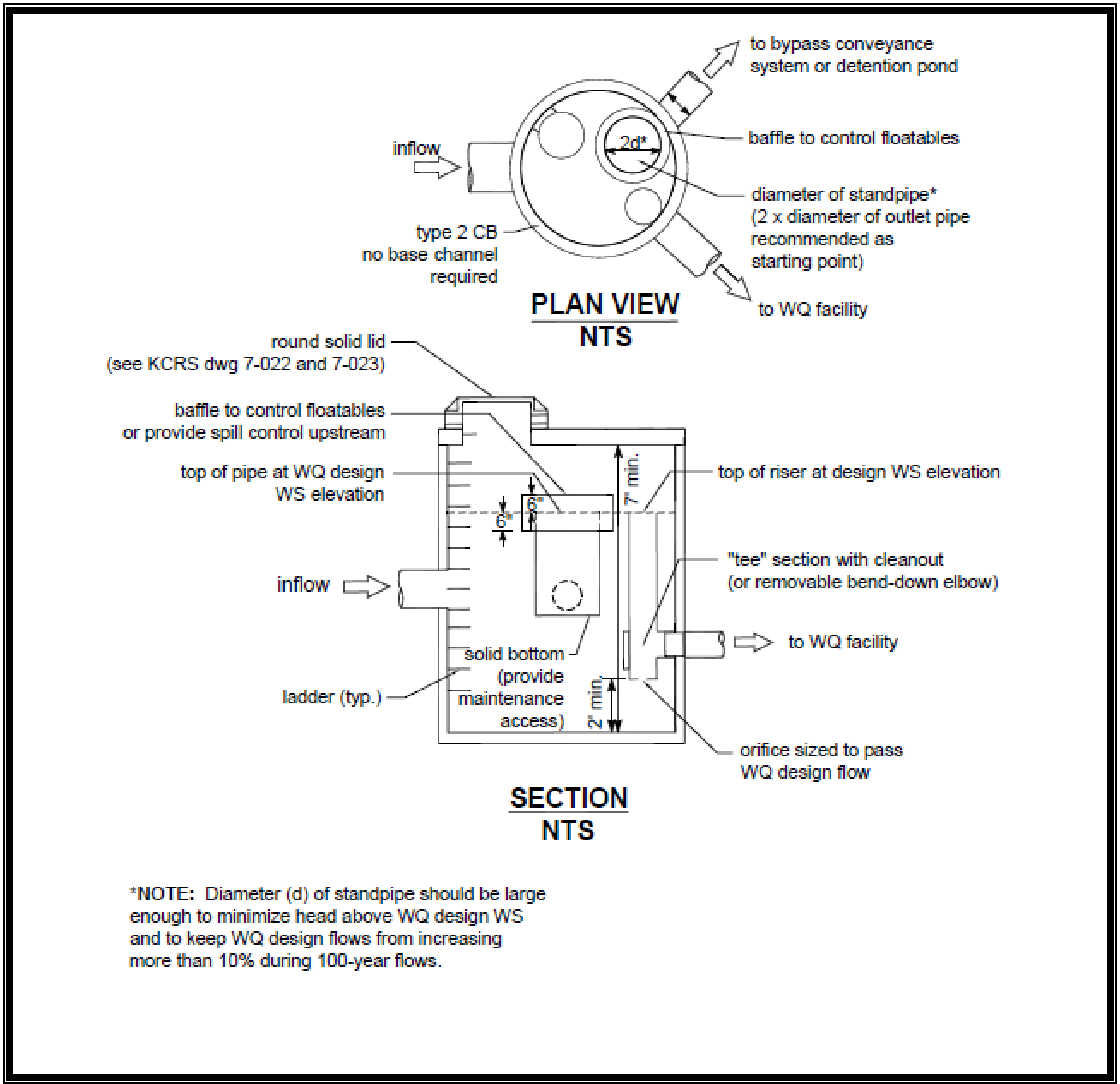

Figure 3.4 Flow Splitter, Option B. (Source, King County Surface Water Design Manual)

General Design Recommendations

- Unless otherwise specified, a flow splitter should be designed to deliver the water quality design flow rate specified to the runoff treatment facility. Flows modeled using a continuous simulation runoff model should use 15-minute time steps.

- The top of the weir should be located at the water surface for the design flow. Remaining flows enter the bypass line.

- The maximum head should be minimized for flow in excess of the water quality design flow. Specifically, flow to the runoff treatment facility at the 100-year water surface should not increase the water quality design flow by more than 10 percent.

- Either design shown in Figure 3.3 and Figure 3.4 or an equivalent design may be used.

- As an alternative to using a solid top plate in Figure 3.3, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the runoff treatment facility rather than back up from the manhole.

- Special applications, such as roads, may require the use of a modified flow splitter. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.

- For ponding facilities, back water effects must be included in designing the height of the standpipe in the manhole.

- Ladder or step and handhold access must be provided. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, should be used.

Materials

- The splitter baffle may be installed in a Type 2 manhole or vault.

- The baffle wall should 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 should be 4 feet; otherwise, dual access points shall 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.

3.8 Outfalls

All piped discharges to streams, rivers, ponds, lakes, or other open bodies of water are designated outfalls and shall provide for energy dissipation to prevent erosion at or near the point of discharge. Properly designed outfalls are critical to reducing the risk of adverse impacts of concentrated discharges from on-site and downstream pipe systems and culverts. Outfall systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, 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.

Outfalls to streams, wetlands, or other waters of the State may be subject to review through the SEPA process, Shorelines Management Act, Thurston County Critical Areas Ordinance requirements and other applicable regulations, as well as subject to state or federal requirements including hydraulic and permitting requirements of the Washington State Department of Fish and Wildlife, Army Corps of Engineers or Washington State Department of Natural Resources. The requirements of these other reviews and permitting processes shall take precedence where more restrictive than those stated herein.

General Design Criteria for Outfall Features

Outfalls shall be designed to pass the peak flow from the design event for conveyances (Section 3.2) and to suffer no structural damage or undercutting during the 100-year, 24-hour storm event. The Project Engineer shall present calculations showing the velocity, discharge, and flow path of the 100-year, 24-hour event. For outfalls downstream of a flow control BMP, the unmitigated 100-year, 24-hour event flow shall be used.

The standard for outfall design is as shown in Figure 3.5. This design is limited to slopes of 2:1 or flatter where native vegetation is well established or where slope armoring is engineered to the Administrator or designee's satisfaction. For sites where the Project Engineer determines, and the Administrator or designee agrees, that the standard is impractical because of lack of space, danger of erosion, etc., alternate outfall designs shown in Figures 3.6 and 3.7 may be used. Other outfall designs will be allowed upon acceptance of the Administrator or designee.

See Table 3.7 for a summary of the rock protection requirements at outfalls.

Table 3.7. 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	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 ¾-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 is assumed to be approximately 3:1.

Outfalls with flow velocity under 12 feet per second and discharge under 2 cfs for the conveyance system design event (Section 3.2) are to be provided (at minimum) with a splash pad (e.g., rock, gabions, concrete).

Outfalls where flow is 2 cfs or greater or velocity is 20 feet per second or greater for the conveyance system design event (Section 3.2), an engineered energy dissipater is required. Examples are stilling basins, drop pools, hydraulic jump pools, baffled aprons, bubble up structures, etc.

Outfalls must be protected against undercutting. Also consider scour, sedimentation, anchor damage, etc. Pipe and fittings materials shall be corrosion resistant such as aluminum, plastic, fiberglass, high density polyethylene, etc. Galvanized or coated steel will not be acceptable.

Outfalls on Steep Slopes

Outfall pipes on steep slopes (refer to Table 3.4) must be anchored and must be fused or butt-welded or mechanically restrained. They may not be gasketed, slip fit, or banded.

On steep slopes, High Density Polyethylene (HDP) pipe may be laid on the surface or in a shallow trench, anchored, protected against sluicing, and hand compacted.

HDP outfall systems must be designed to address the material limitations as specified by the manufacturer, in particular thermal expansion and contraction. The coefficient of thermal expansion and contraction for HDP is on the order of 0.001-inch per foot per Fahrenheit degree. Sliding connections to address this thermal expansion and contraction must be located as close to the discharge end of the outfall system as is practical.

HDP systems longer than 100 feet must be secured at the upstream end and the downstream end placed in a four-foot section of the next larger pipe size. This sliding sleeve connection allows for high thermal expansion/contraction.

HDP shall comply with the requirements of Type III C5P34 as tabulated in ASTM D1248 and have the PPI recommended designation of PE3408 and have an ASTM D3350 cell classification of 345434C or 345534C. The pipe shall have a manufacturer's recommended hydrostatic design stress rating of 800 psi based on a material with a 1,600 psi design basis determined in accordance with ASTM D2837-69. The pipe shall have a suggested design working pressure of 50 psi at 73.4 degrees F and SDR of 32.5.

Outfall Pipe Energy Dissipation

Outfall pipes that discharge directly into a channel or water body shall be provided at a minimum with a rock splash pad (Figure 3.5). See Table 3.7 for minimum rock protection at outfalls.

Due to HDP pipe's ability to transmit flows of very high energy, special consideration for energy dissipation must be made. A sample gabion mattress energy dissipater for this purpose has been provided as Figure 3.6. This mechanism may not be adequate to address flows of very high energy: therefore, a more engineered energy dissipater structure as described above, may be warranted.

Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Examples are drop manholes and rapid expansion into pipes of much larger diameter.

The following sections provide general design criteria for various types of Outfall Features.

General Design Criteria to Protect Aquatic Species and Habitat

Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats. However, new pipe outfalls are also opportunities for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and energy dissipater 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 3.8). 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 area habitat biologist prior to inclusion in design.

Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. Outfalls that discharge to the Puget Sound or a major waterbody may require tide gates. For more information see the Thurston County Critical Areas Ordinance at http://www.co.thurston.wa.us/planning/critical_areas/criticalareas_home.htm and the Shoreline Master Program at http://www.co.thurston.wa.us/planning/shoreline/shoreline_qa.htm. For design guidance see the Washington Department of Fish and Wildlife Marine Shoreline Design Guidelines at http://wdfw.wa.gov/publications/01583/ or the Integrated Streambank Protection Guidelines at http://wdfw.wa.gov/publications/00046/.

Flow Dispersal Trench

The flow dispersal trenches shown in Figure 3.6 and Figure 3.7 should only be used when an outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists, and the natural (existing) discharge is unconcentrated. The 100-year peak discharge rate per dispersal trench shall be less than or equal to 0.5 cfs. Other flow dispersal BMPs are described in Volume V.

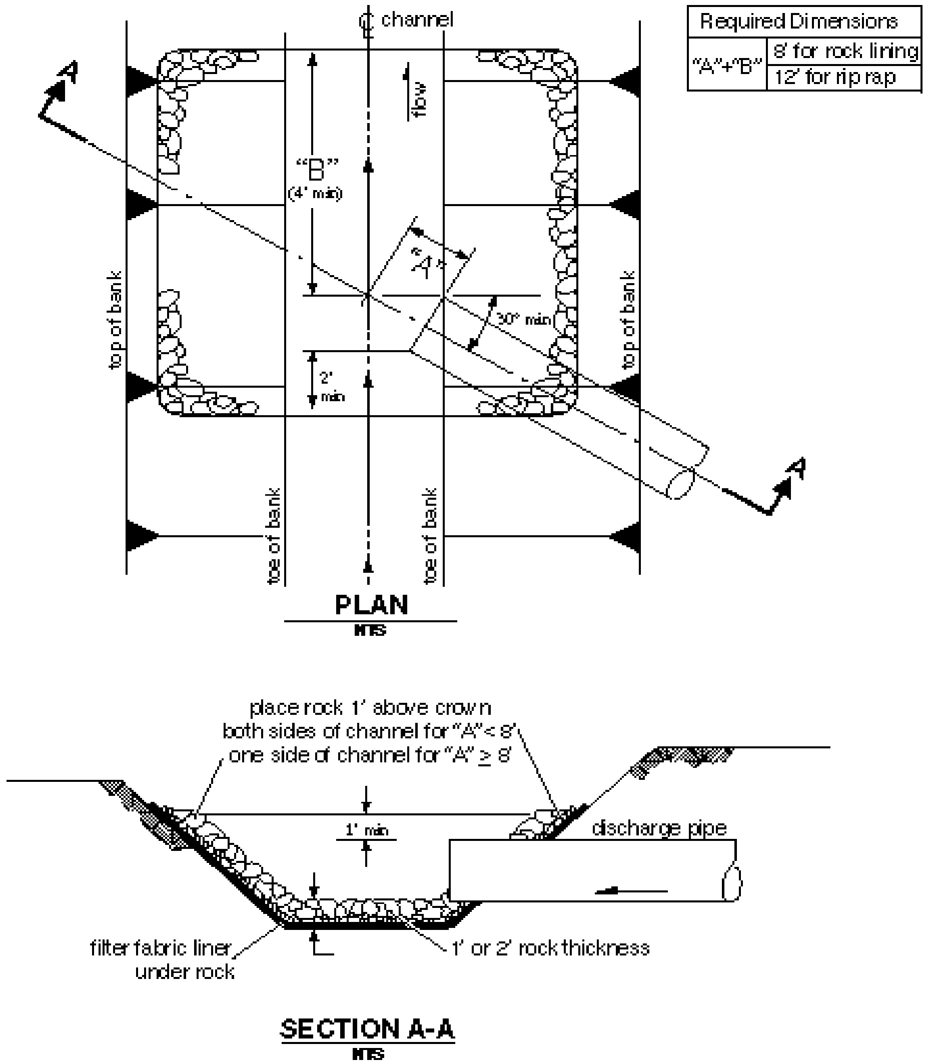

Figure 3.5 Pipe/Culvert Outfall Discharge Protection

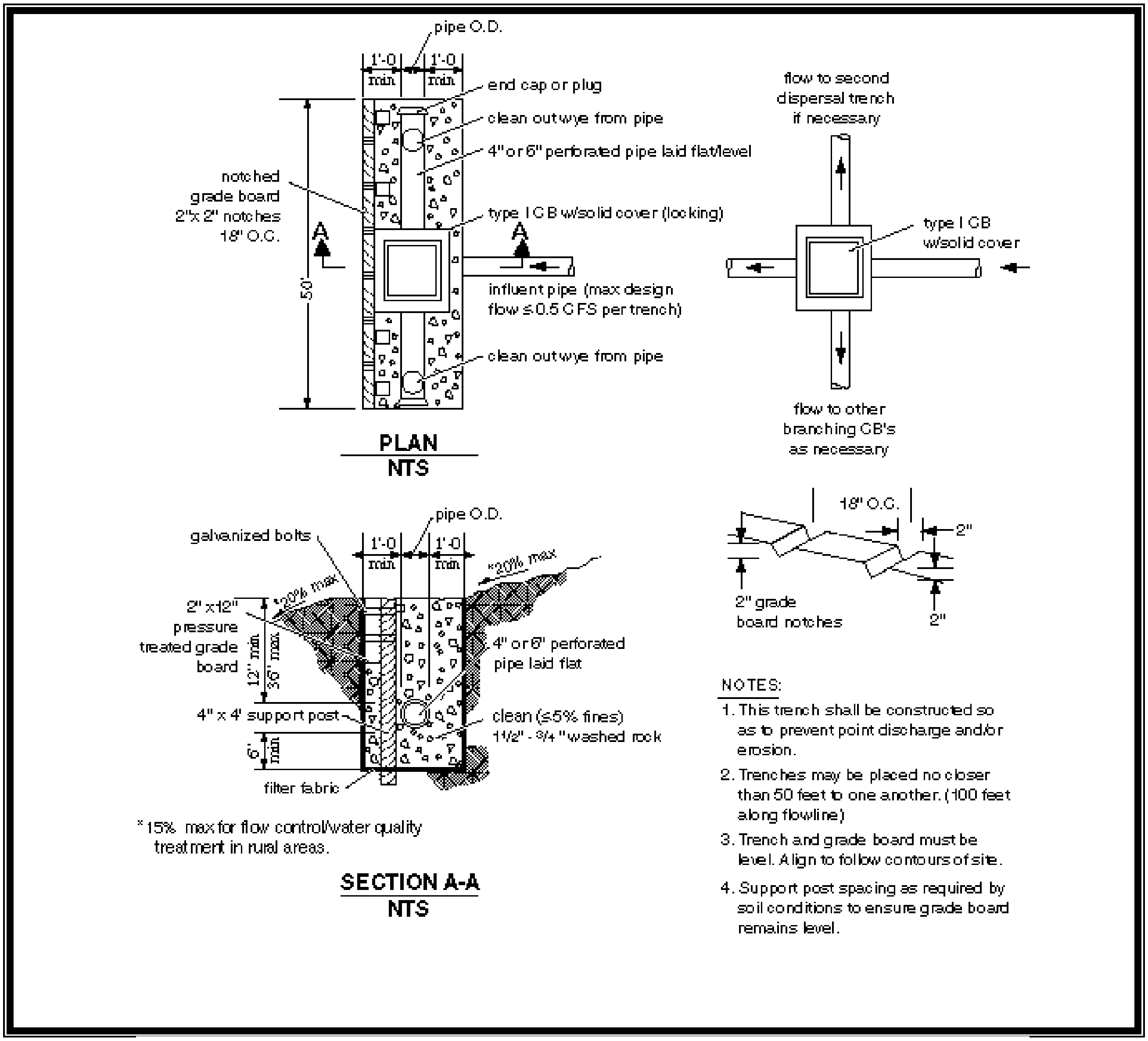

Figure 3.6 Flow Dispersal Trench

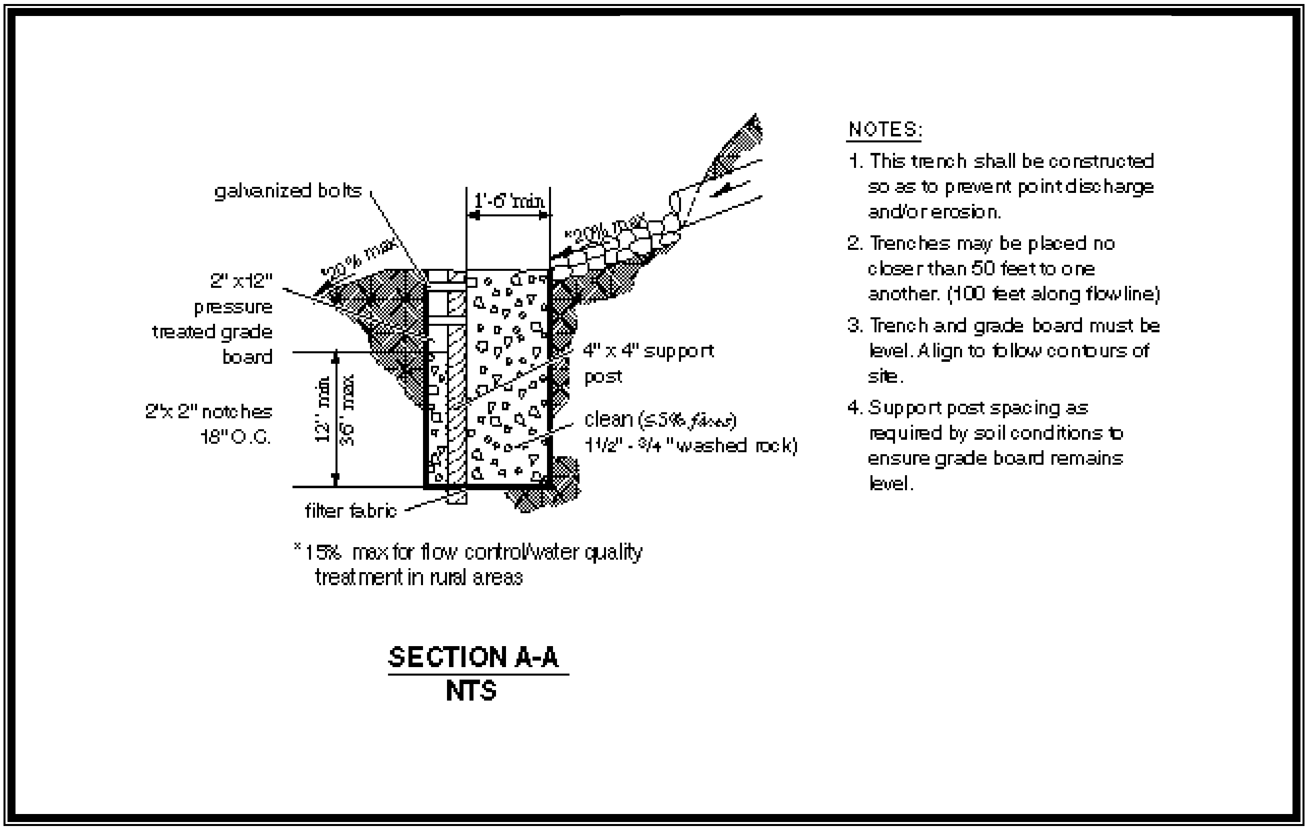

Figure 3.7 Alternative Flow Dispersal Trench

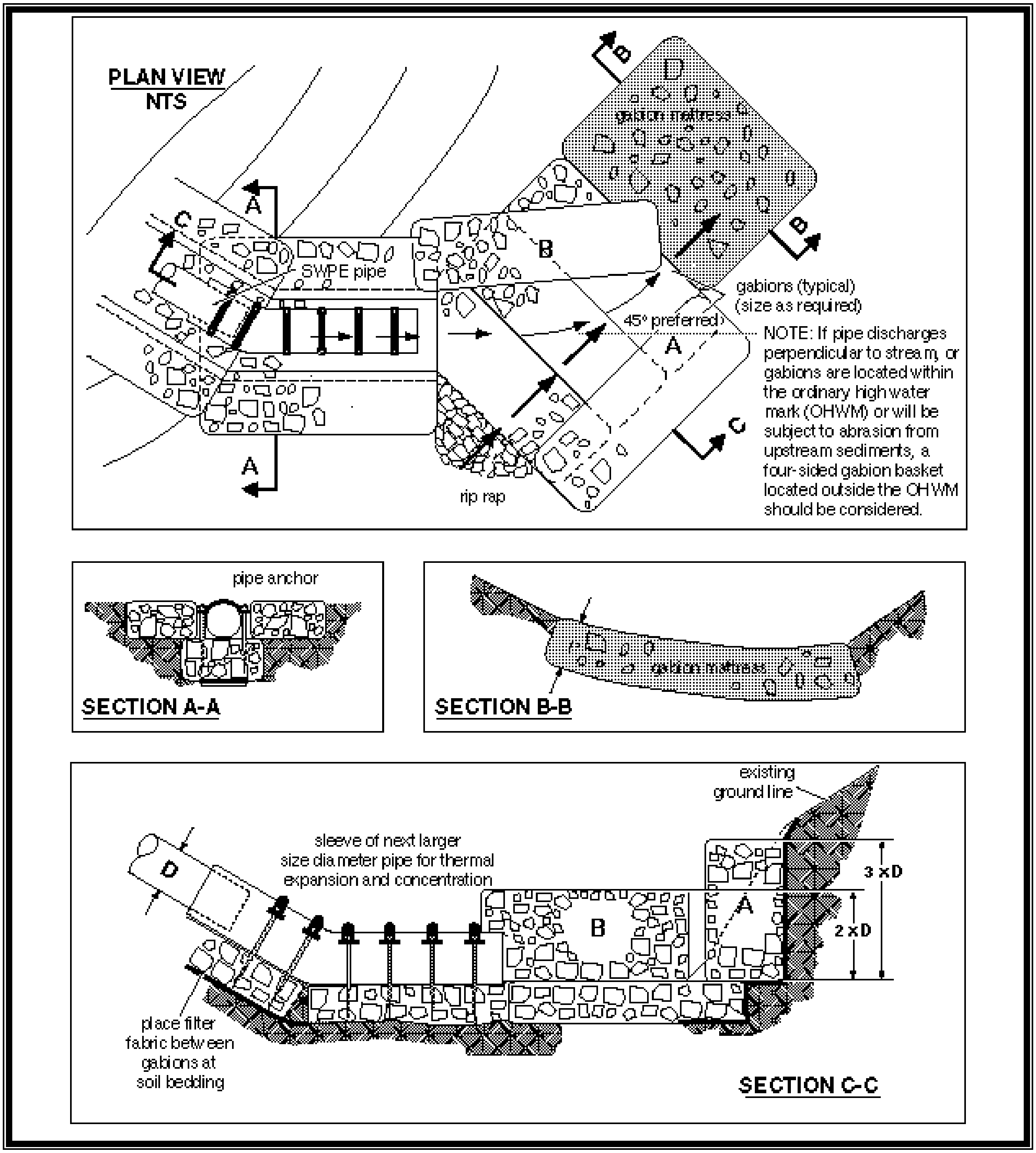

Figure 3.8 Gabion Outfall Detail

Figure 3.9. Diffuser TEE (an example of energy dissipating end feature)

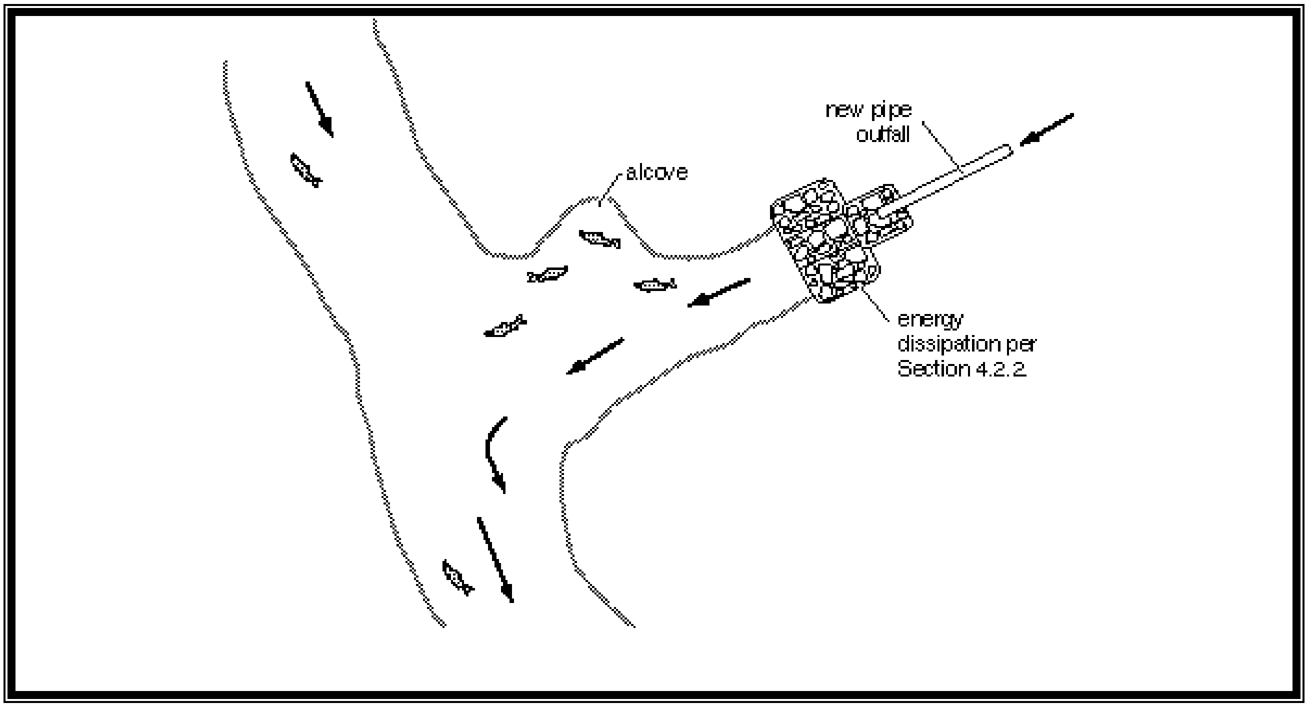

Figure 3.10 Fish Habitat Improvement at New Outfalls

3.9 Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inflow portion of several types of stormwater management facilities (e.g., sand filters, biofiltration swales, filter strips, bioretention areas). There are five flow spreader options presented in this section:

- 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 facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a filter strip.

Options D and E are only for flows that are already unconcentrated and enter a filter strip, bioretention area or continuous inflow biofiltration swale. Other flow spreader options are possible with approval from the Administrator or designee.

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.
- For higher inflows (velocities greater than 5 feet per second for the 100-year recurrence interval 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. The top of the grate should be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the V-notches.

Option A – Anchored Plate (Figure 3.11**)**

- An anchored plate flow spreader should 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 should be lined to reduce erosion and to provide energy dissipation.
- The top surface of the flow spreader plate should be level, projecting a minimum of 2 inches above the ground surface of the water quality facility, or V-notched with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs may also be used.
- A flow spreader plate should extend horizontally beyond the bottom width of the facility 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 recurrence interval flow or the maximum flow that will enter the water quality facility.
- Flow spreader plates should 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 should be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

Option B – Concrete Sump Box (Figure 3.12**)**

- The wall of the downstream side of a rectangular concrete sump box should extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.

- The downstream wall of a sump box should have “wing walls” at both ends. Side walls and returns should 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 should be reinforced with wire mesh for cast-in-place sumps.

- Sump boxes should be placed over bases that consists of 4 inches of crushed rock, five-eighths-inch minus to help assure the sump remains level.

Option C – Notched Curb Spreader (Figure 3.13**)**

Notched curb spreader sections should be made of extruded concrete laid side-by-side and level. Typically five “teeth” per 4-foot section provide good spacing. The space between adjacent “teeth” forms a V-notch.

Option D –Through-Curb Ports (Figure 3.14**)**

Unconcentrated flows from paved areas entering filter strips, bioretention areas, or continuous inflow biofiltration swales can use curb ports or interrupted curbs (Option E) to allow flows to enter the strip or swale. 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 water quality facility.

Openings in the curb should be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening should be a minimum of 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.

Option E – Interrupted Curb (No Figure)

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, gaps should be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening should be a minimum of 12 inches. As a general rule, no opening should discharge more than 10 percent of the overall flow entering the facility.

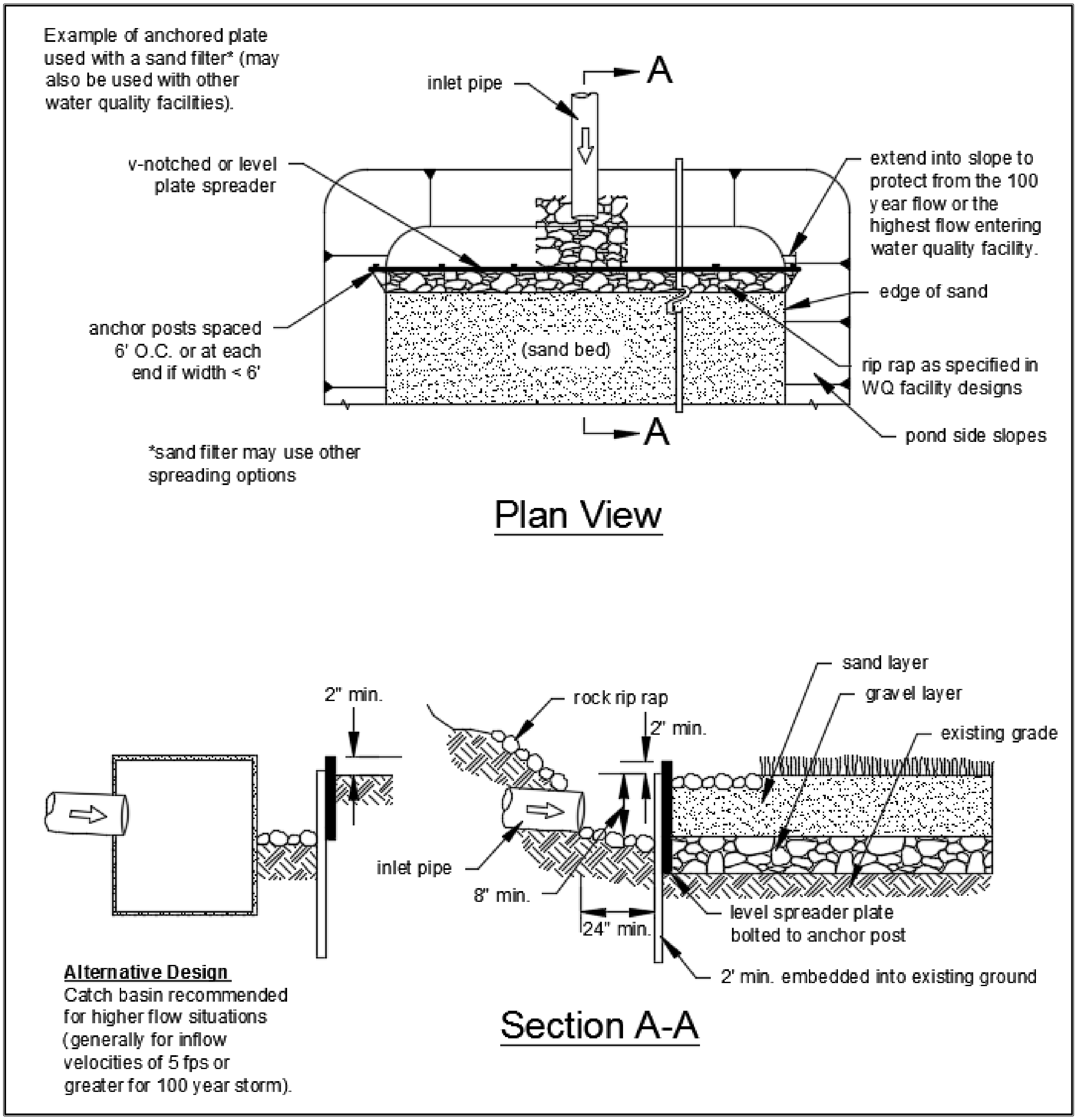

Figure 3.11 Flow Spreader Option A: Anchored Plate. (Source: Stormwater Management Manual for Western Washington)

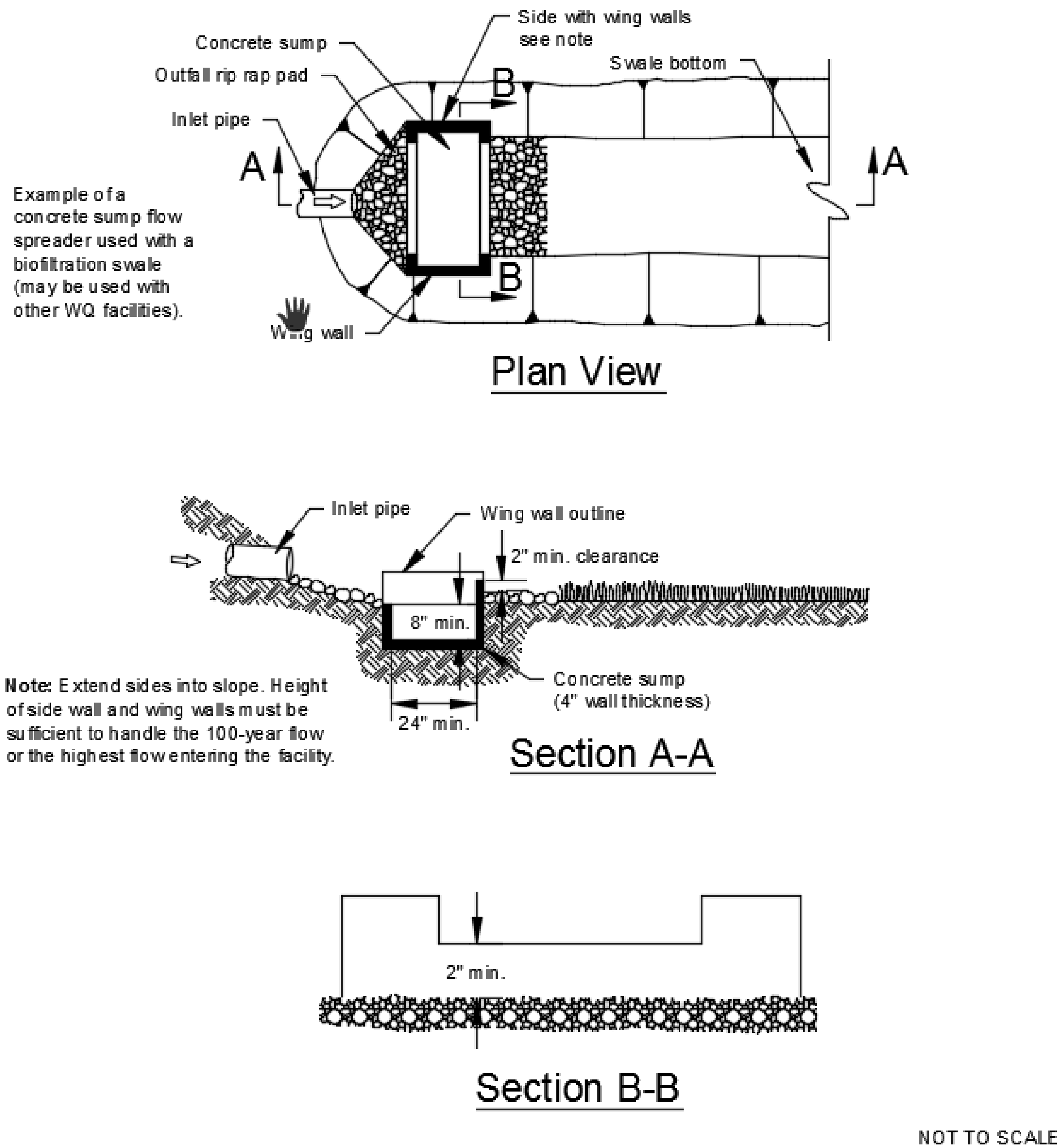

Figure 3.12 Flow Spreader Option B: Concrete Sump Box (Source: Stormwater Management Manual for Western Washington)

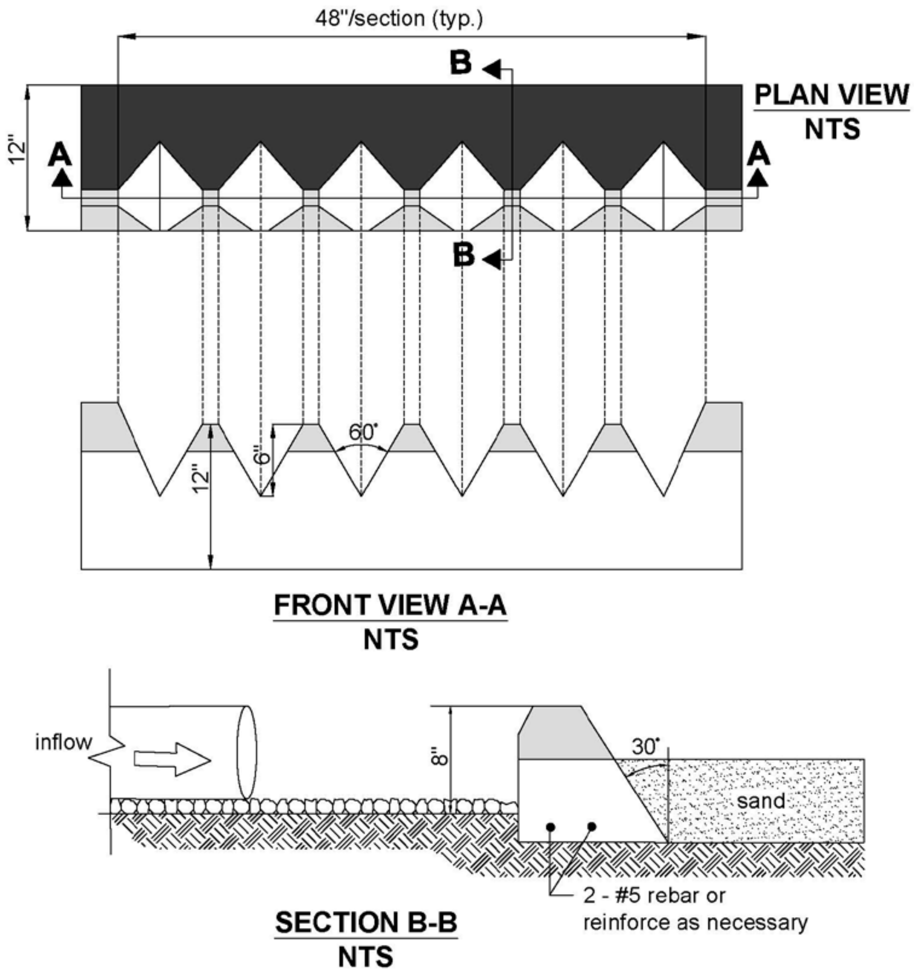

Figure 3.13. Flow Spreader Option C: Notched Curb Spreader. (Source Pierce County Stormwater and Site Development Manual)

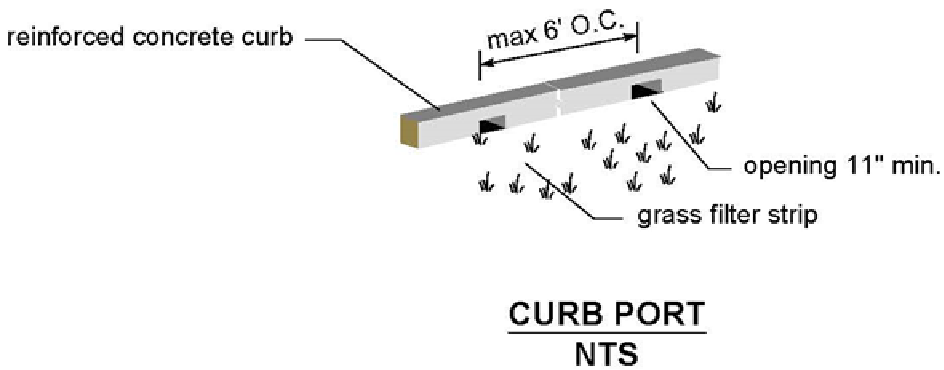

Figure 3.14. Flow Spreader Option D: Through Curb Port. (Source Pierce County Stormwater and Site Development Manual)

3.10 Culvert Criteria

Culverts are single runs of pipe that are open at both ends and have no structures, such as manholes or catch basins.

Approved pipe materials are detailed in Section 3.7.3. Galvanized or aluminized pipe is not permitted in marine environments or where contact with salt water may occur, even infrequently through backwater events.

Culvert Design Criteria

Flow capacity shall be determined by analyzing inlet and outlet control for headwater depth. Nomographs used for culvert design shall be included in the submitted Drainage Report. Appendix III-C also includes several nomographs useful for culvert sizing.

All culverts shall be designed to convey the flows per Section 3.2. The maximum design headwater depth shall be 1.5 times the diameter of the culvert, with no saturation of roadbeds. Minimum culvert diameters are as follows:

- For cross culverts under public roadways – minimum 18 inches, 12 inches if grade and cover do not allow for 18 inches, with County acceptance.
- For roadside culverts, including driveway culverts – minimum 12 inches.
- For culverts on private property – minimum 8 inches.

Inlets and outlets shall be protected from erosion by rock lining, riprap, or bio-stabilization as detailed in Table 3.8, Channel Protection.

Debris and access barriers are required on inlet and outlet ends of all culverts equal to or greater than 18 inches in diameter. Culverts equal to or greater than 36 inches in diameter or within stream corridors are exempt.

Minimum culvert velocity shall be 2 feet per second and maximum culvert velocity shall be 15 feet per second. Thirty (30) feet per second may be used with an engineered outlet protection design. There is no maximum velocity for ductile iron or HDPE pipe, but outlet protection shall be provided.

All CPEP and PVC culverts and pipe systems shall have concrete or rock headwalls at exposed pipe ends.

Bends are not permitted in culvert pipes.

The following minimum cover shall be provided over culverts:

- 2 feet under roads.
- 1 foot under roadside applications and on private property, exclusive of roads.

- If the minimum cover cannot be provided on a flat site, use ductile iron pipe and analyze for loadings.

- Maximum culvert length: 250 feet

- Minimum separation from other pipes:

  - 6 inches vertical (with bedding) (and in accord with the sewer or water purveyor design criteria).

  - 3 feet horizontal.

Culvert trench bedding, backfill and compaction shall be in accordance with the WSDOT standard specifications for the type of culvert pipe used in the application.

All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end section to match the side slope. Ductile pipe shall use PVC or CPEP for beveled end sections.

Fish Passage Criteria

Culverts in stream corridors must meet applicable fish passage requirements of the Washington Department of Fish and Wildlife.

3.11 Open Conveyances

Open conveyances can be roadside ditches, grass lined swales, or a combination thereof. Where space and topography permit, open conveyances are preferred for collecting and conveying stormwater as they better reflect LID design. Consideration must be given to public safety when designing open conveyances adjacent to traveled ways and when accessible to the public. A vegetated open channel BMP is the preferred conveyance method.

Open conveyances shall be designed by one of the following methods:

- Manning's Equation (for uniform flow depth, flow velocity, and constant channel cross-section; see Section 3.4.1).

- Backwater Method (utilizing the energy equation or a computer program; see Section 3.4.2).

Velocities must be low enough to prevent channel erosion based on the native soil characteristics or the compacted fill material. For velocities above 5 feet per second, channels shall have either rock-lined bottoms and side slopes to the roadway shoulder top with a minimum thickness of 8 inches, or shall be stabilized in a fashion acceptable to the County. Water quality shall not be degraded due to passage through an open conveyance. See Table 3.7.

Table 3.7 Channel Protection

Velocity at Design Flow (fps)		REQUIRED PROTECTION		
Greater than	**Less than or equal to**	**Type of Protection**	**Thickness**	**Minimum Height Above Design Water Surface**
0	5	Grass lining or bioengineered lining	N/A	0.5 foot
5	8	Rock lining [(1)] or bioengineered lining	1 foot	2 foot
8	12	Riprap [(2)]	2 feet	2 feet
12	20	Slope mattress gabion, etc.	Varies	2 feet

[(1)] Rock Lining shall be reasonably well graded as follows:

Maximum stone size: 12 inches

Median stone size: 8 inches

Minimum stone size: 2 inches

[(2)] Riprap shall be reasonably well graded as follows:

Maximum stone size: 24 inches

Median stone size: 16 inches

Minimum stone size: 4 inches

Note: Riprap sizing is governed by side slopes on channel, assumed to be approximately 3:1

Channels having a slope less than 6 percent and having peak velocities less than 5 feet per second shall be lined with vegetation.

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted to a minimum 95 percent compaction as verified by a Modified Proctor test. Channel side slopes adjacent to roads shall meet all AASHTO and county road standards.

Channels shall be designed with a minimum freeboard of 0.5 feet when the design flow is 10 cubic feet per second or less and 1 foot when the design flow is greater than 10 cubic feet per second.

Check dams for erosion and sedimentation control may be used for stepping down channels being used for biofiltration.

3.12 Private Drainage Systems

The engineering analysis for a private drainage system is the same as a County system.

Discharge Locations

Stormwater cannot discharge directly onto County roads or into a County system without prior County approval[3], with the exception of single family residences. Discharges to a County system shall be into a structure such as an inlet, catch basin, manhole, through an approved sidewalk underdrain or curb drain, or into an existing or created County ditch. Concentrated drainage will not be allowed to discharge across sidewalks, curbs, or driveways.

All buildings are required to have roof downspouts and subsurface drains directed to either an infiltration system, dispersion system, or to the storm drainage system.

Drainage Stub-outs

If drainage outlets (stub outs) are to be provided for each individual lot, the stub outs shall conform to the requirements outlined below. Note that all applicable Core Requirements in Volume I, in particular Core Requirement #5, must also be addressed for the project site.

- Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved storm water conveyance system or to an approved outfall location.
- Outlets on each lot shall be located with a 5-foot-high, 2" x 4" stake marked "storm" or "drain." For stub-outs to a surface drainage, the stub-out shall visibly extend above surface level and be secured to the stake.
- The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).
- All individual stub-outs shall be privately owned and maintained by the lot home owner including from the property line to the riser on the main line.

[3] A County connection authorization form must be completed and submitted for approval.

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Appendix III-A
Methods for Determining Design Infiltration Rates

This appendix provides details on methods to estimate the design infiltration rate for infiltration facilities. The methods described include:

- Simple Method 1 – Field Testing Procedures
- Simple Method 2 – Soil Property Relationships
- Method 3 – Soil Grain Size Analysis Method

Simple Method 1 – Field Testing Procedures (In-Situ)

1. Excavate to the bottom elevation of the proposed infiltration facility.
2. Measure the infiltration rate of the underlying soil using either the EPA falling head percolation test procedure as modified for **Thurston County** (described below), the EPA falling head percolation test procedure as modified by Clark County (2015) (refer to Clark County Drainage Manual), the double ring infiltrometer test (ASTM D3385)(not described here, use ASTM procedure), or the Department of Ecology large and small scale Pilot Infiltration Test (PIT) described below and presented in the *Stormwater Management Manual for Western Washington* (Ecology 2012).
3. Fill test hole or apparatus with water and maintain at depths above the test elevation for saturation periods specific to the appropriate test.
4. Following the saturation period, the infiltration rate shall be determined in accordance with the specified test procedures.
5. Perform at least three small-scale tests for each proposed infiltration facility location or the minimum required number of infiltration tests at the proposed infiltration facility location as specified in Volume III, Chapter 2, Section 2.3.3 and by recommendations of the geotechnical professional.
6. Determine a representative infiltration rate.

For all field testing procedures, apply safety factor to obtain design infiltration rate (see next section).

Safety Factor for Field Measurements

The following equation incorporates safety factors to account for uncertainties related to testing, depth to the water table or impervious strata, infiltration receptor geometry, and long-term reductions in permeability due to biological activity and accumulation of fine sediment. Note that the safety factors below may not apply to the infiltration testing conducted for bioretention, permeable pavement and/or rain gardens (see Volume V, Sections 2.2.5 and 2.2.6 for additional information). This equation estimates the maximum design infiltration rate, I_{design}. Depending on site conditions, additional reduction of the design infiltration rate may be appropriate. **In no case may the design infiltration rate exceed 30 inches/hour**.

$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging}$

$F_{testing}$ accounts for uncertainties in the testing methods.

- For the full scale PIT method, Ftesting = 0.75;
- For the small-scale PIT method, Ftesting = 0.50;
- For smaller-scale infiltration tests such as the double-ring infiltrometer test, Ftesting = 0.40;
- For grain size analysis, Ftesting = 0.40;
- For the EPA method, the SDI (ASTM D3385) method, Ftesting = 0.50.

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. $F_{testing}$ accounts for uncertainties in the testing methods.

$F_{geometry}$ accounts for the influence of facility geometry and depth to the water table or impervious strata on the actual infiltration rate. A shallow water table or impervious layer reduces the effective infiltration rate of a large pond, but this would not be reflected in a small scale test. $F_{geometry}$ must be between 0.25 and 1.0 as determined by the following equation:
$F_{geometry} = 4\ D/W + 0.05$

Where: D = Depth from the bottom of the proposed facility to the maximum wet season water table or nearest impervious layer, whichever is less

W = Width of facility

If $F_{geometry}$ is calculated as greater than 1, use 1, if calculated value is less than 0.25, use 0.25.

$F_{plugging}$ accounts for reductions in infiltration rates over the long term due to plugging of soils. This factor is:

- 0.7 for loams and sandy loams
- 0.8 for fine sands and loamy sands
- 0.9 for medium sands

- 1.0 for coarse sands or cobbles, or any soil type in an infiltration facility preceded by a water quality facility (not including a pre-treatment unit or forebay for course sediment removal).

Falling Head Percolation Test Procedure (as Modified for Thurston County)[4]

Note: This test may not be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Core Requirement #5.

1. **Number and Location of Tests**

A minimum of three tests shall be performed within the area proposed for an infiltration facility. Tests shall be spaced uniformly throughout the area. For larger facilities or if soil conditions are highly variable, more tests may be required (see minimum testing requirements in Volume III).

2. **Preparation of Test Hole** (as modified for Thurston County)

The diameter of each test hole is 8 inches, dug or bored to the proposed bottom elevation of the infiltration facility or to the most limiting soil horizon. To expose a natural soil surface, the bottom of the hole is scratched with a sharp pointed instrument and the loose material is removed from the test hole. A 6-inch-inner-diameter, 4-foot long, PVC pipe is set into the hole and pressed 6 inches into the soil, then 2 inches of 1/2- to 3/4-inch rock are placed in the pipe to protect the bottom from scouring when water is added.

3. **Soaking Period**

The pipe is carefully filled with at least 12 inches of clear water. The depth of water must be maintained for at least 4 hours and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

In sandy soils with little or no clay, soaking is not necessary. If, after filling the pipe twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

4. **Percolation Rate Measurement**

Except for sandy soils, percolation rate measurements are made at least 15 hours but no more than 30 hours after the soaking period began. The water level is adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel. Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 1/16th-inch, at 30 minute intervals.

[4] (Source: EPA, *On-site Wastewater Treatment and Disposal Systems,* 1980)

The test is continued until two successive water level drops do not vary by more than 1/16th-inch within a 90 minute period. At least three measurements are to be made.

After each measurement, the water level is readjusted to the 6-inch level. The last water level drop is used to calculate the percolation rate.

In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

5. **Percolation Rate Calculation**

The percolation rate is calculated for each test site by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in minutes/inch. To calculate the percolation rate for the area, average the rates obtained from each hole. (If tests in the area vary by more than 20 minutes/inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.) The percolation rate in minutes/inch should be converted to infiltration rate in inches/hour and then t**o compute the design infiltration rate (I_{design}), the final infiltration rates must then be adjusted by the appropriate correction factors outlined previously.**

Example: If the last measured drop in water level after 30 minutes is 5/8-inch, then:

percolation rate = (30 minutes)/(5/8 inch) = 48 minutes/inch. Convert this to inches per hour by inverting & multiplying by 60: infiltration rate – 1/48*60 = 1.25 inches/hour. (At a minimum, a safety factor "$F_{testing}$" of 0.5 is be applied to all field methods for determining infiltration rates.)

Washington Department of Ecology Infiltration PIT Method

The Large-Scale Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale tests such as the Modified Falling Head Percolation Test, 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. It is the preferred method for estimating the measured (initial) saturated hydraulic conductivity (K_{sat}) of the soil profile beneath the proposed infiltration facility. Following is a step-by-step description of the testing procedure.

Infiltration Test

1. Excavate the test pit to the depth of the bottom of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test.

2. The horizontal surface area of the bottom of the test pit should be approximately 100 square feet.

3. Accurately document the size and geometry of the test pit.

4. Install a vertical measuring rod (minimum 5 feet long) marked in half-inch increments in the center of the pit bottom.

5. Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.

6. Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth must not exceed the proposed maximum depth of water expected in the completed facility.

7. Every 15 to 30 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

8. Add water to the pit until 1 hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5 percent variation or less variation in the total flow) while maintaining the same pond water level (usually 6 hours). The total of the pre-soak time plus one hour after the flow rate has stabilized should be no less than 6 hours.

9. After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty. Consider running this falling head phase of the test several times to estimate the dependency of infiltration rate with head.

Data Analysis

Calculate and record the infiltration rate in inches per hour in 30 minute or one-hour increments until 1 hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

To compute the design infiltration rate (I_{design}), apply appropriate correction factors outlined previously.

Example:

The area of the bottom of the test pit is 8.5 feet by 11.5 feet.

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. Divide the flow rate by the area of the test pit and convert to inches per hour to get an average of (9.8 + 12.3) / 2 = 11.1 inches per hour.

To compute the design infiltration rate (I_{design}), the infiltration rate must then be adjusted by the appropriate correction factors outlined previously.

Small-Scale Pilot Infiltration Test

A smaller-scale PIT can be used in any of the following instances:

The drainage area to the infiltration site is less than one acre. This test applies to infiltration facilities with drainage areas less than one acre and may be used to demonstrate infeasibility of bioretention, permeable pavement, or rain gardens in meeting Core Requirement #5.

The site has conditions that make a large-scale PIT infeasible, such as high infiltration rates or lack of a water source that provides a sufficient volume of water to perform the test, and the site geotechnical investigation suggests uniform subsurface characteristics.

Infiltration Test

6. Excavate the test pit to the estimated surface elevation of the proposed infiltration facility. In the case of bioretention, excavate to the estimated elevation at which the imported soil mix will lie on top of the underlying native soil. For permeable pavement, excavate to the elevation at which the imported subgrade materials, or the pavement itself, will contact the underlying native soil. If the native soils (road subgrade) will have to meet a minimum subgrade compaction requirement, compact the native soil to that requirement prior to testing. Note that the permeable pavement design guidance recommends compaction not exceed 90 – 92 percent. Finally, lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.

7. The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular, but accurately document the size and geometry of the test pit.

8. Install a vertical measuring rod adequate to measure the ponded water depth and that is marked in half-inch increments in the center of the pit bottom.

9. Use a rigid pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates. Use a 3 inch diameter pipe for pits on the smaller end of the recommended surface area, and a 4 inch pipe for pits on the larger end of the recommended surface area.

10. 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.

11. 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.

12. 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 – 12 inches) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 – 12 inches).

13. 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.

14. A self-logging pressure sensor may also be used to determine water depth and drain-down.

Data Analysis

See the explanation under the guidance for large-scale pilot infiltration tests.

Simple Method 2 – Soil Property Relationships

USDA Soil Textural Classification

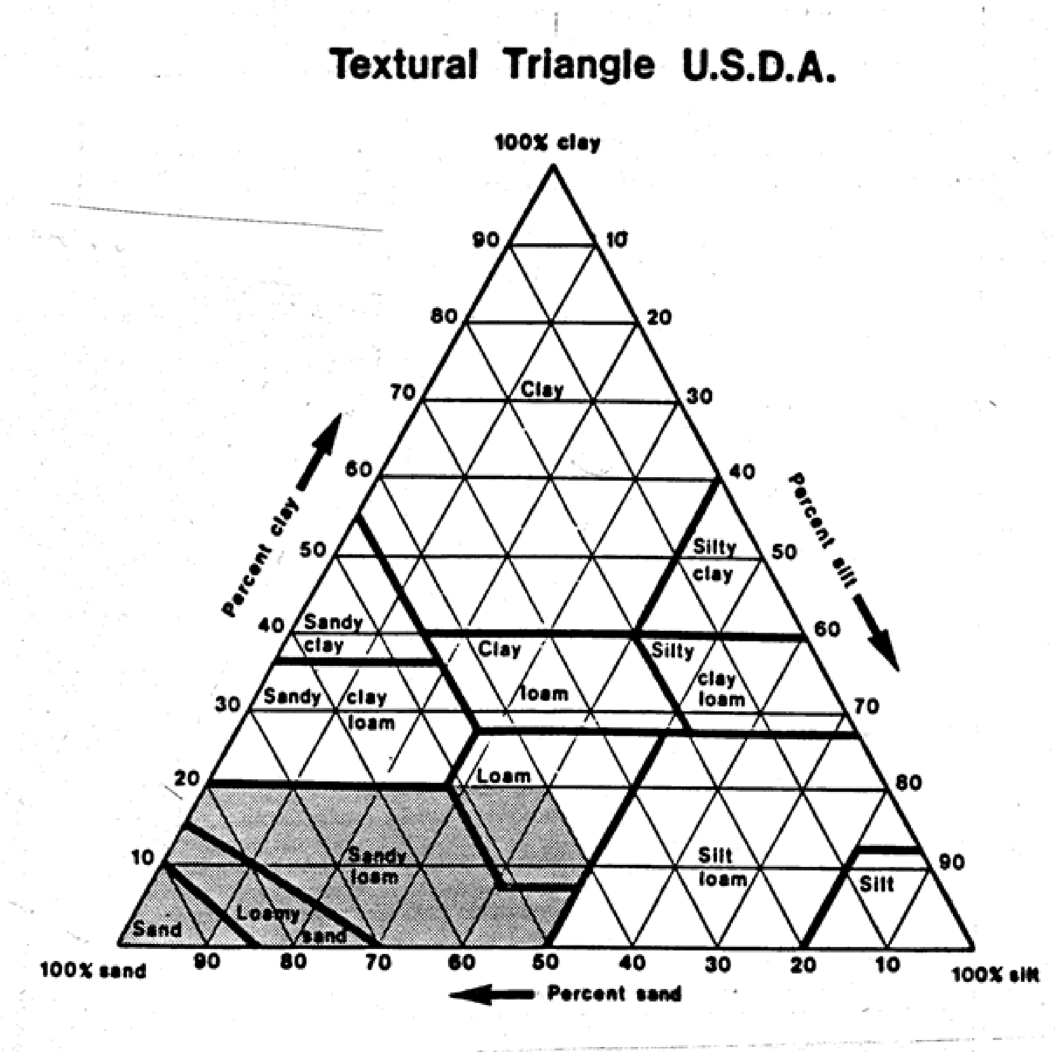
Infiltration rates may be estimated from soil grain size distribution (gradation) data using the United States Department of Agriculture (USDA) textural analysis approach. Conduct the grain size distribution test in accordance with the USDA test procedure (Soil Survey Manual, USDA, October 1993, page 136). This manual only considers soil passing the #10 sieve (2 mm) (US Standard) to determine percentages of sand, silt, and clay for use in Figure A-1. This method may only be applied to projects sites inside the NPDES boundary that trigger Core Requirement #1 through #5 or any project outside the NPDES boundary, and that are underlain by hydrologic soil group A soils (as defined by the NRCS Web Soil Survey and field verified by a qualified professional).

Short-term (field) infiltration rates, required correction factors, and design (long-term) infiltration rates based on gradations from soil samples and textural analysis are summarized in Table A.1. With prior acceptance of Thurston County, the correction factors may be reduced (to a minimum of 2.0) if there is little soil variability, there will be a high degree of long-term facility maintenance, and there is adequate pre-treatment to reduce total suspended solids in influent stormwater.

Table A.1. Recommended Infiltration Rates based on USDA Soil Textural Classification

	*Short-Term Infiltration Rate (in./hr)	Correction Factor, CF	Estimated Design (Long-term) Infiltration Rate (in./hr)
Clean sandy gravels and gravelly sands (i.e., 90% of the total soil sample is retained in the #10 sieve)	20	2	10
Sand	8	4	2
Loamy Sand	2	4	0.5
Sandy Loam	1	4	0.25
Loam	0.5	4	0.13

Source: *Stormwater Management Manual for Western Washington* (Ecology 2005).
*From WEF/ASCE, 1998.



Shaded area is applicable for design of infiltration BMPs
Source: U.S. Department of Agriculture

Figure A-1. USDA Textural Triangle.

Method 3 - Soil Grain Size Analysis Method

The detailed method described below is based on Massmann (2003).

Determine the Saturated Hydraulic Conductivity

For each defined layer below the pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than 6 feet, estimate the saturated hydraulic conductivity (K_{sat}) in centimeters per second (cm/s) using the following relationship (see Massmann 2003, and Massmann et al. 2003). For infiltration facilities 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).

$$\log_{10}\left(K_{sat}\right) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08 f_{fines} \qquad (1)$$

Where, D_{10}, D_{60} and D_{90} are the grain sizes in millimeters (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 US #200 sieve. (K_{sat} is in cm/s)

For bioretention areas, 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 permeable pavement, 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 (reservoir) 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 hydraulic conductivity characteristics. Massmann (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration facility 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 hydraulic conductivity 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, or is heavily over consolidated due to its geologic history (e.g., overridden by continental glaciers), the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt 2003). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity. 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.

For critical designs (facilities that pose a high risk of flooding and property damage in the event of clogging or other failure), the in-situ saturated conductivity of a specific layer can be obtained through the use of a pilot infiltration test (PIT) as described above. Note that some field tests provide a direct estimate of infiltration rate, which is the product of hydraulic conductivity and hydraulic gradient (see Equation 5). In this case, the infiltration rate must be divided by the hydraulic gradient to calculate the hydraulic conductivity. This issue will need to be evaluated on a case-by-case basis when interpreting the results of field tests to ensure an accurate estimate of K_{sat}. It is important to recognize that the gradient in the test may not be the same as the gradient likely to occur in the full-scale infiltration facility in the long-term (i.e., when ground water mounding is fully developed).

Once the saturated hydraulic conductivity for each layer has been identified, determine the effective average saturated hydraulic conductivity below the pond. Hydraulic conductivity estimates from different layers can be combined into an equivalent hydraulic conductivity (K_{equiv}) using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}} \qquad (2)$$

Where:

d is the total depth of the soil column

d_i is the thickness of layer “i” in the soil column

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 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 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 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 pond bottom should not be included in Equation 2.

Equation 2 may over-estimate the effective hydraulic conductivity value at sites with low conductivity layers immediately beneath the infiltration pond. For sites where the lowest conductivity layer is within five feet of the base of the pond, it is suggested that this lowest hydraulic conductivity value be used as the equivalent hydraulic conductivity rather than the value from Equation 2. Using the layer with the lowest Ksat is advised for designing bioretention areas or permeable pavement surfaces.

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.

Calculate the Hydraulic Gradient

The steady state hydraulic gradient (i) is calculated as follows:

$$i = \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} \times CF_{size} \qquad (3)$$

Note: The units in this equation vary from the units normally used in this manual.

Where:

D_{wt} is the depth from the base of the infiltration facility to the water table in feet

K is the saturated hydraulic conductivity in feet/day

D_{pond} is the depth of water in the facility in feet (see Massmann et al. 2003, for the development of this equation)

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 less than or equal to 2/3 acre), the correction factor is equal to 1.0. For large ponds (ponds with area greater than or equal to 6 acres), the correction factor is 0.2, as shown in Equation 4.

$$CF_{size} = 0.73(A_{pond})^{-0.76} \qquad (4)$$

Where, A_{pond} is the area of pond bottom in acres.

This equation generally will result in a calculated gradient of less than 1.0 for moderate to shallow ground water depths (or to a low permeability layer) below the facility, 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 Equation 3. If the calculated 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 facility, 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 the continuous runoff models. As of the date of this update, neither the WWHM or MGSFlood have that capability. However, updates to those models may soon incorporate the capability. Until that time, use a steady-state hydraulic gradient that corresponds with a ponded depth of ¼ of the maximum ponded depth – as measured from the basin floor to the overflow.

Calculate the Infiltration Rate using Darcy's Law

$$f = K\left(\frac{dh}{dz}\right) = Ki \qquad (5)$$

Where:

f is the specific discharge or infiltration rate of water through a unit cross-section of the infiltration facility (L/t)

K is the hydraulic conductivity (L/t)

dh/dz (= "i") is the hydraulic gradient (L/L)

Adjustments to Infiltration Rate

Adjustments to the infiltration rate calculated above are required to adjust for biofouling, siltation and pond aspect ratio.

To account for reductions in the rate resulting from long-term siltation and biofouling, take into consideration the degree of long-term maintenance and performance monitoring anticipated, the degree of influent control (e.g., pre-settling ponds biofiltration swales, etc.), and the potential for siltation, litterfall, moss buildup, etc. based on the surrounding environment.

It should be assumed that an average to high degree of maintenance will be performed on these facilities. A low degree of maintenance should be considered only when there is no other option (e.g., access problems). The infiltration rate estimated in the step above is multiplied by the reduction factors summarized in Table A.3.

Table A.3. Infiltration Rate Reduction Factors to Account for Biofouling and Siltation Effects for Ponds (Massmann, 2003)

Potential for Biofouling	Degree of Long-Term Maintenance/Performance Monitoring	Infiltration Rate Reduction Factor, $CF_{silt/bio}$
Low	Average to High	0.9
Low	Low	0.6
High	Average to High	0.5
High	Low	0.2

The values in this table assume that final excavation of the facility to the finished grade is deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected (e.g., construction runoff is not allowed into the facility after final excavation of the facility).

Ponds located in shady areas where moss and litterfall from adjacent vegetation can build up on the pond bottom and sides, the upgradient drainage area will remain in a disturbed condition long-term, and no pretreatment (e.g., pre-settling ponds, biofiltration swales, etc.) is provided, are one example of a situation with a high potential for biofouling.

A low degree of long-term maintenance includes, for example, situations where access to the facility for maintenance is very difficult or limited, or where there is minimal control of the party responsible for enforcing the required maintenance. A low degree of maintenance should be considered only when there is no other option.

Adjustment for Pond Aspect Ratio

Adjust the infiltration rate for the effect of pond aspect ratio by multiplying the infiltration rate determined above by the aspect ratio correction factor CF_{aspect} as shown in the following equation:

$$CF_{aspect} = 0.02A_r + 0.98 \tag{6}$$

Where, A_r is the aspect ratio for the pond (length/width). In no case shall CF_{aspect} be greater than 1.4. The final infiltration rate will therefore be as follows:

$$f = K \times i \times CF_{aspect} \times CF_{silt/bio} \tag{7}$$

The rates calculated based on Equation 7 are long-term design rates. No additional reduction factor or factor of safety is needed.

Appendix III-B
Design Aids

Single Event Model Guidance

The only approved use of a single event model is for the sizing of conveyance systems. Approved continuous simulation runoff models will be used for the design of water quality and quantity BMPs.

SBUH or SCS Methods

The applicant shall use the Western Washington SCS "curve numbers" included in **Table B.4**, not the SCS national curve numbers. Individual curve numbers for a drainage area may be averaged into a "composite" curve number for use with SCS or SBUH methods. 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 identified relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. These relationships have been characterized by a single runoff coefficient called a "curve number." The National Engineering Handbook – Section 4: Hydrology (NEH-4, SCS, August 1972) contains a detailed description of the development and use of the curve number method.

The curve numbers can be found in *Urban Hydrology for Small Watersheds*, Technical Release 55 (TR-55), June 1986, published by the NRCS. 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 B.5** shows the hydrologic soil group of most soils in Thurston County and provides a brief description of the four groups. For details on other soil types, the NRCS publication described above (TR-55, 1986).

Isopluvial Maps

National Oceanic and Atmospheric Administration (NOAA) isopluvial maps for western Washington are included below. The design engineer shall use the best engineering judgment in selecting the runoff totals for the project site.

Time of Concentration

Time of concentration (T_c) is the sum of travel times for sheet flow, shallow concentrated flow, and channel flow. For lakes and submerged wetlands, travel time can be determined with storage routing techniques if the stage-storage versus discharge relationship is known or may be assumed to be zero.

Sheet Flow

With sheet flow, the friction value (n_s) is used. This is a modified Manning's effective roughness coefficient that includes the effect of raindrop impact, drag over the plane surface, obstacles such as litter, crop ridges and rocks, and erosion and transportation of sediment. These n_s values are for very shallow flow depths of about 0.1 foot and are used only for travel lengths up to 300 feet. Table B.2 gives Manning's n_s values for sheet flow for various surface conditions.

For sheet flow of up to 300 feet, use Manning's kinematic solution to directly compute T_t.

$$T_t = \frac{0.42\,(n_s L)^{0.8}}{(P_2)^{0.527}(S_o)^{0.4}}$$

Where:
- T_t = Travel time (min),
- n_s = Sheet flow Manning's effective roughness coefficient (Table B.2),
- L = Flow length (ft),
- P_2 = 2-year, 24-hour rainfall (in), and
- s_o = Slope of hydraulic grade line (land slope, ft/ft)

The maximum allowable distance for sheet flow shall be 300 feet. The remaining overland flow distance shall be shallow concentrated flow until the water reaches a channel.

Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values from Table B.2 in which average velocity is a function of watercourse slope and type of channel.

The average velocity of flow, once it has measurable depth, shall be computed using the following equation:

$$V = k\sqrt{s_o}$$

Where:
- V = Velocity (ft/s)
- k = Time of concentration velocity factor (ft/s)
- s_o = Slope of flow path (ft/ft)

"k" is computed for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation:

$$k = (1.49(R)^{0.667})/n$$

where:
- R = An assumed hydraulic radius
- n = Manning's roughness coefficient for open channel flow (see Table B-3)

Open Channel Flow

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangle sheets. The k_c values from Table B.2 used in the Velocity Equation above or water surface profile information can be used to estimate average flow velocity.

Lakes or Wetlands

This travel time is normally very small and can be assumed as zero. Where significant attenuation may occur due to storage effects, the flows should be routed using a "level pool routing" technique.

Limitations

The following limitations apply in estimating travel time (T_t).

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet.
- In watersheds with storm drains, carefully identify the appropriate hydraulic flow path to estimate Tc.
- Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and a level pool routing technique used to determine the outflow rating curve through the culvert or bridge.

Design Storm Hyetographs

The standard design hyetograph is the SCS Type 1A 24-hour rainfall distribution, resolved into 6-minute time intervals (see Table B.8). Various interpretations of the hyetograph are available and may differ slightly from distributions used in other unit hydrograph based computer simulations. Other distributions will be accepted with adequate justification and as long as they do not increase the allowable release rates.

For project sites with tributary drainage areas above elevation 1,000 feet MSL, an additional total precipitation must be added to the total depth of rainfall for the 25-, 50-, and 100-year design storm events to account for the potential average snow melt which occurs during major storm events.

The MSL "factor" is computed as follows:

$$M_s \text{ (in inches)} = 0.004\ (MB_{el} - 1000)$$

Where: M_s = Rainfall amount to be added to P_r

MB_{el} = The mean tributary basin elevation above sea level (in feet)

Sub-Basin Delineation

Within an overall drainage basin, it may be necessary to delineate separate sub-basins based on similar land uses and/or runoff characteristics or when hydraulically "self-contained" areas are found to exist. When this is necessary, separate hydrographs shall be generated, routed, and recombined, after travel time is considered, into a single hydrograph to represent runoff flows into the quantity or quality control facility.

Hydrograph Phasing Analysis

Where flows from multiple basins or subbasins having different runoff characteristics and/or travel times combine, the design engineer shall sum the hydrographs after shifting each hydrograph according to its travel time to the discharge point of interest. The resultant hydrograph shall be either routed downstream as required in the downstream analysis see (Volume 1 Chapter 3 [Drainage Report section 8]), or routed through the control facility.

Included in this appendix are the 2-, 10-, 25-,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. The Applicant shall use the NOAA Isopluvials for selection of the design storm precipitation.

Rational Method

The only approved use of the Rational Method is for the sizing of conveyance systems. This method is applicable to smaller drainage basins, 25 acres in size or less. This method provides an estimate of peak discharge (Q_p in cubic feet per second [cfs]) using the following formula:

$$Q_p = CIA$$

Where: C = runoff coefficient (unitless),

A = area of watershed (acres), and

I = rainfall intensity (inches per hour) for a chosen frequency expressed as:

$$I = \frac{m}{(T_c)^n}$$

Where: m, n are regression coefficients (unitless), and

T_c = time of concentration (in hours).

Runoff coefficient (*C*) values are listed in Table B-6 for a range of land cover types. Regression coefficients (*m*, *n*) for determining rainfall intensity can be found in Table B-7. Time of concentration (T_c) is calculated as described in the Single Event Model Guidance section above.

Source: NOAA

Western Washington Isopluvial 2-year, 24-hour

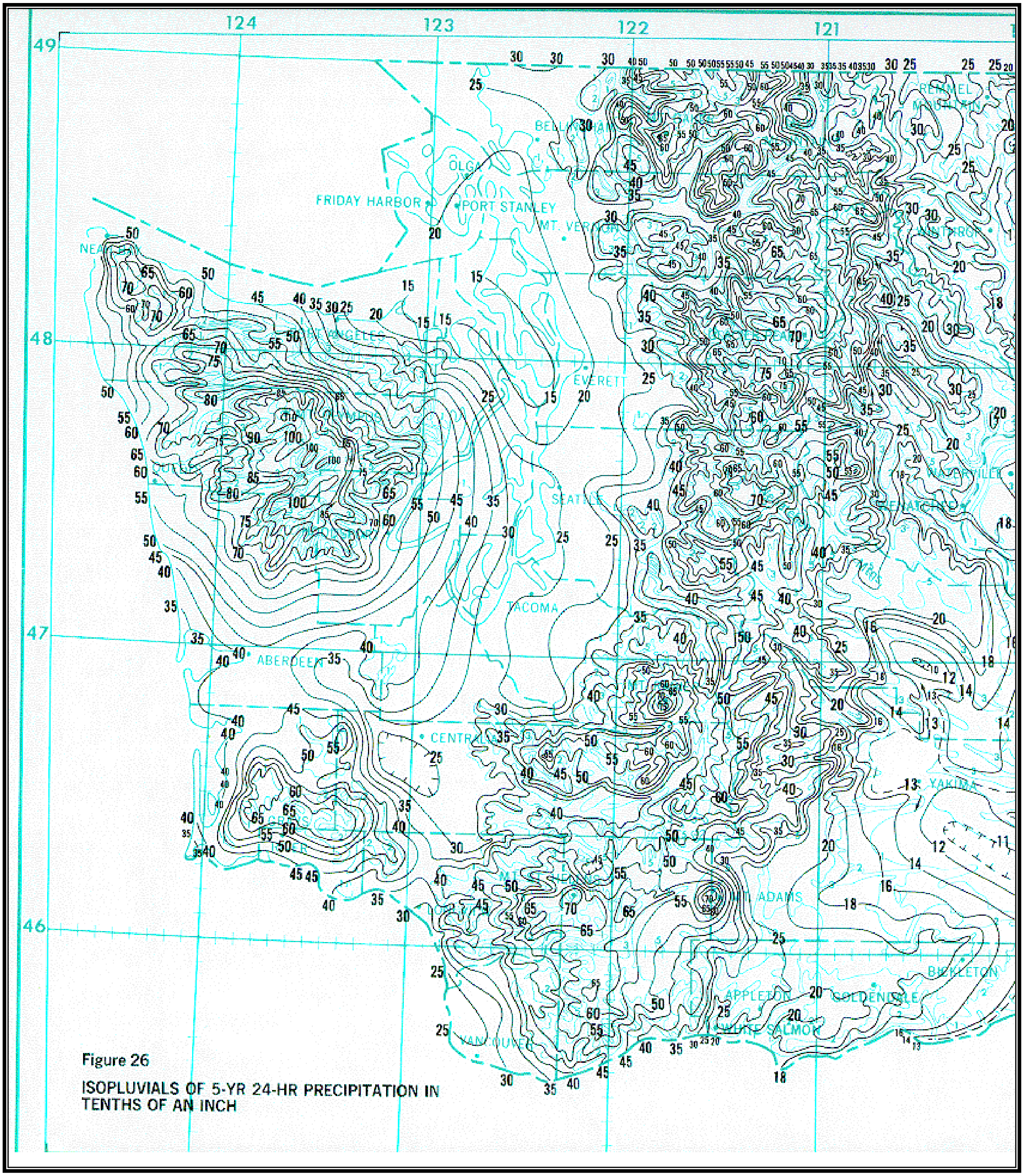
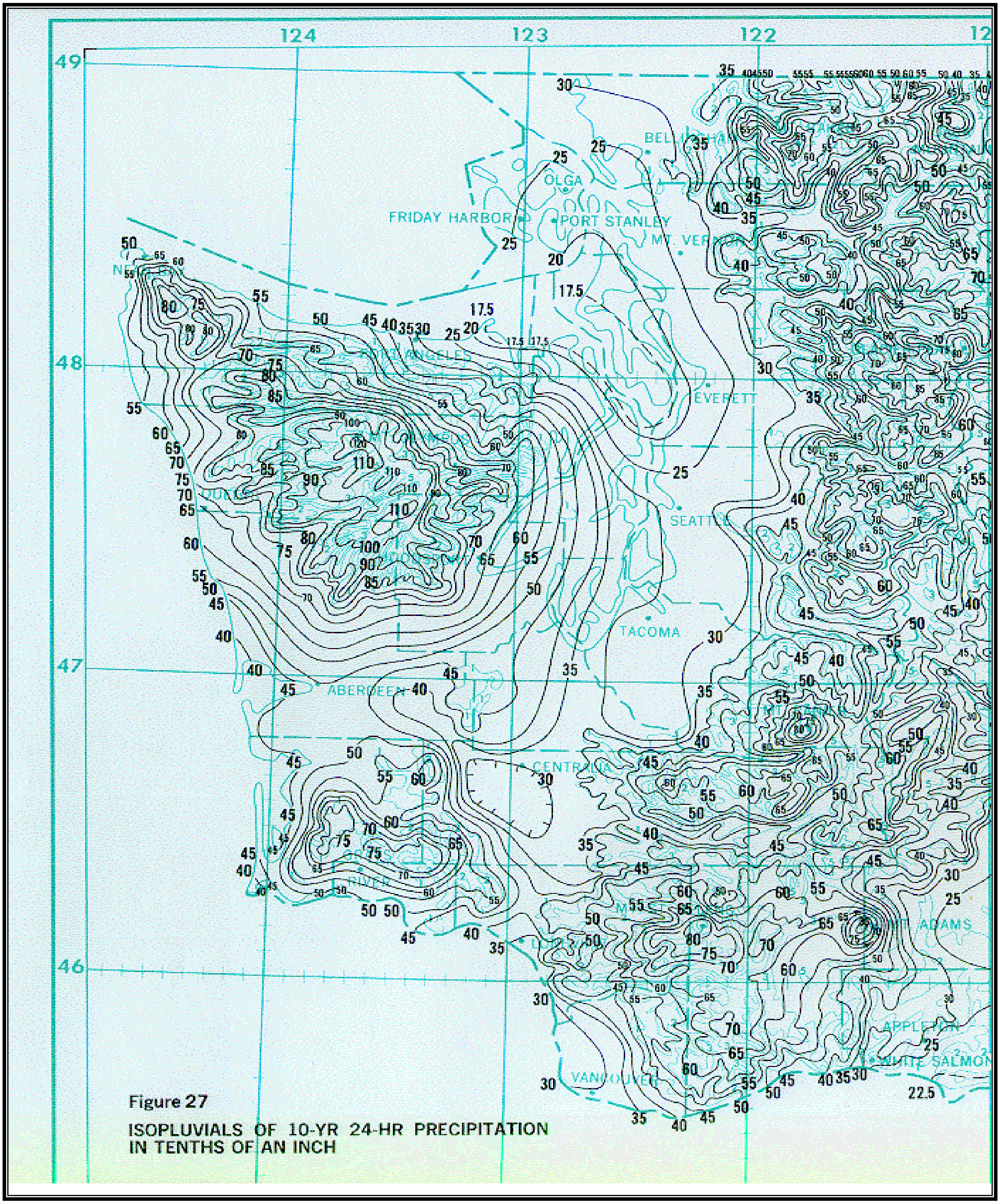


Figure 26

ISOPLUVIALS OF 5-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

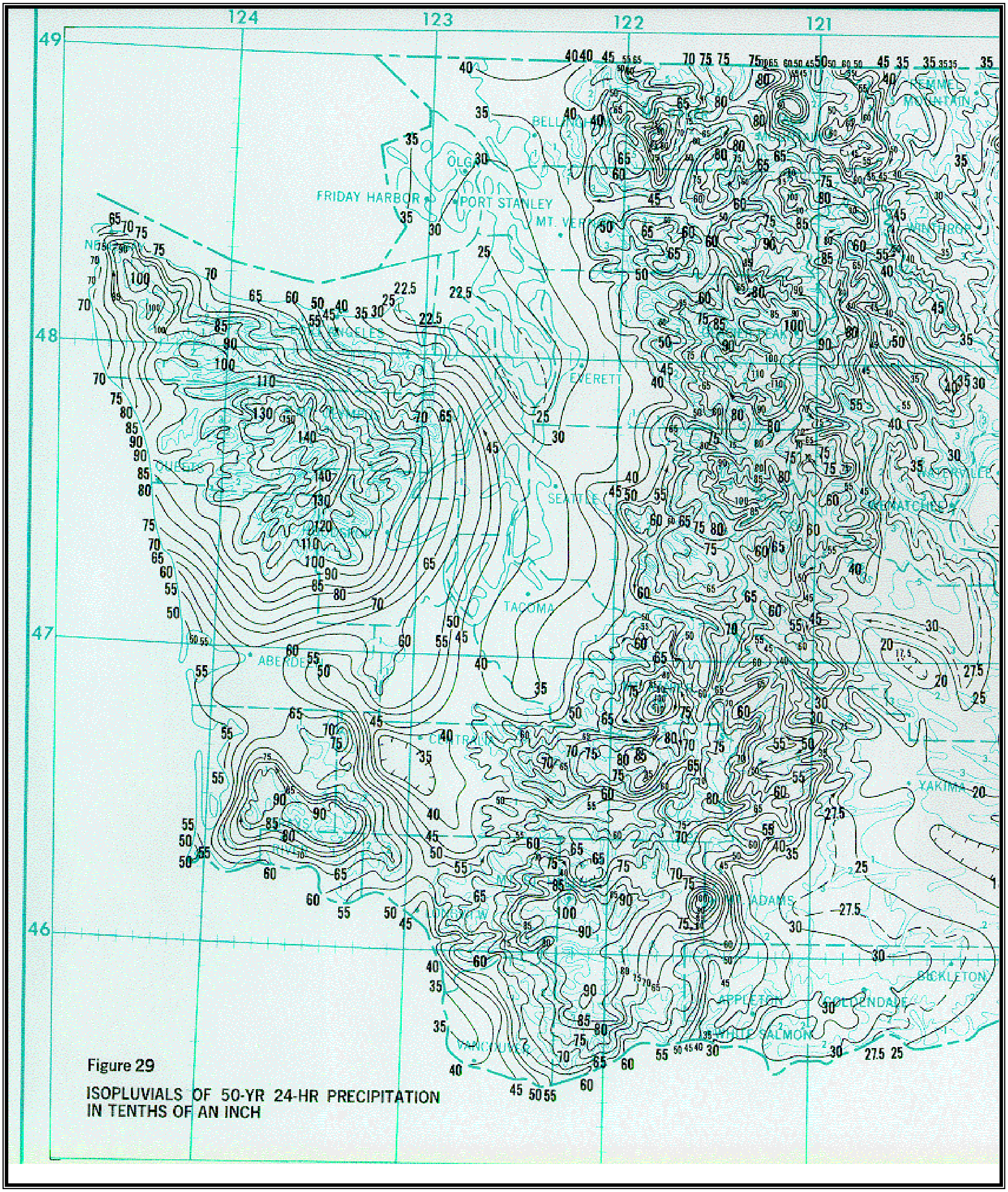
Western Washington Isopluvial 5-year, 24-hour



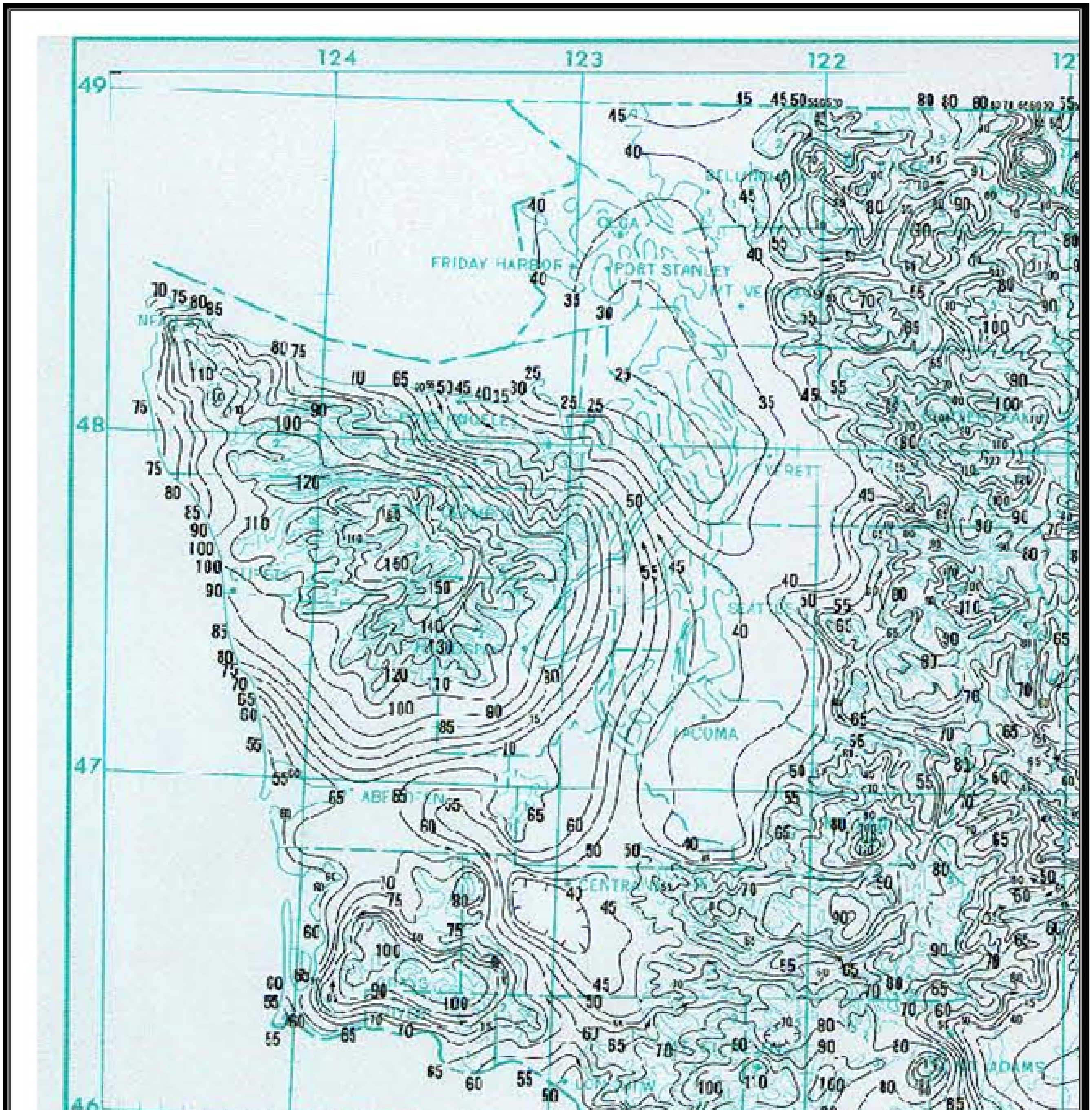
Western Washington Isopluvial 10-year, 24-hour

Source: NOAA

Western Washington Isopluvial 25-year, 24-hour



Western Washington Isopluvial 50-year, 24-hour



Western Washington Isopluvial 100-year, 24-hour

Table B.2. "n" and "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	**n_s***
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover ($s \leq 0.20$ ft/ft)	0.06
Cultivated soil with residue cover ($s > 0.20$ ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	**k_s**
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.025)	13
7. Paved and gravel areas (n = 0.012)	27

Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	**k_c**
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe (n = 0.024)	21
7. Concrete pipe (0.012)	42
8. Other waterways and pipe	0.508/n

Channel Flow (Continuous stream, R = 0.4)	**k_c**
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other streams, man-made channels and pipe n** determined from Table B.3	0.807/n**

Ref: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table B.3. Values of the Roughness Coefficient, "n"

Type of Channel and Description	Manning's "n"
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	0.025
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as above, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as above, but some weeds	0.040
5. Same as 4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Flood plains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as above, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as above, but with flood stage reaching branches	0.120

Ref: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table B.4. Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas

(Sources: TR 55, 1986, and Stormwater Management Manual, 1992.)				
	CNs for hydrologic soil group			
Cover type and hydrologic condition.	A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (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
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Volume V to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	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
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (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

Single family residential[3]**:** Dwelling Unit/Gross Acre	Should only be used for subdivisions > 50 acres	Average Percent impervious area[3,4]	
1.0 DU/GA		15	Separate curve number
1.5 DU/GA		20	shall be selected for
2.0 DU/GA		25	pervious & impervious
2.5 DU/GA		30	portions of the site or
3.0 DU/GA		34	basin
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	
PUDs, 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	
For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55 , (210-VI-TR-55, Second Ed., June 1986).			

[1] Composite CNs 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 Volume V, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" and "Flow Credit for Roof Downspout 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 B.5. Major Soil Groups in Thurston County

Soil Type *	Hydrologic Soil Group	Soil Type *	Hydrologic Soil Group
ALDERWOOD	C	MUKILTEO	C/D
BALDHILL	B	NEWBERG	B
BAUMGARD	B	NISQUALLY	B
BELLINGHAM	C	NORMA	D
BOISTFORT	B	OLYMPIC	B
BUNKER	B	PHEENEY	C
CAGEY	C	PILCHUCK	C
CATHCART	B	PITS	*
CENTRALIA	B	PRATHER	C
CHEHALIS	B	PUGET	D
DELPHI	B	PUYALLUP	B
DUPONT	D	RAINIER	C
DYSTRIC XEROCHREPTS	C	ROCK OUTCROP	*
ELD	B	RAUGHT	B
EVERETT	A	RIVERWASH	D
EVERSON	D	SALKUM	B
GALVIN	D	SCAMMAN	D
GILES	B	SCHNEIDER	B
GODFREY	D	SEMIAHMOO	C
GROVE	A	SHALCAR	D
HOOGDAL	C	SHALCAR VARIANT	D
HYDRAQUENTS	D	SKIPOPA	D
INDIANOLA	A	SPANA	D
JONAS	B	SPANAWAY	B
KAPOWSIN	D	SULTON	C
KATULAS	C	TACOMA	D
LATES	C	TENINO	C
MAL	C	TISCH	D
MASHEL	B	VAILTON	B
MAYTOWN	C	WILKESON	B
MCKENNA	D	XERORTHENTS	C
MELBOURNE	B	YELM	C

**See the description of the map unit*

Soils Table Notes:

Hydrologic Soil Group Classifications, as Defined by the NRCS (formerly 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 NRCS Database for Thurston surveys, SCS, TR-55, Second Edition, June 1986, Exhibit A-1. Revisions made from SCS, Soil Interpretation Record, Form #5, September 1988 and various county soil surveys.*

Table B.6. Runoff Coefficients for Rational Method Calculations.

Type of Cover	Flat	Rolling (2%-10%)	Hilly Over 10%)
Pavement and Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives and Walks	0.75	0.80	0.85
Gravel Pavement	0.50	0.55	0.60
City Business Areas	0.80	0.85	0.85
Suburban Residential	0.25	0.35	0.40
Single Family Residential	0.30	0.40	0.50
Multi Units, Detached	0.40	0.50	0.60
Multi Units, Attached	0.60	0.65	0.70
Lawns, Very Sandy Soil	0.05	0.07	0.10
Lawns, Sandy Soil	0.10	0.15	0.20
Lawns, Heavy Soil	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay and Loam	0.50	0.55	0.60
Cultivated Land, Sand and Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	0.90
Parks and Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland and Forests	0.10	0.15	0.20
Meadows and Pasture Land	0.25	0.30	0.35
Pasture with Frozen Ground	0.40	0.45	0.50
Unimproved Areas	0.10	0.20	0.30

Source: WSDOT Hydraulics Manual (2007)

Table B.7. Regression Coefficients for Rational Method Calculations.

	2-year MRI		5-year MRI		10-year MRI		25-year MRI		50-year MRI		100-year MRI	
Location	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**
Olympia	3.82	0.466	4.86	0.472	5.62	0.474	6.63	0.477	7.40	0.478	8.17	0.480
Centralia and Chehalis	3.63	0.506	4.85	0.518	5.76	0.524	7.00	0.530	7.92	0.533	8.86	0.537
Tacoma	3.57	0.516	4.78	0.527	5.70	0.533	6.93	0.539	7.86	0.542	8.79	0.545

Source: WSDOT Hydraulics Manual (2007).
MRI: Mean Recurrence Interval (frequency).

Table B.8. SCS Type IA Storm Rainfall Distribution, 6-minute intervals.

Time (hours)	Incremental Rainfall	Cumulative Rainfall	Time (hours)	Incremental Rainfall	Cumulative Rainfall
0	0	0	3.8	0.004	0.109
0.1	0.002	0.002	3.9	0.003	0.112
0.2	0.002	0.004	4	0.004	0.116
0.3	0.002	0.006	4.1	0.004	0.12
0.4	0.002	0.008	4.2	0.003	0.123
0.5	0.002	0.01	4.3	0.004	0.127
0.6	0.002	0.012	4.4	0.004	0.131
0.7	0.002	0.014	4.5	0.004	0.135
0.8	0.002	0.016	4.6	0.004	0.139
0.9	0.002	0.018	4.7	0.004	0.143
1	0.002	0.02	4.8	0.004	0.147
1.1	0.003	0.023	4.9	0.005	0.152
1.2	0.003	0.026	5	0.004	0.156
1.3	0.003	0.029	5.1	0.005	0.161
1.4	0.003	0.032	5.2	0.004	0.165
1.5	0.003	0.035	5.3	0.005	0.17
1.6	0.003	0.038	5.4	0.005	0.175
1.7	0.003	0.041	5.5	0.005	0.18
1.8	0.003	0.044	5.6	0.005	0.185
1.9	0.003	0.047	5.7	0.005	0.19
2	0.003	0.05	5.8	0.005	0.195
2.1	0.003	0.053	5.9	0.005	0.2
2.2	0.003	0.056	6	0.006	0.206
2.3	0.004	0.06	6.1	0.006	0.212
2.4	0.003	0.063	6.2	0.006	0.218
2.5	0.003	0.066	6.3	0.006	0.224
2.6	0.003	0.069	6.4	0.007	0.231
2.7	0.003	0.072	6.5	0.006	0.237
2.8	0.004	0.076	6.6	0.006	0.243
2.9	0.003	0.079	6.7	0.006	0.249
3	0.003	0.082	6.8	0.006	0.255
3.1	0.003	0.085	6.9	0.006	0.261
3.2	0.003	0.088	7	0.007	0.268
3.3	0.003	0.091	7.1	0.007	0.275
3.4	0.004	0.095	7.2	0.008	0.283
3.5	0.003	0.098	7.3	0.008	0.291
3.6	0.003	0.101	7.4	0.009	0.3
3.7	0.004	0.105	7.5	0.01	0.31

Time	Incremental Rainfall	Cumulative Rainfall	Time	Incremental Rainfall	Cumulative Rainfall
(hours)			(hours)		
7.6	0.021	0.331	11.4	0.004	0.641
7.7	0.024	0.355	11.5	0.004	0.645
7.8	0.024	0.379	11.6	0.004	0.649
7.9	0.024	0.403	11.7	0.004	0.653
8	0.022	0.425	11.8	0.004	0.657
8.1	0.014	0.439	11.9	0.003	0.66
8.2	0.013	0.452	12	0.004	0.664
8.3	0.01	0.462	12.1	0.004	0.668
8.4	0.01	0.472	12.2	0.003	0.671
8.5	0.008	0.48	12.3	0.004	0.675
8.6	0.009	0.489	12.4	0.004	0.679
8.7	0.009	0.498	12.5	0.004	0.683
8.8	0.007	0.505	12.6	0.004	0.687
8.9	0.008	0.513	12.7	0.003	0.69
9	0.007	0.52	12.8	0.004	0.694
9.1	0.007	0.527	12.9	0.003	0.697
9.2	0.006	0.533	13	0.004	0.701
9.3	0.006	0.539	13.1	0.004	0.705
9.4	0.006	0.545	13.2	0.003	0.708
9.5	0.005	0.55	13.3	0.004	0.712
9.6	0.006	0.556	13.4	0.004	0.716
9.7	0.005	0.561	13.5	0.003	0.719
9.8	0.006	0.567	13.6	0.003	0.722
9.9	0.005	0.572	13.7	0.004	0.726
10	0.005	0.577	13.8	0.003	0.729
10.1	0.005	0.582	13.9	0.004	0.733
10.2	0.005	0.587	14	0.003	0.736
10.3	0.005	0.592	14.1	0.003	0.739
10.4	0.004	0.596	14.2	0.004	0.743
10.5	0.005	0.601	14.3	0.003	0.746
10.6	0.005	0.606	14.4	0.003	0.749
10.7	0.004	0.61	14.5	0.004	0.753
10.8	0.005	0.615	14.6	0.003	0.756
10.9	0.005	0.62	14.7	0.003	0.759
11	0.004	0.624	14.8	0.004	0.763
11.1	0.004	0.628	14.9	0.003	0.766
11.2	0.005	0.633	15	0.003	0.769
11.3	0.004	0.637	15.1	0.003	0.772

Time	Incremental Rainfall	Cumulative Rainfall	Time	Incremental Rainfall	Cumulative Rainfall
(hours)			(hours)		
15.2	0.004	0.776	19	0.003	0.887
15.3	0.003	0.779	19.1	0.003	0.89
15.4	0.003	0.782	19.2	0.002	0.892
15.5	0.003	0.785	19.3	0.003	0.895
15.6	0.003	0.788	19.4	0.002	0.897
15.7	0.004	0.792	19.5	0.003	0.9
15.8	0.003	0.795	19.6	0.003	0.903
15.9	0.003	0.798	19.7	0.002	0.905
16	0.003	0.801	19.8	0.003	0.908
16.1	0.003	0.804	19.9	0.002	0.91
16.2	0.003	0.807	20	0.003	0.913
16.3	0.003	0.81	20.1	0.002	0.915
16.4	0.003	0.813	20.2	0.003	0.918
16.5	0.003	0.816	20.3	0.002	0.92
16.6	0.003	0.819	20.4	0.002	0.922
16.7	0.003	0.822	20.5	0.003	0.925
16.8	0.003	0.825	20.6	0.002	0.927
16.9	0.003	0.828	20.7	0.003	0.93
17	0.003	0.831	20.8	0.002	0.932
17.1	0.003	0.834	20.9	0.002	0.934
17.2	0.003	0.837	21	0.003	0.937
17.3	0.003	0.84	21.1	0.002	0.939
17.4	0.003	0.843	21.2	0.002	0.941
17.5	0.003	0.846	21.3	0.003	0.944
17.6	0.003	0.849	21.4	0.002	0.946
17.7	0.002	0.851	21.5	0.002	0.948
17.8	0.003	0.854	21.6	0.003	0.951
17.9	0.003	0.857	21.7	0.002	0.953
18	0.003	0.86	21.8	0.002	0.955
18.1	0.003	0.863	21.9	0.002	0.957
18.2	0.002	0.865	22	0.002	0.959
18.3	0.003	0.868	22.1	0.003	0.962
18.4	0.003	0.871	22.2	0.002	0.964
18.5	0.003	0.874	22.3	0.002	0.966
18.6	0.002	0.876	22.4	0.002	0.968
18.7	0.003	0.879	22.5	0.002	0.97
18.8	0.003	0.882	22.6	0.002	0.972
18.9	0.002	0.884	22.7	0.002	0.974

Time	Incremental Rainfall	Cumulative Rainfall			
(hours)					
22.8	0.002	0.976			
22.9	0.002	0.978			
23	0.002	0.98			
23.1	0.002	0.982			
23.2	0.002	0.984			
23.3	0.002	0.986			
23.4	0.002	0.988			
23.5	0.002	0.99			
23.6	0.002	0.992			
23.7	0.002	0.994			
23.8	0.002	0.996			
23.9	0.002	0.998			
24	0.002	1			

Appendix III-C – Nomographs for Culvert Sizing Needs

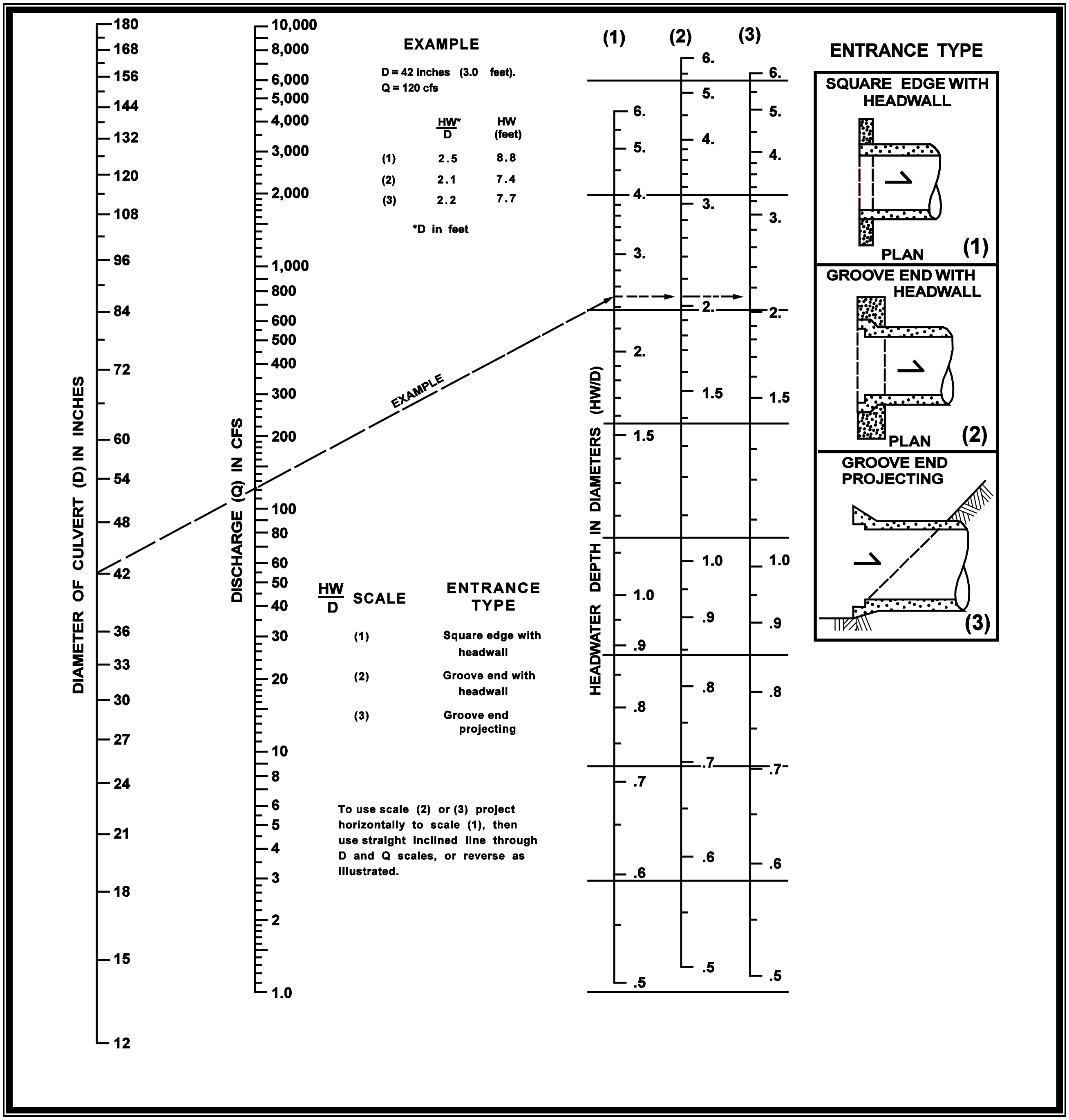


Figure C.1. Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control.

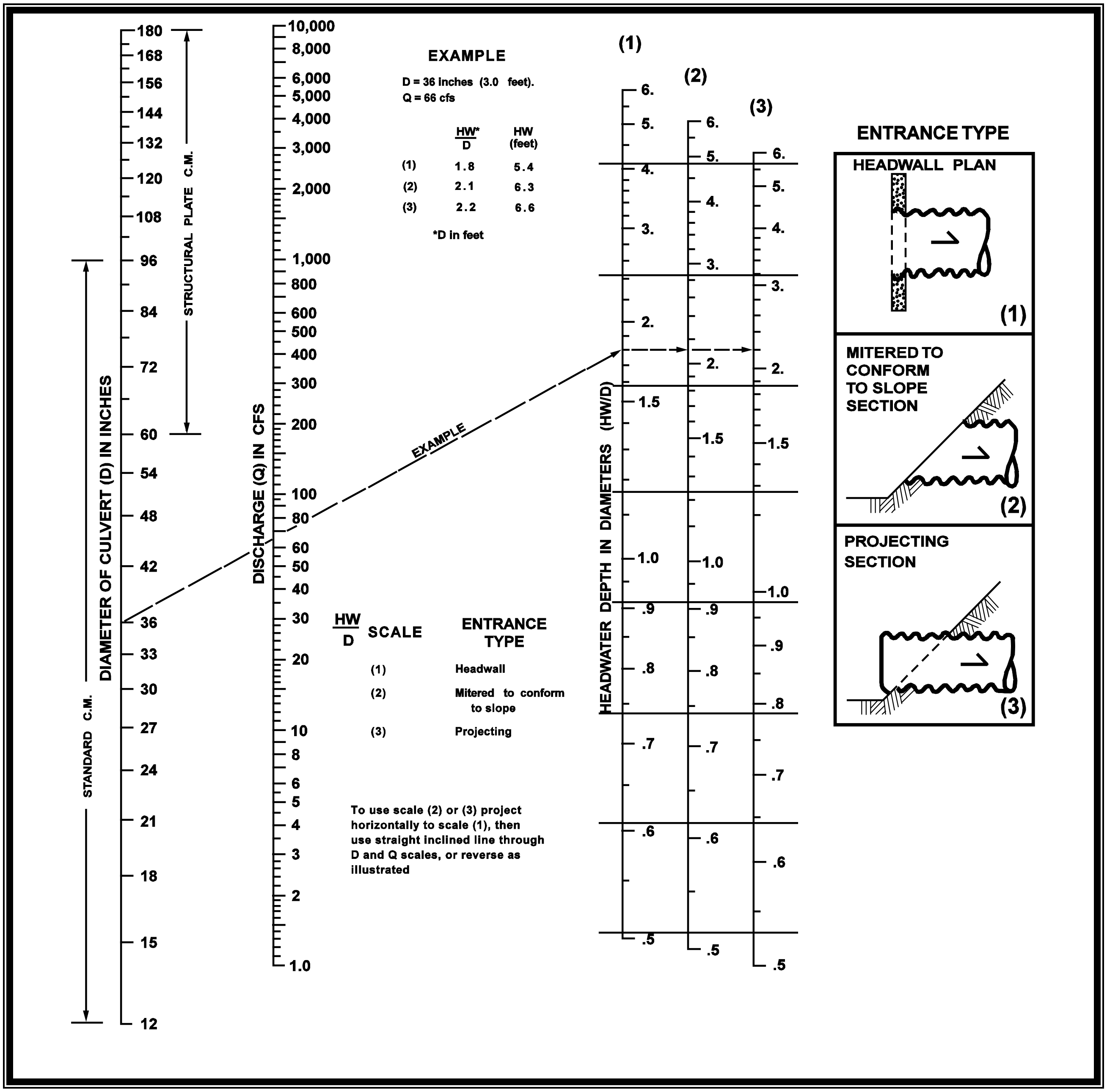


Figure C.2. Headwater Depth for Corrugated Pipe Culverts with Inlet Control.

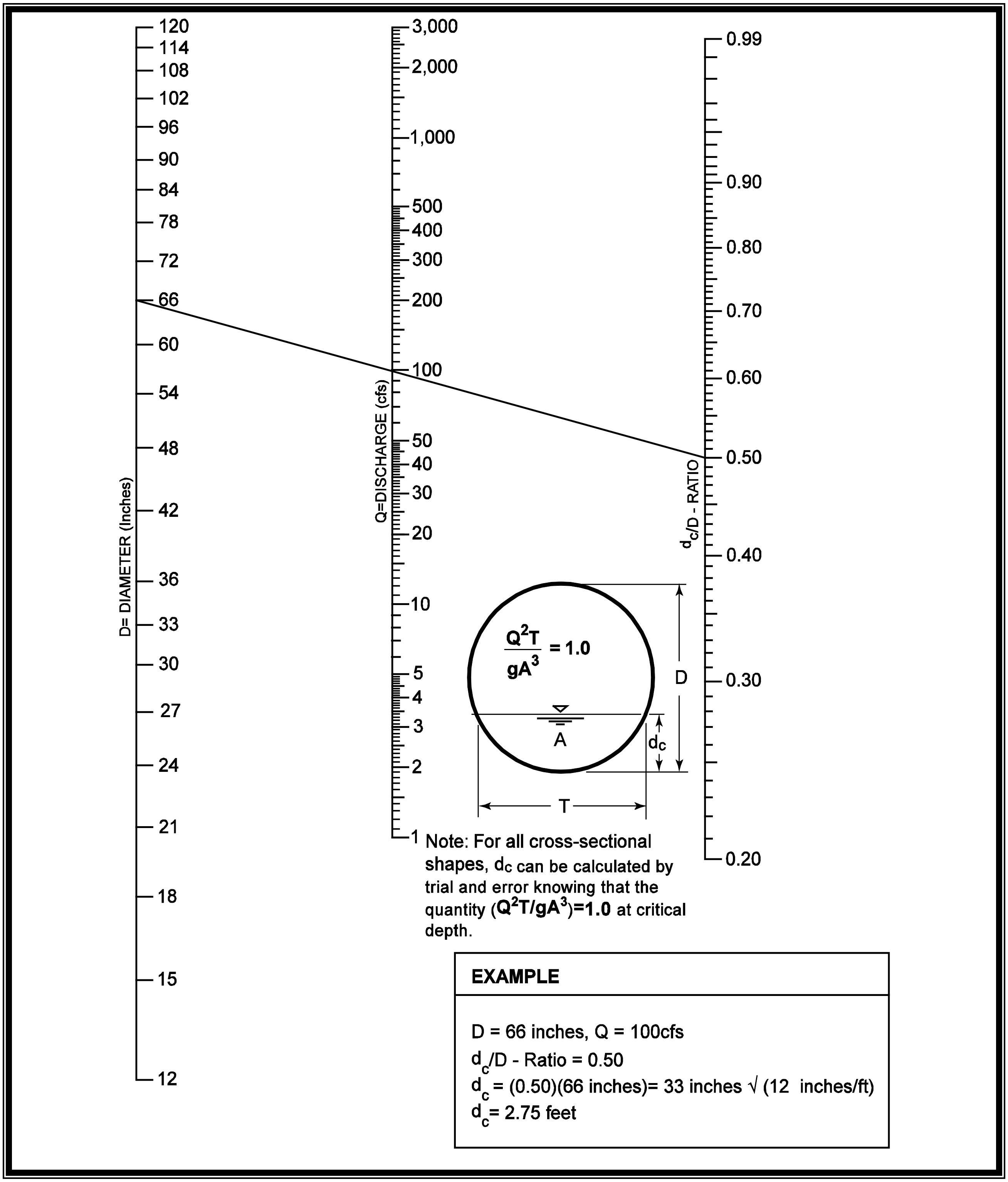


Figure C.3. Critical Depth of Flow for Circular Culverts.

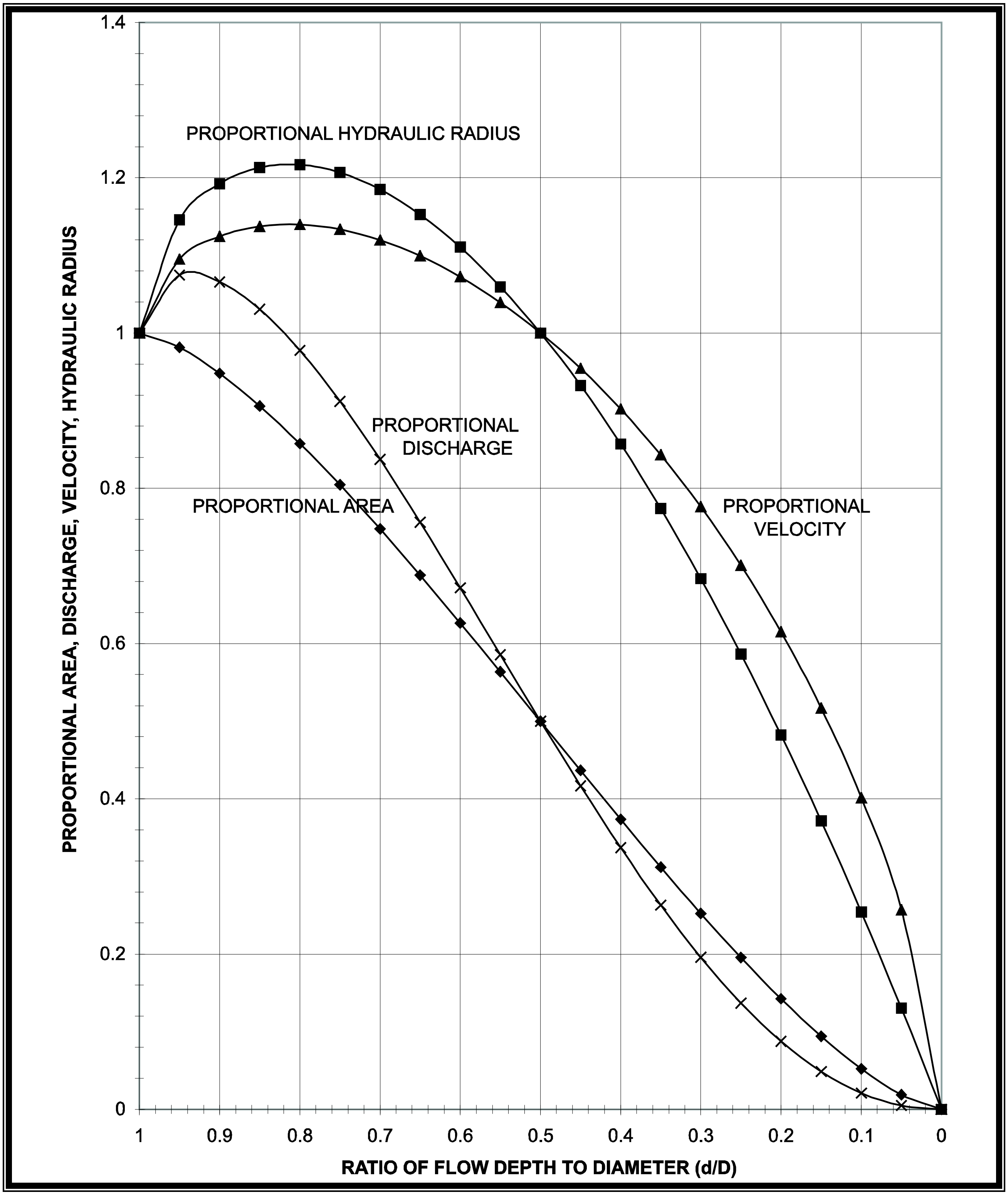


Figure C.4. Circular Channel Ratios.

Appendix III-D – On-site Stormwater Management BMP Infeasibility Criteria

The following tables present infeasibility criteria that can be used to justify not using various on-site stormwater management BMPs for consideration in the List #1 or List #2 option of Core Requirement #5. This information is also included under the detailed descriptions of each BMP, but is provided here in this appendix for additional clarity and efficiency. Where any inconsistencies or lack of clarity exists, the requirements in the main text of each volume shall be applied. If a project is limited by one or more of the infeasibility criteria specified below, but still wishes to use the given BMP, they may propose a functionally equivalent design to the county for review and approval.

Lawn and Landscaped Areas	
BMP	**Infeasibility Criteria**
Soil Preservation and Amendment	• Structural and Engineered soils on slopes, cuts or fill areas where a geotechnical engineer has recommended alternative soil restoration methods. • Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved.
Roofs	
BMP	**Infeasibility Criteria**
Full Dispersion	• Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved. • A 65 to 10 ratio of forested or native vegetation area to impervious area cannot be achieved. • A minimum forested or native vegetation flowpath length of 100 feet (25 feet for sheet flow from a non-native pervious surface) cannot be achieved.

Bioretention or Rain Gardens	• Note: criteria with setback distances are as measured from the bottom edge of the bioretention soil mix.
	• Site setbacks provided in Volume V, Appendix E cannot be achieved.
	• 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 downgradient flooding.
	    • Within 50 feet from the top of slopes that are greater than 20% and over 10 feet of vertical relief.

<table>
<tr><td></td><td>

- In accordance with TCC 24 limitations may exist and reports may be required when bioretention area is within a Landslide Hazard Area or a Marine Bluff 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 stormwater drainage system or private storm sewer system.
- Where there is a lack of usable space for bioretention areas 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 or building foundations.
- Where infiltrating water would threaten shoreline structures such as bulkheads.

The following criteria can be cited as reasons for infeasibility without further justification (though some require professional services to make the observation):

- Where they are not compatible with surrounding drainage system as determined by the county (e.g., project drains to an existing stormwater collection system whose elevation or location precludes connection to a properly functioning bioretention area).

</td></tr>
<tr><td>Bioretention or Rain Gardens (continued)</td><td>

- Where land for bioretention is within a Geologic Hazard Area or associated buffer (as defined by TCC Title 17 or Title 24.
- Within setbacks provided in Section 3.4.6.
- Where the site cannot be reasonably designed to locate bioretention areas on slopes less than 8 percent.
- For properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)):
    - Within 100 feet of an area known to have deep soil contamination.
    - Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater.
    - Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area.

</td></tr>
</table>

	o 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 or a drinking water supply well. • Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and grey water reuse systems (per WAC 246-272A-0210). This requirement may be modified by the Thurston County Health Department 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. 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 percent or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.
Bioretention or Rain Gardens (continued)	• Where field testing indicates potential bioretention/rain garden sites have a measured (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.30 inches per hour. A small-scale or large-scale PIT in accordance with Appendix III-A shall be used to demonstrate infeasibility of bioretention areas. If the measured native soil infiltration rate is less than 0.30 in/hour, bioretention/rain garden BMPs are not required to be evaluated as an option in List #1 or List #2. In these slow draining soils, a bioretention area with an underdrain may be used to treat pollution-generating surfaces to help meet Core Requirement #6, Runoff Treatment. If the underdrain is elevated within a base course of gravel, it will also provide some modest flow reduction benefit that will help achieve Core Requirement #7. • Within 100 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is greater than 1,100 gallons.
Downspout Infiltration Systems	• Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved. • The lot(s) or site does not have outwash or loam soils. • There is not at least 12 inches or more of permeable soil from the proposed bottom (final grade) of the infiltration system to the

	seasonal high groundwater table. • Lot size of greater than 22,000 square feet where downspout dispersion is feasible. • Within 100-feet of a drinking water supply well.
Downspout Dispersion Systems	• Downspout Dispersion Systems Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved. • A vegetated flowpath at least 50 feet in length from the downspout to the downstream property line, structure, slope over 20 percent, stream, wetland, or other impervious surface is not feasible. • A vegetated flowpath of at least 25 feet in between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface is not feasible.
Perforated Stub- Out Connections	• Site setbacks and design criteria provided in Volume III, Section 3.9.5 cannot be achieved. • There is not at least 12 inches or more of permeable soil from the proposed bottom (final grade) of the perforated stub-out connection trench to the highest estimated groundwater table. • The only location available for the perforated stub-out connection is under impervious or heavily compacted soils. • For sites with septic systems, the only location available for the perforated portion of the pipe is located upgradient 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. • The connecting pipe discharges to a stormwater facility designed to meet Core Requirement #7.
Other Hard Surfaces	
BMP	**Infeasibility Criteria**
Full Dispersion	• See Full Dispersion under "roofs" section above.
Permeable Pavement	• Setbacks and site constraints provided in Volume V, Section 2.2.6 cannot be achieved. 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) o Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area. o 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 or drinking water supply well. • 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 percent 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 site cannot reasonably be designed to have a porous asphalt surface at less than 5 percent slope, or a pervious concrete surface at less than 10 percent slope, or a permeable interlocking concrete pavement surface (where appropriate) at less than12 percent slope. Grid systems upper slope limit can range from 6 to 12 percent; check with manufacturer and local supplier. • Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or downgradient flooding. • In accordance with PCC Title 18E limitations may exist and reports may be required when permeable pavement is within 300 feet of a landslide hazard area or within 200 feet of an erosion hazard area. • Where infiltrating and ponded water below the new permeable pavement area would compromise adjacent impervious pavements. • Where infiltrating water below a new permeable pavement area would threaten existing below grade basements or building foundations. • 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. • Excessively steep slopes where water within the aggregate base layer or at the subgrade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where

	surface runoff velocities may preclude adequate infiltration at the pavement surface. • Where permeable pavements cannot provide sufficient strength to support 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 subgrades. The following criteria can be cited as reasons for infeasibility without further justification (though some require professional services to make the observation): • Within setbacks provided that the length of sheet flow across the paved section is no more than twice the length of sheet flow across the porous pavement section.in Section 3.5.6. • For properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)): o Within 100 feet of an area known to have deep soil contamination. o Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater. o Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area o 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.
Permeable Pavement (continued)	• Where the subgrade soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the soil suitability criteria for providing treatment. See soil suitability criteria for treatment in Chapter 6 of Volume V. Note: In these instances, the county may approve installation of a six-inch sand filter layer meeting county specifications for treatment as a condition of construction. • Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5 percent are considered suitable for residential access roads. • Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5 percent are considered suitable for residential access roads.

	• Where appropriate field testing indicates soils have a measured (a.k.a., initial) subgrade soil saturated hydraulic conductivity less than 0.3 inches per hour. Only small-scale PIT or large-scale PIT methods in accordance with Appendix III-A shall be used to evaluate infeasibility of permeable pavement areas. (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.) • Where the road type is classified as arterial or collector rather than access. See RCW 35.78.010, RCW 36.86.070, and RCW 47.05.021. Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces associated with the collector or arterial. • Where replacing existing impervious surfaces unless the existing surface is a non-pollution generating surface over an outwash soil with a saturated hydraulic conductivity of four inches per hour or greater. • At sites defined as “high-use sites.” For more information on high-use sites, refer to the Glossary in Volume I; and Volume V, Section 2.1, Step 3. • In areas with “industrial activity” as defined in the Glossary (located in Volume I). • 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.
Bioretention or Rain Gardens	• See Bioretention or Rain Gardens under “roofs” section above.
Sheet Flow Dispersion	• Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved. • Positive drainage for sheet flow runoff cannot be achieved. • Area to be dispersed (e.g., driveway, patio) cannot be graded to have less than a 15 percent slope. • At least a 10-foot wide vegetation buffer for dispersion of the adjacent 20 feet of impervious surface cannot be achieved.
Concentrated Flow Dispersion	• Site setbacks and design criteria provided in Volume V, Appendix E cannot be achieved. • A minimum 3 foot length of rock pad and 50-foot flowpath for every 700 sf of drainage area followed with applicable setbacks cannot be achieved.

Thurston County
Drainage Design and Erosion Control Manual

Volume IV
Source Control

Prepared for
Thurston County Water Resources Division,
Department of Resource Stewardship

December 2016

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Tables

Figures

Chapter 1 - Introduction to Volume IV

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* provides guidance to businesses, homeowners and public agencies in Thurston County on how to prepare and implement a source control plan for best management practices (BMPs) to prevent pollutants from contaminating stormwater runoff and entering rivers, lakes, streams, and Puget Sound.

The source control plan is a standalone document that is included as an element of the Stormwater Maintenance Plan (if one is required). Any structural BMPs required for specific land uses should be shown on the Drainage and Erosion Control Plan drawings and discussed in the Drainage and Erosion Control Report for the project.

The implementation of source control BMPs is required by several programs, which are listed in Section 1.2 below. Every person and business in Thurston County is required to use BMPs as part of their stormwater planning. You need to select BMPs from this volume to prevent stormwater pollution. Refer to Section 1.5 below for introductory information on BMPs. Information on stormwater treatment BMPs can be found in Volume I, Chapter 4 and Volume V.

1.2 How Do I Know What Applies to My Project?

The source control BMPs included in this Volume apply to all businesses, residences and public agencies in Thurston County that discharge stormwater under the provisions of the federal Clean Water Act (CWA) and Coastal Zone Management Act, the County's National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit, and the Puget Sound Partnership Action Agenda.

The requirements of this Volume apply to all permanent and temporary activities at public facilities, commercial and industrial facilities, agriculture and livestock farms, and residential dwellings. Anyone involved in a particular activity, whether they do so as an employee, supervisor, manager, landlord, tenant, or homeowner, must take part in implementing appropriate BMPs. BMPs need to be selected from this volume. Thurston County complies with the Endangered Species Act and all other relevant federal regulations in this effort.

Operators under Ecology's Industrial Stormwater General Permit, Boatyard General Permit, or Sand and Gravel General Permit should use Volume IV of the *Stormwater Management Manual for Western Washington* to identify applicable (mandatory) and recommended operational and structural source control BMPs. All three permits require permittees to develop and implement Stormwater Pollution Prevention Plans (SWPPPs). Industrial SWPPPs and Boatyard SWPPPs must include Operational Source Control BMPs and Structural Source Control BMPs listed as "applicable" in the volume referenced above.

1.3 When in the Design Process Should I Consult this Volume?

Source control, or preventative measures, is more effective than treating runoff once it has been polluted. It is recommended that you read all relevant sections of this Volume if a potential pollution problem is identified or prior to designing any stormwater treatment facilities. For non-residential projects completing the full design process, the "Worksheet for Commercial and Industrial Activities" in Chapter 3 shall be submitted with the **Drainage Scoping Report**. Updated submittals and appropriate supplemental materials will be included in the **Preliminary Drainage Report** and **Final Drainage Report**.

1.4 What Pollutants are Addressed in this Volume?

The NPDES permit mentioned above requires Thurston County to show progress in eliminating virtually all non-stormwater discharges to the stormwater drainage system. In other words, **nothing but uncontaminated stormwater may be discharged** to any stormwater drainage system. There are severe state and federal penalties for anyone violating the terms of these permits. See Thurston County Code Chapter 15.05, *Thurston County Stormwater Standards* and Thurston County Code Chapter 15.07, *Illicit Discharge Detection and Elimination*,, for more information.

The pollutant descriptions provided below are brief. You can obtain more information on a particular pollutant by calling one of the information numbers listed in Chapter 8.

1.4.1 pH

pH value is a relative measure of whether a substance is acidic or basic. The pH value of a body of water is vitally important, since most aquatic life can only live within a relatively narrow band of pH values (6 to 8). Some sources that can contribute to a change in pH of stormwater and water bodies are cement in concrete pouring, paving, and recycling operations; solutions from metal plating; chemicals from printing businesses and other industrial processes; and household cleaners such as bleaches and deck washes.

1.4.2 Total Suspended Solids (TSS)

This represents particulate solids such as eroded soil, heavy metal precipitates, and biological solids, which can cause turbidity in receiving waters and sedimentation in streams and lakes. TSS is the most common pollutant present in stormwater runoff. These sediments can destroy the desired habitat for fish and can impact drinking water supplies. The sediment may be carried to rivers, streams, lakes, or the Puget Sound where they may be toxic to aquatic life and make dredging necessary.

1.4.3 Oils and Greases

Oils and greases are petroleum-based or food-related. Petroleum-based compounds can be immediately toxic to fish and wildlife and, if they reach drinking water aquifers, make humans sick too. Food-based oils and greases may not be toxic to us, but can coat fish gills and insects, suffocating them as well as using up oxygen in the water.

1.4.4 Oxygen-Demanding Substances

Degradable organic matter, such as yard, food, and pet wastes, and some chemical wastes, can have a drastic effect on water quality if they are allowed to enter stormwater. As these substances are broken down by bacteria, the oxygen in the water is consumed in the process. This stresses and can eventually kill fish and other creatures in the water. Chemical oxygen demand (COD) and biological oxygen demand (BOD) are two parameters that indicate the amount of oxygen that is used up by various pollutants.

1.4.5 Metals

Metals are utilized in many products important to our daily lives. Certain metals, such as cadmium, copper, lead, and zinc, are known as heavy metals. They wear off of our car brakes, engines, and tires. They come from our paint and moss-killing roof strips. They are found in herbicides we use at our homes. These metals can cause severe health and reproductive problems in fish and animals that live in water and sediments that become contaminated by runoff.

1.4.6 Bacteria and Viruses

Bacteria and viruses from pet wastes, failing septic systems and agricultural areas can contaminate drinking water and close down swimming and shellfish areas. A group of bacteria called **fecal coliform bacteria** are typically used as the indicators for pollution by more serious disease-causing microorganisms called pathogens. The Washington State Department of Ecology (Ecology) has made changes to the State Water Quality Standards that include the use of new bacterial indicators: *E. coli* for fresh water and enterococci for marine water will replace fecal coliform bacteria, except that fecal coliform will still be used for marine waters that contain shellfish beds.

1.4.7 Nutrients

In the context of water quality, nutrients are mainly compounds of nitrogen and phosphorus. When nutrients are allowed to enter water bodies, certain plant species, such as algae, may grow too abundant. As the algae multiplies, it can clog shorelines, streams, pipe intakes, and drainage channels. As it decays, the decomposition process depletes the oxygen and fish and animal death can occur. Sources of nutrients can include fertilizers, failing septic systems, and yard and animal wastes.

1.4.8 Toxic Organic Compounds

A number of organic chemicals are toxic when they get into the aquatic environment. Many pesticides, herbicides, rodenticides, and fungicides are deadly to aquatic life. The same is true of compounds such as antifreeze, wood preservatives, cleansers, and a host of other, more exotic organics derived from industries or past practices (such as polychlorinated biphenyls [PCBs], DDT, and chlordane).

1.4.9 Other Chemicals and Substances

There are a host of other chemicals that can cause problems if allowed to enter the aquatic environment. Some of the most common chemicals and substances that pollute stormwater are oils, greases, soaps, and detergents. Common household bleach can be deadly to fish and other animals if drained directly to water bodies. Diatomaceous earth backwash from swimming pool filters can clog gills and suffocate fish. Arsenic used in rat and mole killing compounds is also toxic. Even those compounds classified as **biodegradable or environmentally friendly** can have devastating **immediate** effects on aquatic life, often by using up oxygen in the water as they degrade.

1.5 What are Best Management Practices?

Best Management Practices (BMPs) are a set of activities designed to reduce stormwater pollution. BMPs are separated into two broad categories: *source control* and *treatment*.

1.5.1 Source Control BMPs

Source control BMPs prevent contaminants from entering stormwater runoff by controlling them at the source. There are two categories of source control BMPs:

1. **Operational** source control BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. They include process changes such as raw material/product changes and recycling of wastes. Examples include:
    - Formation of a pollution prevention team
    - Good housekeeping practices
    - Preventive maintenance procedures
    - Spill prevention and clean up
    - Employee training
    - Inspections of pollutant sources
    - Record keeping
2. Structural source control BMPs are physical, structural or mechanical devices or facilities intended to prevent pollutants from entering stormwater. Examples of structural source control BMPs include:
    - Enclosing and/or covering the pollutant source, i.e., within a building or other enclosure, a roof over storage and working areas, a temporary tarpaulin, etc.
    - Physically segregating the pollutant source to prevent contact with uncontaminated stormwater that runs onto the site from surrounding areas.
    - Devices that separate contaminated runoff and send it to appropriate treatment instead of discharging into the main stormwater flow. For instance, polluted runoff could be discharged to a sanitary sewer if a permit is first obtained from the sewer service provider. Contact your local sewer service provider to determine what the requirements for industrial pre-treatment are for your location.

1.5.2 Treatment Best Management Practices

Treatment BMPs are used to treat stormwater that is already contaminated. Most treatment BMPs require planning, designing, permitting and construction, but cannot remove 100 percent of contaminants once they enter stormwater. The difficulty of treatment, combined with the typical expense of treatment BMPs, makes source control BMPs the preferred choice. There may be instances where treatment BMPs are required, however. This volume identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, storage and transfer of materials, etc. After identifying the required treatment BMPs, the reader can refer to Volume I, Chapter 4 and Volume V for additional information about treatment BMPs.

1.6 Explanation of Required BMPs

Every person/business in Thurston County is required to use BMPs. You need to select BMPs from this volume. The BMPs outlined in Chapters 3 and 4 include required and/or suggested BMPs. Any required BMPs are presented first for each section, and are identified by headings. Please note that in some instances there are required BMPs that are mandated by various federal, state, or county laws. Any additional suggested BMPs are also presented for each BMP. You are encouraged to utilize suggested BMPs to further protect our water quality. For instance, if only one BMP is required, you may wish to couple it with another suggested BMP to prevent pollution from ever getting into stormwater in the first place.

Some businesses are or will be required to obtain a NPDES permit for stormwater discharges. These permits are issued and regulated by Ecology.

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 treatment BMPs listed in their permits. Operators under individual industrial stormwater permits may include additional BMPs from this manual, if desired.
- All sites covered under the Boatyard Stormwater General Permit must include and implement the applicable (mandatory) BMPs in their Boatyard SWPPP.
- 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.

The BMPs outlined in this volume are focused on source control, that is, using methods to prevent pollution from ever getting into stormwater in the first place. Many of these BMPs are common sense and housekeeping issues. For instance, you can sweep an indoor or outdoor work area instead of hosing it into a storm drain or other drainage conveyance. The use of source control BMPs is always the first line of defense in stormwater pollution prevention efforts for several reasons:

- In the majority of cases, source control BMPs are all that is needed to correct stormwater pollution problems.
- Most source control BMPs are relatively inexpensive and easy to implement.
- Treatment BMPs are utilized after pollution has entered stormwater. These BMPs are expensive, and can never remove 100 percent of the pollution in stormwater. It is far better to use source control BMPs where possible and prevent the pollution in the first place. This volume identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, storage and transfer of materials, etc. Additional information about treatment BMPs are found in Volume V of this manual.

(NOTE: At times, the type of pollutants present or the condition of a site could mean treatment BMPs are required.)

The core requirements for stormwater source control are contained in Volume I, Section 2.4.4 Core Requirement #3: Source Control of Pollution. In accordance with this core requirement, all known, available and reasonable source control BMPs shall be applied to all projects. Chapter 5 of this volume contains details on many source control BMPs, with references to appropriate documents for others.

Stormwater treatment may also be required for certain types of businesses, based on the information provided in this volume and in Volume I, Section 2.4.7 Core Requirement #6: Runoff Treatment and in Volume V. Volume V contains detailed information about stormwater treatment BMPs.

1.7 What if I am Already Implementing Best Management Practices?

Businesses already implementing BMPs in accordance with other federal, state, or county programs usually do not have to implement additional BMPs. Persons or businesses qualifying for exemptions include businesses required to obtain a general or individual NPDES permit for stormwater discharges (who must comply with the requirements of that permit). See regulatory requirement R.2 in Chapter 7 of this volume for details.

If you have a stormwater permit, the County assumes you are implementing the appropriate BMPs. If the County finds that you have not implemented your BMPs, or that the BMPs that you have implemented are not effectively addressing the discharge of contaminants, then you will be required to implement additional BMPs, potentially including more expensive treatment BMPs, to meet requirements. **Everyone** must implement BMPs, but how each business accomplishes this may differ.

1.8 How Do I Get Started?

If you are a landlord, tenant, or owner of a single-family residence, proceed to Chapter 2 for General Principles that everyone should implement, and Chapter 5 for BMPs that are recommended for you.

If you own a business or industry, review the General Principles in Chapter 2, and complete the worksheet in Chapter 3. If you checked off any of the activities that are being performed outdoors, use the activity code on the worksheet to find the BMPs recommended for you in Chapter 4.

Thurston County has prepared commercial and residential source control plan templates to assist you in preparing your Source Control Plan, these are available on the Thurston County stormwater website. If you have questions, please contact Thurston County Department of Resource Stewardship, Water Resources Division (360) 754-4681. They can provide assistance over the phone and at your business site.

1.9 Related Stormwater Requirements

Under current state and county law, if you own commercial property and lease or rent it, you can be held responsible for water quality problems caused by your tenants. Make sure your tenants are informed of their responsibilities under the auspices of this manual and Thurston County Code.

You need an accidental spill plan if your business has the potential for a spill. If you are currently under a pretreatment permit for discharge to sewers, you can amend it to include stormwater. Please contact Thurston County Department of Resource Stewardship, Water Resources Division at (360) 754-4681 for information on developing these plans.

You are responsible for obtaining prior approval for your stormwater discharge to the county system. This means obtaining proper building and environmental permits from the county and state. Please contact the Thurston County Development Services (360) 786-5490 or go to http://www.co.thurston.wa.us/ for more information. For Ecology permits, call (360) 407-6400.

Chapter 2 - Principles of Pollution Prevention

This chapter describes simple pollution prevention principles that every business and homeowner should consider. Most of these are common sense, housekeeping types of solutions. With collective action by individuals and businesses throughout the county in implementing each of these principles, the improvement in water quality can be substantial. Although most of these principles are aimed at commercial or industrial activities, many items apply to individual residents as well.

1. **Avoid the activity or reduce its occurrence**

   Avoid a potentially polluting activity or do it less frequently, especially if it takes place outdoors. Do a larger run of a process and reduce the number of times it needs to be repeated. Avoid one solvent-washing step altogether or have raw materials delivered closer to the time of use to avoid stockpiling and exposure to the weather. Apply lawn care chemicals following directions and only as needed. Many lawns are excessively fertilized. Do not apply herbicides right before it rains. Ecology or the Thurston County Department of Public Health and Social Services can provide pollution prevention assistance.

2. **Move the activity indoors**

   Move a potentially polluting activity indoors out of the weather. This prevents runoff contamination and you provide more control for a cleanup if a spill occurs. For example, unload and store chemicals inside a garage area instead of outside. Be aware that moving storage areas indoors may require installation of fire suppression equipment or other building modifications as required by the International Building Code (IBC), applicable fire codes, or local ordinances.

3. **Cleanup spills quickly**

   Promptly contain and cleanup solid and liquid pollutant leaks and spills on any exposed soil, vegetation, or paved area. Commercial spill kits are available, but readily available absorbent such as kitty litter also work well in many cases. Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. which can contaminate stormwater.

4. **Use less material**

   Don't buy or use more material than you really need. This not only helps keep potential disposal, storage, and pollution problems to a minimum, but will probably save you money, too.

5. **Use the least** toxic materials available

   Investigate the use of materials that are less toxic. For example, replace a caustic-type detergent or a solvent with a more environmentally friendly product. This might allow you to discharge process water to the sanitary sewer instead of paying for expensive disposal. Even if you do switch to a biodegradable product, only uncontaminated water is allowed to enter the stormwater drainage system.

6. Create and maintain vegetated areas near activity locations

Vegetation can filter pollutants out of stormwater. Route stormwater through vegetated areas located near your activity. Many low impact development (LID) stormwater BMPs can be used to manage stormwater from small source areas, like bioretention areas designed at depressions in parking lots. These BMPs are described in Volume V.

Wastewater other than stormwater runoff, such as wash water, must be discharged to a wastewater collection system, and may not be discharged to a storm drainage system.

High-use sites may require conveyance of runoff to an oil removal treatment system. For more information on high-use sites, refer to Volume I, Section 4.2.7.1, Step 7a.

7. Locate activities as far as possible from surface drainage paths

Activities located as far as possible from known drainage paths, ditches, streams, other water bodies, and drains will be less likely to pollute, since it will take longer for material to reach the drainage feature. This gives more time to react to a spill, or if it is a housekeeping issue, may protect the local waters long enough for you to clean up the area around the activity. Don't forget that groundwater protection is important throughout Thurston County, no matter where the activity is located, so the actions taken on your site on a day-to-day basis are always important, even in dry weather.

8. Maintain stormwater drainage systems

Pollutants can concentrate over time in storm drainage facilities such as catch basins, vaults, ditches, and storm drains. When a large storm event occurs, turbulent runoff can mobilize these pollutants and carry them to receiving waters. Develop and implement maintenance practices, inspections, and schedules for treatment devices (e.g., detention ponds, oil/water separators, vegetated swales, etc.). Requirements for cleaning stormwater facilities are discussed in Chapter 5, specifically BMP S.9.

Repair or replace cracked or otherwise damaged pavement in areas used for secondary spill containment, high-intensity parking, and any other drainage areas that are subjected to pollutant material leaks or spills.

Maintenance standards can be found in Volume V, Appendix V-C.

9. Reduce, reuse, and recycle as much as possible

Look for ways to recycle instead of just disposing. This saves money and keeps hazardous and non-hazardous materials out of landfills. You can learn more about other businesses that have made process changes allowing recycling of chemicals by calling Ecology at 1-800-RECYCLE and requesting publication No. 92-45 and No. 90-22.

Another unique recycling opportunity for businesses is available through the Industrial Materials Exchange, which covers the entire Pacific Northwest. This free service acts as a waste or surplus "matchmaker", turning one company's waste into another company's asset. For instance, waste vegetable oil can become biofuel for another business. Go to the Industrial Materials Exchange web site to list your potentially usable solid or chemical waste in their publication: <http://www.govlink.org/hazwaste/business/imex/submit.cfm>

10. Be an advocate for stormwater pollution prevention

Help friends, neighbors, and business associates find ways to reduce stormwater pollution in their activities. Most people want clean water and do not pollute intentionally. Share your ideas and the BMPs in this volume to get them thinking about how their everyday activities affect water quality.

11. Report problems

We all must do our part to protect water, fish, wildlife, and our own health by implementing proper BMPs, and reporting water quality problems that we observe. In Thurston County, call (360) 754-4681 to report incidents involving storm drains or ditches. Report spills or illicit discharges by calling 360-867-2099 or via the Thurston County web site at http://www.co.thurston.wa.us/stormwater/dumping/dumping-home.html. Also contact Ecology's Southwest Regional office at (360) 407-6300 to report spills.

12. Provide oversight and training

Assign one or more individuals at your place of business to be responsible for stormwater pollution control. Hold regular meetings to review the overall operation of BMPs. Establish responsibilities for inspections, operation and maintenance (O&M), documentation, and availability for emergency situations. Train all team members in the operation, maintenance, and inspection of BMPs and reporting procedures.

13. Dust control

Sweep paved material handling and storage areas regularly as needed, to collect and dispose of dust and debris that could contaminate stormwater. Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, or receiving water unless necessary for dust control purposes to meet air quality regulations and unless the pollutants are conveyed to a treatment system approved by the County.

14. Eliminate illicit connections

An illicit connection is formally defined in Thurston County Code Chapter15.07, but generally includes any connection to the county stormwater system that is not intended, permitted, or used for collecting and conveying stormwater. A common problem with the stormwater drainage system for most communities is the existence of illicit connections of wastewater to the storm drainage system. Many businesses and residences have internal building drains, sump overflows, process wastewater discharges, and even sanitary sewer and septic system pipes that were connected to the nearby storm drainage system in the past as a matter of course.

All businesses and residences in Thurston County must examine their plumbing systems to determine if illicit connections exist. Any time it is found that toilets, sinks, appliances, showers and bathtubs, floor drains, industrial process waters, and/or other indoor activities are connected to the stormwater drainage system, these connections must be immediately rerouted to the sanitary or septic system, holding tanks, or process treatment system. Methods to eliminate illicit connections are described in detail in Chapter 5, BMP S.1.

15. Dispose of waste properly

Every business and residence in Thurston County must dispose of solid and liquid wastes and contaminated stormwater properly. There are generally four options for disposal depending on the type of materials. These options include:

- Sanitary sewer and septic systems
- Recycling facilities
- Municipal solid waste disposal facilities
- Hazardous waste treatment, storage, and disposal facilities.

Additional information on disposal is described in Chapter 5, BMP S.2.

Chapter 3 - Commercial and Industrial Activities Worksheet

This worksheet and the associated BMPs are organized by business activity. The goal of BMPs is to ensure that **only uncontaminated stormwater is discharged** into any stormwater drainage system.

Complete the entire worksheet by checking the appropriate boxes for all activities that occur at your work place. If you checked off any of the activities **that are being performed outdoors or can drain to the stormwater drainage system**, use the activity code on the worksheet to find the BMPs recommended for you in Chapter 4. If you perform an activity indoors and control all discharges from the activity (e.g., process water, washwater, lubricants, solvents, fugitive dust, granular material, blow down waste) so that no stormwater exposure occurs, you do not have to institute BMPs for that activity.

If you have checked activities as occurring indoors, the County may require you to demonstrate how your facility qualifies as 'indoors' or not exposed to the elements. No indoor drains or process water discharges can connect to the storm drainage system without a permit. You must ensure that liquids, powders, dusts, and fine granular materials stay confined indoors; otherwise, you will be subject to all of the BMP requirements. For discharges to the sanitary sewer, permits must be obtained from your sewer service provider.

If you checked off any of these activities as occurring outdoors at your business, use the activity code to find the appropriate BMPs described in Chapter 4.

If you have questions, please contact Thurston County Department of Resource Stewardship, Water Resources Division at (360) 754-4681. They can provide assistance over the phone and also at your business site.

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	Outdoor
A1.1	Cleaning or Washing of Tools, Engines, and Manufacturing Equipment • Includes parts washers and all types of manufactured equipment components.		
A1.2	Cleaning or Washing of Cooking Equipment • Includes vents, filters, pots and pans, grills, and related items.		
A1.3	Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures • Includes cleaning and washing at all types of establishments, including fleet vehicle yards, car dealerships, car washes, and maintenance facilities.		
A1.4	Collection and Disposal of Wastewater from Mobile Interior Washing Operations • Includes carpet cleaners, upholstery cleaners, and drapery cleaners.		
A2.1	Loading and Unloading Areas for Liquid or Solid Material • Includes raw materials, intermediate products, finished products, waste, or fuel.		
A2.2	Fueling at Dedicated Stations • Includes gas stations, pumps at fleet vehicle yards or shops, and other privately owned pumps.		
A2.3	Engine Repair and Maintenance • This covers oil changes and other engine fluids.		
A2.4	Mobile Fueling of Vehicles and Heavy Equipment • Includes fleet fueling, wet fueling, and wet hosing.		
A3.1	Concrete and Asphalt Mixing and Production at Stationary Sites • Applies to mixing of raw materials on site to produce concrete or asphalt.		
A3.2	Concrete Pouring, Concrete Cutting, and Asphalt Application at Temporary Sites • Includes construction sites, and driveway and parking lot resurfacing.		
A3.3	Manufacturing and Postprocessing of Metal Products • Includes machining, grinding, soldering, cutting, welding, quenching, rinsing, etc.		
A3.4	Wood Treatment Areas • Includes wood treatment using pressure processes or by dipping or spraying.		
A3.5	Commercial Composting • Includes commercial composting facilities operating outside.		
A3.6	Landscaping and Vegetation Management Activities, Including Vegetation Removal, Herbicide and Insecticide Application, Fertilizer Application, Irrigation, Watering, Gardening, and Lawn Care • Includes businesses involved in landscaping, applying pesticides and managing vegetation.		

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	Outdoor
A3.7	Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment • Includes surface preparation and the applications of paints, finishes, and/or coatings.		
A3.8	Commercial Printing Operations • Includes materials used in the printing process.		
A3.9	Manufacturing Activities – Outside • Includes outdoor manufacturing areas.		
A3.10	Agricultural Crop Production • Includes commercial scale farming.		
A3.11	Application of Pesticides, Herbicides, Fungicides and Rodenticides for purposes other than landscaping • Includes moss removal and outdoor insect extermination.		
A4.1	Storage or Transfer (Outside) of Solid Raw Materials, By-products, or Finished Products		
A4.2	Storage and Treatment of Contaminated Soils • This applies to contaminated soils that are excavated and left on site.		
A4.3	Temporary Storage or Processing of Fruits or Vegetables • Includes processing activities at wineries, fresh and frozen juice makers, and other food and beverage processing operations.		
A4.4	Storage of Solid Wastes and Food Wastes • Includes regular garbage and all other discarded non-liquid items.		
A4.5	Recyclers and Scrap Yards • Includes scrapped equipment, vehicles, empty metal drums, and assorted recyclables.		
A4.6	Treatment, Storage, or Disposal of Dangerous Wastes • Refer to Ecology and the Thurston County Health Department for more information, see Chapter 7.		
A4.7	Storage of Liquid, Food Waste, or Dangerous Waste Containers • Includes containers located outside a building and used for temporary storage.		
A4.8	Storage of Liquids in Permanent Aboveground Tanks • Includes all liquids in aboveground tanks.		
A4.9	Parking and Storage for Vehicles and Equipment • Includes public and commercial parking lots		
A4.10	Storage of Pesticides, Fertilizers, or other products that can leach pollutants		
A5.1	Demolition of Buildings • Applies to removal of existing buildings and subsequent clearing of the rubble.		
A5.2	Building Repair, Remodeling, and Construction • Applies to construction of buildings, general exterior building repair work and remodeling of buildings.		

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	**Outdoor**
A6.1	Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots		
A6.2	Dust Control at Manufacturing Sites • Includes grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash.		
A6.3	Soil Erosion and Sediment Control (ESC) at Industrial Sites • Includes industrial activities that take place on soil.		
A7.1	Commercial Animal Handling Areas • Includes kennels, fenced pens, veterinarians, and businesses that board animals.		
A7.2	Keeping Livestock in Stables, Pens, Pastures or Fields • Applies to all types of livestock.		
A7.3	Log Sorting and Handling • Applies to log yards typically located at sawmills, ports, and pulp mills.		
A7.4	Boat Building, Mooring, Maintenance, and Repair • Includes all types of maintenance, repair, and building operations.		
A7.5	Logging • Applies to logging activities that fall under Class IV general forest practices.		
A7.6	Mining and Quarrying of Sand, Gravel, Rock, Minerals, Peat, Clay, and Other Materials • This does not include excavation at construction sites.		
A7.7	Swimming Pool and Spa Cleaning and Maintenance • Includes every swimming pool and spa not at a single family residence. Commercial pool cleaners are included here for all pools.		
A7.8	De-icing and Anti-icing Operations for Airports and Streets • Includes aircraft, runways/taxiways, streets and highways.		
A7.9	Roof and Building Drains at Manufacturing and Commercial Buildings • These sites will be referred to ORCAA.		
A7.10	Urban Streets • BMPs for addressing pollutants found on paved surfaces, including street sweeping.		
A7.11	Railroad Yards		
A7.12	Maintenance of Public and Private Utility Corridors and Facilities • Includes public and private utility maintenance activities.		
A7.13	Maintenance of Roadside Ditches		
A7.14	Maintenance of Stormwater Drainage and Treatment Facilities		
A7.15	Spills of Oil and Hazardous Substances		

Chapter 4 - Best Management Practices for Commercial and Industrial Activities

This chapter coordinates with the worksheet in Chapter 3. That worksheet and the BMPs are organized by the different activities that businesses perform. If you perform the listed activity indoors, controlling all discharges from the activity (e.g., process water, washwater, lubricants, solvents, fugitive dust, granular material, blow down waste, etc.) such that no exposure to stormwater occurs, then you do not have to institute new BMPs for that activity. However, if you checked the column for activities performed outdoors, match the number from the worksheet to the activities listed in this chapter to find the suggested BMPs you should implement.

If you have questions, please contact Thurston County Department of Resource Stewardship, Water Resources Division at (360) 754-4681. They can provide assistance over the phone and also at your business site.

4.1 Explanation of Required BMPs

Every business in Thurston County is required to use the BMPs described in this manual to control stormwater pollution. In some instances, there are BMPs mandated by various federal, state, or county laws. If you are subject to those laws and regulations via another permit or formal regulatory approval, you are encouraged, but not required to use additional BMPs to further protect our water quality. Developers are responsible for ensuring that discharges from their BMPs meet water quality requirements.

Some businesses are (or will be) required to obtain a NPDES permit for stormwater discharges. These permits are issued and regulated by Ecology. Types of businesses (listed by Standard Industrial Classification code) that must obtain this type of permit are listed in Chapter 7. Businesses regulated under the NPDES stormwater program may be exempt from implementing some BMPs outlined in this volume, since they will be implementing BMPs required by the state. Refer to Volume I and Section A7 of this volume for more information about NPDES permits for industries.

The BMPs outlined in this volume are focused on source control: that is, methods to prevent pollution from reaching stormwater in the first place. The use of source control BMPs is always the first line of defense in stormwater pollution prevention efforts for several reasons:

- In many cases, source control BMPs are adequate to correct stormwater pollution problems.
- Most source control BMPs are relatively inexpensive and easy to implement.
- Treatment BMPs are used after pollution has entered stormwater. These BMPs are more expensive, and can never remove 100 percent of stormwater pollution. This source control volume identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, storage and transfer of materials, etc.

- NOTE: At times, the type of pollutants present or the condition of a site could mean treatment BMPs are required. Information about treatment BMPs are found in Volume V of this manual.

Core Requirements for stormwater source control are contained in Volume I, Section 2.4.4 Core Requirement #3: Source Control of Pollution. In accordance with this core requirement, all known, available and reasonable source control BMPs shall be applied to all projects. Chapter 5 of this volume contains details on types of source control BMPs, with references to appropriate documents for others.

Stormwater treatment may also be required for certain types of businesses, based on the information provided in this volume and in Volume I, Section 2.4.7 Core Requirement #6: Runoff Treatment and in Volume V, Runoff Treatment BMPs. Volume V contains detailed information about stormwater treatment BMPs.

Section A1

Cleaning or Washing Activities

A1.1 Cleaning or Washing of Tools, Engines, and Manufacturing Equipment

This activity applies to businesses and public agencies that clean manufacturing equipment such as saws, grinders, screens, and other processing devices outside of buildings, and businesses engaged in pressure washing of engines, equipment, and portable objects.

Description of Pollutant Sources: Pollutant sources include toxic hydrocarbons, organic compounds, oils and greases, nutrients, heavy metals, pH, suspended solids, and oxygen demanding substances (i.e., BOD and COD).

Pollutant Control Approach: The preferred approach is to cover and/or contain the cleaning activity, or conduct the activity inside a building. Washwater must be conveyed to a sanitary sewer after approval by your sewer service provider, temporarily stored before proper disposal, or recycled, with no discharge to the ground, a storm drain, or surface water. Washwater may be discharged to the ground after proper treatment in accordance with *Ecology guidance WQ-R-95-56, "Vehicle and Equipment Washwater Discharges,"* /*Best Management Practices Manual November 2012,* or most recent update. The quality of any discharge to the ground after proper treatment (gravity separation followed by media filtration) must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC. Contact the Ecology Southwest Regional Office for an NPDES permit application for discharge of washwater to surface water or to a storm drain after on-site treatment.

Required BMPs

The following BMPs (or equivalent measures) are required of all businesses and public agencies that clean or wash tools, engines, equipment, and portable objects:

- Illicit connections to the stormwater drainage system must be eliminated. See BMP S.1 in Chapter 5 for detailed information.
- Train employees to control washing operations to prevent stormwater contamination.
- All washwater must discharge to a holding tank, process treatment system, or sanitary sewer--never to the stormwater drainage system. See BMP S.3 in Chapter 5 for instructions.
- Pressure washing must be performed in a designated area (such as a wash pad) provided with a sump drain and stormwater run-on prevention (Figures 4.1 and 4.2). See BMPs S.6 and S.7 in Chapter 5 for information on sumps (or holding tanks) and run-on prevention. Contact your sewer service provider for pre-treatment requirements and for washing operation policy.

(Photo courtesy of Seattle Public Utilities)

Figure 4.1. Wash Pad for Tool and Equipment Washing.

Figure 4.2. Uncovered Washing Area for Tools, Engines, Equipment, and Portable Objects, with Drains to a Sanitary Sewer, Process Treatment, or a Dead-End Sump.

Suggested BMPs

The following BMPs are not required but can provide additional pollution control:

- If soaps or detergents are used, use the least toxic cleaner capable of doing the job. Use non-phosphate detergent, if possible, to reduce loadings at your local wastewater treatment plant.
- Limit the amount of water used in washing activities to reduce the potential of runoff carrying pollutants beyond the designated wash pad or capture system.
- Recycle washwater for subsequent washings.
- Implement one or more of the stormwater treatment BMPs found in Volume V.

NOTE: For discharging wash waters containing soaps and detergents, the use of infiltration, bioretention, biofiltration, wet ponds, and wetlands must not result in the violation of groundwater quality standards.

A1.2 Cleaning or Washing of Cooking Equipment

This activity applies to businesses that clean cooking equipment such as vent filters, grills, and grease traps outside of buildings.

Description of Pollutant Sources: Pollutants of concern consist of oil and grease, nutrients, suspended solids, and oxygen demanding substances (i.e., BOD and COD).

Pollutant Control Approach: Businesses engaged in this activity that cannot connect discharges to a sanitary sewer, holding tank, or process water treatment system must contact Ecology and obtain a NPDES wastewater permit.

Required BMPs
The following BMPs or equivalent measures are required of all businesses engaged in cleaning or washing of cooking equipment:

- Illicit connections to the stormwater drainage system must be eliminated. See BMP S.1 in Chapter 5 for detailed requirements.
- Employees must be educated about the need to prevent stormwater contamination from washing operations.
- Washwater cannot be discharged to the stormwater drainage system.
- Paved washing areas must be swept daily to collect loose solid materials for proper disposal.
- Greasy buildup on cooking equipment must be removed and properly disposed of prior to washing to reduce the amount of material that can potentially contaminate runoff.
- Move the activity indoors with drainage to a sanitary sewer, holding tank, or process treatment system (Figure 4.3). See BMP S.3 in Chapter 5 for further information on drainage alternatives. Any connection to the sanitary sewer requires the approval of the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your sewer service provider, if your site is not within the LOTT service area.

  OR

  Use a tub or similar device to contain washwater. This water must be recycled for subsequent washing, or disposed of in a holding tank or sanitary sewer.

  OR

  If the washing activity cannot be moved indoors or contained in a tub, then the washing area must drain to a sanitary sewer, holding tank, or process treatment system, and provisions must be made to prevent stormwater run-on onto the washing area. See BMP S.3 in Chapter 5 for detailed drainage requirements and BMP S.7 for run-on prevention schemes. If discharging to a sanitary sewer, permits must be obtained from the LOTT Alliance Industrial Pretreatment

Program at (360) 528-5708 or your local sewer service provider if your site is not within the LOTT service area.

(Photo courtesy of Seattle Public Utilities)

Figure 4.3. Cleaning and Washing Cooking Equipment Indoors.

- If a holding tank is used for storage of washwater, the contents must be pumped out before it is full and disposed of appropriately to a sanitary sewer or wastewater treatment system.

Suggested BMPs

The following BMPs are not required but can provide additional pollution protection:

- A cover should be placed over a designated wash area to keep rain from falling on dirty equipment and producing contaminated runoff.

A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures

Description of Pollutant Sources: Pollutant sources include the commercial cleaning of vehicles,, aircraft, vessels, carpets, 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.

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. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for advice and consultation on appropriate treatment and for approvals to discharge to sanitary sewer. Washwater must be conveyed to a sanitary sewer after approval by the LOTT Alliance Industrial Pretreatment Program, or temporarily stored before proper disposal or recycling, with no discharge to the ground, a storm drain, or surface water.

The Industrial Stormwater General Permit prohibits the discharge of process wastewater (e.g., vehicle washing wastewater) to groundwater 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 after proper treatment in accordance with *Ecology guidance WQ-R-95-56, Vehicle and Equipment Washwater Discharges/Best Management Practices Manual, November 2012, or most recent update*. . The quality of any discharge to the ground after proper treatment (gravity separation followed by media filtration) must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC. Contact the Ecology Southwest Regional Office to discuss permitting options for discharge of washwater to surface water or to a storm drain after on-site treatment.

Required BMPs

Conduct vehicle and 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 operation 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 vehicles and/or equipment being washed.

- Convey the washwater to a sump (like a grit separator) and then to a sanitary sewer (if allowed by the your sewer service provider), or other appropriate wastewater treatment or recycle 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.
- Any discharge to the sanitary sewer requires the approval of the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider. Contact the utility for details on approved systems.

Suggested BMPs

- Mark the wash area at gas stations, multifamily residences, and any other business where non-employees wash vehicles.
- All valves must be positive control valves (e.g. gate valve). A pneumatic or electric valve system is preferable, however, operators may use a manually operated positive control valve for uncovered wash pads. The valve may be opened upon completion of a wash cycle. After draining the sump or separator, the valve shall be closed..
- Use phosphate-free biodegradable detergents when practicable.
- Consider recycling the washwater.
- Operators may use soluble/emulsifiable detergents in the wash medium, but 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. Check with the local sanitary sewer provider or the manual referenced in Section A1.3 above.
- At 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 at an authorized location per Section A1.3.

Charity car washes are not allowed to discharge washwater to the County stormwater drainage system. For optional fund-raiser information, contact the Puget Sound Car Wash Association at (800) 509-9274. Online, visit: http://www.streamteam.info/actions/carwashing/.

- New and used car dealerships may wash vehicles in the parking stalls without soap, or if an approved treatment system for the washwater is in place.

At industrial sites, contact the Ecology Southwest Regional Office for NPDES permit requirements even if soaps, detergents, and/or other chemical cleaners are not used in washing trucks.

A1.4 Collection and Disposal of Wastewater in Mobile Interior Washing Operations

This activity applies to businesses that wash carpets and other interior items on a mobile site-to-site basis. The typical fleet washing process includes use of machines that spray the washwater solution onto the carpet or upholstery and then vacuums the dirty solution up into a portable tank with limited capacity.

Description of Pollutant Sources: Pollutants of concern are nutrients, suspended solids, organic compounds (such as pesticides and chemicals used for flea and odor control), and oxygen demanding substances (i.e., BOD and COD).

Pollutant Control Approach: Previously, common practice was to discharge the dirty solution to the ground or to a drain connected to the stormwater drainage system between site visits. **These practices are now illegal.** This point must be made clear to all employees. Wastewater from mobile washing operations may be permitted for sanitary sewer disposal if it does not contain high concentrations of toxic materials.

Required BMPs
The following BMPs are required of all businesses doing mobile interior wash activities:

- Wastewater from mobile washing operations must be poured into a sanitary sewer drain at the site of collection, the business office, or at another proper location. If discharging to a sanitary sewer, permits must be obtained from the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.
- Absolutely no wastewater from mobile interior wash activities can be disposed of outdoors, or to a drain connected to the stormwater drainage system.
- Some chemicals used for flea and odor control are listed by U.S. Environmental Protection Agency (U.S. EPA) as toxics. The LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider will need to know the type of chemicals and amount of water you intend to discharge. If the discharge is approved, they will then issue a permit for your activity.
- If sanitary sewer disposal is not available or not allowed, the collected wastewater must be returned to the business site for process treatment or transfer to a holding tank. See BMP S.3 in Chapter 5 for details on these drainage/disposal alternatives.

Suggested BMPs
The following BMPs are not required, but can provide additional pollution protection:

- Use the least toxic detergents and cleaners that will get the job done. Select non-phosphate detergents when possible.
- Limit the amount of water used in interior washing operations. This will save you time, money, and effort when it comes to proper disposal.
- Recycle washwater for more than one use.

Section A2

Transfer of Liquid or Solid Materials

A2.1 Loading and Unloading Areas for Liquid or Solid Material

Description of Pollutant Sources: Loading and unloading of liquid and solid materials at industrial and commercial facilities is typically conducted at shipping and receiving, outside storage, and fueling areas. Transferred materials can include raw materials, waste materials, fuels, and scrap metals. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, alkalis, and other chemicals during transfer are potential causes of 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.

Required 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 that are covered by containers, logs, or other material after the areas are cleared.

- Place drip pans, storm drain covers or other temporary containment devices at locations where leaks or spills may occur such as hose connections, hose reels, and filler nozzles. Always use pans when making and breaking connections (Figure 4.4). Check loading/unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.

    - Consistent with applicable fire code requirements and to the extent practicable, conduct unloading or loading of solids and liquids in a manufacturing building or under a roof, 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, or slope the edge such that the stormwater can flow to an internal stormwater drainage system that leads to an approved treatment BMP. Do not allow stormwater to drain 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 loading/unloading area or place them in designated "alleyways" to avoid being covered by material, containers, or equipment.

    - Retain the necessary materials for rapid cleanup of spills on site.

- To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train the employees, especially fork lift operators, in its execution and post it or otherwise have it readily available to employees and regulatory officials.

- Report spills of reportable quantities to Ecology Southwest Regional Office at (360) 407-6300.
- Prepare and implement an emergency spill cleanup plan for the facility (BMP A7.15 Spills of Oil and Hazardous Substances) which includes the following BMPs:
  - Ensure cleanup of liquid/solid spills in the loading/unloading area immediately if a significant spill occurs, upon completion of the loading/unloading activity, or at the end of the working day.
  - Retain and maintain an appropriate oil spill cleanup kit on site for rapid cleanup of material spills (see BMP A7.15 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 (Figure 4.4) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Loading/Unloading from/to Marine Vessels:

- Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements.

Transfer of Small Quantities from Tanks and Containers:

- Refer to BMPs A4.8 Storage of Liquids in Permanent Aboveground Tanks and A4.7 Storage of Liquid, Food Waste, or Dangerous Waste Containers for requirements on the transfer of small quantities from tanks and containers, respectively.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.4. Drip Pan for Connections at Loading and Unloading Areas for Liquid Material.

Suggested 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 (Figures 4.5 and 4.6) to prevent contact with rainwater.
- Design the loading/unloading area with berms, sloping, etc. to prevent the run-on of stormwater.

Figure 4.5. Loading Docks with an Overhang to Prevent Material Contact with Rainwater.

Figure 4.6. Door Skirts to Enclose the Trailer End of a Truck to Prevent Material Contact with Rainwater.

At Tanker Truck Transfer Areas to Above/Below-Ground Storage Tanks:

- Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.

- Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, spill control oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the highest fuel dispenser nozzle through-put rate or the peak flow rate of the 6-month, 24-hour storm event over the surface of the containment pad, whichever is greater. The volume of the spill containment sump shall be a minimum of 50 gallons with an adequate grit sedimentation volume.

A2.2 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 under-ground fuel storage facilities. In addition to general service gas stations, fueling may also occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typical causes of stormwater contamination at fueling stations include leaks/spills of fuels, lube 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. Substantial remodeling includes replacing the canopy or relocating or adding one or more fuel dispensers in such a way that the Portland cement concrete (or equivalent) paving in the fueling area is modified. The facility must use a treatment BMP for contaminated stormwater and wastewaters in the fueling containment area.

Required BMPs
For New or Substantially Remodeled Fueling Stations:

- Prepare an emergency spill response and cleanup plan (per BMP A7.15 Spills of Oil and Hazardous Substances) and have designated trained person(s) available either on site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.

- Train employees on the proper use of fuel dispensers. Post signs in accordance with fire codes. 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.

- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.

- Keep drained oil filters in a suitable container or drum.

- Design the fueling island to control spills (dead-end sump or spill control separator in compliance with the applicable fire codes) and to treat collected stormwater and/or wastewater to required levels. Slope the concrete containment pad around the fueling island toward drains: trench drains, catch basins, and/or a dead-end sump. The slope of the drains shall not be less than 1 percent. Drains to treatment facilities must have a normally closed shutoff valve. The spill control sump must be sized in compliance with the applicable fire code.

OR

- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of 4 inches (or in accordance with the applicable fire code) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. Raised sills are not required at the open-grate trenches that connect to an approved drainage-control system.

- The fueling pad must be paved with Portland cement concrete, or equivalent. Asphalt is not considered an equivalent material.

- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad (Figure 4.7). The roof or canopy shall, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Convey all roof drains to storm drains outside the fueling containment area.

Figure 4.7. Roof at Fueling Island to Prevent Stormwater Runon.

- Convey stormwater collected on the fuel island containment pad to a sanitary sewer system, if approved by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider; or to an approved treatment system such as an oil/water separator and a basic treatment BMP (basic treatment BMPs are listed in Volume V and include media filters and biofilters). 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 or grease.

- Alternatively, collect stormwater from the fuel island containment pad and hold for proper off-site disposal.

- Obtain approval from the LOTT Alliance Industrial Pretreatment Program or your local sewer service provider for conveyance of any fuel-contaminated stormwater to a sanitary sewer and 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. Contact the LOTT Alliance at (360) 528-5708 or your local sewer service provider.

- 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 practicable 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 all of the other required BMPs and fire prevention requirements.

- If a roof or canopy is impractical, the concrete fueling pad must be equipped with emergency spill control, including a shutoff valve for the drainage from the fueling area. Maintain the valve in the closed position. Clean up spills and dispose of materials off site in accordance with BMP A7.15 Spills of Oil and Hazardous Substances.
- The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider, or to oil removal treatment such as an American Petroleum Institute (API) or coalescent plate oil/water separator, or equivalent treatment, and then to a basic treatment BMP. See Volume V for more information. 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 or grease.

A2.3 Engine Repair and Maintenance

Description of Pollutant Sources: This activity applies to businesses and public agencies where fuel filters, engine oil, and other fluids such as battery acid, coolants, and transmission and brake fluids are removed and replaced in vehicles and equipment. It also applies to mobile vehicle maintenance operations, such as at construction sites. Related vehicle maintenance activities are covered under the following activity headings in this volume, and other BMPs provided in this volume:

- A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures
- A2.1 Loading and Unloading Areas for Liquid or Solid Material
- A2.2 Fueling at Dedicated Stations
- A2.4 Mobile Fueling of Vehicles and Heavy Equipment
- A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment
- A4.1 Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products
- A4.7 Storage of Liquid, Food Waste, or Dangerous Waste Containers
- A4.8 Storage of Liquids in Permanent Aboveground Tanks
- A4.9 Parking and Storage for Vehicles and Equipment
- A7.15 Spills of Oil and Hazardous Substances

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, pH, and heavy metals.

Pollutant Control Approach: Control of leaks and spills of fluids using good housekeeping and cover and containment BMPs.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies engaged in engine and vehicle repair:

- Employees must be educated about the need for careful handling of automotive fluids. Employees at businesses or agencies who routinely change or handle these fluids must be trained in spill response and cleanup procedures. Inspect all incoming vehicles, parts, and equipment stored temporarily outside for leaks.
- 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.

- Empty fuel filters before disposal.
- Spill cleanup materials, such as rags and absorbent materials, must always be kept close at hand when changing oil and other fluids. You can comply more easily with sewer and stormwater requirements by running a 'dry shop', thereby reducing your consumption/discharge of liquids. Soiled rags and other cleanup material must be properly disposed of or cleaned and reused. Contact Thurston County Waste Management at (360) 867-2300 or your local solid waste hauler for proper disposal options.
- No drains inside maintenance buildings may connect to the sanitary sewer without prior written approval of your sewer service provider. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider. Interior drains will not be allowed to be connected to the stormwater drainage system.
- Do not hose down the maintenance/repair area. Instead, sweep the area weekly to collect dirt, and wipe up spills with rags and other absorbent materials.
- If the work is done at a mobile location, such as a construction site, a tarpaulin, ground cloth, or drip pans must be used beneath the vehicle or equipment to capture all spills and drips (Figure 4.8). The collected drips and spills must be recycled or disposed of properly. See BMP S.2 in Chapter 5 for disposal options.

Figure 4.8. Drip Pan for Use at Mobile Sites.

- If this activity occurs at a stationary business location, the activity area must be moved indoors. An exception to this requirement would be equipment that is too large to fit under a roofed area. In this case, the outdoor area must be paved, provided with a sump drain, and provision made for stormwater run-on prevention. See BMP S.6 and S.7 in Chapter 5 for more on paving, sump drains and holding tanks, and run-on prevention. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for information on requirements for disposal to sewer. If you are on a septic tank, sump contents will need to be pumped and disposed of by an oil recycler or hazardous waste company.

- Recycle oil, antifreeze, batteries, and air conditioning coolant.
- Contaminated stormwater runoff from vehicle staging and maintenance areas must be conveyed to an API or coalescing plate oil and water separator followed by a basic treatment BMP (see Volume V), applicable filter, or other equivalent oil treatment system.

Suggested BMPs

- Drain all fluids from wrecked vehicles and 'parts' cars/equipment upon arrival. Recover air conditioning gases.
- Use reusable cloth rags to cleanup drips and small spills instead of disposables: these can be professionally laundered and reused. Do not attempt to launder these at home or at a coin-op laundry.
- Use absorbent pillows or booms in or around storm drains and catch basins to absorb oil and fuel.

A2.4 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.

Historically mobile fueling has been conducted for off-road vehicles that are operated for extended periods of time in remote areas. This includes construction sites, logging operations, and farms. Mobile fueling of on-road vehicles is also conducted commercially in the State of Washington.

Note that some local fire departments may have restrictions on mobile fueling.

Pollutant Control Approach: Proper training of the fueling operator, and the use of spill/drip control and reliable fuel transfer equipment with backup shutoff valving are needed.

Required BMPs

Organizations and individuals conducting mobile fueling operations must implement the following BMPs. The operating procedures for the driver/operator should be simple, clear, effective and their implementation verified by the organization that will potentially be liable for environmental and third party damage.

- Ensure that all mobile fueling operations are approved by the applicable Thurston County fire district or Fire Marshal and comply with applicable fire codes.
- In fueling locations that are in close proximity to sensitive aquifers, designated wetlands, wetland buffers, or other waters of the state, Thurston County acceptance is necessary to ensure compliance with additional local requirements.
- Ensure compliance with all 49 CFR 178 requirements for DOT 406 cargo tanker. Documentation from a U.S. Department of Transportation Registered Inspector shall be proof of compliance.
- Ensure the presence and the constant observation/monitoring by the driver/operator at the fuel transfer location at all times during fuel transfer and ensure that the following procedures are implemented at the fuel transfer locations:
    - Locating the point of fueling at least 25 feet from the nearest storm drain 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 drain to ensure no inflow of spilled or leaked fuel. Covers are not required for storm drains that convey the inflow to a spill control separator approved by Thurston County, including the Thurston County Fire Marshal. Potential spill/leak conveyance surfaces must be impervious and in good repair.
    - Place a drip pan or an absorbent pad under each fueling location prior to and during all dispensing operations. The pan (must be liquid tight) and

the absorbent pad must have a capacity of at least 5 gallons. There is no need to report spills retained in the drip pan or the pad.

- Manage the handling and operating 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 drains, and receiving waters.
- Avoid extending the fueling hoses across a traffic lane without fluorescent traffic cones, or equivalent devices, conspicuously placed so that all traffic is blocked 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 the Thurston County Fire Marshal 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 district (or fire department) and the Ecology Southwest Regional Office in the event of any spill entering surface water or groundwater. 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.
- Maintain a minimum of the following spill cleanup materials in all fueling vehicles, that are readily available for use:
  - Non-water absorbents capable of absorbing at least 15 gallons of diesel 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 absorbent capacity (Figure 4.9)

- A non-spark generating shovel (a steel shovel could generate a spark and cause an explosion in the right environment around a spill)
- Two, 5-gallon buckets with lids.

Figure 4.9. Spill Containment Boom.

- 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.
- Include the following fuel transfer site components:
  - Automatic fuel transfer shut-off nozzles; and
  - An adequate lighting system at the filling point.

Section A3

Production and Application Activities

A3.1 Concrete and Asphalt Mixing and Production at Stationary Sites

Description of Pollutant Sources: This activity applies to businesses and agencies that mix raw materials on-site to produce concrete or asphalt. It also applies to subsequent uses such as pouring concrete structures and making other concrete or asphalt products. Mobile concrete pouring and asphalt application are covered under **Activity A3.2** in this section. Requirements for stockpiling of raw materials are covered under **Activity A4.1 Storage or Transfer (Outside) of Solid Raw Materials, By-products or Finished Products.**

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, heavy metals, and pH.

Pollutant Control Approach: Cover and contain processes where possible and prevent stormwater run-on and contamination, where feasible.

Any facility categorized under SIC Code 2951 (asphalt paving mixtures and blocks) or SIC Code 3273 (ready-mix concrete) may need to comply with Ecology's sand and gravel general permit. Contact Ecology at (360) 407-6400 for additional information.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and public agencies active in concrete and asphalt mixing and production:

- Eliminate all illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for a detailed discussion on identifying and eliminating these connections.
- All process water from production, pouring, and equipment cleaning must be discharged to a dead-end sump, process water treatment system, or sanitary sewer (subject to approval by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside of the LOTT service area), or recycled. Never wash fresh concrete or concrete mixer washout into streets, stormwater drainage systems, streams, other water bodies, or to groundwater.
- A BMP maintenance schedule must be established and employees educated about the need to prevent stormwater contamination through the use and proper maintenance of BMPs.

Suggested BMPs

- The production and pouring area should be swept at the end of each workday to collect loose chunks of aggregate and raw materials for recycling or proper disposal. See BMP S.2 in Chapter 5 for disposal options.
- Sweep all driveways and gutters that show accumulation of materials to minimize the amount that could be carried off site by rain and enter the stormwater drainage system.

- Asphalt plants should use an oil/water separator to treat stormwater runoff. See Volume V of this manual, Runoff Treatment BMPs, for more information.

- Production and pouring areas shall be protected from stormwater run-on. See BMP S.7 in Chapter 5 for methods of run-on protection.

- Use absorbent materials in and around storm drains and catch basins to filter out contaminants. See Volume V of this manual, Runoff Treatment BMPs, for more information.

- Pave the mixing, production, and pouring areas. A sump drain in these areas is probably not advisable due to potential clogging problems, but could be used in a curing area. Sweep these areas to remove loose aggregate and recycle or dispose of properly.

- Use storm drain covers or similarly effective containment devices to prevent runoff from entering the stormwater drainage system. Accumulations of dirty runoff must be disposed of properly.

Contact the Thurston County Storm and Surface Water Utility at (360) 754-4681 for information about water quality treatment BMPs for these types of operations. Visit Ecology's Web site for accepted water quality treatment at:
<http://www.ecy.wa.gov/programs/wq/stormwater/index.html>.

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

A3.2 Concrete Pouring, Concrete Cutting, and Asphalt Application at Temporary Sites

Description of Pollutant Sources: This activity applies to businesses and public agencies that apply asphalt or pour or cut concrete for building construction and remodeling, road construction, sidewalk, curb and gutter repairs and construction, sealing of driveways and roofs, and other applications. These activities are typically done on a temporary site-to-site basis where permanent BMP measures do not apply. Concrete pouring activities can severely alter the pH of receiving waters and slurry from aggregate washing can harden in storm pipes, reducing capacity and creating flooding problems. Concrete cutting uses water for cooling and the fine particulates suspended in the resulting slurry are particularly hard to treat.

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, heavy metals, suspended solids, and pH.

Pollutant Control Approach: Train employees on proper procedures, sweep or shovel aggregate chunks, collect accumulated runoff and solids, and wash equipment in designated areas.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies doing concrete pouring and asphalt application at temporary sites:

- Employees must be educated on the pollution hazards of concrete and asphalt application and cutting.
- Loose aggregate chunks and dust must be swept or shoveled and collected (not hosed down a storm drain) for recycling or proper disposal at the end of each workday, especially at work sites such as streets, driveways, parking lots, sidewalks, curbs, and gutters where rain can readily pick up the loose material and carry it to the nearest stormwater conveyance. Small amounts of excess concrete, grout, and mortar can be disposed of in the trash.
- Storm drain covers or similarly effective containment devices must be placed over all nearby drains at the beginning of each day. Shovel or vacuum slurry and remove from the site. All accumulated runoff and solids must be collected and properly disposed of (see BMP S.2 in Chapter 5 for disposal options) at the end of each workday, or more often if necessary.
- Exposed aggregate washing (where the top layer of unhardened concrete is hosed or scraped off to leave a rough finish) must be done with a mechanism for containment and collection of the discarded concrete slurry.
- Cleaning of concrete application and mixing equipment or concrete vehicles must be done in a designated area where the rinse water is controlled and properly disposed. See Volume II, Section 3.1, BMP C154 for more information.

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

Suggested BMPs

- Avoid the activity when rain is occurring or expected.
- If possible, portable asphalt mixing equipment should be covered by an awning, a lean-to, or another simple structure to avoid contact with rain. See BMP S.4 in Chapter 5 for further details on cover structures.
- Recycle broken concrete and asphalt.

A3.3 Manufacturing and Postprocessing of Metal Products

Description of Pollutant Sources: This activity applies to businesses such as mills, foundries, and fabricators that manufacture or postprocess metal products. A variety of activities such as machining, grinding, soldering, cutting, welding, quenching, etching, bending, coating, cooling, and rinsing may take place. These businesses may be required to obtain a NPDES permit from Ecology. See Chapter 7 for a discussion of NPDES requirements. Note: Painting, finishing and coating of metal products is covered under **A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment.**

Pollutants of concern include toxic organic compounds, heavy metals, oils and greases, pH, suspended solids, and chemical oxygen demand (COD).

Pollutant Control Approach: Cover and contain operations. Apply good housekeeping practices such as sweeping and preventative maintenance practices to prevent the contamination of stormwater. Avoid storing metals where they can be exposed to rain.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in metals manufacturing or post processing:

- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for detailed information on identifying and eliminating illicit connections.
- Process wastewater (including contact cooling water, filter backwash, cooling tower blow down, etc.) from processing and production, and stormwater runoff from activity areas, must discharge to a sanitary sewer, holding tank, or process treatment system. Such systems require an Ecology NPDES permit for discharge to surface water or storm drain. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside the LOTT service area to obtain permits for discharge to the sewer. See BMP S.3 in Chapter 5 for detailed requirements.
- Employees must be educated in proper handling to control their work with metal products to minimize pollution.
- The activity area must be swept at the end of each workday to collect and dispose of metal fragments and product residues properly. See BMP S.2 in Chapter 5 for disposal alternatives. Do not allow metal fragments, residues, or dust to accumulate in areas exposed to stormwater.

Suggested BMPs

- Limit the amount of water used in quenching and rinsing. Recycle used water where possible.
- Cover the activity area to prevent rain from contacting the process and reduce the amount of runoff that has to be detained or treated. See BMP A3.9.
- Refer to the BMPs under sections A2 Transfer of Liquid or Solid Materials and A4 Storage and Stockpiling Activities, and utilize those BMPs which are applicable for materials storage and maintenance activities in your shop.

A3.4 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 areas 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 source control BMPs listed below.

Required 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 and properly dispose of soils with visible surface contamination (green soil) to prevent the spread of chemicals to groundwater and/or surface water via stormwater runoff.
- If any treated wood is observed to be contributing chemicals to the environment in the treated wood storage area, relocate it on a concrete chemical containment structure until the surface is clean and until it is drip free and surface dry.
- Cover and/or enclose, and contain with impervious surfaces, all wood treatment areas. 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, 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.

- Place treated lumber from dip tanks or retorts in a covered paved storage area for at least 24 hours before placement in outside storage. Use a longer storage period during cold weather unless the temporary storage building is heated. Prior to moving wood outside, ensure that the wood is drip free and surface dry.

Suggested BMP

- Consider using preservative chemicals that do not adversely impact receiving surface water and groundwater.

A3.5 Commercial Composting

Description of Pollutant Sources: Commercial compost 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, oxygen demanding substances (i.e., BOD and COD), organics, coliform bacteria, acidic pH, and suspended solids. Stormwater at a compost facility consists of runoff from areas at the facility that are not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

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 groundwater 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).

The Thurston County Public Health and Social Services Department regulates solid waste facilities in accordance with WAC 173-304. The Public Health & Social Services Department should be contacted at (360) 867-2664 to obtain permits and requirements for composting and recycling facilities.

Pollutant Control Approach: Consider zero leachate discharge.

Required BMPs

- See WAC 173-350-220, Composting Facilities
- View Siting and operating Composting Facilities in Washington State Good Management Practices for common sense actions that a facility can adopt to help run a successful program. This document is available at: https://fortress.wa.gov/ecy/publications/documents/1107005.pdf
- See Ecology's Organic Materials Management Rule and Law page for the most up-to-date information: <www.ecy.wa.gov/programs/swfa/organics/law.html>.
- Contact other federal, state, and Thurston County agencies with environmental or zoning authority for applicable permit and regulatory information. The Thurston County Public Health and Social Services Department is responsible for issuing solid waste handling permits for commercial compost facilities.
- Apply for coverage under the Industrial Stormwater General Permit if the facility discharges stormwater to surface water or a municipal stormwater system. If all stormwater from the facility properly infiltrates to groundwater, the Industrial Stormwater General Permit is not required.

- There are some cases where an Individual State Waste discharge Permit is required. Check with the Ecology Southwest Regional Office and health department to discuss your permitting options.
- Store finished compost in a manner to prevent contamination of stormwater.
- Compost pads are required for all uncovered facilities in areas of the state with wet climates (per water quality regulations).
- Provide curbing for all compost pads to prevent stormwater run-on and leachate run-off.
- Slope all compost pads sufficiently to direct leachate to the collection device.
- Provide one or more sumps or catch basins capable of collecting all leachate generated by the design storm and conveying it to the leachate holding structure for all compost pads.
- Convey all leachate from composting operations to a sanitary sewer, holding tank, or on-site treatment system designed to treat the leachate and total suspended solids. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local service provider for permits and information.
- Ponds used to collect, store, or treat leachate and other contaminated waters associated with the composting process must be lined to prevent groundwater contamination. Apply all known available and reasonable methods of prevention and treatment (AKART) to all pond liners, regardless of the construction materials.

Suggested BMPs

- Cleanup debris from yard areas regularly.
- Locate stored residues in areas designed to collect leachate.
- Limit storage times of residues to prevent degradation and generation of leachate.
- Consider using leachate as make-up water in early stages of the composting process. Since leachate can contain pathogenic bacteria, do not use leachate to water finished product or nearly finished product.

A3.6 Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources: Landscaping can include grading, soil transfer, vegetation removal, pesticide and fertilizer application, and watering. Stormwater contaminants include toxic organic compounds, heavy metals, oils, total suspended solids, coliform bacteria, fertilizers, and pesticides.

Lawn and vegetation management can include control of objectionable weeds, insects, mold, bacteria, and other pests with herbicides or pesticides. Examples include weed control on golf course lawns, access roads, and utility corridors and during landscaping; sap stain and insect control on lumber and logs; rooftop moss removal; killing nuisance rodents; fungicide application to patio decks; and residential lawn/plant care. 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 the vegetation and poor application of herbicides, pesticides or fertilizers can cause appreciable stormwater contamination.

Pollutant Control Approach: Control fertilizer, herbicide and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.

Develop and implement an integrated pest management (IPM) plan and use pesticides only as a last resort. Refer to Appendix IV-B *Example of an Integrated Pest Management Program* for more information. Carefully apply pesticides/herbicides in accordance with label instructions. Maintain appropriate vegetation, with proper fertilizer application where practicable, to control erosion and the discharge of stormwater pollutants. Where practicable, grow plant species appropriate for the site, or adjust the soil properties of the subject site to grow desired plant species.

Required BMPs for Landscaping

- Do not dispose of grass clippings and other collected vegetation into waterways or stormwater drainage systems.
- Use mulch or other erosion control measures when soils are exposed for more than 1 week during the dry season or 2 days during the rainy season.
- If oil or other chemicals are handled, store and maintain appropriate oil and chemical spill cleanup materials in readily accessible locations. Ensure that employees are familiar with proper spill cleanup procedures.

Suggested BMPs for Landscaping

- Conduct mulch-mowing whenever practicable.
- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
- Dispose of grass clippings, leaves, sticks, or other collected vegetation by composting, if feasible.

- Till fertilizers into the soil rather than dumping or broadcasting onto the surface. Determine the proper fertilizer application for the types of soil and vegetation encountered.

- 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.

- Use manual and/or mechanical methods of vegetation removal rather than applying herbicides, where practical.

Required BMPs for the Use of Pesticides

- Develop and implement an IPM plan (see section on integrated pest management below) and use pesticides only as a last resort.

- Implement a pesticide-use plan and include at a minimum: a list of selected pesticides and their specific uses; brands, formulations, application methods, and quantities to be used; equipment use and maintenance procedures; safety, storage, and disposal methods; and monitoring, record keeping, and public notice procedures. All procedures shall conform to the requirements of Chapter 17.21 Revised Code of Washington (RCW) and Chapter 16-228 WAC.

- 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. 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 thuringiensis (Bt) application to control tent caterpillars, apply it before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.

- Apply the pesticide according to label directions. Do not apply pesticides in quantities that exceed manufacturer’s instructions.

- Mix the pesticides and clean the application equipment in an area where accidental spills will not enter surface or groundwater, and will not contaminate the soil.

- Store pesticides in enclosed areas or in covered impervious containment. Do not discharge pesticide contaminated stormwater or spills/leaks of pesticides to storm drains. Do not hose down paved areas to a storm drain or conveyance ditch. Store and maintain appropriate spill cleanup materials in a location known to all near the storage area.

- Cleanup any spilled pesticides. Keep pesticide contaminated waste materials in designated covered and contained areas.

- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.

- Spraying pesticides within 100 feet of open waters including wetlands; ponds; and streams, sloughs, and any drainage ditch or channel that leads to open water, may have additional regulatory requirements beyond just following the pesticide label.
- Additional requirements may include:.
  - Obtaining a discharge permit from Ecology,
  - Obtaining approval from Thurston County,
  - Using an aquatic labeled pesticide.
- Flag all sensitive areas including but not limited to, wells, creeks, and wetlands prior to spraying.
- Post notices and delineate the spray area prior to the application, as required by Thurston County or by Ecology.
- Conduct spray applications during weather conditions as specified in the label direction and applicable local and state regulations. Do not apply during rain or immediately before expected rain.

Suggested BMPs for the Use of Pesticides

- 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. The following are three possible mechanisms for disease control by compost addition (USEPA publication 530-F-9-044):
  - Successful competition for nutrients by antibiotic production
  - Successful predation against pathogens by beneficial microorganism; and
  - Activation of disease-resistant genes in plants by composts.
- Installing an amended soil/landscape system can preserve both the plant system and the soil system more effectively. This type of approach provides a soil/landscape system with adequate depth, permeability, and organic matter to sustain itself and continue working as an effective stormwater infiltration system and a sustainable nutrient cycle.
- Once a pesticide is applied, evaluate its effectiveness for possible improvement. Records should be kept showing the effectiveness of the pesticides used.
- Develop an annual evaluation procedure including a review of the effectiveness of pesticide applications, impact on buffers and sensitive areas (including potable wells), public concerns, and recent toxicological information on pesticides used/proposed for use. 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.

- Rinsate from equipment cleaning and/or triple-rinsing of pesticide containers should be used as product or recycled into product.

For more information, contact the Washington State University (WSU) Extension Home-Assist Program at 360-867-2151; Bio-Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA 94707; or U.S. EPA to obtain a publication entitled "Suspended, Canceled and Restricted Pesticides" which lists all restricted pesticides and the specific uses that are allowed.

Suggested BMPs for Vegetation Management

- Use at least an 8-inch "topsoil" layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium (see soil preservation and amendment in Volume III, Section 3.1 for soil mix and installation guidance). Amending existing landscapes and turf systems can substantially improve the permeability of the soil, improve the disease and drought resistance of the vegetation, and reduce fertilizer demand. 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 fungi do not, however, repel root-feeding lawn pests such as Crane Fly larvae, and are toxic to ruminants such as cattle and sheep. They cause no known adverse effects to the host plant or to humans. Endophytic grasses are commercially available and can be used in areas such as parks or golf courses where grazing does not occur. Local agricultural or gardening resources such as WSU Extension office can offer advice on which types of grass are best suited to the area and soil type.

- Use the seeding and planting BMPs: C120 temporary and permanent seeding procedures, C121 mulching, C122 nets and blankets, and C124 sodding, found in Volume II, or equivalent BMPs.

- Adjusting the soil properties of the subject site can assist in selecting the desired plant species and suppressing weeds. For example, layering specific strata of organic matters (e.g., composted forest product residuals) helps a constructed wetland resist the invasion of reed canary grass by creating a mildly acidic pH and carbon-rich soil medium. Consult a soil restoration specialist for site-specific conditions.

- 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 0.75 inches deep.

- Mowing is a stress-creating activity for turfgrass. Grass productivity is decreased and there is less growth of roots and rhizomes when mown too short. 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. 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 one-third of the grass blade height will prevent stressing the turf. Use a mulching mower and leave the clippings on the lawn to foster nutrient cycling.

Suggested BMPs for Irrigation

- 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. Improper irrigation can encourage pest problems, leach nutrients, and make a lawn completely dependent on artificial watering. The amount of water applied depends on the normal rooting depth of the turfgrass species used, the available water holding capacity of the soil, and the efficiency of the irrigation system. Consult with your local water purveyor, the Thurston Conservation District (360-754-3588), or the WSU Extension office to help determine optimum irrigation practices.

Suggested BMPs for Fertilizer Management

- Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site depending on plant, soil, and climatic conditions. Evaluate soil nutrient levels through regular testing to determine how much nutrients the soil needs, if any, which also saves money. For details on soils testing, contact the Thurston Conservation District, a soils testing professional, or WSU Extension Service.

- Apply fertilizers in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and groundwater. Do not fertilize when the soil is dry. Plants need moisture to take up fertilizer and avoid fertilizer "burn". Alternatively, do not apply fertilizers within 3 days prior to predicted rainfall. The longer the period between fertilizer application and either rainfall or irrigation, the less fertilizer runoff occurs. After a rain, but well before the next storm is a good time for application.

- Use slow release fertilizers such as methylene urea, IDBU, 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.

- Time the fertilizer application to periods of maximum plant uptake. Generally Ecology recommends fall and spring applications , although WSU turf specialists recommend four fertilizer applications per year.

Properly trained persons should apply all fertilizers. At commercial and industrial facilities do not apply fertilizers to grass swales, filter strips, or buffer areas that drain to sensitive water bodies unless approved by the County.

Suggested BMPs for Integrated Pest Management
An integrated pest management (IPM) program might consist of the following steps:

Step 1 Correctly identify problem pests and understand their life cycle.

Step 2 Establish tolerance thresholds for pests.

Step 3 Monitor to detect and prevent pest problems.

Step 4 Modify the maintenance program to promote healthy plants and discourage pests.

Step 5 Use cultural, physical, mechanical, or biological controls first if pests exceed the tolerance thresholds.

Step 6 Evaluate and record the effectiveness of the control and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

For an elaboration of these steps refer to Appendix IV-B, Example of an IPM Program.

A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and 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.

Required BMPs

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and overspray. Use ground or drop cloths underneath outdoor painting, scraping, sandblasting work, and properly clean and temporarily store collected debris daily.
- Do not conduct spraying, blasting, or sanding activities over open water or where wind may blow paint or waste into water.
- Wipe up spills with rags and other absorbent materials immediately. Do not hose down the area to a storm drain, conveyance ditch, or to a receiving water.
- On marine dock areas, sweep rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.
- Use an 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 brushes and tools covered with non-water-based paints, finishes, or other materials in a manner that allows collection of used solvents, turpentine, or paint thinners for recycling or proper disposal.
- Store toxic materials under cover (tarpaulin, etc.) during precipitation events and when not in use to prevent contact with stormwater.
- Enclose or contain all work while using a spray gun or conducting sand blasting and in compliance with applicable Olympic Region Clean Air Agency (ORCAA), Occupational Safety and Health Administration (OSHA), and Washington

Industrial Safety and Health Act (WISHA) requirements. Do not conduct outside spraying, grit blasting, or sanding activities during windy conditions that render containment ineffective.

Suggested BMPs

- Conduct incidental cleaning of paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can be dumped into a sanitary sewer drain, NOT a stormwater drain.
- 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.

A3.8 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 waste material storage area and area where chemicals are offloaded at external unloading bays. Pollutants can include total suspended solids, 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.

Required BMPs

- Discharge process wastewaters to a sanitary sewer (if approved by LOTT Alliance Industrial Pretreatment Program (360) 528-5708 or your local sewer service provider) or to an approved process wastewater treatment system.
- Do not discharge process wastes or wastewaters into storm drains 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.

Suggested BMPs

- 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.
- Try to use press washes without listed solvents, and with the lowest VOC content possible. Don't 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 the following Ecology publications are recommended: *A Guide for Screen Printers*, publication No. 94-137 and *A Guide for Lithographic Printers*, publication No. 94-139.

A3.9 Manufacturing Operations (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 pollutant materials remain.

Pollution Control Approach: Cover and contain outside manufacturing and prevent stormwater run-on and contamination, where feasible.

Required BMPs

- Sweep paved areas regularly, as needed, to prevent contamination of stormwater. Do not wash down areas into storm drains.
- Eliminate or minimize the contamination of stormwater by altering the activity.
- Enclose the activity (Figure 4.10). If possible, enclose the manufacturing activity in a building.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.10. Commercially Available Bermed Workspace.

- Cover the activity and connect floor drains to a sanitary sewer (Figure 4.11), if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside of the LOTT service area. Berm or slope the floor as needed to prevent drainage of pollutants to outside areas.
- Isolate and segregate pollutants, as feasible. Convey the segregated pollutants to a sanitary sewer, process treatment, or dead-end sump, depending on available methods and applicable permit requirements.

(Photo courtesy of Seattle Public Utilities)

Figure 4.11. Structure Used to Cover Manufacturing Operations.

A3.10 Agricultural Crop Production

This activity applies to farming of crops on a commercial scale. Crop farming practices can cause a large variety of pollution problems in receiving waters. Many of these practices can be altered without adversely affecting the farmers' ability to produce the same crops.

One of the most effective BMPs for stormwater pollution prevention the farmer can pursue is education. Contact the Thurston County Conservation District at (360) 754-3588. They will help develop a farm plan that covers all aspects of the farming operation, with particular care and attention to soil conservation and water resource protection. Conservation tillage and many other measures can help save money. The agencies also have access to grants to pay for conservation plantings and stream corridor fencing.

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, nutrients, Oxygen demanding substances (i.e., BOD and COD), suspended solids (e.g., sediments), fecal bacteria.

Crop farms should implement agricultural practices proven to limit erosion. Several farming techniques aimed at reducing erosion have been proven successful. Individual farms should implement the combination of the following BMPs that best suits conditions present:

Suggested BMPs

- Maintain ground cover. Cover bare areas with material such as mulch or green manure (cover crops) during times when land is not in production.
- Practice conservation tillage. Implement tillage or planting systems in which at least 30 percent of the soil surface is covered by plant residue after planting.
- Practice conservation cover. Establish and maintain perennial vegetation cover to protect soil and water resources on land retired from agricultural production.
- Utilize contour farming. Plow, prepare, plant and cultivate land on contours perpendicular to the slope of the land in a terrace-like fashion, so that runoff cannot proceed directly along a row but rather is impeded by rows in its path, thus allowing for more infiltration and hindering erosion.
- Plant critical areas. Plant vegetation such as trees, shrubs, vines, grasses, and legumes on highly erodible or critical areas to stabilize the soil.
- Plant and maintain vegetated buffers and filter strips. Maintain a strip of permanent vegetation downslope of crop fields so that sediments and associated pollutants in surface water runoff can be filtered out. These filter strips are especially important along stream banks, shorelines, and drainage ditches. Contact the Thurston County Conservation District at (360) 754-3588 and the Natural Resources Conservation Service at (360) 704-7740 for more information. In some instances, these organizations may be able to provide plant materials for such work free or for a low cost.
- Practice conservation irrigation. Replace flood irrigation systems with sprinkler head or drip irrigation systems that use less water. These irrigation methods

reduce the amount of crop field runoff and thereby reduce erosion and pollutant transport.

Some other suggested BMPs to consider for your farm include the following:

- Use an IPM plan and reduce reliance on pesticides. Information on integrated pest management is available from the Washington State University/Thurston County Cooperative Extension Service. BMP S.8 in Chapter 5 provides some details on integrated pest management and in Appendix IV-B for an example. See Activity 3.6 for information on BMPs for pesticide and fertilizer use.
- If possible, fertilized crops should be planted as far as possible from surface drainages. This will help keep nutrients out of water bodies.
- Contact the Natural Resources Conservation Service (formerly the Soil Conservation Service) at (360) 704-7740 for information on developing specific fertilization schedules. Applying fertilizers at the right time and in the right quantity can help minimize pollution.
- If possible, crop cultivation should be avoided on steep slopes.

A3.11 Application of Pesticides, Herbicides, Fungicides, and Rodenticides for Purposes Other than Landscaping

This activity applies to businesses and government agencies using pesticides, herbicides, fungicides and rodenticides for purposes such as removing moss from rooftops or decks, killing nuisance rodents and some insects (such as termites and carpenter ants) that live outdoors but can invade the home if left unchecked. Businesses and government agencies involved in these activities must comply with Thurston County Public Health and Social Services Department regulations and Washington State Department of Agriculture pesticide regulations. See Chapter 7 for more information on these regulations. The BMPs listed are intended to complement other regulations. Application of pesticides for landscaping purposes must follow the BMPs discussed under **A3.6 Landscaping and Lawn/Vegetation Management.**

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, Chemical oxygen demand (COD)

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies applying pesticides, herbicides, fungicides and rodenticides for non-landscaping purposes:

- Proper application practices must be used to avoid excessive application. Follow the manufacturers' guidelines and directions carefully.
- Never apply pesticides, herbicides, fungicides or rodenticides when rain is expected, or during rain events.
- Do not apply chemicals when it is windy. Early morning is typically the calmest time of day.
- Employees must be educated regarding the pollution potential of misusing the chemicals they are working with.
- Manage residues properly. Triple rinse or pressure rinse empty containers and mixing and application equipment. Collect all rinse water, and use it for diluting the next batch.

Suggested BMPs

- Use manual pest control measures, such as scraping or using high-pressure sprayers to remove moss from roofs and decks, before resorting to chemicals. Rodent traps can also be highly effective, without endangering pets and children as chemical baits can.
- IPM is a comprehensive approach to the use of pesticides. IPM minimizes pesticide application and stresses selection of proper products and tailored application rates. It is a sensible long-term strategy rather than a hit-and-run operation, and as such is probably the most effective BMP measure that can be utilized under this activity. See BMP S.8 in Chapter 5 for more details on integrated pest management and in Appendix IV-B for an example.

Section A4

Storage and Stockpiling Activities

A4.1 Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products

Description of Pollutant Sources: Some pollutant sources such as solid raw materials, by-products, or products such as gravel, sand, salts, topsoil, compost, logs, sawdust, wood chips, lumber and other building materials, concrete, and metal products are often stored outside in large piles or stacks at commercial or industrial establishments. Bulk materials stored outside may leach or erode when contacted by stormwater. Contaminants include total suspended solids, BOD, COD, organics, and dissolved metals or salts (sodium, calcium, 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 total suspended solids.

Required BMPs

- Do not hose down the contained stockpile area to a storm drain or a conveyance to a storm drain or receiving water.
- The source control BMP options listed below are applicable for stockpiles greater than 5 cubic yards of erodible or water soluble materials such as soil, road de-icing salts, compost, unwashed sand and gravel, or sawdust. Also included are outside storage areas for solid materials such as logs, bark, lumber, and metal products. Choose one or more of the following Source Controls:
    - Store in a building or paved and bermed covered area as shown in Figure 4.12;
    - Place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material (Figure 4.13); or
    - Pave the area and install a stormwater 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, or other materials.
- For large stockpiles that cannot be covered, 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 contaminated stormwater is not discharged directly to surface waters without being conveyed through a treatment BMP.
- Convey contaminated stormwater from the stockpile area to a wet pond, wet vault, settling basin, media filter, or other appropriate treatment system, depending on the contamination.

*

Figure 4.12. Covered and Secured Storage Area for Bulk Solids.

Figure 4.13. Temporary Plastic Sheeting Covering Raw Materials Stored Outdoors.

Suggested BMPs

- 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.

A4.2 Storage and Treatment of Contaminated Soils

Description of Pollutant Sources: This activity applies to businesses and agencies that store and treat soils contaminated with toxic organic compounds, petroleum products, or heavy metals. Such contamination typically comes to light when an environmental audit is done or old underground tanks are removed. The soils are usually excavated and taken off site for treatment via aeration and perhaps chemical stabilization. Stormwater runoff that comes in contact with contaminated soil can carry those contaminants along with loose dirt into receiving waters.

Pollutants of concern include toxic organic compounds, oils and greases, and heavy metals.

Pollutant Control Approach: The Thurston County Public Health and Social Services Department at (360) 867-2664 regulates and permits businesses treating contaminated soil. In addition, a permit from ORCAA is required if the treatment method for removing soil contaminants involves forcing air through, or extracting air from, the soil. Contact these agencies for additional information regarding the appropriate pollutant control approach.

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

A4.3 Temporary Storage or Processing of Fruits or Vegetables

Description of Pollutant Sources: This activity applies to businesses that temporarily store fruits and vegetables outdoors prior to processing or sale, or that crush, cut, or shred fruits or vegetables for wines, frozen juices, and other food and beverage products. Nutrients and soil washing off of fruit can have a detrimental effect on receiving waters.

Pollutants of concern include nutrients, suspended solids, oxygen demanding substances (i.e., BOD and COD), and color.

Pollutant Control Approach: Store and process fruits and vegetables indoors or under cover whenever possible. Educate employees about proper procedures. Eliminate illicit connections to the stormwater drainage system. Cover and contain operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater.

Required BMPs
The following BMPs or equivalent measures are required of all businesses engaged in *storage* of fruits or vegetables:

- Employees must be educated on benefits of keeping the storage area clean.
- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for details on detecting and eliminating these connections.
- No untreated water used to clean produce can enter the stormwater drainage system. Minimize the use of water when cleaning produce to avoid excess runoff.
- Cleanup materials, such as brooms and dustpans, must be kept near the storage area.
- Gutters, storm drains, and catch basins on the property must be cleaned as needed. See BMP S.9 in Chapter 5 for details on catch basin cleaning requirements.

The following BMPs or equivalent measures are required of all businesses that *process* fruits or vegetables:

- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for details on detecting and eliminating these connections.
- Employees must be educated on benefits of keeping the processing area clean.
- Cleanup materials, such as brooms, dustpans, and shovels, must be kept near the storage area.
- The processing area must be swept or shoveled daily to collect dirt and fruit and vegetable fragments for proper disposal.
- The processing area must be enclosed in a building or shed, or covered with provisions for stormwater run-on prevention. See BMPs S.4, S.5, and S.7 in Chapter 5 for more on covering and run-on prevention.

OR

- The processing area must be paved and sloped to a sanitary sewer drain, holding tank, or process treatment system collection drain, and stormwater run-on prevention must be provided for the processing area. Call LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 for information on discharging to the sanitary sewer or your local sewer provider if not located within the LOTT service area. See BMPs S.6 and S.3 in Chapter 5 for details on paving and drainage.

Suggested BMPs
The following BMPs are not required but can provide additional pollution protection:

- Cover storage areas for fruits and vegetables. See BMPs S.4 and S.5 in Chapter 5 for more details on coverings.
- A containment curb, dike, or berm can be used to prevent off-site runoff from storage or processing areas and also to prevent stormwater run-on. See BMP S.7 in Chapter 5 for more information. Note that run-on prevention is required for processing areas, but not for storage areas.
- The storage area should be swept or shoveled daily to collect dirt and fruit and vegetable fragments for proper disposal. Keep hosing to a minimum.

A4.4 Storage of Solid Wastes and Food Wastes

Description of Pollutant Sources: This activity applies to businesses and public agencies that store solid wastes and food wastes outdoors. This includes ordinary garbage. If improperly stored, these wastes can contribute a variety of different pollutants to stormwater. Requirements for handling and storing solid waste may include a permit from the Thurston County Public Health and Social Services Department. For more information, call the Waste Management Section at (360) 867-2664

NOTE: Dangerous solid wastes must be stored and handled under special guidelines. Businesses and agencies that store dangerous wastes must follow specific regulations outlined by Ecology and, in some cases, the county health department. Ecology regulations are outlined in Chapter 7. Please contact Ecology at (360) 407-6300 and the Thurston County Public Health and Social Services Department at (360) 867-2664 for the specific requirements and permitting information.

Pollutants of concern include toxic organic compounds, oils and greases, heavy metals, nutrients, suspended solids, and oxygen demanding substances (i.e., BOD and COD).

Pollutant Control Approach: Store wastes in suitable containers with leak-proof lids. Sweep or shovel loose solids. Educate employees about the need to check for and replace leaking containers.

Required BMPs
The following BMPs are required of all businesses and public agencies engaged in storage of non-dangerous solid wastes or food wastes:

- All solid and food wastes must be stored in suitable containers. Piling of wastes without any cover is not acceptable.
- Storage containers must be checked for leaks and replaced if they are leaking, corroded, or otherwise deteriorating.
- Storage containers must have leak-proof lids or be covered by some other means (Figure 4.14). Lids must be kept closed at all times. This is especially important for dumpsters, as birds can pick out garbage and drop it, promoting rodent, health, and stormwater problems.

OR

- If lids cannot be provided for the waste containers, or they cannot otherwise be covered, there is another option: a designated waste storage area must be provided with a containment berm, dike, or curb, and the designated area must drain to a sanitary sewer (contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider prior to any connections) or holding tank for further treatment. See BMP S.7 and S.3 in Chapter 5 for more information.

Figure 4.14. Solid Waste Dumpsters with Properly Sealed Lids.

- Employees must be trained to frequently check storage containers for leaks and to ensure that the lids are on tightly.
- The waste storage area must be swept or otherwise cleaned frequently to collect all loose solids for proper disposal in a storage container. Do not hose the area to collect or clean solids.
- If you clean your containers, all rinse water from cleaning must be disposed of in a sanitary sewer or septic system.
- Clean out catch basins on your property that receive drainage from your waste storage area. See BMP S.9 in Chapter 5 for details on catch basin cleaning.

Suggested BMPs

- If the amount of waste accumulated appears to frequently exceed the capacity of the storage container, then another storage container should be obtained and utilized.
- Store containers such that wind will not be able to knock them over.
- Designate a storage area, pave the area, and slope the drainage to a holding tank to prevent stormwater run-on or run-off. If a holding tank is used, the contents must be pumped out before the tank is full and properly disposed of. See BMP S.2 in Chapter 5 for more information on disposal options.
- Compost appropriate wastes. Contact Thurston County Waste Management at (360) 867-2300 for more information on composting.
- Recycle your solid wastes. The Industrial Materials Exchange program facilitates the transfer of excess materials and wastes to those who can use them. Industrial Materials Exchange can be reached at (206) 296-4899, toll free 1-888-TRY-IMEX or on the Web at: http://www.hazwastehelp.org/imex/.

A4.5 Recyclers and Scrap Yards

Description of Pollutant Sources: This activity applies to businesses and public agencies that salvage and store scrap metal, scrap equipment, junk appliances and vehicles, empty metal drums, and recyclable items such as cans, bottles, paper products, construction materials, metals, and beverage containers. This does not apply to businesses and agencies that store these items for less than 2 weeks. Businesses engaged in these activities may be required to obtain an NPDES permit for industrial stormwater discharges from Ecology. See the discussion of NPDES requirements in Chapter 7 for more information. For these permit holders, the BMPs listed below should be used to complement NPDES requirements.

Potential sources of pollutants include paper, plastic, metal scrap debris, engines, transmissions, radiators, batteries, and other contaminated materials 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 these facilities include: toxic hydrocarbons, polychlorinated biphenyls (PCBs), other toxic organic compounds, heavy metals, oils and greases, suspended solids, oxygen demanding substances (i.e., BOD and COD), ethylene and propylene glycol, and acidic pH.

Required BMPs
For facilities subject to Ecology's industrial stormwater general permit refer to BMP Guidance Document No. 94-146 "Vehicle Recyclers: A Guide for Implementing the Industrial Stormwater General National Pollutant Discharge Elimination System (NPDES) Permit Requirements," Ecology, March 2011, Web site: <www.ecy.wa.gov/biblio/94146.html>.

For facilities not subject to Ecology's industrial stormwater general permit, apply the BMPs in BMP Guidance Document No. 94-146 (see above), as well as the following required BMPs where applicable, depending on the pollutant sources existing at those facilities:

- Gasoline, engine fluids, Freon, and other contaminated liquids must be drained from scrapped items in a designated area and disposed of or recycled properly before the items are placed in the scrap storage area. See BMP S.2 in Chapter 5 for acceptable disposal options. The designated fluid draining area must be covered and paved, or if not covered, must be paved and sloped to a drain and holding tank. See BMP S.3 in Chapter 5 for drainage alternatives. Batteries must also be removed and recycled properly prior to storage.

- Employees must be educated about the need for stormwater pollution protection, and proper maintenance of BMPs. They also must have training in spill cleanup procedures, and appropriate cleanup materials must be stocked near the fluid draining area.

- Catch basins on the property must be cleaned as needed. See BMP S.9 in Chapter 5 for more details.
- If the storage area is small, the scrap or recycling materials must be covered. See BMPs S.4 and S.5 in Chapter 5 for further details on coverings.

OR

- If the storage area cannot be covered, an enhanced stormwater treatment system capable of removing dissolved metals must be used. See the BMP selection process in Volume I for more information.

Suggested BMPs

- The material storage area can be paved and sloped to a drain and holding tank. See BMP S.6 in Chapter 5 for details on this drainage strategy.
- Use of a containment dike, curb, or berm can help prevent contaminated runoff from leaving the site, and can function to direct runoff to one of the treatment methods mentioned under the Required BMPs. See BMP S.7 in Chapter 5 for more details.
- Recycle, reuse, or let others use your scrap materials.
- Chemicals can be added to enhance settling or adjust pH in a wet pond/vault or filtration system. However, this is usually a more complex and expensive way to deal with contaminated runoff. See BMP C252 and C253 in Volume II for details on these systems.

A4.6 Treatment, Storage, or Disposal of Dangerous Wastes

This activity applies to businesses and public agencies that are permitted by Ecology to treat, store, or dispose of dangerous wastes. Ecology regulates these facilities with specific requirements, which include the need for a NPDES permit. Detailed BMPs are not included in this volume since site requirements for these facilities are well beyond the level of typical BMP applications. See Chapter 7 for reference information.

The Thurston County Public Health and Social Services Department also administers some aspects of dangerous waste treatment, storage, and disposal. Call (360) 867-2664 for more information.

A4.7 Storage of Liquid 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 accumulated food wastes, vegetable or animal grease, used oil, liquid feedstock or cleaning chemicals, or Dangerous Wastes (liquid or solid), unless the business is permitted by Ecology to store the wastes. Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, oxygen demanding substances, (i.e., BOD and COD) are potential pollutant constituents.

Pollutant Control Approach: Store containers in impervious containment under a roof or other appropriate cover, or inside a building. For storage areas used on site for less than 30 days, a portable temporary secondary system can be used in lieu of a permanent system as described above.

Required BMPs

- Place tight-fitting lids on all containers.
- 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.
- Businesses accumulating Dangerous Wastes that do not contain free liquids need only to store these wastes in a sloped designated area with the containers elevated or otherwise protected from stormwater run-on.
- 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 (Figure 4.15).
- If the material is a Dangerous Waste, the business owner must comply with any additional Ecology requirements as specified in Chapter 7, Section 7.2, R.2.
- Storage of reactive, ignitable, or flammable liquids must comply with the applicable fire codes.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.15. Outdoor Drum Storage Unit with Locking Doors.

- Cover dumpsters or keep them under cover, such as a lean-to, to prevent the entry of stormwater. Replace or repair leaking garbage dumpsters.
- Drain dumpsters and/or dumpster pads to sanitary sewer. Dumpster drains must not discharge to stormwater systems. Keep dumpster lids closed. Install waterproof liners.
- Keep containers with Dangerous Waste, food waste, or other potential pollutant liquids inside a building unless this is impracticable due to site constraints or applicable fire code requirements.
- Store containers in a designated paved area that is covered, bermed, or diked to contain leaks and spills. Slope the secondary containment to drain into a dead-end sump for the collection of leaks and small spills.
- For liquid wastes, surround the containers with a dike as illustrated in Figure 4.16. The dike must be of sufficient height to trap a volume of either 10 percent of the total enclosed volume of the stored containers or 110 percent of the volume contained in the largest container, whichever is greater.

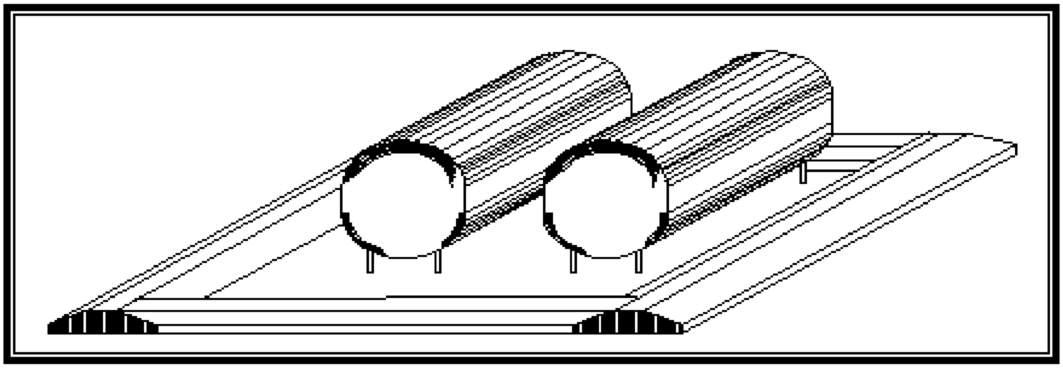

Figure 4.16. Containment Berm Used to Control Liquid-Material Leaks or Spills.

- Where material is temporarily stored in drums, use a containment system, as illustrated, in lieu of the above system (Figure 4.17).

(Photo courtesy of Seattle Public Utilities)

Figure 4.17. Temporary Secondary Containment.

- 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 (Figure 4.18).

- For contaminated stormwater in the containment area, connect the sump outlet to a sanitary sewer, if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider, or to appropriate treatment such as an API or coalescent plate oil/water separator, or other appropriate system (see Volume V). Equip the sump outlet with a normally closed valve to prevent the release of spilled or leaked liquids, especially flammables (in compliance with fire codes), and dangerous liquids. This valve may be opened only for the conveyance of contaminated stormwater to treatment.

Figure 4.18. Mounted Containers with Drip Pans.

- Another option for discharge of contaminated stormwater is to pump it from a dead-end sump or catchment to a tank truck or other appropriate vehicle for off-site treatment and/or disposal.

A4.8 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. 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. Stormwater collected in the containment area may need to be discharged to treatment such as an **API** or **coalescent plate** oil/water separator, or equivalent BMP. Add safeguards against accidental releases including protective guards around tanks to protect against vehicle or forklift damage, and tag valves to reduce human error. *Tank water and condensate discharges are process wastewater that may need an NPDES permit.*

Required 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.
- All installations shall comply with the applicable fire and electric codes.
- Locate permanent tanks in impervious (Portland cement concrete or equivalent) secondary containment surrounded by dikes as illustrated in Figure 4.19, or use Underwriters Laboratory approved double-walled tanks. The dike must be of sufficient height to trap a volume of either 10 percent of the total enclosed volume of the tank or 110 percent of the volume contained in the largest tank, whichever is greater.

(Photo courtesy of Seattle Public Utilities)

Figure 4.19. Aboveground Storage Tanks with Secondary Containment.

- Slope the secondary containment to drain to a dead-end sump (optional), or equivalent, for the collection of small spills.
- Include a tank overfill protection system to minimize the risk of spillage during loading.
- If the tank containment area is uncovered, equip the outlet from the spill-containment sump with a shutoff valve. The shutoff valve is normally closed and operators may open it manually or automatically, only to convey contaminated stormwater to approved treatment or disposal or convey uncontaminated stormwater to a storm drain. 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 through an API or coalescent plate type oil/water separator (Volume V, Treatment BMPs) or other approved treatment prior to discharge to storm drain or surface water.

A4.9 Parking and Storage for Vehicles and Equipment

Description of Pollutant Sources: Parked vehicles at 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, oils and greases, metals, and suspended solids.

Required BMPs

- If washing of a parking lot is conducted, discharge the washwater to a sanitary sewer (if allowed by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708) or other approved wastewater treatment system, or collect it for off-site disposal.
- Do not hose down the area to a storm drain or receiving water. Sweep parking lots, storage areas, and driveways regularly to collect dirt, waste, and debris.
- An oil removal system such as an API or coalescent plate oil and water separator, or equivalent BMP (see Volume V), approved by Thurston County, is applicable for parking lots meeting the threshold vehicle traffic intensity level of a high-use site. For more information on high-use sites, refer to Volume I, Section 4.2.7, and Volume V, Section 3.1

A4.10 Storage of Pesticides, Fertilizers, or Other Products That Can Leach Pollutants

This activity applies to businesses, public agencies and farms that store non-liquid pesticides, fertilizers, or a variety of other products, such as treated lumber, metal building materials, and metal tools, that have the potential to leach pollutants into underlying soil or stormwater runoff. The main problem with the potential pollutants from these sources is their solubility. Once dissolved, they are difficult or impossible to filter out of runoff. If there is any question as to whether materials on your site have the potential to leach pollutants into stormwater runoff or underlying soil, call Thurston County Public Works at (360) 867-2300 and ask to speak to a water quality person. The storage of liquid pesticides is covered under activity **A4.7 Storage of liquid chemicals, waste oils, solvents or petroleum products in portable containers.**

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, oxygen demanding substances (i.e., BOD and COD), nutrients, fecal bacteria, suspended solids.

Required BMPs

The following BMPs or equivalent measures are required of all businesses, public agencies and farms engaged in storage of pesticides, fertilizers or finished products that can leach pollutants:

- Employees must be trained on the proper storage, handling, application and disposal of fertilizers and pesticides, from keeping bags intact to storing in a covered or contained area.
- Outdated or banned pesticides must be disposed of at an approved hazardous waste facility. Do not hose storage areas to a storm drain or conveyance ditch.

Suggested BMPs

- Contained storage areas should drain to a sump or a holding tank. Note that this only applies to finished products other than treated lumber. The sump should have an outlet pipe for discharges to the stormwater drainage system. The sump must be cleaned at least once per year, and solid materials and residues collected in the bottom of the sump must be properly disposed of. See BMP S.2 in Chapter 5 for information on disposal options.
- Storage areas for pesticides, fertilizers, and finished products that can leach pollutants should be covered. See BMPs S.4 and S.5 in Chapter 5 for further information on coverings. Stormwater runon prevention must be provided for the covered area, or the stored materials must be raised off the ground. See BMP S.7 in Chapter 5 for more information on runon prevention options.
- Storage areas for treated lumber should be paved, and either covered or sloped to drain to a dead-end sump or treatment system. Material collected from the sump must be disposed of as a hazardous waste (it may be economical to install an evaporation system for the uncovered area). Stormwater runon must be prevented from entering the covered area if the lumber is not elevated off the ground. See BMPs S.4 and S.7 in Chapter 5 for more information on roof covers and runon prevention.

- Paved storage areas for finished products should be swept weekly and collected materials disposed of properly. Small amounts of fertilizers can be disposed of in the regular garbage after double wrapping in plastic.

- Use less pesticide or fertilizer, or store less finished product, so that the size of the designated storage areas can be smaller and stormwater contamination potential is reduced.

- If it is not feasible to use the source-control BMPs listed above, use one or more of the following stormwater treatment BMPs (described in Volume V) :

    - LID.08:Bioretention with an underdrain to prevent groundwater contamination

    - MF-01,02,03,04: Filtration

    - WP-03: Wet pond with nutrient control, for fertilizer storage only

    - WP-01: Constructed wetland

    - BF-01,02,03: Vegetated biofilter.

Section A5

Construction and Demolition Activities

A5.1 Demolition of Buildings

Description of Pollutant Sources: This activity applies to removal of existing buildings by controlled explosions, wrecking balls, or manual methods, and subsequent clearing of the rubble. The loose debris can contaminate stormwater.

Pollutants of concern include toxic organic compounds, heavy metals, and suspended solids. Waste from concrete sawing is of particular concern due to its effect on aquatic organisms and because it is extremely hard to settle out.

Pollutant Control Approach: Regularly cleanup debris that can contaminate stormwater. Protect the stormwater drainage system from dirty runoff and loose particles. Sweep paved surfaces daily.

Required BMPs
The following BMPs or equivalent measures are required of all businesses and public agencies engaged in building demolition:

- Storm drain covers or a similarly effective containment device must be placed on all nearby drains to prevent dirty runoff and loose particles from entering the stormwater drainage system (Figure 4.20). Covers shall be placed at the beginning of the workday and the accumulated materials collected and disposed of before removing the covers at the end of the workday. If storm drains are not present, dikes, berms, or other methods must be used to protect overland discharge paths from runoff. See BMPs S.2 and S.7 in Chapter 5 for more information on runoff control and disposal options.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.20. Commercially Available Gutter Guard Being Replaced.

- Street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the demolition must be swept at the end of each workday to collect and properly dispose of loose debris and garbage.

- Contact Thurston County Development Services at (360) 786-5490 and Olympic Region Clean Air Agency to obtain required permits. Additional information is available at the following web sites:
www.co.thurston.wa.us/permitting/index.htm and https://www.orcaa.org/.

Suggested BMPs

- Water should be sprayed throughout the site to help control wind blowing of fine materials such as soil, concrete dust, and paint chips. The amount of water must be controlled so that runoff from the site does not occur, yet dust control is achieved. Oils must never be used for dust control.

- If possible, a wall should be constructed to prevent stray building materials and dust from escaping the area during demolition.

- Schedule demolition to take place at a dry time of the year.

A5.2 Building Repair, Remodeling, Painting, and Construction

Description of Pollutant Sources: This activity refers to activities associated with construction of buildings and other structures, remodeling of existing buildings and houses, and general exterior building repair work. Work done on docks, piers, bridges, or other structures over water are of particular concern. Concrete pouring is covered under **A3.2 Concrete Pouring and Asphalt Application at Temporary Sites**.

Pollutants of concern include toxic hydrocarbons, toxic organics, suspended solids, heavy metals, pH, oils, and greases.

Pollutant Control Approach: Employees must be educated about the need to control site activities. Control leaks, spills, and loose material. Utilize good housekeeping practices.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in building repair, remodeling, and construction:

- Employees must be educated about the need to control site activities to prevent stormwater pollution, and also trained in spill cleanup procedures.
- Spill cleanup materials, appropriate to the chemicals being used on site, must be available at the work site at all times.
- The work site must be cleaned up at the end of each workday, with materials such as solvents put away indoors or covered and secured so that vandals will not have access to them.
- The area must be swept daily to collect loose litter, paint chips, grit, and dirt.
- Absolutely no substance can be dumped on pavement, on the ground, or in or toward storm drains, regardless of its content, unless it is water only.
- For wood treating activities drop cloths must be placed where space and access permit before the work begins. Additional drip pans must be used in areas where drips are likely to occur that cannot be protected with a drop cloth.
- Ground or drop cloths must be used underneath scraping, sandblasting work. Ground cloths, buckets, or tubs must also be used anywhere that work materials are laid down.
- Incidental cleaning of paint brushes and other tools that are covered with water-based paints must be cleaned in sinks connected to sanitary sewers or in portable containers that can subsequently be dumped into a sanitary sewer drain. Brushes and tools covered with non-water-based finishes or other materials must be cleaned in a manner that enables collection of used solvents for recycling or proper disposal and cannot be discharged to the sanitary sewer. See BMP S.2 in Chapter 5 for disposal options.

- Storm drain covers or similarly effective devices must be used if dust, grit, washwater, or other pollutants may escape the work area. This is particularly necessary on rainy days. The cover or containment device shall be placed over the storm drain at the beginning of the workday, and accumulated dirty runoff and solids must be collected and disposed of before removing the cover at the end of the day.

Suggested BMPs
The following BMPs are not required, but can provide additional pollution protection:

- Recycle materials whenever possible.
- Light spraying of water on the work site can control some of the dust and grit that can blow away. Oils must never be used for dust control. Never spray to the point of runoff from the site.
- Activities such as tool cleaning should occur over a ground cloth or within a containment device such as a tub.

Section A6

Dust Control and Soil and Sediment Control

A6.1 Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

Description of Pollutant Sources: Dust can cause air and water pollution problems particularly at demolition sites, disturbed land areas, and unpaved roadways and parking lots.

Pollutant Control Approach: Minimize dust generation and apply environmentally friendly and government approved dust suppressant chemicals, if necessary.

Required BMPs

- Sprinkle or wet down soil or dust with water as long as it does not result in a wastewater discharge (Figure 4.21).

Figure 4.21. Dust Suppression by Water Spray.

- Use only local and/or state government approved dust suppressant chemicals such as those listed in Ecology publication No. 96-433, “Techniques for Dust Prevention and Suppression.” Apply according to the manufacturer’s recommendations. See also BMP C126, Polyacrylamide for Soil Erosion Protection, in Volume II of this manual.

- 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.

- Avoid driving over treated areas as this will break the crust formed by the dust suppressant, rendering it less effective.

- Apply stormwater containment to prevent the conveyance of sediments and/or dust suppressant chemicals into storm drains or receiving waters.

- The use of motor oil for dust control is prohibited. Take care when using lignin derivatives and other high BOD chemicals in areas susceptible to contaminating surface water or groundwater.

- Consult with the Ecology Southwest Regional Office on discharge permit requirements if the dust suppression process results in a wastewater discharge to the ground, groundwater, storm drain, or surface water.

Suggested 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 chemicals approved for that use.

- 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.

Suggested BMPs for Dust Generating Areas

- Prepare a dust control plan. Helpful references include: Control of Open Fugitive Dust Sources (EPA-450/3-88-088) and Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures (EPA-450/2-92-004).

- Limit exposure of soil (dust source) as much as feasible.

- Stabilize dust-generating soil by growing and maintaining vegetation, mulching, topsoiling, and/or applying stone, sand, or gravel.

- Apply windbreaks in the soil such as trees, board fences, tarpaulin curtains, bales of hay, etc.

- Cover dust-generating piles with wind-impervious fabric, or equivalent material.

Additional information on dust control can be found in Volume II of this manual and the Olympic Region Clean Air Agency.

A6.2 Dust Control at Manufacturing Sites

Description of Pollutant Sources: Industrial material handling activities can generate considerable amounts of dust that can contaminate stormwater. This dust is typically removed using exhaust systems. Dusts can be generated at cement and concrete product mixing facilities, and wherever powdered materials are handled. Particulate materials that are of concern to air pollution control agencies include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

Pollutant Control Approach: Prevent dust generation and emissions where feasible, regularly cleanup dust that can contaminate stormwater, and convey dust contaminated stormwater to proper treatment.

Required BMPs

- Clean powder material handling equipment and vehicles as needed to remove accumulated dust and residue.
- 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 in the recommended manner, approved dust suppressants such as those listed in Ecology publication "Techniques for Dust Prevention and Suppression," No. 96-433 (Ecology 1996). 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 the Ecology Southwest Regional Office or Thurston County.

Suggested BMPs

- In manufacturing operations, train employees to handle powders carefully to prevent generation of dust.
- Use dust filtration/collection systems such as bag house filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Control of zinc dusts in rubber production is one example.
- Use water spray to flush dust accumulations to sanitary sewers where allowed by Thurston County or to other appropriate treatment system. Contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for details.
- Install sedimentation basins, wet ponds, wet vaults, vegetated filter strips, or equivalent sediment removal BMPs to remove total suspended solids (TSS). Refer to Volume V Runoff Treatment BMPs for more information about these BMPs.
- Additional information on dust control can be found in Volume II of this manual.

A6.3 Soil Erosion and Sediment Control at Industrial Sites

Description of Pollutant Sources: Industrial activities on soil areas, exposed and disturbed soils, steep grades, 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 total suspended solids caused by eroded soil.

Required BMPs

- Apply one or more of the following cover practices:
  - Vegetative cover such as grass, trees, or shrubs on erodible soil areas
  - Covering with mats such as clear plastic, jute, or synthetic fiber; and/or
  - Preservation of natural vegetation including grass, trees, shrubs, and vines.
- Apply one or more of the following structural practices to control sediment:
  - Vegetated swale,
  - Dike,
  - Silt fence,
  - Check dam,
  - Gravel filter berm,
  - Sedimentation basin
  - Proper grading

    For design information refer to Volume II, Standards and Specifications for BMPs.

Section A7

Other Activities

A7.1 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: Prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

Required 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 animals are kept in unpaved and uncovered areas, the ground must either have vegetative cover or some other type of ground cover, such as mulch.
- 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.

A7.2 Keeping Livestock in Stables, Pens, Pastures, or Fields

This activity applies to management of all types of livestock. Manure from livestock can pollute stormwater and local water bodies. Animals that are not fenced off from creeks and streams can also cause severe erosion of stream banks, which in turn can silt up fish spawning areas. Certain areas of Thurston County require the filing of a livestock management plan. Contact the Thurston County Conservation District at (360) 754-3588 for more information and assistance in preparing such a plan. Thurston County/WSU Cooperative Extension at (360) 867-2151 also has literature to help you more effectively manage your pastures and livestock. Feedlots containing more than 100 animals may require an NPDES permit for Concentrated Animal Feeding Operations.

Pollutants of Concern: Nutrients, suspended solids, oxygen demanding substances (i.e., BOD and COD), fecal bacteria.

Required BMPs
The following BMPs or equivalent measures are required of all businesses and citizens keeping livestock in stables, pens, pastures, or fields:

- Restrict animal access to creeks and streams, preferably by fencing. There are ways to fence and still allow animals drinking access to the stream, without allowing bank trampling and minimizing fecal inputs into the stream. Contact the Thurston County Conservation District for more information on fencing, including how to get money to provide such fencing. They can also help you with replanting the stream banks to prevent further erosion. A minimum setback of 20 feet from the center of the streambed will be required on each side. Major tributaries and large farm ditches should be fenced as well.

- Dispose of manure from stables and pens properly. Do not pile it where rain will wash nutrients into constructed or natural stormwater drainage systems that leave your land. Place it within a bermed area to contain runoff, or cover it with a tarpaulin. It may also be placed in a grassy area as far from watercourses as possible, so that any seepage has a chance to be filtered and absorbed by the grasses before reaching a creek or stream.

Suggested BMPs

- On fields where animals are pastured, a rotational grazing system should be developed. This would mean that a field would need to be divided into a minimum of four equal units, and the stock rotated from one unit to another. The stock should not be allowed onto the pastures until the grass reaches a minimum height of 6 inches. They should be moved to the second field when the grass height is down to approximately 3 inches. Each field should be allowed to recover for a period of 21 to 28 days prior to regrazing.

- Monitor grazing carefully. If 90 percent of the plants' leaves are removed, the roots will stop growing for at least 18 days. If only 40 percent or less of the leaves are removed, the roots will continue to grow. Not only will overgrazing or overstocking limit pasture production, but the pastures become vulnerable to the invasion of unpalatable or poisonous weed species such as tussock, moss, buttercup, tansy ragwort, and thistle.

- Grazing should be discontinued starting in early October. Neither the animals nor the fields benefit from grazing during the winter. Since the plants are basically dormant, the protein content is extremely low. The fields become compacted and rutted, thus reducing soil tilth, which in turn reduces summer grass yields. Fence off a small portion of your pasture to sacrifice during winter, and feed hay and grain instead of grazing.
- Proper pasture management should also include the practices of clipping and harrowing the fields after the stock has been removed. This is done to assure uniform growth and to avoid excessive damage to the stand and a consequent reduction in yields. This would also be the optimum time to apply fertilizer, such as manure, to the fields in a manner which does not contribute to runoff.
- Weed control is very important for maintaining highly productive pastures. If you follow the practices described above, you will go a long way toward effective weed control. You may occasionally need to apply herbicides, but do so judiciously. Remember that it is much easier to take care of a few thistles early on than it is to get rid of a field full.

A7.3 Log Sorting and Handling

Description of Pollutant Sources: Log yards are 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, oxygen demanding substances (i.e., BOD and COD), settleable solids, total suspended solids (including soil), high and low pH, heavy metals, pesticides, wood-based debris, and leachate.

The following are pollutant sources:

1. Log storage, rollout, sorting, scaling, and cutting areas
2. Log and liquid loading areas
3. Log sprinkling
4. Debarking, bark bin, and conveyor areas
5. Bark, ash, sawdust and wood debris piles, and solid wastes
6. Metal salvage areas
7. Truck, rail, ship, stacker, and loader access areas
8. Log trucks, stackers, loaders, forklifts, and other heavy equipment
9. Maintenance shops and parking areas
10. Cleaning areas for vehicles, parts, and equipment
11. Storage and handling areas for hydraulic oils, lubricants, fuels, paints, liquid wastes, and other liquid materials
12. Pesticide usage for log preservation and surface protection
13. Application of herbicides for weed control
14. Contaminated soil resulting from leaks or spills of fluids.

Ecology's Baseline General Permit Requirements
Industries with log yards 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 Suggested operational, source control, and treatment BMPs are presented in detail in Ecology's Guidance Document: Industrial Stormwater General Permit Implementation Manual for Log Yards, publication No. 0410-031. It is recommended that all log yard facilities obtain a copy of this document.

A7.4 Boat Building, Mooring, Maintenance, and Repair

Description of Pollutant Sources: Sources of pollutants at boat and ship building, repair, and maintenance facilities at boatyards, shipyards, ports, and marinas include pressure washing, surface preparation, paint removal, sanding, painting, engine maintenance and repairs, and material handling and storage, if conducted outdoors.

Potential pollutants include spent abrasive grits, solvents, oils, ethylene glycol, washwater, paint over-spray, cleaners/detergents, anti-corrosive compounds, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Proper application of anti-fouling paints is of particular concern in marine environments. Pollutant constituents include total suspended solids, oil and grease, organics, copper, lead, tin, and zinc. Related activities are covered under the following activity headings in this volume, and other BMPs provided in this volume:

A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures

A2.2 Fueling at Dedicated Stations

A7.15 Spills of Oil and Hazardous Substances

Pollutant Control Approach: Apply good housekeeping, preventive maintenance, and cover and contain BMPs in and around work areas.

Required BMPs

The following BMPs or equivalent measures are required of all businesses, public agencies, and private boat owners engaged in boat building, mooring, maintenance and repair that are not covered by Ecology's NPDES Boatyard General Permit:

- Maintenance and repair activities that can be moved on-shore must be moved accordingly. This action reduces some of the potential for direct pollution impact on water bodies.
- Blasting and spray painting activities must be sheltered by hanging tarps to block the wind and prevent dust and overspray from escaping. Move the activity indoors if possible. See Chapter 7 for details on Olympic Region Clean Air Agency (ORCAA) limitations.
- Ground cloths must be used for collection of drips and spills in painting and finishing operations, and paint chips and used blasting sand from sand blasting (Figure 4.22).
- Collect spent abrasives regularly and store under cover to await proper disposal.

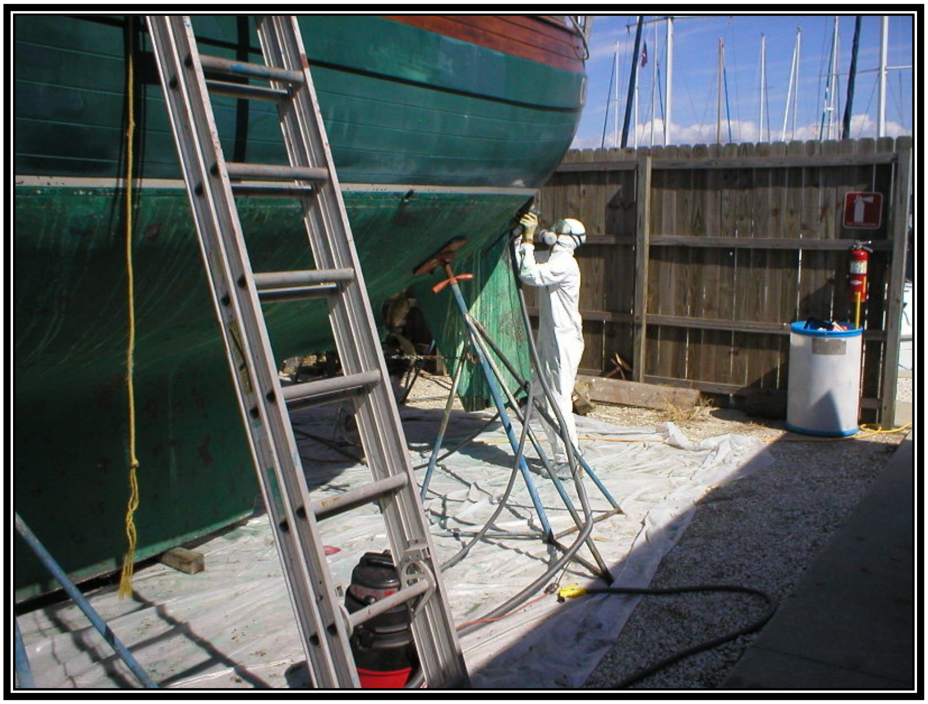

Figure 4.22. Drop Cloth Used During Hull Sanding.

- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.
- Bilge water must be collected for proper disposal rather than discharged on land or water. See BMP S.2 in Chapter 5 for detail on disposal options. Several companies are available for bilge pumpout services. The problem can be avoided if oil-absorbent pads are used to capture the oil in the bilge water before or during pumping. If pads are used, they must be recycled or properly disposed of.
- Ballast water that has an oily sheen on the surface must be collected for proper disposal rather than discharged on land or water. See BMP S.2 in Chapter 5 for details on disposal options.
- Maintenance yard areas must be swept and cleaned, without hosing down the area, at least once per week or as needed. This prevents sandblasting materials, scrapings, paint chips, oils, and other loose debris from being carried away with stormwater. The collected materials must be disposed of properly. See BMP S.2 in Chapter 5 for disposal options.
- Docks and boat ramps must be swept at least once per week or as needed, and the collected materials must be disposed of properly. Dry docks must be swept before flooding.

- Paint and solvent mixing, fuel mixing and similar handling of liquids shall be performed on shore, or such that no spillage can occur directly into surface water bodies.

- Routine cleanup materials such as oil-absorbent pads, brooms, dustpans, mops, buckets, and sponges must be stocked near docks.

- When washing your boat in the water, no pollutants, including soaps or detergents, may enter the stormwater drainage system or receiving water.

- Comply with BMP A2.3 and A4.2 if engine repair and maintenance are conducted.

- In the event of an accidental discharge of oil or hazardous material into waters of the state or onto land with a potential for entry into state waters, immediately notify the yard, port, or marina owner or manager, Ecology, and the National Response Center at 1-800-424-8802 (24-hour). If the spill can reach or has reached marine waters, contact the U.S. Coast Guard at (206) 217-6200.

Suggested BMPs

- Boat construction and structural repair activities should be covered with drop cloths or other protection to avoid grit, paint, or other materials from contaminating stormwater.

- Consider instead washing the boat in a suitable controlled area (see BMP A1.3- Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures) while it is out of the water.

- Materials such as paints, tools, and ground cloths should be stored indoors or in a covered area when not in use.

- Select the least toxic anti-fouling paint available.

- Boat interiors should be routinely cleaned, with proper disposal of collected materials, so that accumulations of water drained from them are not contaminated.

- Use sanders that have dust containment bags and avoid sanding in windy conditions.

- All used oil should be recycled if feasible. Most marinas now offer used oil recycling services. To dispose of filters, let drain 24 hours, then double wrap in plastic and dispose of in the regular garbage, or take them to the Thurston County Waste and Recovery Center, HazoHouse for disposal and recycling. Pending state legislation may make disposal in the garbage illegal, so contact the HazoHouse at (360) 786-5494 for current information.

- Use one of the following treatment BMPs when paint chips or blasting grit are prevalent in the work area:

    - IN-01: Infiltration basin

- WP-02: Wet pond or WP-03 wet vault
- WP-01: Constructed wetland
- BF-01,02,03: Vegetated biofilter
- MF-04: Filtration with media designed for the pollutants that are present
- Equivalent BMP (see Volume V).

A7.5 Logging

Description of Pollutant Sources: This activity covers logging activities that fall under the Washington State Forest Practices Act category of Class IV general forest practices. These are situations where timber harvesting is done in the process of converting forest lands into other land uses, such as home and business construction. Stormwater runoff from bare ground exposed during logging contains large amounts of dirt and other pollutants. This material can clog ditches and stream channels, thus reducing carrying capacity and increasing flooding, as well as smothering spawning beds for fish. Simply controlling runoff and not allowing it to leave the site will prevent these harmful effects. Clearing and grading activities are covered in detail in Volume II of this manual.

Coverage under Ecology's construction stormwater general permit is required for construction sites that result in the disturbance of one acre or more of land. Compliance with the Construction Stormwater Pollution Prevention requirements in Ecology's manual is required, as applicable. Virtually all logging operations will require a permit from the Washington State Department of Natural Resources (WDNR). Sensitive/critical areas and wetlands ordinances for Thurston County also contain requirements for logging activities in the vicinity of water bodies.

Pollutants of concern include suspended solids, oils and greases, oxygen demanding substances (i.e., BOD and COD), nutrients, toxic organic compounds, and heavy metals.

Pollutant Control Approach: Maintain required buffers adjacent to critical areas, including streams and wetlands. Keep sediments out of water bodies and off paved areas.

Required BMPs

- Vegetation along stream corridors, and adjacent to other water bodies and wetlands, must be preserved. Maintenance of a vegetated buffer enables filtration of most of the pollutants of concern for this activity. The above-mentioned ordinances contain specific requirements for buffer setbacks.
- Logging access roads must have a crushed rock or spall apron construction entrance where they join the pavement to prevent sediments from being tracked onto the pavement.
- On-site fueling and maintenance operations must follow the required BMPs as outlined in A2.4 Mobile Fueling of Vehicles and Heavy Equipment; A2.3 Engine Repair and Maintenance; and A.4.7 Storage of Liquid or Dangerous Waste Containers.

Suggested BMPs

- Erosion potential can be reduced by avoiding logging on steep slopes.
- If access roads are constructed for logging, they should be provided with drainage ditches that divert runoff into vegetated areas or stormwater treatment systems.
- Plant vegetated buffers in areas where they are already lost downslope of proposed logging areas, with sufficient lead time to allow for effective growth.

A7.6 Mining and Quarrying of Sand, Gravel, Rock, Minerals, Peat, Clay, and Other Materials

Description of Pollutant Sources: This activity applies to surface excavation and on-site storage of sand, gravel, and other materials that are mined. All mining operations that have stormwater runoff from the site are required to apply for a NPDES permit with Ecology. Ecology has specific BMPs required by the permit. Some additional BMPs to help meet Ecology's discharge performance standards are listed below.

Pollutants of concern are suspended solids, nutrients, pH, and metals.

Pollutant Control Approach: Provide containment and or cover for any on-site storage areas to prevent run-on and discharge of suspended solids and other pollutants.

Suggested BMPs

- If the material is appropriate, use excavated spoil material to form compacted berms along downslope sides of the site to contain runoff. Berms should be seeded to promote growth of grass or other vegetation to limit erosion from the berms. Safety considerations must be examined to prevent flooding due to berm failure.
- Semi-permanent stockpiles should be seeded to promote vegetation growth to limit erosion from the stockpiles.
- Use sedimentation basins to promote settling of suspended solids, or infiltration basins to filter suspended solids, to cleanup runoff before it leaves the site. See Volume V for a further discussion of treatment BMPs.
- Use anchored tarps to cover stockpiles at small-scale mining operations if there is a potential for contaminated stormwater to leave the site.

A7.7 Swimming Pool and Spa Cleaning and Maintenance

Description of Pollutant Sources: This activity applies to all municipal and commercial swimming pools and spas, including county health department—regulated facilities. Pools and spas at hotels, motels, and apartment and condominium complexes are covered here. Pools at single-family residences are covered in Chapter 3 of this volume. Commercial pool and spa cleaning services must follow these required BMPs for all pools they service.

Pollutants of concern include nutrients, suspended solids, chlorine, pH, and chemical oxygen demand (COD).

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 stormwater 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. Dispose of pool or spa water to the sanitary sewer after getting preapproval from the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.

Required BMPs

- The preferred method of pool or spa water disposal is to the sanitary sewer. If a sanitary sewer is available, all county health department—regulated facilities are required to connect for draining and backwash. Contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for specific instructions on allowable flow rates and timing before starting to drain the pool. Never discharge pool water to a septic system, as it will cause the system to fail.
- If discharge to the sanitary sewer is not possible, pool and spa water may be discharged to a ditch or stormwater drainage system if the discharge water is:

- Dechlorinated to a concentration of 0.1 ppm or less (some guidance on dechlorination is provided in the Department of Health's Water System Design Manual, Revised 12/09, DOH Publication 331-123. The Department of Health manual further references AWWA. 1999b. C651 – AWWA Standard for Disinfecting Water Mains. American Water Works Association, Denver, CO. and AWWA. 2002. C652 – AWWA Standard for Disinfecting Water Storage Facilities. American Water Works Association, Denver, CO. for more details.) Contact a pool chemical supplier to obtain the neutralizing chemicals needed),
- pH-adjusted if necessary,
- Reoxygenated,
- Volumetrically and velocity controlled to prevent resuspension of sediments.
- 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 Thurston County stormwater system. You are required to contact Thurston County Department of Resource Stewardship, Water Resources Division at (360) 754-4681 prior to discharge for instructions on allowable flow rates for the system or ditch that is being discharged to. Neutralizing chemicals are available for dechlorinating water. Letting the pool or spa "sit" may also reduce chlorine levels. Use a test kit to determine if the concentration has reached zero.
- State law may allow discharges of pool water to the ground. However, the water must not cross property lines or impact neighboring properties, and a satisfactory means for distributing the water to the ground must be used so there is no runoff. Check with Ecology prior to release.
- Diatomaceous earth used in pool filters cannot be discharged to surface waters, stormwater drainage systems, or septic systems, or on the ground.
- Ensure that the pool/spa/hot tub/fountain system is free of leaks and operates within the design parameters.
- Do not provide any permanent links to stormwater 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.

Suggested BMPs

- Hire a professional pool-draining service to collect all pool water for off-site disposal.

A7.8 De-icing and Anti-icing Operations for Airports and Streets

Description of Pollutant Sources: De-icing and/or anti-icing compounds are used on highways, streets, airport runways, and on aircraft to control ice and snow. Typically ethylene glycol and propylene glycol are de-icing chemicals used on aircraft. De-icing chemicals commonly used on highways and streets include calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The de-icing and anti-icing compounds become pollutants when they are conveyed to storm drains or to surface water after application where they deplete oxygen in the receiving water. Leaks and spills of these chemicals can also occur during their handling and storage.

BMPs for Airport De/anti-icing Operations

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 anti-icing chemicals must be consistent with aviation safety and the operational needs of the aircraft operator.

Required BMPs for Aircraft:

- Conduct aircraft de-icing or anti-icing applications in impervious containment areas. Collect aircraft de-icing spent chemicals, such as glycol, draining from aircraft in de-icing or anti-icing application areas and convey to a sanitary sewer, treatment, or other approved disposal or recovery method. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 to obtain permit for discharges to sanitary sewer. Divert de-icing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.
- Do not discharge spent de-icing chemicals or stormwater contaminated with aircraft de-icing chemicals from application areas including gate areas, into storm drains. No discharge should occur to surface water or groundwater, directly or indirectly.
- Transfer de-icing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas (see Storage of Liquids in Aboveground Tanks).

Suggested BMPs for Aircraft:

- Establish a centralized aircraft de/anti-icing facility, if feasible and practicable, or in designated areas of the tarmac equipped with separate collection drains for the spent de-icing liquids.
- Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler, if practicable.

Required 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 BMP Storage

or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this volume. Consider other material storage and transfer approaches only if the anti-icing the material cannot reach surface or groundwater.

Suggested BMPs for Airport Runways/Taxiways:

- Include limits on toxic materials and phosphorous in the specifications for de/anti-icing chemicals, where applicable.
- Consider using anti-icing materials rather than de-icing if it will result in less adverse environmental impact.
- Select cost-effective de/anti-icing chemicals that cause the least adverse environmental impact.

BMPs for Streets/Highways

Required BMPs for Streets/Highways:

- Select de and anti-icing chemicals that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Where practicable, use roadway de-icing, such as calcium magnesium acetate, potassium acetate, or similar materials that cause less adverse environmental impact than urea and sodium chloride.
- Store and transfer de-icing and anti-icing materials on an impervious containment pad in accordance with BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this volume.
- Sweep/cleanup accumulated de-icing and anti-icing materials and grit from roads as soon as possible after the road surface clears.

Suggested BMPs for Streets/Highways:

- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Include limits on toxic metals in the specifications for anti-icing chemicals.

A7.9 Roof and 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, building vents, and other air emission sources. Vapors and entrained liquid and solid droplets/particles have been identified as potential pollutants in roof/building runoff. Metals, solvents, acidic/alkaline pH, oxygen demanding substances (i.e., BOD and COD), and organics are some of the pollutant constituents identified.

Ecology has performed a study on zinc in industrial stormwater. The study is presented in Ecology Publication 08-10-025 *Suggested Practices to reduce Zinc Concentrations in Industrial Stormwater Discharges,* Web site: <fortress.wa.gov/ecy/publications/publications/0810025.pdf>. 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.

Required BMPs

- If leachates and/or emissions from buildings are suspected sources of stormwater pollutants, then sample and analyze the stormwater draining from the building.
- If residual material is present, sweep the area routinely to remove any zinc residuals.
- 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.
- Bare galvanized metal shall not be used for materials that convey stormwater, such as roofs, canopies, siding, gutters, downspouts, roof drains, and pipes. Any galvanized materials shall have an inert, non-leachable finish, such as baked enamel, fluorocarbon paint (such as Kynar or Hylar), factory-applied epoxy, pure aluminum, or asphalt coating. Acrylic paint, polyester paint, field-applied, and Galvalume coatings are not acceptable. Paint/coat the galvanized surfaces as described in Ecology Publication # 08-10-025.

A7.10 Urban Streets

Description of Pollutant Sources: Streets can be the sources of vegetative debris, paper, fine dust, vehicle liquids, tire wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products. Street surface contaminants have been found to 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.

Suggested 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 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 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. They use 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 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, and rainfall patterns.
- Train operators in those factors that result in optimal pollutant removal. These factors include controlling 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 unimpeded by parked vehicles.
- Establish programs for prompt vacuum sweeping, removal, and disposal of debris from special events that will generate higher than normal loadings. This includes leaf-fall during the autumn.
- Disposal of street sweeping solids must comply with "Recommendations for Management of Road maintenance materials" described in Appendix IV-C of this volume.
- Inform citizens about the importance of eliminating yard debris, oil, and other wastes in street gutters in order to reduce street pollutant sources.

A7.11 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 ; fueling; outside material storage; the erosion and loss of soil particles from the railroad bed; maintenance and repair activities at railroad terminals, switching yards, and maintenance yards; and herbicides used for vegetation management.

Waste materials can include waste oil, solvents, degreasers, antifreeze solutions, radiator flush, acids, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludges, machine chips with residual machining oil, and toxic fluids/solids lost during transit. Potential pollutants include oil and grease, total suspended solids, oxygen demanding substances (i.e., BOD and COD), 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.

Required BMPs

- Implement the applicable BMPs in this chapter depending on the pollution 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 (BMP A2.1).
- During maintenance do not discard debris or waste liquids along the tracks or in railroad yards.

In areas subjected to leaks/spills of oils or other chemicals, convey stormwater to appropriate treatment such as a sanitary sewer (if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708), to an API or coalescent plate oil/water separator for floating oils, or other appropriate treatment BMP (as approved by Thurston County). See Volume V.

A7.12 Maintenance of Public and Utility Corridors and Facilities

Description of Pollutant Sources: Passageways and equipment at petroleum product, natural gas, and water pipelines and 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 that is removed from underground transformer vaults, and leaks/spills from petroleum pipelines. The following are potential pollutants: oil and grease, total suspended solids, oxygen demanding substances (i.e., BOD and COD), organics, PCB, pesticides, and heavy metals.

Pollutant Control Approach: Control of fertilizer and pesticide applications, soil erosion, and site debris that can contaminate stormwater.

Required BMPs

- Implement BMPs included in Chapter 4, A.6 Landscaping and Lawn/Vegetation Management and in Chapter 7, Section 7.2, R.6 Pesticide Regulations.

- 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 sediment 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 Chapter 7, Section 7.2-R2.)

- Within utility corridors, prepare maintenance procedures and an implementation schedule that provides for vegetative, gravel, or equivalent cover that minimizes bare or thinly vegetated ground surfaces within the corridor to prevent the erosion of soil.

- 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 many 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 from Section A4 of this volume, Storage Activities, for the storage of waste materials that can contaminate stormwater.

Suggested 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. 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.

A7.13 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 ESC (refer to Activity A3.6 Landscaping and Lawn/Vegetation Management).

Required 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 vegetative cover to be re-established by the next wet season, thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter.
- 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 top of the slope of the ditch as long as it does not block the sightlines required for safety.
- Maintain diversion ditches on top of cut slopes constructed to prevent slope erosion by intercepting surface drainage to retain their diversion shape and capability.
- Do not leave ditch cleanings on roadway surfaces. Sweep, collect, and dispose of dirt and debris remaining on the pavement at the completion of ditch cleaning operations.
- 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 it is not dangerous waste but contaminants are present, consult with the Thurston County Health Department 360-867-2664 for disposal options.
- Inspect culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to those culverts conveying perennial and/or salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

Suggested BMPs

- Install biofiltration swales, bioinfiltration swales and filter strips to treat roadside runoff wherever practicable and use engineered topsoils wherever necessary to maintain adequate vegetation (CH2M Hill 2000). Consider using the Media Filter Drain BMP where adequate slope and level of traffic permit it. These systems can improve infiltration and stormwater pollutant control upstream of roadside ditches. See Volume V of this manual, Runoff Treatment BMPs, for additional information about biofiltration swales, bioinfiltration swales, filter strips, and media filter drains.

- 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 the Thurston County Health Department 360-867-2664 to discuss use or disposal options for the soil portion. For more information, please see "Recommendations for Management of Material Generated from Road Maintenance Activities," in Appendix IV-C of this volume.

A7.14 Maintenance of Stormwater Drainage and Treatment Facilities

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 and water separators, bioretention, 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 oil from stormwater collection, conveyance, and treatment systems to obtain proper operation.

Required BMPs

Maintain stormwater treatment facilities per the operations and maintenance (O&M) procedures presented in Volume V, Appendix V-C, in addition to the following BMPs:

- Inspect and clean treatment BMPs, conveyance systems, and catch basins (Figure 4.23) as needed, and determine whether improvements or maintenance are needed.
- 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 storm sewer system, by methods like those found in C-220, Storm Drain Inlet Protection.
- Regularly remove debris and sludge from BMPs used for flow control, treatment, etc. and truck to an appropriate local or state government approved disposal site.
- Clean catch basins in accordance with the information provided in Volume V, Appendix V-C. Additional information is also included in Chapter 5 of this volume, BMP S.9 Cleaning Catch Basins.
- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catch basin.
- Install monuments on storm drain inlet rims that state: “Dump No Waste - Drains to Groundwater,” “Streams,” “Lakes,” where possible (Figure 4.24).

Figure 4.23. Catch Basin Cleaning with a Vacuum Truck.

Figure 4.24. "No Dumping" Storm Drain Button.

- Disposal of sediments and liquids from the catch basins must comply with "Recommendations for Management of Road maintenance materials" described in Appendix IV-C of this volume.
- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for details on detecting and eliminating these connections.
- Select additional applicable BMPs from this chapter depending on the pollutant sources and activities conducted at the facility. Those BMPs include:
  - A4.7 – Storage of Liquid, Food Waste, or Dangerous Waste Containers
  - A6.3 – Soil ESC at Industrial Sites
  - A7.10 – Urban Streets
  - A7.15 – Spills of Oil and Hazardous Substances.

A7.15 Spills of Oil and Hazardous Substances

Description of Pollutant Sources: Federal law 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 Control Plan (SPECP). The SPECP is required if the above ground storage capacity of the facility is 1,320 gallons or more of oil, or any single container with a capacity in excess of 660 gallons and which, due to their 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(1)(i)}.

State Law requires owners of businesses that produce dangerous wastes to have a SPECP. These businesses should refer to Chapter 7, Section 7.2, R-2. 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 SPECP.

Required BMPs

- Prepare a 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 to be used in the event of a spill, such as notifying key personnel. Agencies such as Ecology, Thurston County Fire Marshal, the local Fire District (call 911), Washington State Patrol, Thurston County, U.S. Coast Guard, and the U.S. EPA 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 and Thurston County if a spill may reach sanitary or storm sewers, groundwater, or surface water, in accordance with federal and Ecology spill reporting requirements.
- Immediately cleanup 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 (Figure 4.25).

(Photo courtesy of Seattle Public Utilities)

Figure 4.25. Example of Spill Kit Contents.

Suggested 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.

Chapter 5 - General Source Control Best Management Practices

This chapter describes source control BMPs recommended in Chapters 2 and 4, organized by BMP type.

This chapter describes BMPs common to several activities described in Chapters 2 and 4. This chapter organizes BMPs by general activity—for example, BMP S.2 describes proper waste disposal applicable to several activities, such as engine repair (A 2.3), concrete mixing (A 3.1), and building demolition (A 5.1).

5.1 Index of BMP Descriptions

BMP	BMP Categories
S.1	Eliminate Illicit Stormwater Drainage System Connections
S.2	Dispose of Collected Runoff and Waste Materials Properly
S.3	Connect Process Water Discharges to a Sanitary Sewer, Holding Tank, or Water Treatment System
S.4	Cover the Activity with a Roof or Awning
S.5	Cover the Activity with an Anchored Tarpaulin or Plastic Sheet
S.6	Pave the Activity Area and Slope to a Sump or Holding Tank
S.7	Surround the Activity Area with a Curb, Dike, or Berm or Elevate the Activity
S.8	Implement Integrated Pest Management (IPM) Measures
S.9	Clean Catch Basin

5.2 Source Control BMPs

S.1 Eliminate Illicit Storm Drain Connections

Many businesses and residences hooked internal building drains, sump overflows, process wastewater discharges, and even sanitary sewer and septic system pipes to the storm drain in the past, allowing a variety of pollutants to flow directly to receiving waters instead of the sanitary sewer or septic system. Frequently, these connections are unknown to the current owner, and do not appear on any plans for the site. Because of the pollution potential these connections represent, the Environmental Protection Agency, under the mandate of the NPDES stormwater permits, has made elimination of illegal connections a top priority.

All businesses and residences in Thurston County must examine their plumbing systems to identify any potential illicit connections. Start with an examination of the site plans, to better understand what piping systems were initially installed, making piping that does not appear on the plan a priority for investigation. Wherever toilets, sinks, appliances, showers and bathtubs, floor drains, industrial process waters, or other indoor activities are connected to the stormwater drainage system, immediately reroute them to the sanitary or septic system, holding tanks, or process treatment system.

Industries and businesses that have been issued an NPDES Baseline General Permit by Ecology, and are allowed specific discharges under that permit are exceptions to this requirement. Please refer to R.4 in Chapter 7 to determine if your type of business is required to have a NPDES permit.

If sanitary facilities (such as toilets) are connected to the stormwater drainage system, you must obtain a permit from your local sewer utility and reroute them to the sanitary sewer. If sanitary service is not available, contact the Thurston County Public Health and Social Services Department at (360) 867-2673 for septic permits.

Dye testing with a non-toxic dye is one way to determine where a pipe or structure drains if not obvious by observations or on plans. The dye is put into the structure and flushed with some water. Observations are then made at ends-of-pipes, drainage ditches, catch basins, and manholes to look for the color coming through. Contact Thurston County Department of Resource Stewardship, Water Resources Division (360) 754-4681 if you need assistance in locating structures adjacent to your property.

Smoke testing can also help detect illegal connections and is best done by qualified personnel. To conduct smoke testing, shut off all indoor discharges, place a smoke bomb or other smoke-generating device in a storm drain manhole, and force air in after it. Station personnel at each suspect drain location to observe if smoke is coming out. Identify smoking drains for future rerouting.

Drains which are found to connect to the stormwater drainage system must either be permanently plugged or disconnected and rerouted as soon as possible. Plug unused drains with concrete or similar permanent materials. If a drain pipe is to be rerouted and a sanitary sewer services the property, then the local sewer provider must be contacted. Restrictions on certain types of discharges, particularly industrial process waters, may require pretreatment of discharges before entering the sanitary sewer. It is the responsibility of the property owner or business operator to follow through on rerouting illicit storm drainage connections to the sanitary sewer.

If the property is not served by a sanitary sewer, alternate measures will be necessary. If the discharge is simply domestic waste, a septic system may be feasible. If it is necessary to install a septic system, the proper permits will need to be obtained from the Thurston County Public Health and Social Services Department at (360) 867-2673. If the discharge is anything other than domestic waste, then a holding tank or on-site treatment will be necessary. Contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for specific directions for installation and disposal.

S.2 Dispose of Collected Runoff and Waste Materials Properly

Every business and residence in Thurston County must dispose of solid and liquid wastes and contaminated stormwater properly. There are generally four options for disposal depending on the type of materials. These options include:

- Sanitary sewer and septic systems
- Recycling facilities
- Municipal solid waste disposal facilities
- Hazardous waste treatment, storage, and disposal facilities.

Many liquid wastes and contaminated stormwater (depending on the pollutants and associated concentrations present) may be put into the sanitary sewer, subject to approval by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.

If wastes cannot be legally discharged to a sanitary sewer or septic system, one of the other three disposal options must be used. Sumps or holding tanks may be useful for storing liquid wastes temporarily. The contents must be disposed of in the sanitary sewer or at a dangerous waste facility depending on the nature of the waste.

Recycling facilities are a recommended option for many commercial and household items, including used oils, used batteries, old equipment, glass, some plastics, metal scrap materials, solvents, paints, wood and land clearing wastes, and various other solid wastes. Solid wastes that cannot be recycled and that are not hazardous must be disposed of at a licensed municipal solid waste disposal facility. The list in Chapter 8 of this volume has the phone numbers and addresses of these facilities in Thurston County.

Dangerous and hazardous wastes must be properly transported to an appropriate hazardous waste treatment, storage, and disposal facility. Included in Chapter 8 is a list of companies dealing in these activities.

Costs of disposal vary considerably from option to option. Especially in the case of dangerous wastes, different types of wastes should be kept segregated. Disposal costs are usually determined by the most hazardous or difficult to dispose of waste present, so you can keep your costs down by not mixing wastes. The Thurston County Department of Public Works (360) 867-2300 can help you determine the best disposal options for your waste.

S.3 Connect Process Water Discharges to a Sanitary Sewer, Holding Tank, or Wastewater Treatment System

This BMP is a core requirement for all industrial and commercial activities that generate contaminated process wastewater, such as washing activities, composting activities, and production and processing activities. The water used in these activities cannot drain to surface waters or groundwater untreated. Process water must drain to a sanitary sewer, holding tank, or wastewater treatment system, or it can be recycled.

The first priority for these businesses is discharge of process water to a sanitary sewer via a new or existing plumbing connection. In order to connect to the sewer, you must contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for information on permits for the connection. Pretreatment of industrial wastewaters will often be necessary before it is allowed to discharge to the sewer, and more information can be obtained by calling the number above.

If a sanitary sewer is not available, or if it is determined that a discharge connection is not allowed, the only remaining options are holding tanks or an on-site wastewater treatment facility. Consideration should be given to using a holding tank for used process water if the volume of process water generated by the activity is not excessive. The contents of the holding tank must be pumped out or drained before the tank is full and disposed of properly (see BMP S.2 in this chapter for information on disposal options). If a sanitary sewer connection cannot be made and a holding tank is not used, a wastewater treatment facility must be constructed on the site. This treatment facility must be designed to receive and effectively treat all discharges of process water from the business. Ecology must be contacted for approval of such a facility, since discharges from the treatment facility will enter surface waters or be spread on land. See Chapter 7 for Ecology's requirements for discharges of process waters.

For all types of process water discharges the following measures are required if the activity is to remain uncovered. Define a designated area for the activity and provide a mechanism for prevention of stormwater run-on into the activity area. This can be a curb, dike, or berm (see BMP S.7 in this chapter for more information) or similar effective means to prevent run-on. In this manner, only the precipitation that falls within the activity area is discharged and/or treated along with the activity process water. The designated area should be paved and sloped to a central collection drain. The collection drain must connect to the sanitary sewer (with pretreatment if required), the on-site holding tank, or the on-site treatment facility, whichever method is selected.

This process water BMP can be made more effective if the activity is covered, thus reducing the total amount of water to be treated.

S.4 Cover the Activity with a Roof or Awning

Not every activity can or needs to be located inside a building. In many cases, a simple roof or awning will protect the activity from coming into contact with stormwater, and usually at a lower cost than a complete building. If you do decide to build one of these structures, you will need to obtain permits from Thurston County Development Services (360) 786-5490. They will also be able to help you with fire code requirements and zoning code provisions.

The roof structure can be designed in several ways. One option is a lean-to type of structure, where sheets of corrugated steel, fiberglass, aluminum, or similar impermeable material are attached to the wall of a building and are supported by sturdy poles. Similarly, if there is no building to attach to, roofing materials can be sufficiently supported at all four corners as a standalone cap, or a waterproof tent canopy can be used.

The area of the roof cover should be sufficient to prevent any precipitation from reaching the covered materials. An example of this type of structure is provided in Figure 5.1.

(Photo courtesy of Seattle Public Utilities)

Figure 5.1. Structure Used to Cover Manufacturing Operations.

Another option for covering an activity is to use an overhanging awning of sufficient size to prevent rain from reaching the materials. Many of the building permit, fire code, and zoning requirements will also apply to these structures. An example of an awning cover is shown in Figure 5.2.

Figure 5.2. Loading Docks with an Overhang to Prevent Material Contact with Rainwater.

Activities such as fueling operations may be more conveniently covered by an island-type overhanging roof. This type of roof is supported by columns along the center of the structure rather than at the corners, enabling vehicles easy access underneath while still providing sufficient protection from rain. An example of this type of roof structure is shown in Figure 5.3.

Figure 5.3. Roof at Fueling Island to Prevent Stormwater Runon.

Note that floating fuel stations (such as some used for refueling boats) cannot be covered, according to the fire code.

The particular roof cover option used at a given site is subject to the site layout and available space, affordability, and limitations imposed by other regulations. Structural cover options other than those given above can be used if they perform the same function. This BMP should usually be implemented in conjunction with sump or sanitary sewer drains and provisions for prevention of stormwater run-on into the covered area. BMPs S.6 and S.7 in this chapter present information on sump installation and run-on prevention.

S.5 Cover the Activity with an Anchored Tarpaulin or Plastic Sheet

Some activities, such as stockpiling of raw materials, can be effectively covered with a sturdy tarpaulin or heavy plastic sheet made of impermeable material. Weights such as bricks, tires, or sandbags should be used to anchor the cover in place. Care should be taken to ensure that the tarpaulin or sheet covers the activity completely and that stormwater run-on does not penetrate significantly under the cover. If several sheets are used to form a cover, the sheets should be tethered together or laid in an overlapping manner. If necessary, pins or stakes should be used to anchor the tarpaulin to the ground. The tarpaulin must be inspected daily to ensure that no holes or gaps are present in the tarpaulin coverage. An example of this type of cover is shown in Figure 5.4.

Figure 5.4. Temporary Plastic Sheeting Anchored over Raw Materials Stored Outdoors.

The tarpaulin covering will be easier to keep in place and will last longer if some form of wind protection is possible. Attempts should be made to locate stockpiles adjacent to buildings where winds are reduced, but not in between buildings where a wind tunnel effect can occur.

Tarpaulins are an inexpensive and cost effective BMP for many activities. This BMP can be combined with runoff containment/run-on prevention curbs, dikes, and berms for better effectiveness (see BMP S.7 for more information).

S.6 Pave the Activity Area and Slope to a Sump or Holding Tank

This BMP applies to several activities that cannot be covered effectively. It is particularly suited to activities with the potential for leaks and spills, but that otherwise do not generate excessive amounts of polluted runoff. Examples are storage of liquid chemicals, waste oils, and solvents in portable containers such as drums; loading and unloading of liquids from trucks; and painting, finishing, and coating activities. A sump or holding tank serves to provide spill containment until the liquids can be pumped out and properly disposed of. If the activity produces large amounts of runoff, this BMP will not be very effective because the stray contaminants will overflow the sump or pass through the sump before collection and disposal are possible. To prevent run-on, the area should be enclosed with a berm, curb, or dike. The following implementation information is intended for situations where this BMP can be effective.

A designated activity area should be paved and sloped to drain to a central collection point. A sump, vault, or holding tank should be installed underneath this collection drain. Some materials, such as gasoline, can react with asphalt pavement and break it down, releasing additional pollutants. If the area is not yet paved and materials are present which may react with asphalt, the area must be paved with concrete. If the area is already paved with asphalt, an asphalt sealant can be applied which can aid in preventing pavement degradation. Whichever paving material is used, the paved surface must be free of gaps and cracks.

The sump or holding tank should have a capacity large enough to contain the entire volume of a potential spill. An example of a paved activity area with a sump drain is shown in Figure 5.5.

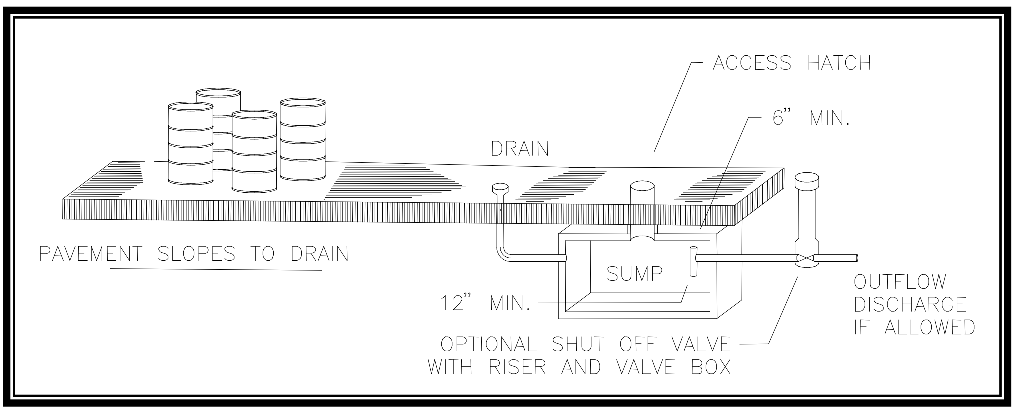

Figure 5.5. Paved Area With Sump Drain.

Wash pads may frequently need to use a sump arrangement like this. To keep disposal costs down, a drain cover, plug, or shutoff valve upstream of the sump should be used at times when the activity is not occurring.

The cost of constructing a sump and the disposal of accumulated contents can be high, so businesses should consider whether other allowable alternative BMPs can be used.

Commercial services that pump sumps and holding tanks are listed in the Yellow Pages of the phone directory under Environmental and Ecological Services or by searching on the internet using key words such as “hazardous waste removal” .

BMPs S.4, S.5, and S.7 in this chapter present information on covering activities and run-on prevention.

S.7 Surround the Activity Area with a Curb, Berm, or Dike, or Elevate the Activity

This set of BMP options can be an effective means for prevention of stormwater run-on to an activity area. In addition, a curb, berm, or dike can be used for containment of spills in the activity area, or for containment of contaminated activity runoff. Generally, a containment BMP is most applicable to spill control situations; that is, sites where runoff is relatively clean, but occasional spills may occur. This BMP may be less expensive to implement than paving the activity area and providing proper drainage collection, but can also be more difficult to maintain if stormwater ponding occurs inside a containment dike.

If a curb, dike, or berm is used to prevent stormwater run-on to a covered activity area, and the activity area is paved or otherwise impermeable, the berm should be placed underneath the covering so that rain will not pond inside it. Stormwater run-on can also be prevented by elevating the activity with a platform or other type of pedestal.

Containment may be achieved with concrete curbing, an earthen berm, a tub such as a plastic wading pool, or some other dike material, depending on the activity, its size, and resources available. Activities that require more space and therefore cannot be contained with a tub may need to be surrounded by a curb, dike, or berm. Aboveground storage tanks of liquids, storage of chemicals or wastes in numerous drums, and stockpiling of fertilizer are examples of activities that can be contained effectively in this manner. As the activity area gets larger, containment with an earthen berm can probably be provided less expensively than concrete curbing.

If a curb, berm, or dike is used for runoff containment, and other containment sizing regulations (such as fire codes, Ecology or Thurston County Environmental Health restrictions) do not apply, it should function so that all stormwater runoff from rain events up to the 6-month storm is contained in the immediate activity area until it infiltrates into the ground or is properly disposed of later. This approach is applicable for activities that involve liquid material storage, and that may consequently incur spills. It is also applicable to stockpile areas where runoff is typically polluted with suspended solids. If a stormwater treatment system is presently on site, a valve should be installed in the containment dike so that excess stormwater can be drained out of the activity area and directed to the treatment system. This valve should always be kept closed unless excess stormwater is being discharged, so that any spills that occur within the activity area can be effectively contained.

Difficulties in maintenance may arise with disposal of the captured water on sites without stormwater treatment capability. The collected rainwater may need to be treated before discharge. If the activity is located on impermeable ground, then potentially contaminated water will accumulate within the containment area. If contaminated, this accumulated water cannot simply be drained from the area; it must be collected and disposed of at a licensed disposal facility. During the wet season, this course of action can lead to frequent draining that may prove costly. In addition, some type of monitoring would be needed to determine if ponded water is contaminated. Depending on the monitoring requirements, this can also be very costly.

For storage of small items, the simplest containment device is a tub or wading pool. A plastic child's wading pool may be sufficient for some activities that do not require a lot of space, such as storing painting materials, and temporary storage of wastes in drums. An example of this is shown in Figure 5.6. Make sure the material you are using does not react with the plastic.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 5.6. Temporary Spill Containment.

For larger areas, a containment curb, dike, or berm may be necessary. If an earthen berm is used, it must be seeded with grass or other vegetation so that it does not erode. Sketches of a containment berm are shown in Figure 5.7.

The volume of the containment area shall be the greater of either 110 percent of the volume of the largest tank, or 10% of volume of all tanks if there are multiple tanks

It should be noted that neglect and poor maintenance can render the containment useless. Other BMPs should be considered before containment. Commercial products are available that are a combination containment box/elevated pedestal. These effective devices prevent stormwater run-on by elevating containers off the ground, and allow for collection of spills and drips inside the pedestal box. Similar arrangements can be constructed by hand as well.

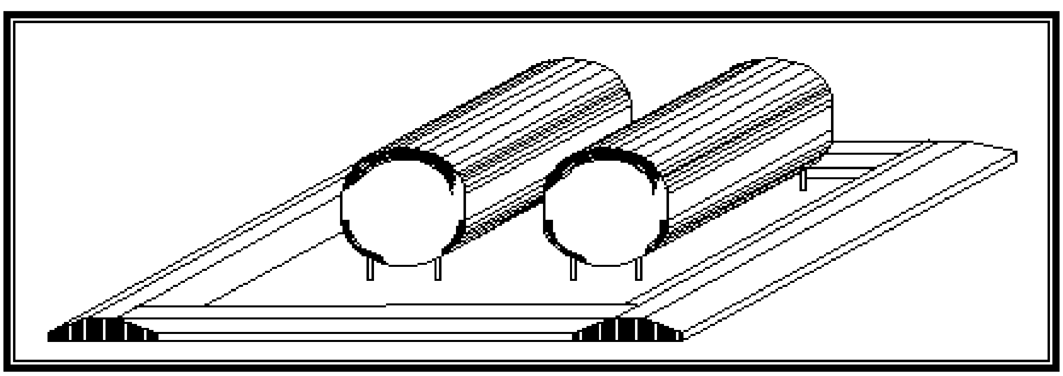

Figure 5.7. Containment Berm Used to Control Liquid-Material Leaks or Spills.

BMPs S.4, S.5, and S.6 in this chapter provide information on covering activities and sump installation.

S.8 Implement Integrated Pest Management Measures

Use of herbicides, fungicides, and rodenticides should always be done with extreme caution, not only because of the potential harm to humans and pets, but also because of the potential harm to fish, wildlife, and our water resources. In light of the toxic nature of these compounds, special attention should be given to pesticide usage in all applications. The discussion below applies more to large-scale pesticide users, but should be considered for backyard applications as well.

Commercial, agricultural, municipal, and other large scale pesticide users, such as golf courses and parks, should adhere to the principles of integrated pest management, a decision-making process for pest management that strives for intelligent, environmentally sound control of pests. It is a systems approach to pest management that combines agronomic, biological, chemical, and genetic information for educated decisions on the type of control to use, the timing and extent of chemical application, and whether non-chemical means can attain an acceptable level of pest control.

Integrated pest management is a preventive measure aimed at knowing the exact pests being targeted for control, the locations and times when pests will pose problems, the level of pest-induced damage that can be tolerated without taking action, the most vulnerable life stage, and control actions that are least damaging to the environment. The major components of integrated pest management are as follows:

- Monitoring and inventory of pest populations
- Determination of pest-induced injury and action levels
- Identification of priority pest problems
- Selection and timing of least toxic management tools
- Site-specific treatment with minimized chemical use
- Evaluation and adjustment of pesticide applications.

Monitoring of pest populations is a key to successful integrated pest management implementation. Pest problems are universally easier to control if the problem can be discovered early. With integrated pest management pesticides are used only as a last resort. Maximization of natural controls, including biological controls and removal of pests by hand, is always the first choice.

More information on integrated pest management is available from the Washington State Department of Agriculture and from the Washington State University Extension Service. Refer to Appendix IV-B for an example of an Integrated Pest Management Program.

S.9 Cleaning Catch Basins

Cleaning catch basins regularly (Figure 5.8) is one of the most important stormwater source control measures that a business can take as they are a last line of defense before runoff enters the stormwater conveyance system.

Figure 5.8. Catch Basin Cleaning with a Vacuum Truck.

Catch basins are typically located under low spots in parking lots, along curbs and road edges, and where storm drain pipes combine flows. Catch basins on the surface collect runoff for storm drains that are typically located directly underneath them. Most catch basins have some storage in the bottom that never drains to an outflow pipe. This permanent storage area is intended to trap sediments, debris, and other particles that can settle out of stormwater, thus preventing clogging of downstream pipes and washing of these solids into receiving waters.

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 6 inches clearance from the debris surface to the invert of the lowest pipe. Some catch basins (for example, WSDOT Type 1L basins) may have as little as 12 inches sediment storage below the invert. These catch basins will need more 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. For additional information on the maintenance of catch basins, refer to Volume V, Appendix V-C.

Several companies offer catch basin cleaning services. Pertinent equipment dealers and cleaning services can be found in the telephone Yellow Pages under headings like “Sewer Cleaning Equipment and Supplies” and “Sewer Contractors”. A list of operators that offer catch basin cleaning services (as well as maintenance for other stormwater BMPs) can be found at http://www.co.thurston.wa.us/stormwater/facilities/facilities-contractors.html

All of the solids and stagnant water collected from catch basin sumps must be disposed of properly. None of the sump contents can be flushed into the catch basin outflow pipe. Depending on the nature of the pollutants in the sump, and the associated types of activities taking place on the site, the sump contents may need to be disposed of as hazardous waste. Contractors who perform catch basin cleanout services will be required to follow specified disposal requirements.

The use of other BMPs, such as frequent sweeping of activity areas, covering activity areas, reducing activity occurrence, and containing runoff from activity areas will help reduce catch basin cleaning frequency, thus saving time and money. All businesses and agencies should set up maintenance schedules for all of their BMPs so that coordinated BMP maintenance efforts result in reduced catch basin cleaning frequencies.

Chapter 6 - Best Management Practices for Single-Family Residences

The actions we take each day in and around our homes have a profound effect on surface water quality and fish habitat in this region. Stormwater goes directly to our rivers, groundwater, lakes, streams, and to Puget Sound. It does not go to the wastewater treatment plant. Any pollutants that get into the stormwater go directly to surface waters or groundwater. Small amounts of pollution from many different sources can significantly affect our waterways. Yard maintenance, waste storage, car washing and maintenance, and pool cleaning are some of the activities that can adversely impact water quality. Stormwater BMPs discussed in this section are practical ways to keep stormwater from becoming polluted in the first place. It is recommended that all residents in Thurston County use these BMPs. **Please note that some of these procedures are required by various state, or county laws, and are noted as required BMPs.**

Below is a general list of BMPs for Thurston County residents. The list includes brief information on applicability. For more information on the following BMPs, refer to the information in Sections 3.1 through 3.7 of this chapter. Additionally, BMPs addressing maintenance of roof runoff systems and on-site stormwater management features are described in Volumes III and V.

6.1 Automobile Washing

Many residents wash their cars in the driveway or on the street. Washwaters typically flow to a storm drain or ditch, which discharges stormwater directly to the underlying groundwater or to the nearest river, stream, lake, or Puget Sound. Soaps and detergents, even the biodegradable ones, can have immediate and long-term effects on aquatic life in water bodies. The grime washed off the car also contains a variety of pollutants that can harm fish and wildlife.

6.1.1 Suggested BMPs

6.1.1.1 Away from Home (preferred option):

- Consider not washing your car at home. Take it to a commercial car wash that has a recycle system and discharges wastewater to the sanitary sewer for treatment.

6.1.1.2 At Home:

- Wash your car directly over your lawn or make sure the washwater drains to a vegetated area. This allows the water and soap to soak into the ground instead of running off into a local water body.
- Ideally, no soaps or detergents should be used, but if you do use one, select one without phosphates.

- Commercial products are available that allow you to clean a vehicle without water. These were developed for areas where water is scarce, so a water saving benefit is realized, as well as reduced pollution.
- Use a hose nozzle with a shut-off valve to save water.
- Do not wash your car if rain is expected. Rain events will rapidly wash any chemicals and cleaning products from your property into the stormwater system (and to downstream waters).
- Pour the bucket of soapy, dirty washwater down your sink. This way the water doesn't pollute surface water. Instead, it's treated at the wastewater treatment plant or by your septic system.

6.2 Automobile Maintenance

Many of us are "weekend mechanics". We enjoy the cost savings of changing our own oil and antifreeze, topping off the battery with water, and generally making our car perform its best. There is a lot of potential for stormwater pollution associated with these activities; however, the following BMPs will help you minimize pollution while servicing your car, truck, van, or RV.

6.2.1 Required BMPs

- Recycle all oils, antifreeze, solvents, and batteries. Many local car parts dealers and gas stations accept used oil and oil filters. The Household Hazardous Waste facilities at the Thurston County Waste and Recovery Center accept oil, oil filters, antifreeze, and solvents. Some businesses will buy automotive batteries. Check the Yellow Pages or the internet to find such businesses.
- Never dump new or used automotive fluids or solvents on the ground, in a storm drain or street gutter, or in a water body. Eventually, it will make its way to local surface waters or groundwater, including the water we drink.
- Do not mix wastes. The chlorinated solvents in some carburetor cleaners can contaminate a huge tank of used oil, rendering it unsuitable for recycling. Always keep your wastes in separate containers which are properly labeled and store them out of the weather.

6.2.2 Suggested BMPs

- Fix all leaks, to keep the leaky material off streets and out of surface water.
- To dispose of oil filters, punch a hole in the top and let drain for 24 hours. This is where a large funnel in the top of your oil storage container will come in handy. After draining, wrap in 2 layers of plastic and dispose of in your regular garbage or recycle by taking it to the Thurston County Waste and Waste and Recovery Center. Call the Thurston County Department of Public Works at (360) 867-2300 for up-to-date information on the appropriate disposal of consumer products.

- Use care in draining and collecting antifreeze to prevent accidental spills. Spilled antifreeze tastes sweet and can be deadly to animals that ingest it.
- Perform your service activities on concrete or asphalt or over a plastic tarpaulin to make spill cleanup easier. Keep a bag of kitty litter on hand to absorb spills. If there is a spill, sprinkle a good layer on the spill, let it absorb for a little while and then sweep it up. Place the contaminated litter in a plastic bag, tie it up, and dispose of it in your regular garbage. Take care not to leave kitty litter out in the rain; it will form a sticky goop that is hard to clean up.
- If you are doing body work outside, be sure to use a tarpaulin to catch material resulting from grinding, sanding, and painting. Dispose of this waste by double bagging in plastic and placing in your garbage.

6.3 Storage of Solid Wastes and Yard Wastes

Improper storage of recycling, yard waste, and trash at residences can lead not only to water pollution problems, but problems with neighborhood pets and vermin as well. Following the BMPs listed below can help keep your property a clean and healthy place to live.

6.3.1 Suggested BMPs

- Recycle as much as you can. Most Thurston County residents have access to curbside pickup for yard waste and recyclable materials. Also, look under "recycling" in the phone book for firms which take other recyclables.
- All waste containers kept outside should have lids (Figure 6.1). If your lid is damaged, please call your local solid waste hauler to get the lid repaired or replaced. The Thurston County web site lists haulers for your neighborhood: <www.co.thurston.wa.us/wwm/>

Figure 6.1. Waste Dumpster with Properly Sealed Lid.

- Leaking waste containers should be replaced. If your container is damaged, please call your local solid waste hauler.
- Store waste containers under cover if possible, or on grassy areas.
- Inspect the storage area regularly to pick up loose scraps of material and dispose of them properly.
- Purchase products which have the least amount of packaging materials.
- Compost biodegradable materials such as grass clippings and vegetable scraps instead of throwing them away. Your flowerbeds will love the finished compost, and you'll be helping to conserve limited landfill space. Call Thurston County Department of Public Works at (360) 867-2300 for more information on composting or information on yard waste collections. See the section on composting for BMPs relating to that activity.
- A fun alternative to traditional composting is worm composting. You can let worms do all the work for you by keeping a small vermiculture box just outside your kitchen. For more information on getting started with worms, call the number listed above.

6.4 Composting

Composting is an earth-friendly activity as long as some common sense rules outlined below are followed. If you choose to compost, the following BMPs should be utilized. More information can be found on-line at: http://www.mgftc.org/resources/composting-information/

6.4.1 Suggested BMPs

- Compost piles must be located on an unpaved area where runoff can soak into the ground or be filtered by grass and other vegetation. Compost piles should be located in an area of your yard not prone to water ponding during storms, and should be kept well away from wetlands, streams, lakes, and other drainage paths.
- Compost piles must be maintained and turned over regularly to work properly. Large piles of unattended compost may create odor and vermin problems.
- Avoid putting hazardous, inorganic, plastics or metal waste in the pile.
- Cover the compost pile (Figure 6.2) for two reasons:
  1. To keep stormwater from washing nutrients into waterways.
  2. To keep excess water from cooling down the pile, which will slow down the rate of decomposition.

(photo courtesy of Green Culture)

Figure 6.2. Covered Compost Bin.

Build bins of wood, chicken wire, or fencing material to contain compost so it can't be washed away. You can purchase reduced price compost bins through Thurston County’s web-site or find information on building your own bins. Call Thurston County Department of Public Works to get free composter designs and materials lists or see: http://www.mgftc.org/resources/composting-information/ .

- Building a small earthen dike around your compost pile is an effective means of preventing nutrient-rich compost drainage from reaching stormwater paths.

6.5 Yard Maintenance and Gardening

This section deals with the normal yard maintenance activities we all perform at our homes. Over watering, over fertilizing, improper herbicide application, and improper disposal of trimmings and clippings can all contribute to serious water pollution problems. Following the BMPs listed below will help alleviate pollutant runoff.

6.5.1 Required BMPs

- Follow the manufacturer's directions exactly for mixing and applying herbicides, fungicides, and pesticides, and use them sparingly. Never apply when it is windy or when rain is expected. Never apply over water, within 100 feet of a well-head, or adjacent to streams, wetlands, or other water bodies. Triple-rinse empty containers, using the rinsate for mixing your next batch of spray, and then double-bag and dispose of the empty container in your regular garbage. Never dispose of grass clippings or other vegetation in or near storm drains, streams, lakes, or Puget Sound.

6.5.2 Suggested BMPs

- Use natural, organic soil amendments when possible. The excellent soil conditioning properties of the organic matter aid water retention in lighter soils and help to break up and aerate heavier soils, so roots can grow better and less watering is needed. It contains both readily available and long term nitrogen and other nutrients commonly lacking in Northwest soils. The slow release of nitrogen better matches the needs of plants. Thus, there is much less potential for nitrates to leach into surface or groundwater due both to less "excess nitrogen" and less water use. Better vegetative growth can also reduce erosion and runoff.

- Follow manufacturer's directions when applying fertilizers. More is not better, either for your lawn or for local water bodies. Never apply fertilizers over water or adjacent to ditches, streams, or other water bodies. Remember that organic fertilizers have a slow release of nitrogen, and less potential to pollute then synthetic fertilizers.

- Let your yard go dormant during the summer. Watering deeply but slowly once each rainless month will help support a dormant lawn. Avoid heavy traffic on a dormant lawn, or regularly water high-use areas to prevent damage. When the rains return in the fall overseed any thin areas to thicken the lawn and help crowd out weeds.

- Save water and prevent pollution problems by watering your lawn sensibly. Lawns and gardens typically need the equivalent of 1 inch of rainfall per week. Water deeply, but slowly once a week for a healthier lawn. You can check on how you're doing by putting a wide mouth jar out where you're sprinkling, and measure the water with a small plastic ruler. Overwatering to the point of runoff can carry polluting nutrients to the nearest water body.

- Consider planting a vegetated buffer zone adjacent to streams or other water bodies on your property. Call the Thurston County Conservation District at (360) 754-3588 for advice and assistance in developing a planting plan. The Stream Team program (360) 754-4681 at the County may even be able to help you plant it!

- Reduce the need for pesticides and fertilizers on lawns by improving the health of the soil. Aerating, thatching, and topdressing with compost will improve soil health and help desired grasses compete with weeds and moss.
- Make sure all fertilizers and pesticides are stored in a covered location. Rain can wash the labels off of bottles and convert 50 pounds of boxed fertilizer into either a solid lump or a river of nutrients.
- Use a mulching mower and mow higher to improve soil/grass health and reduce or eliminate pesticide use.
- Compost all yard clippings, or use them as mulch to save water and keep down weeds in your garden. See Composting section for more information.
- Practice organic gardening and virtually eliminate the need to use pesticides and fertilizers. Contact Thurston County Cooperative Extension at (360) 867-2163 for information and classes on earth-friendly gardening.
- Pull weeds instead of spraying and get some healthy exercise, too. If you must spray, use the least toxic formulations that will get the job done. The Master Gardener program listed above can help advise you on which spray to use.
- Work fertilizers into the soil instead of letting them lie on the ground surface exposed to the next rain storm.
- Plant native vegetation which is suited to Northwest conditions, they require less water and little to no fertilizers and pesticides.
- Contact your local waste disposal company for curbside pickup and recycling of yard waste.
- For more information on lawn care, see http://www.co.thurston.wa.us/health/ehcsg/pdf/lawn_care.pdf

6.6 Swimming Pool and Spa Cleaning and Maintenance

Despite the fact that we immerse ourselves in it, the water from pools and spas is far from chemically clean. Nutrients, pH, and chlorine can adversely affect fish and wildlife in water bodies. Following these BMPs will ensure the cleanliness of your pool and the environment.

6.6.1 Required BMPs

- Pool and spa water must be dechlorinated to 0.1 mg/L if it is to be emptied into a ditch or to the stormwater drainage system. Contact your pool chemical supplier to obtain the neutralizing chemicals you will need. The rate of flow into the ditch or drainage system must be regulated so that it does not cause problems such as erosion, surcharging, or flooding. Water discharged to the ground or a lawn must not cross property lines and must not produce runoff.
- If pool and spa water cannot be dechlorinated, it must be discharged to the sanitary sewer. Prior to draining, your local sewer provider must be notified to

ensure they are aware of the volume of discharge and the potential effects of chlorine levels. A pool service company can help you determine the frequency of cleaning and backwash of filters.

- Diatomaceous earth used in pool filters cannot be disposed of in surface waters, on the ground, or into stormwater drainage systems or septic systems. Dry it out as much as possible, bag it in plastic, and dispose of at the landfill.

6.6.2 Suggested BMPs

- Hire a professional pool service company to collect all pool water for proper disposal. Make sure to ask them where they will dispose of it and the kind of permits they hold to do so.

6.7 Household Hazardous Material Use, Storage, and Disposal

Once we really start looking around our houses, the amount of hazardous materials we have on site is a real eye-opener. Oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish remover, and wood preservatives are just a few hazardous materials that most of us have around the house.

When products such as these are dumped on the ground or in a storm drain, they can be washed directly to receiving waters where they can harm fish and wildlife. They can also infiltrate into the ground and contaminate drinking water supplies. The same problem can occur if they are disposed of with your regular garbage; the containers can leak at the landfill and contaminate groundwater. The same type of contamination can also occur if hazardous products are poured down a sink or toilet into a septic system. Don't pour them down the drain if you're on municipal sewers, either. Many compounds can “pass through” the wastewater treatment plant without treatment and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency.

With such a diversity of hazardous products present in all homes in Thurston County, a large potential for serious environmental harm exists if improper methods of storage, usage, and disposal are employed. Using the following BMPs will help keep these materials out of our soils, sediments, and waters.

6.7.1 Required BMPs

- Hazardous Materials must be used in accordance with the manufacturer recommendation or guidelines as shown on the label.
- Always store hazardous materials in properly labeled containers, never in food or beverage containers which could be misinterpreted by a child as something to eat or drink.
- Dispose of hazardous materials and their containers properly. Never dump products labeled as poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive danger, warning, caution, or dangerous outdoors, in a storm drain, or into sinks, toilets or drains. Call the Thurston County Department of

Public Works at (360) 867-2300 for information on disposal methods, collection events, and alternative products. Household hazardous wastes from Thurston County residents and non-residents are accepted at the HazoHouse, at the Thurston County Waste and Recovery Center in Hawks Prairie at 2418 Hogum Bay Road NE.

6.7.2 Suggested BMPs

- Check hazardous material containers frequently for signs of leakage. If a container is rusty and has the potential of leaking soon, place it in a secondary container before the leak occurs and prevent a cleanup problem.
- Hazardous materials should be stored out of the reach of children.
- Store hazardous materials containers under cover and off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels being washed off, etc.
- Keep appropriate spill cleanup materials on hand. Kitty litter is good for many oil-based spills.
- Ground cloths and drip pans must be used under any work outdoors which involves hazardous materials such as oil-based paints, stains, rust removers, masonry cleaners, and others bearing label warnings as outlined above (Figure 6.3).

Figure 6.3. Drip Pan for Capturing Spills and Drips During Engine Repair and Maintenance.

- Latex paints are not a hazardous waste, but are not accepted in liquid form at the landfill. To dispose of, leave uncovered in a protected place until dry, then place in the garbage. If your can is at least half full, you can take it to the HazoHouse to be placed in Swap Shop area. If you wish to dry waste paint quickly, mix kitty litter or sawdust in the can to absorb the paint. Once paint is dry, leave the lid off when you place it in the garbage so your garbage collector can see that it is no longer liquid.

- Use less toxic products whenever possible. Ecology maintains a hotline at 1-800-RECYCLE, or see information online at https://fortress.wa.gov/ecy/recycle/
- If an activity involving the use of a hazardous material can be moved indoors out of the weather, then do so. Make sure you can provide proper ventilation, however.
- Follow manufacturers' directions in the use of all materials. Over-application of yard chemicals, for instance, can result in the washing of these compounds into receiving water bodies. Never apply pesticides when rain is expected.
- When hazardous materials are in use, place the container inside a tub or bucket to minimize spills and store materials above the local Base Flood Elevation (BFE).

6.8 Pet Waste Management

Pet waste that washes into lakes, rivers, 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 in waters we use for swimming, boating and fishing. Most importantly, in many urban areas, pet waste is the largest source of bacterial loading to streams. It can carry diseases that could make water unsafe for contact and lead to beach closures or affect shellfish harvest. These include:

- Campylobacteriosis—bacterial infection
- Salmonellosis—bacterial infection
- Toxocariasis—roundworm infection
- Toxoplasmosis—protozoan parasite infection
- Giardiasis—protozoan parasite infection
- Fecal Coliform—bacteria in feces, indicates contamination
- E. coli—bacteria in feces, may cause disease.

Cleaning up after your pet can be as simple as taking a plastic bag or pooper scooper along on your next walk. Then choose one of the following:

6.8.1 Suggested BMPs

- Bag it – Put waste in a securely closed bag and deposit it in the trash. Do not put it in your yard waste container because pet waste may carry diseases, and yard waste treatment may not kill disease organisms.

- Bury it – Bury waste at least 1 foot deep and cover with soil in your yard or garden (not in food-growing areas).
- Flush it – Only flush pet wastes if your home is served by a sanitary sewer which goes to a sewage treatment plant. Water from your toilet goes through a treatment process that removes pollutants before it is discharged into the environment.
- To prevent plumbing problems, don't flush debris or cat litter. Cat feces may be flushed, but used litter should be put in a securely closed bag in the trash. Septic systems are not designed to accommodate the high pollutant load of pet waste. To prevent premature failure or excessive maintenance costs do not flush pet wastes to your septic system.
- Compost it – waste from small animals other than dogs and cats (rabbits, rodents, etc.), can be put in your compost bin.

6.9 On-Site Sewage Maintenance and Operation

Thurston County is responsible for ensuring that stormwater discharged from stormwater management systems we operate does not harm or impair the use of the receiving waters (streams, rivers, lakes, groundwater or Puget Sound). Sample tests of stormwater discharges and receiving water occasionally indicate high levels of fecal coliform bacteria.

One potential source of bacteria is malfunctioning on-site sewage systems (septic systems). Septic system failures have been documented on private property in Thurston County.

Septic systems vary widely in their design and complexity. Owners of septic systems should contact the Thurston County Department of Public Health and Social Services (Environmental Health Division) at (360) 867-2673 to request an as-built of their system. As-built requests are also available at the Development Review counter at 2000 Lakeridge Drive SW, Olympia. More information is available at: <www.co.thurston.wa.us/permitting>.

In its simplest design the septic tank is the first stage of a private sewage disposal system. The septic tank is a water-tight tank below ground that is usually made of concrete but may be fiberglass, plastic or steel. Septic tanks have one or two access ports for inspection and maintenance which are usually buried a few inches below the ground.

The tank receives household wastewater through an inlet pipe at one end, settles out larger material to the bottom, breaks down waste material with bacteria present in the tank and delivers the partially treated wastewater out another pipe on the opposite end of the tank to the disposal field.

The disposal field is the second stage of the private sewage disposal system and completes the final breakdown of wastewater with organisms in the soil.

The disposal field consists of narrow trenches filled with gravel and perforated pipes that distribute the wastewater to the field. With proper maintenance, a well-designed system can last a long time; however, disposal fields will clog if forced to handle large particles that should settle out in the bottom of the septic tank.

6.9.1 Required BMPs

Owners of septic systems must follow all of the requirements of the Thurston County Department of Public Health and Social Services, Environmental Health Division. They can be contacted at Thurston County Health Department at (360) 867-2673, or on the web at http://www.co.thurston.wa.us/health/ehoss/index.html, for further information and specific requirements applicable to your system.

6.9.2 Suggested BMPs

6.9.2.1 Regular Inspection and Maintenance

Septic tanks require regular inspection and maintenance. Inspections should be done to measure accumulated sludge every 3 to 5 years. Pumping frequency can vary depending on tank size, family size and garbage disposal use. Failure to remove sludge periodically will result in reduced settling capacity and eventual overloading of the disposal field, which can be difficult and expensive to remedy. Maintenance is required on complex systems, those serving more than one single family residence, and commercial establishments.

6.9.2.2 Eliminate or Restrict Garbage Disposal Use

Eliminating or restricting garbage disposals can significantly reduce the loading of solids to the septic tank thus reducing the pumping frequency.

6.9.2.3 Reduce and Spread Water Use Out Over the Day

Septic tanks are limited in their ability to handle rapid large increases in the amount of water discharged into them. Excess wastewater flow can cause turbulence in the tank flushing accumulated solids into the disposal field. Over time this will impair the ability of the disposal field to function. Limit water using appliances to one at a time. Do one load of clothes a day rather than several in one day. Practice water conservation at home.

6.9.2.4 Chemical Use

Septic systems are to be used for the disposal of household wastewater only. Never dispose of excess or unwanted chemicals into the septic system. Occasional use of household cleaners in accordance with the manufacturers' recommendations should not harm your septic system. There is little evidence that products advertised for use as septic system cleaners and substitutes for pumping actually work as advertised.

For additional information on proper operation of your septic system or to report a failing septic system in your neighborhood, contact Thurston County Environmental Health at (360) 867-2673or at: <www.co.thurston.wa.us/health/ehoss/index.html>.

6.10 Activities in Wetlands and Wetland Buffers

Wetlands and associated buffers are vegetated ecosystems through which water passes. These areas characteristically have a high water table and are often subject to periodic flooding. Wetlands can be very effective in removing sediments, nutrients and other pollutants from stormwater.

Maintaining wetlands and associated buffers helps to slow stormwater runoff, trap sediments and other pollutants and reduce the volume of runoff by allowing infiltration to occur. Reducing the velocity of runoff reduces soil erosion and increases contact time with soil and vegetation. Increasing contact of stormwater with soils and vegetation in a wetland or riparian area can be effective in removing sediments, nutrients and other pollutants from stormwater runoff.

Buffer areas are important to both the wetland and the upland areas as habitat for aquatic wetland-dependent wildlife and as buffers during extreme weather events. Other functions of buffer areas that contribute to water quality include shading, flood attenuation and shoreline stabilization.

Persons responsible for maintenance of wetland areas are encouraged to call Thurston County Development Services at (360)786-5490 prior to performing work in wetlands or their buffers.

6.10.1 Required BMPs

- Removal by hand of manmade litter and control of noxious weeds that are included on the state noxious weed list (Washington Administrative Code [WAC] 16-750) or invasive plant species as identified by Thurston County. Control may be conducted by clipping, pulling, over-shading with native tree and shrub species, or non-mechanized digging. Alternative methods such as mechanical excavation, barrier installation, or herbicide use may be allowed if acceptable to the Department of Resource Stewardship and acquisition of any necessary permits, per Thurston County Code Title 17 Environment, 17.15 - Critical Areas.

- Check with Thurston County Development Services and Planning on guidelines for vegetation and hazardous tree removal in critical areas.

6.10.2 Suggested BMPs

- To prevent possible contamination limit fertilizer and herbicide use around wetlands and their buffers.
- Limit access to wetlands and their buffers. To avoid compaction do not establish trails within the wetland areas.

Chapter 7 - Regulations and Requirements

The information in this chapter is provided to help you comply with additional Thurston County and Washington State water quality regulations that may apply to your project, industry, or business. Applicable state regulations are summarized for your convenience. Relevant regulations are listed but it is your responsibility to obtain the current version of any ordinances, statutes, or regulations that apply to your project.

7.1 Thurston County Codes and Ordinances

The following is a list of selected Thurston County codes and ordinances, which may apply to land development and stormwater management in Thurston County. A complete list of all Thurston County ordinances is available at: www.thurston.wa.us.

Title 8 Health and Sanitation

- 8.12 Sanitary Landfill Operations
- 8.20 Out-of-County Waste
- 8.24 Solid Waste Management-Reduction and Recycling
- 8.30 LOTT Discharge and Industrial PreTreatment Regulations

Title 13 Roads and Bridges

- 13.28 Construction and Permits
- 13.52 Trees and Vegetation

Title 14 Buildings and Construction

Thurston County Building Code

- 14.28 Uniform Plumbing Code
- 14.32 International Fire Code
- 14.37 International Building Code Appendix J, Grading
- 14.38 Development in Floor Hazard Areas
- 14.40 Construction in Mudslide Hazard Areas
- 14.44 Mobile Homes
- 14.48 Building Permits

Title 15 Public Works

- 15.40 Standards Adoption

15.05 Thurston County Stormwater Standards

15.07 Illicit Discharge and Detection Ordinance

15.09 Sewer Systems

15.16 Right-of-Way Acquisition and Relocation Assistance

Title 16 Waterways and Vessels

16.04 Regulations and Restrictions on the Use of County Waters

Title 17 Environment

17.09 State Environmental Policy Act

17.12 Black Lake Stormwater Control Area

17.15 Agricultural Activities Critical Areas

PART 100 Purpose

PART 200 Definitions.

PART 300 Review Standards

PART 400 Administrative Action

PART 500 Aquifer Recharge Areas

PART 600 Geologic Hazard Areas

PART 700 Important Habitats and Species

PART 800 Special Management Areas

PART 900 Floodplains, Streams and Wetlands

17.20 Mineral Extraction Code

17.25 Thurston County Forest Lands Conversion Ordinance

17.30 Noxious Weed Containment

Title 18 Platting and Subdivisions

18.04 General Provisions

18.12 Preliminary Plat

18.16 Final Plat

18.20 Dedications – Plats and Short Plats

18.24 Agreement and Bond for Improvements

18.28 Large Lot Subdivisions

18.32 Short Plats

18.40 Street Requirements

18.42 Thurston County Road Standards

18.44 Drainage Requirements

18.46 Utility Requirements

18.47 Open Space Standards

Title 19 Shoreline Master Program

Title 20 Zoning

20.04 Core Requirements

20.07 Lot, Yard, Use and Structure Regulations

20.30 Planned Rural Residential Development (PRRD)

20.31 Mobile Home Park Standards and Regulations

20.32 Open Space

20.37 Site Plan Review

20.44 Parking and Loading

20.45 Landscaping and Screening

20.54 Special Use

Title 21 Lacey Urban Growth Area Zoning

Title 22 Tumwater Urban Growth Area Zoning

Title 23 Olympia Urban Growth Area Zoning

Title 24 **Thurston County Critical Areas Ordinance**

24.01 General Provisions

24.03 Definitions

24.05 Administrative Procedures

24.10 Critical Aquifer Recharge Areas

24.15 Geologic Hazard Areas

24.20 Frequently Flooded Areas

24.25 Fish and Wildlife Habitat Conservation Areas

24.30 Wetlands

24.35 Special Reports

24.40 Critical Area Review Permit

24.45 Reasonable Use Exception

24.65 Critical Area Tracts and Delineations

24.90 Emergency Authorization

24.92 Enforcement, Violations and Penalties

7.2 State, Federal, and Other Regulations and Requirements

R.1 Ecology requirements for the discharge of process wastewaters directly to surface waters

R.2 Ecology requirements for generators of dangerous (hazardous) wastes

R.3 Ecology stormwater NPDES permit requirements

R.4 Ecology requirements for underground and aboveground storage tanks.

R.5 U.S. EPA and Ecology requirements for spill-control and prevention plans

R.6 Washington State Department of Agriculture (WSDA) pesticide regulations

R.7 Puget Sound Air Pollution Control Agency (PSAPCA) air quality regulations

R.8 Requirements of Native American Tribes

R.1 Washington State Department of Ecology Requirements for the Discharge of Process Wastewaters Directly to Surface Waters

If a public sanitary sewer is not available, process wastewater may be discharged, after suitable treatment, to a surface water body like a lake or stream, or to a drainage field. If the discharge is to a surface water body, Ecology must be contacted to obtain approval of the type and design of the treatment system, as well as the design and location of the outfall and the need for an NPDES permit. If a septic tank and drainfield are used for treatment, requirements of the Thurston County Environmental Health Division will also apply; contact the On-Site Sewage Program directly at (360) 867-2673 for more information.

Ecology's requirements can be found at WAC Chapter 173-240. Some of the specific requirements include:

1. An engineering report must be prepared describing the proposed project. The general contents of the engineering report are specified by Ecology (WAC Chapter 173-240). The report is reviewed and approved by Ecology.

2. The treatment system must be designed in accordance with *Criteria for Sewage Works Design,* August 2008, by Ecology.

3. The outfall must be designed in accordance with specific dilution zone dimensions (WAC Chapter 173-201A-100).

4. The quality of the discharge into the receiving water must be treated and diluted (according to the dilution criteria noted above) so as to not result in a violation of water quality standards (WAC Chapter 173-201A).

5. The treatment plant must be properly maintained and operated by a certified operator (WAC Chapter 173-230).

R.2 Ecology Requirements for Dangerous Waste Generators

The state dangerous waste regulations (WAC Chapter 173-303) cover accumulation, storage, transportation, treatment, and disposal. Of interest to this volume is the temporary accumulation of waste until taken from the site to a permitted disposal site. Only portions of those regulations that apply to temporary storage are summarized here.

Permitted Generators
Businesses that generate 220 pounds or more of dangerous waste, either per batch or in the aggregate, over 1 month must comply with the storage specifications outlined below:

If placed in containers:

1. If the container is not in good condition (for example, severe rusting or apparent structural defects) or if it begins to leak, the owner must replace the container.

2. The container must be labeled as to its contents.

3. The container must be lined with a material that does not react with the waste.

4. The container must be kept closed except when adding or removing waste.

5. The container must not be opened, handled, or stored in a manner which may cause a rupture or leak.

6. Examine the containers for leakage at least weekly.

7. Containers storing reactive or ignitable waste must meet the requirements of the International Fire Code.

8. Incompatible wastes must be stored separately.

9. Ecology may require secondary containment of the storage area. Specifically, the storage area must:

    a. Be capable of collecting and holding spills and leaks.
    b. If uncovered, be capable of handling a 25-year recurrence interval storm.
    c. Have a base that is free of cracks or gaps and is sufficiently impervious to leaks, spills, and rainfall.
    d. Be sloped or designed so that liquids can drain to a point for removal.
    e. Have positive drainage control (e.g., a valve) to ensure containment until any liquid is removed, which must occur in a timely manner.
    f. Have a holding capacity equal to 10 percent of the volume of all containers or the volume of the largest container, whichever is greater.
    g. Not allow run-on of rainfall from areas adjacent to the storage area.

If the waste does not contain free liquids, the above requirements need not be met, provided that the area is sloped or the containers are elevated.

If placed in tanks:

1. The tank must be lined with a material that does not react with the waste.

2. The tank, tank area, and its ancillary equipment must be inspected according to a written schedule.

3. If retired, the tank is to be cleaned of all contents, and those contents properly disposed of.

4. Tanks storing reactive or ignitable waste must meet the requirements of the International Fire Codes.

5. Incompatible wastes must be stored separately.

The generators must have a designated employee on site or on call with the responsibility for coordinating all emergency response measures. Spills are to be contained and cleaned up as soon as practicable.

Small-Quantity Waste Generators

These are businesses that generate less than 220 pounds of dangerous waste per month or per batch (or 2.2 pounds of extremely hazardous waste). Small-quantity generators still fall under Ecology regulations to the extent that the materials must be properly stored on site until shipment. The wastes must be moved from the property whenever the accumulated quantity equals or exceeds 220 pounds or whenever the material has resided on site for 180 days. The waste must be disposed of at an approved facility. If the business is in compliance with these requirements, they are also considered solid waste generators, and are regulated by Thurston County Department of Public Health and Social Services, Environmental Health Division. For technical assistance and site visits, contact Thurston County Environmental Health (360) 867-2664 or the Thurston County Department of Resource Stewardship, Water Resources Division at (360) 754-4681. Regulations governing small-quantity generators are currently being reviewed to possibly raise the accumulation limit. Call the Hazardous Waste Line at 1-800-287-6429 for the most up-to-date information.

Dangerous Waste Spill Plans

A recent state law established the requirement that generators of dangerous wastes in excess of 220 pounds/month (2,640 pounds/year) prepare a waste reduction plan, called a spill plan, not to be confused with the SWPPP (see R.4). The required content of the plan is set forth in *Pollution Prevention Planning - Guidance Manual*, January 1992, publication No. 91-2, for WAC Chapter 173-307.

Many of the actions described in these plans may benefit stormwater quality and thus should be integrated into any decisions about the selection of the BMPs described in Chapters 4 and 5 of this volume.

See WAC Chapters 173-303 and -307 for further details, as well as the above-named publication.

R.3 Ecology Stormwater NPDES Permit Requirements

The NPDES program requires industries or industrial-type activities to obtain permits for stormwater discharge.

Coverage is under Ecology's general permit for stormwater discharges associated with industrial or construction activities for each regulated facility. A business must obtain permit coverage if its primary activity falls under one of the categories listed in the permit or its fact sheet. The permit and fact sheet may be viewed on Ecology's Web site at: www.ecy.wa.gov/programs/wq/stormwater/industrial/index.html.

Examples of types of industrial facilities required to be covered under the General Permit for Industrial activities include the following business types if they discharge stormwater to surface water from their sites:

1. Lumber & Wood Products Industries
2. Paper and Allied Products Industries
3. Primary Metals Industries
4. Mining and gas/oil extraction industries (Note: Gravel Mines have a separate NPDES permit and would be required to be covered under that General Permit).
5. Hazardous waste treatment, storage and disposal facilities.
6. Landfills, land application sites and dumps
7. Recycling facilities including salvage yards, automobile junkyards, and metal scrap yards.
8. Transportation facilities including railway stations, airports, ferry terminals, petroleum bulk stations and terminals.
9. Industries involved in food products, printing, painting, glass products industrial and commercial machinery, transportation equipment, warehousing and storage.

The NPDES Stormwater Permit program requires the preparation of a SWPPP and compliance with the general permit conditions. Alternatively a site can apply for an individual permit if special circumstances would warrant it. A NPDES permit is also required for certain activities such as gravel mining not included under the industrial permit and municipalities for discharge to surface water, or a storm drain that discharges to surface water or to surface water and groundwater.

R.4 Ecology Requirements for Underground and Aboveground Storage Tanks

Underground Storage Tanks

Underground storage tanks (UST) that contain fuel and other petroleum products are regulated by Ecology under **WAC Chapter 173-360 Underground Storage Tank Regulations.** This law applies to USTs that have a capacity of greater than 110 gallons. USTs which store federally listed or otherwise regulated hazardous waste, heating fuel on the premises where used, farm or residential USTs less than 1,100 gallons in size and other types are exempt from these regulations (WAC Chapter 173-360-110).

The state UST regulations require permits for USTs in use after July 1991. Specific performance criteria such as design, integrity testing, inventory control, UST performance monitoring, spill control, and reporting for new USTs are outlined in this regulation. USTs in existence prior to adoption of this regulation in 1990 must meet the upgrade criteria or new UST requirements by 1998 or complete closure of the system.

USTs that have been closed or taken out of service after December 1988 must complete closure (removal or in-place closure) in accordance with WAC Chapter 173-360. Requirements for UST closure with Ecology include submittal of a 30-day notice of closure, site assessment, and completion of any applicable cleanup actions. A report of the closure actions must be submitted to Ecology.

Aboveground Storage Tanks

Aboveground storage tanks (AST) which store dangerous wastes are regulated under **WAC Chapter 173-303 Dangerous Waste Regulations**, which is administered by Ecology. Underground storage tanks which store dangerous wastes must also meet the criteria for tanks in this regulation. Businesses which store, handle or generate dangerous wastes are regulated under this regulation based on the volume of dangerous waste generated. The Dangerous Waste Regulations have specific requirements for AST integrity, corrosion protection, secondary containment, leak detection, and use and management criteria, in addition to general requirements for businesses that have dangerous wastes.

For ASTs which contain other types of materials such as petroleum products or raw materials, Ecology guidance document ***Guidelines to Prevent, Control, and Contain Spills from the Bulk Storage of Petroleum Products*** is available for technical guidance.

Inquiries about business-specific requirements and permitting for USTs and ASTs should be directed to Ecology, Southwest Regional Office at (360) 407-6300.

R.5 U.S. EPA and Washington State Department of Ecology Emergency Spill Cleanup Requirements

USEPA – Spill Prevention Control and Cleanup Plans (40 CFR 112)
This federal regulation requires that owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, or consuming oil and oil products are required to have a Spill Prevention and Control and Cleanup Plan (SPCC), provided that the facility is not transportation related; and, that the aboveground storage of a single container is in excess of 660 gallons, or an aggregate capacity greater than 1,320 gallons, or a total below ground capacity in excess of 42,000 gallons.

The plan must:

1. Be well thought out in accordance with good engineering.
2. Achieve three objectives - prevent spills, contain spills that occur, cleanup spills.
3. Identify name, location, owner, and type of facility.
4. Have date of initial operation and oil spill history.
5. Designate the person responsible.
6. Be approved and certified by the person in authority.
7. Contain a facility analysis.
8. Tanks must have secondary containment and leak detection.

Ecology Dangerous Wastes (WAC 173-303-350)
The regulations state that generators must have a contingency plan that must include:

1. Actions taken in the event of a spill.
2. Descriptions of arrangements with local agencies.
3. Identification of the owner's emergency coordinator.
4. List of emergency equipment.
5. Evaluation plan for business personnel.

See Federal Regulation 40 CFR 112 and WAC 173-303-350 for further information.

R.6 Washington State Department of Agriculture Pesticide Regulations

The State of Washington encourages integrated pest management (IPM) when possible. IPM makes use of physical, biological, and selective chemical methods to control pests, helping to protect the environment. IPM techniques for schools and homeowners can be found on Ecology's website:

http://www.ecy.wa.gov/programs/swfa/upest/

Pesticide laws for agricultural operations are administered by the state's Department of Agriculture, under the Washington Pesticide Control Act (RCW Chapter 15.58), Washington Pesticide Application Action (RCW Chapter 17.21), and regulations in WAC Chapter 16.228. The requirements relevant to water quality protection are:

1. Persons who apply pesticides are required to be licensed **except**:

    a. People who use general-use pesticides on their own or their employer's property.

    b. Grounds maintenance people using only general use pesticides on an occasional basis not amounting to a regular occupation.

    c. Governmental employees who apply general use pesticides without utilizing any kind of motorized or pressurized apparatus.

    d. Employees of a commercial applicator or a government agency who are under direct on-site supervision by a licensed applicator.

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

3. No person shall pollute streams, lakes, and other water supplies in pesticide loading, mixing, and application.

4. 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, human beings, desirable plants, or animals.

See WAC Chapter 16.228 for further details.

R.7 Olympic Region Clean Air Agency Air Quality Regulations

Thurston County is under the jurisdiction of regional air quality authorities who in turn must function under Washington State and federal air quality regulations. The Olympic Region Clear Air Agency (ORCAA) is the regulatory agency for air quality in Thurston County.

The air authority requires registration of and regulates sources of air emissions, including:

1. Spray painting
2. Asphalt plants
3. Rock crushers
4. Non-road engines
5. Incinerators
6. Fuel storage tanks and reservoirs
7. Dry-cleaners
8. Soil and groundwater remediation
9. Composters
10. Auto body repair and painting
11. Outdoor burning
12. Building demolition and asbestos removal

Other air emission sources are exempt from registration but are still required to comply with applicable air pollution requirements. A list of these sources can be found in the ORCAA regulations.

ORCAA requires that reasonable and appropriate precautions be taken to prevent fugitive particulate material from becoming airborne when handling, loading, transporting, or storing particulate material or when constructing, altering, repairing or demolishing a building, road, or untreated open area. Reasonable precautions include: the paving of parking lots and storage areas; housekeeping measures to minimize the accumulation of mud and dust and prevent its tracking onto public roads; and stabilizing storage piles with water spray, chemical stabilizers, tarps, or enclosure.

ORCAA regulations prohibit the release of an air contaminant or water vapor, including an air contaminant whose emission is not otherwise prohibited if the air contaminant or water vapor causes detriment to the health, safety, or welfare of any person, or causes damage to property or business. It also prohibits installation of any device which would conceal or mask an emission of an air contaminant which would otherwise violate ORCAA's Regulations or WAC 173-400.

ORCAA regulations may be viewed on the agency's Web site at: <www.orcaa.org>.

R.8 Requirements of Native American Tribes

Three tribes are located in Thurston County—the Nisqually Indian Tribe, the Confederated Tribes of the Chehalis Reservation (with reservation boundaries that also cross into neighboring Grays Harbor County) and the Squaxin Island Tribe (the tribal center is located in Mason County) have usual and accustomed lands within Thurston County. Tribal staff review federal, state, and local permits for projects on tribal lands or projects on non-tribal lands that may affect treaty-reserved resources or areas. Both tribes have lands and continuing treaty interests in natural resources. Check with the respective tribes for more information on the treaty rights and the permit review role of the tribe.

Chapter 8 - Quick Reference Phone Numbers and Web Sites

Environmental Protection Agency (U.S. EPA) – Region X	800-424-4372
Thurston County:	
Water Resources Division, Department of Resource Stewardship	360-754-4681
Department of Public Works	360-867-2300
After-hours water and sewer emergencies (paging service)	800-926-7761
Thurston County Waste Line (automated information)	360-786-5494
LOTT Alliance Industrial Pretreatment Program	360-528-5708
Development Services – Permits	360-786-5490
Weed Control/ Noxious Chemical Use	360-786-5576
Thurston County Public Health and Social Services Department:	
On-Site Sewage	360-867-2673
Asbestos Removal	360-867-2664
Hazardous Waste Section	360-867-2664
Solid Waste	360-867-2664
University of Washington Center for Urban Water Resources	253-254-7030
Washington State Department of Agriculture	360-902-2010 877-301-4555
Washington State Department of Ecology	360-407-6000
Southwest Regional Office	360-407-6300
Dangerous/Hazardous Waste	360-407-6300
NPDES Stormwater or Wastewater Permits	360-407-6400
Spill Reporting	800-424-8802
Recycling	800-732-9253
Groundwater Quality and Protection	360-407-6400
Underground and Aboveground Storage Tanks	360-407-7170
Washington State University/Thurston County Cooperative Extension	360-867-2151
Industrial Materials Exchange	206-263-8899
Nisqually Tribe	360-456-5221
Confederated Tribes of the Chehalis	360-273-5911
Olympic Region Clean Air Agency (ORCAA)	800-422-5623
Underground Utility Locate "Call Before You Dig"	800-424-5555

Washington State Departments:

Washington State Department of Ecology - Stormwater Home Page
<http://www.ecy.wa.gov/programs/wq/stormwater/index.html>

Washington State Department of Health
<http://www.doh.wa.gov/>

Washington Department of Fish and Wildlife
<http://wdfw.wa.gov/>

Washington State Government Information and Services
<http://www.access.wa.gov/>

Washington State Department of Ecology – Flood Information
<http://www.ecy.wa.gov/programs/sea/floods/>

Washington State Department of Ecology - Digital Coastal Atlas
<http://fortress.wa.gov/ecy/coastalatlas> >

Federal Departments:

Federal Emergency Management Agency (FEMA)
<http://fema.gov/>

U.S. EPA Office of Water, Academy 2000
<http://epa.gov/watertrain/>

U.S. Geological Survey (USGS) Departments:

USGS Historical Water Resource Data
<http://wa.water.usgs.gov/realtime/historical.html>

USGS National Water Information System (NWISWeb)
<http://water.usgs.gov/nwis/>

Water Quality and NPDES:

Natural Resources Conservation Service (NRCS) and U.S. Department of Agriculture (USDA)
<http://www.nrcs.usda.gov/>

National Climatic Data Center Data Archive
<http://www.ncdc.noaa.gov/>

National Weather Service Hydrologic Forecasts (River Flooding)
http://water.weather.gov/ahps/

USGS Real Time Gauging Info
<http://wa.water.usgs.gov/realtime/current.html>

U.S. Army Corps of Engineers Real Time Gauge Info
<http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm>

The Central Puget Sound Water Suppliers' Forum
<http://www.ci.seattle.wa.us/Forum>

Thurston County:

Thurston County Homepage
<http://www.co.thurston.wa.us/home/index.asp

http://www.co.thurston.wa.us/stormwater/

< http://www.co.thurston.wa.us/waterresources/>

Thurston County Mapping
<http://www.geodata.org>

Thurston Conservation District
<http://www.thurstoncd.com/>

Other Agencies:

Thurston County Public Health and Social Services
<http://www.co.thurston.wa.us/health/ehadm/index.html>

NWS River Forecast Center - Flood Outlook
<http://www.nwrfc.noaa.gov/river/fop.cgi>

NOAA Tide and Current Predictions
https://tidesandcurrents.noaa.gov/tide_predictions.html

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Appendix IV-A –Recycling and Disposal of Vehicle Fluids and Other Wastes*

	Recommended Management
Antifreeze	Store separately for resale. Separate ethylene glycol from propylene glycol for off-site recycling. If not recyclable, send to Treatment, Storage, and Disposal Facility (TSDF) for disposal.
Batteries	INTACT: Accumulate under cover prior to sale, deliver to recycler or, return to manufacturer. BROKEN: Accumulate acid from broken batteries in resistant containers with secondary containment. Send to TSDF for disposal.
Brake fluid	Accumulate in separate, marked, closed container. Do not mix with waste oil. Recycle.
Fuel	Store gasoline, and diesel separately for use or resale. Mixtures of diesel, gasoline, oil, and other fluids may not be recyclable and may require expensive disposal.
Fuel filters	Drain fluids for use as product. With approval of local landfill operator, dispose of in dumpster, if needed.
Oil filters	Puncture the filter dome and drain it for 24 hours. Put oil drained from filters into a “USED OIL ONLY” container. Keep drained filters in a separate container marked “USED OIL FILTERS ONLY.” Locate a scrap metal dealer who will pick up and recycle filters. With approval of local landfill operator, dispose of drained filters to dumpster.
Paint	Accumulate oil-based and water-based paints separately for use or resale. If not recyclable, send accumulations to TSDF for disposal.
Power steering fluid	Same as for used oils.
Shop towels/oily rags	Use cloth towels that can be laundered and reused. Accumulate used shop towels in a closed container. Sign up with an industrial laundry service that can recycle towels.
Solvents	Consider using less hazardous solvents or switching to a spray cabinet that doesn't use solvent. Accumulate solvents separately. Consider purchasing a solvent still and recycling solvent on site. Do not mix with used oil. Do not evaporate as a means of disposal.
Transmission oil, differential and rear end fluids	Accumulate in a “USED OIL ONLY” container. Arrange for pickup for off-site recycling.
Used oils; including, crankcase oil, transmission oil, power steering fluid and differential/rear end oil	Keep used oil in a separate container marked “USED OIL ONLY.” Do not mix with brake fluid, or used antifreeze. Do not mix with any other waste if burning for heating. Arrange for pickup for off-site recycling.
Windshield washer fluid	Accumulate separately for use or resale. Discharge to on-site sewage disposal, or, if acceptable by the Industrial Pretreatment Program ((253) 798-3013) discharge to sanitary sewer.

* Ecology’s Hazardous Waste Program developed this information.

The Hazardous Waste Services Directory is now available online at :

<apps.ecy.wa.gov/hwsd/default.htm>.

Appendix IV-B –
Example of an Integrated Pest Management Program

Integrated Pest and Vegetation Management (IPM) is a natural, long-term, ecologically-based systems approach to controlling pest populations. IPM is used to reduce pest populations, maintain them at levels below those causing health concerns or economic damage. The goals of IPM are to both encourage optimal selective pesticide use (away from prophylactic, broad spectrum use), and to maximize natural controls to minimize environmental side effects.

For more information on Thurston County's IPM policy, visit the County web site at: < http://www.co.thurston.wa.us/health/ehhw/IPM.html>.

Introduction

True integrated pest and vegetation management is a powerful approach that anticipates and prevents most problems through appropriate cultural practices and careful observation. Knowledge of the life cycles of host plants and both beneficial and pest organisms is also important. The integrated pest management section of this study guide is adapted from *Least Toxic Pest Management for Lawns* by Sheila Daar. Following the integrated pest management process gives you the information you need to minimize damage by weeds, diseases, and pests and to treat those problems with the least toxic approaches.

The IPM Process

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.

Every landscape has a population of some pest insects, weeds, and diseases. This is good because it supports a population of beneficial species that keep pest numbers in check. Beneficial organisms may compete with, eat, or parasitize disease or pest organisms. 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. For instance, European crane flies usually don't do serious damage to a lawn unless there are between 25 to 40 larvae per square foot feeding on the turf in February (in normal weather years). Also, most people consider a lawn healthy and well maintained even with up to 20 percent weed cover, so treatment, other than continuing good maintenance practices, is generally unnecessary.

Step Three: Monitor to detect and prevent pest problems.

Regular monitoring is a key practice to anticipate and prevent major pest outbreaks. It begins with 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.
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
Use cultural, physical, mechanical, or biological controls first. If those prove insufficient, use the chemical controls described below that have the least non-target impact. When a pest outbreak strikes (or monitoring shows one is imminent), implement integrated pest management then consider control options that are the least toxic, or have the least non-target impact. Here are two examples of an integrated pest management approach:

1. **Red thread disease** is most likely under low nitrogen fertility conditions and most severe during slow growth conditions. Mow and bag the clippings to remove diseased blades. Fertilize lightly to help the grass recover, then begin grasscycling and change to fall fertilization with a slow-release or natural-organic fertilizer to provide an even supply of nutrients. Chemical fungicides are not recommended because red thread cannot kill the lawn.

2. **Crane fly damage** is most prevalent on lawns that stay wet in the winter and are irrigated in the summer. Correct the winter drainage and/or allow the soil to dry between irrigation cycles; larvae are susceptible to drying out, so these changes can reduce their numbers. It may also be possible to reduce crane fly larvae numbers by using a power de-thatcher on a cool, cloudy day when feeding is occurring close to the surface. Studies are being conducted using beneficial nematodes that parasitize the crane fly larvae; this type of treatment may eventually be a reasonable alternative.

Only after trying suitable non-chemical control methods, or determining that the pest outbreak is causing too much serious damage, should chemical controls be considered. If chemical controls prove necessary, determine what products are available and choose a product that is the least toxic and has the least non-target impact. Refer to the operational BMPs for the use of pesticides below for guidelines on choosing, storing, and using lawn and garden chemicals.

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. Review your landscape maintenance and cultural practices to see if they can be modified to prevent or reduce the problem.

A comprehensive integrated pest management program should also include the proper use of pesticides as a last resort, and vegetation/fertilizer management to eliminate or minimize the contamination of stormwater.

Appendix IV-C – Recommendations for Management of Material Generated from Road Maintenance Activities

Introduction

This appendix addresses materials generated from stormwater maintenance activities such as street sweeping and the cleaning of catch basins and, to a limited extent, other stormwater conveyance and treatment facilities. Limited information is available on the characteristics of materials from maintenance of detention/retention ponds, bioswales, and similar stormwater treatment facilities. The recommendations provided here may be generally applicable to these facilities, with extra diligence given to material characterization.

These recommendations do not constitute rules or regulations, but are suggestions for road maintenance materials handling, reuse, and disposal using current regulations and the present state of knowledge of road maintenance materials constituents. The recommendations address the liquid and solid materials collected during routine maintenance of stormwater catch basins, detention/retention ponds, ditches and similar stormwater treatment and conveyance structures, and street and parking lot sweeping. In addition to these recommendations, end users and other authorities may have their own requirements for road maintenance materials reuse and handling.

"Road Maintenance Materials" include liquid and solid materials collected during maintenance of stormwater catch basins and detention/retention ponds, ditches and similar stormwater treatment and conveyance structures, and materials collected during street and parking lot sweeping.

"Road Maintenance Materials," 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 road maintenance materials. Road maintenance material also does not include flood debris, landslide debris, and chip seal gravel.

Road maintenance materials do not ordinarily classify as dangerous waste. The owner of the stormwater facility and/or collector of road maintenance materials is considered the waste generator and is responsible for determining whether the waste designates as dangerous waste. Sampling to date has shown that material from routine maintenance of streets and stormwater facilities does not classify as dangerous waste (see Table C.6). However, it is possible that road maintenance materials from spill sites could classify as dangerous waste. Road maintenance materials from areas with exceptionally high average daily traffic counts may contain contaminants – such as heavy metals, total petroleum hydrocarbons (TPH), and carcinogenic polycyclic aromatic hydrocarbons(c-PAH) – at levels that limit reuse options.

Contamination in Road Maintenance Materials Solids

Road maintenance materials is solid waste. While road maintenance materials from normal street and highway maintenance is not dangerous waste, it is solid waste, as defined under The

Solid Waste Management Act (Chapter 70.95 RCW) and under Solid Waste Handling Standards (Chapter 173-350 WAC). The Solid Waste Management Act gives local health departments (Thurston County Environmental Health Division of Department of Public Health and Social Services) primary jurisdiction over solid waste management. Road maintenance materials solids may contain contaminants at levels too high to allow unrestricted reuse. There are no specific references in the Solid Waste Handling Standards to facilities managing road maintenance materials solids, although these facilities will typically fit under the section dealing with Piles Used for Storage and Treatment (Section 320). There are no specific references for reuse and disposal options for road maintenance materials in the Solid Waste Handling Standards because they do not apply to clean soils. Clean soils are defined as ‘soils and dredged materials which are not dangerous wastes, contaminated soils, or contaminated dredged material…’ (WAC 173-350-100). Whether or not a soil is a clean soil depends primarily upon the level of contaminants and, to a lesser degree, on the background level of contaminants at a particular location and the exposure potential to humans or other living organisms. Therefore, evaluate both the soil and potential land application sites to determine if a soil is a clean soil. Thurston County Environmental Health should be contacted to determine if a road maintenance material meets the definition of “clean soil” when it will be reused as a soil.

There is no simple regulatory mechanism available to classify road maintenance materials solids for uncontrolled reuse or disposal. Road maintenance materials are not defined simply as solid waste. Local health districts have historically used the Model Toxics Control Act (MTCA) Cleanup Regulation Method A residential soil cleanup levels to approximate “clean” and to make decisions on land application proposals. The MTCA regulation is not intended to be directly applied to setting contaminant concentration levels for land application proposals. However, they may provide human health and environmental threat information and a useful framework for such decisions, when used in conjunction with other health and environmental considerations. In addition to MTCA, Ecological Soil Screening Levels from EPA, ODEQ Risk-based concentrations, Toxicological benchmarks from Oak Ridge National Labs, and natural background levels can be considered. Contact the Thurston County Environmental Health to determine local requirements for making this determination.

Using the old MTCA regulations, many local health departments have set a criterion of 200 mg/kg Total Petroleum Hydrocarbons (TPH) for diesel and heavy fuel oils as a threshold level for clean soil. Using the new MTCA terrestrial ecological evaluation procedures, allowable TPH levels for land application could range from 200 to 460, depending on site characteristics and intended land use. Road maintenance materials sampling has historically yielded TPH values higher than 200 mg/kg for hydrocarbons in the diesel and heavy oil range. These values typically reflect interference from natural organic material and, to a lesser extent, relatively immobile petroleum hydrocarbons. The mobile hydrocarbons that are of concern for groundwater protection are generally not retained with road maintenance materials solids. Ecology's Manchester Lab has developed an analytical method to reduce the problem of natural organic material being included in the TPH analysis for diesel and heavier range hydrocarbons. This method, called NWTPH-Dx, reduces the background interference associated with vegetative matter by as much as 85 percent to 95 percent. However, even with the new methodology, TPH test results for road maintenance materials may still be biased by the presence of natural vegetative material and may still exceed 200 mg/kg. Where the laboratory results report no ‘fingerprint’ or chromatographic match to known petroleum hydrocarbons, the soils should not be considered to be petroleum contaminated soils. Table C.1 at the end of this appendix lists typical TPH levels in street sweeping and catch basin solids.

Road maintenance materials solids frequently contain levels of carcinogenic PAHs (c-PAH) that make unrestricted use inappropriate. This is complicated further by analytical interference caused by organic matter that raises practical quantitation or reporting limits. To greatly reduce the level of interference, the use of U.S. EPA Test Method 8270, incorporating the silica gel cleanup step, is recommended. The calculated c-PAH value can vary greatly depending upon how non-detect values are handled. The new MTCA Method A criterion for c-PAH is 0.1 mg/kg (the sum of all seven c-PAH parameters multiplied by the appropriate toxicity equivalency factor) for unrestricted land uses. The MTCA criteria for soil cleanup levels for industrial properties is 2.0 mg/kg. Following this guidance, most sites where road maintenance materials could be reused as soil will be commercial or industrial sites, or sites where public exposure will be limited or prevented. Table C.1 at the end of this appendix lists typical TPH levels in street sweeping and catch basin solids.

Permitting of road maintenance materials treatment and storage facilities as solid waste handling facilities by the Thurston County Environmental Health Division is required. Under the Solid Waste Management Act, local health departments have primary jurisdiction over solid waste management.

Road maintenance materials handling facilities are subject to the requirements of the Solid Waste Handling Standards. Specific requirements depend upon the manner in which the waste is managed. Most facilities are be permitted under the section dealing with Piles Used for Storage and Treatment (Section 320).

For most facilities, permit requirements include a plan of operation, sampling, record keeping and reporting, inspections, and compliance with other state and local requirements. The plan of operation should include a procedure for characterization of the waste and appropriate reuse and disposal options, consistent with the recommendations in this document and applicable federal, state, and local requirements.

Ecology suggests a road maintenance materials site evaluation (see sample at end of this appendix) is suggested for all road maintenance materials as a method to identify spill sites or locations that are more polluted than normal. Ecology based the disposal and reuse options listed below on characteristics of routine road maintenance materials and are not appropriate for more polluted wastes. The collector of road maintenance materials should evaluate it for its potential to be classified as dangerous waste. The collector should also be aware that this waste may not meet end users requirements.

Road maintenance materials suspected to be dangerous waste should not be collected with other road maintenance materials. Material in catch basins with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes, or oily sheen) should be left in place or segregated until tested. Base testing activities based on probable contaminants. Road maintenance materials that is suspected to be dangerous waste should be collected and handled by someone experienced in handling dangerous waste. If collecting potential dangerous waste because of emergency conditions, or if the waste becomes suspect after it is collected, it should be handled and stored separately until a determination as to proper disposal is made. Road maintenance materials treatment and storage facilities should have separate “hot load” storage areas for such waste. **Dangerous Waste** includes road maintenance materials known and suspected to be dangerous waste. This waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC) unless testing determines it is not dangerous waste.

Spills should be handled by trained specialists. Public works maintenance crews and private operators conducting street sweeping or cleaning catch basins should have written policies and procedures for dealing with spills or suspected spill materials. Emergency Spill Response telephone numbers should be immediately available as part of these operating policies and procedures.

The end recipient of road maintenance materials must be informed of its source and may have additional requirements for its use or testing that are not listed here. This document is based primarily on average road maintenance materials' chemical constituents and their potential affect on human health and the environment. There are physical constituents (for example, broken glass or hypodermic needles) or characteristics (for example, fine grain size) that could also limit reuse options. Additional treatment such as drying, sorting, or screening may also be required, depending on the needs and requirements of the end user.

Road maintenance materials treatment and storage facilities owned or operated by governmental agencies should be made available to private waste collectors and other governmental agencies on a cost recovery basis. Proper road maintenance materials collection and disposal reduces the amount of waste released to the environment. The operators of road maintenance materials facilities should restrict the use of their facilities to certified and/or licensed waste collectors who meet their training and liability requirements.

The use of road maintenance materials solids under this guidance should not lead to designation as a dangerous waste site, requiring cleanup under MTCA. Exceeding MTCA Method A unrestricted land use cleanup levels in road maintenance materials and products made from road maintenance materials does not automatically make the site where road maintenance materials is reused a cleanup site. A site is reportable only if “a release poses a threat to human health or the environment” (Model Toxic Control Act). The reuse options proposed below are designed to meet the condition of not posing a threat to human health or the environment.

Testing of road maintenance materials solids will generally be required as part of a plan of operation that includes procedures for characterization of the waste. Testing frequency, numbers of samples, parameters to be analyzed, and contaminant limit criteria should all be provided as part of an approved plan of operation. However, street sweepings that consist primarily of leaves, pine needles, branches, and grass clippings do not require testing. Tables C.4 and C.5 at the end of this appendix provide some recommended parameters and sampling frequencies for road maintenance materials solids from routine street maintenance. These are provided as guidance only, and are intended to assist the county and the Thurston County Public Health and Social Services Department in determining appropriate requirements. Sampling requirements may be modified, over time, based on accumulated data. When the material is from a road maintenance materials facility or an area that has never been characterized by testing, the test should be conducted on a representative sample before co-mingling with other material. Testing in these instances would be to demonstrate that the waste does not designate as dangerous waste and to characterize the waste for reuse. At a minimum, the parameters in Table C.4 are recommended for these cases. Note that it will generally not be necessary to conduct TCLP analyses when the observed values do not exceed the recommended values in Table C.4. Table C.6 illustrates some observed relationships between total metals and TCLP metals values.

For further information on testing methods and sampling plans, refer to:

- SW 846 (U.S. EPA, Office of Solid Waste, Test Methods for Evaluating Solid Wastes, 3rd Edition); and
- Standard Methods for the Examination of Water and Wastewater (American Public Health Association, et al., 18th Edition, 1992).

For road maintenance materials not exceeding the suggested maximum values in Table C.4, the following road maintenance materials solids reuse and disposal options are recommended:

- Compost street sweepings that consist primarily of leaves, pine needles and branches, and grass cuttings from mowing grassy swales. Remove litter and other foreign material prior to composting or the composting facility must provide for such removal as part of the process. Dispose of the screened trash is solid waste at an appropriate solid waste handling facility.
- It is possible to reuse coarse sand screened from street sweeping after recent road sanding, providing there is no obvious contamination from spills. The screened trash is solid waste and must be disposed of at an appropriate solid waste handling facility.
- Screen roadside ditch cleanings, not contaminated by a spill or other release and not associated with a stormwater treatment system such as a bioswale, to remove litter and separated into soil and vegetative matter (leaves, grass, needles, branches, etc.). The soils from these activities are typically unregulated as solid waste. Ditching material that may be contaminated must be stored, tested, and handled in the same manner as other road maintenance materials solids. It is the generator's responsibility to visually inspect and otherwise determine whether the materials may be contaminated.
- Construction road maintenance materials – solids collected from sweeping or in stormwater treatment systems at active construction sites – may be placed back onto the site that generated it, or managed by one of the methods listed below, provided that it has not been contaminated as a result of a spill. For concrete handling at construction site, refer to BMP C151 and C154 in Volume II.
- Use screened road maintenance materials soils as feedstock materials for topsoil operations. Reserve this option for road maintenance materials soils with very low levels of contaminants. Evaluate the allowable level of contaminants based on the proposed use of the soil. At a minimum, the contaminate level in the soil

should be below established action levels for in situ soils. Do not dilute road maintenance materials soils with clean soils or composted material used as a substitute for treatment or disposal. There may be unscreened physical contaminants (for example, glass, metal, nails, etc.) in road maintenance. Where present, these contaminants in road maintenance materials could preclude its use as feedstock material for topsoil operations.

- Fill in parks, play fields, golf courses, and other recreational settings, where direct exposure by the public is limited or prevented. One way to accomplish is to cover the fill with sod, grass, or other capping material to reduce the risk of soil being ingested. The level of contaminants in the road maintenance materials must be evaluated to ensure that the soils meet the definition of clean soils when used in this manner.
- Fill in commercial and industrial areas, including soil or top dressing for use at industrial sites, roadway medians, airport infields, and similar sites where there is limited direct human contact with the soil, and stabilize the soils with vegetation or other means. Evaluate the level of contaminants in the road maintenance materials to ensure that the soils meet the definition of clean soils when used in this manner.
- Top dressing on roadway slopes, road or parking lot construction material, road or parking lot subgrade, or other road fill. Evaluate the level of contaminants in the road maintenance materials to ensure that the soils meet the definition of clean soils when used in this manner.
- Daily cover or fill in a permitted municipal solid waste landfill, provided the road maintenance materials solids have been dewatered. Road maintenance materials solids may be acceptable as final cover during a landfill closure. Consult the Thurston County Environmental Health and the landfill operator to determine conditions of acceptance.
- Treatment at a permitted contaminated soil treatment facility.
- Recycling through incorporation into a manufactured product, such as Portland cement, prefab concrete, or asphalt. Consult the facility operator to determine conditions of acceptance.
- Other end-use as approved by the Thurston County Department of Public Health and Social Services.
- Disposal at an appropriate solid waste handling facility.

For road maintenance materials that exceed the suggested maximum values in Table C.4, the following road maintenance materials solids reuse and disposal options are recommended:

- Treatment at a permitted contaminated soil treatment facility.

- Recycling through incorporation into a manufactured product, such as Portland cement, prefab concrete, or asphalt. The facility operator should be consulted to determine conditions of acceptance.
- Other end-use as approved by the Thurston County Department of Public Health and Social Services.
- Disposal at an appropriate solid waste handling facility.

Road Maintenance Materials Liquids
General Procedures:

Road maintenance materials collection should emphasize retention of solids in preference to liquids. Road maintenance materials solids are the principal objective in road maintenance materials collection and are substantially easier to store and treat than liquids.

Road maintenance materials liquids require treatment before their discharge. Road maintenance materials liquids usually contain high amounts of suspended and total solids and adsorbed metals. Treatment requirements depend on the discharge location.

The Industrial Pretreatment Program responsible for O&M 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 Ecology's *Stormwater Management Manual for Western Washington* (see Volume V for further detail).

The following options are required, in order of preference, for disposal of catch basin decant liquid and water removed from stormwater treatment facilities.

Discharge of catch basin decant liquids to the municipal sanitary sewer is the <u>preferred disposal option</u>. Discharge to a municipal sanitary sewer requires the approval of the Industrial Pretreatment Program of your sewer service provider. Approvals for discharge to a sanitary sewer will likely contain pretreatment quantity, and location conditions to protect the municipal system. Following the Industrial Pretreatment Program's conditions is a permit requirement.

Discharge of catch basin decant liquids may be allowed into a basic or enhanced stormwater treatment BMP.

If option 1 is not available, discharge liquid collected from cleaning catch basins and stormwater treatment wet vaults back into the storm sewer system only 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 stormwater treatment facility (see Volume V). If pretreatment does not remove visible sheen from oils, the treatment facility must be able to prevent the discharge of oils causing a visible sheen.

- The discharge is as near to the treatment facility as is practical, to minimize contamination or recontamination of the collection system.
- The storm sewer system owner/operator has granted approval and has determined that the treatment facility will accommodate the increased loading. Part of the approval process may include pretreatment conditions to protect the treatment BMP. Following local pretreatment conditions is a permit requirement.

Ecology must approve in advance flocculants for the pretreatment of catch basin decant liquids. The liquids must be nontoxic under the circumstances of use.

Reasonably available will be determined by the stormwater utility and by the circumstances, including such factors as distance, time of travel, load restrictions, and capacity of the stormwater treatment facility. Some jurisdictions may choose not to allow discharge back to the storm sewer system.

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.

Site Evaluation

Ecology suggests the use of a site evaluation as a method to identify spill sites or locations that potentially contain dangerous wastes.

The site evaluation will aid in determining if waste is a dangerous waste and in determining what to test for if dangerous waste is suspected. The site evaluation will also help to determine if the waste does not meet the requirements of the end users.

There are three steps to a site evaluation:

1. A **historical review** of the site for spills, previous contamination, and nearby toxic cleanup sites and dangerous waste and materials.

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 never collected waste at a site before. At a minimum, the historical review should include operator knowledge of the area's collection history or records kept 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" Web page, tracking more than 15,000 sites. This information is available from Ecology through the Internet at < http://www.ecy.wa.gov/fs/ > or by calling a toll-free telephone number (800-633-7585). The Web page allows anyone with Internet 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 Web site is <iaspub.epa.gov/triexplorer/tri_release.chemical>.

2. An **area visual inspection** for potential contaminant sources such as a past fire, leaking tanks and electrical transformers, and surface stains.

   Evaluate the area around the site for contaminant sources prior to collection of the waste. The area visual inspection may be done either as part of multiple or as single site inspections. If the inspection finds a potential contaminant source, delay the waste collection until the potential contaminant is assessed.

   A second portion of the area visual inspection is a subjective good housekeeping evaluation of the area. Locations with poor housekeeping commonly cut corners in less obvious. Inspect these areas in greater detail for illegal dumping and other contamination spreading practices.

3. **A 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 site evaluation.

   For example, if the stormwater facility has an unusual color in or around it, then there is a strong possibility that someone dumped something into it. Some colors to be particularly wary of are yellow-green from antifreeze dumping and black and/or 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 dangerous waste. 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.

Table C.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 – 4,300	
King County (1) (Herrera 1995)		123 – 11,049 (Median 1,036)
Snohomish County and Selected Cities (1) (W & H Pacific, 1993)	163 – 1,500 (Median 760)	163 – 1,562 (Median 760)
City of Portland (2) (Bresch)		MDL – 1,830 (Median 208)
City of Seattle – Diesel Range(2) (Herrera 2009)	330-520	780-1700
City of Seattle – Motor Oil(2) (Herrera 2009)	2000-2800	3500-7000
Oregon (1) (Collins; ODOT 1998) Oregon (3) (Collins; ODOT 1998)	1,600 – 2,380 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 C.2. Typical c-PAH Values in Road maintenance materials 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
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=½ 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=½PQL; if the average concentration (using ND=½ PQL) is greater than the maximum detected value, then ND=Maximum value.

The new Method A soil cleanup level for unrestricted land use is 0.1 mg/Kg for BAP. (WAC 173-340-900, Table 740-1).

The new Method A soil cleanup level for industrial properties is 2 mg/Kg for BAP. (WAC 173-340-900, Table 745-1).

Table C.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)**
Arsenic (As)	<3 – 24	0.39 – 5.4	4 – 56	0.250	< 5 – 50 (9.3)
Cadmium (Cd)	0.5 – 2.0	<0.22 – 4.9	0.2 – 5.0	0.5	
Chromium (Cr)	19 – 241	5.9 – 71	13 – 100	25.8	
Copper (Cu)	18 – 560	25 – 110	12 – 730	29	9.1 – 3,280 (166)
Lead (Pb)	24 – 194	42 – 640	4 – 850	80	3 – 3,690 (154)
Nickle (Ni)	33 – 86	23 – 51	14 – 41	23	
Zinc (Zn)	90 – 558	97 – 580	50 – 2,000	130	44 – 4,170 (479)
Mercury (Hg)	0.04 – 0.16	0.024 – 0.193			< 0.03 – 3.8 (0.16)

Table C.4. Recommended Parameters and Suggested Values for Determining Reuse and Disposal Options.

Parameter	Suggested Maximum Value
Arsenic, Total	20.0 mg/kg (a)
Cadmium, Total	2.0 mg/kg (b)
Chromium, Total	42 mg/kg (c)
Copper (Cu), Total	100 mg/kg (e)
Lead, total	250 mg/kg (d)
Nickel	100 mg/kg (e)
Zinc	270 mg/kg (e)
Mercury (Inorganic)	2.0 mg/kg (f)
PAHs (Carcinogenic)	0.1 – 2.0 mg/kg (see Note at (g) below)
TPH (Heavy Fuel Oil)	2,000 mg/kg (see Note at (h) below)
TPH (Diesel)	200 mg/kg (see Note at (h) below)
TPH (Gasoline)	100 mg/kg (i)
Benzene	0.03 mg/kg (i)
Ethylbenzene	6 mg/kg (i)
Toluene	7 mg/kg (i)
Xylenes (Total)	9 mg/kg (i)

(a) Arsenic: from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses

(b) Cadmium: from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses.

(c) Chromium; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses

(d) Lead; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses

(e) Nickel and Zinc; from MTCA Table 749-2: Protection of Terrestrial Plants and Animals

(f) Mercury; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses

(g) PAH-Carcinogenic; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses and Table 745-1, industrial properties, based on cancer risk via direct contact with contaminated soil (ingestion of soil) in residential land use situations and commercial/industrial land uses. Note: The Thurston County Environmental Health may permit higher levels as part of a Plan of Operation, where they determine that the proposed end use poses little risk of direct human contact or ingestion of soil.

(h) TPH: from MTCA Tables 749-2 and 749-3: Protection of Terrestrial Plants and Animals. Values up to 460 mg/kg may be acceptable where the soils are capped or covered to reduce or prevent exposure to terrestrial plants and animals. Where the laboratory results report no 'fingerprint' or chromatographic match to known petroleum hydrocarbons, the soils will not be considered to be petroleum contaminated soils.

(i) BETX; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses.

Table C.5. Recommended Sampling Frequency for Road Maintenance Materials Solids.

Cubic Yards of Solids	Minimum Number of Samples
0 – 100	3
101 – 500	5
501 – 1,000	7
1,001 – 2,000	10
>2,000	10 + 1 for each additional 500 cubic yards

Modified from Ecology's Interim Compost Guideline (no longer in effect)

Table C.6. 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)
Arsenic	<3 – 56	<0.02 – 0 .5	5.0
Cadmium	<0.22 – 5	0.0002 – 0.03	1.0
Chromium	5.9 – 241	0.0025 – 0.1	5.0
Copper	12 – 730	0.002 – 0.88	none
Lead	4 – 850	0.015 – 3.8	5.0
Nickel	23 – 86	<0.01 – 0.36	none
Zinc	50 – 2,000	0.04 – 6.7	none
Mercury	0.02 – 0.19	0.0001 – 0.0002	0.2

Data from Thurston County (Thurston County 1993), King County (Herrera 1995) and Ecology (Serdar; Ecology 1993).

Table C.7. Typical Catch Basin Decant Values Compared to Surface Water Quality Criteria.

Parameter	State Surface Water Quality Criteria		Range of Values Reported	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 C.8. Typical Values for Conventional Pollutants in Catch Basin Decant.

Parameter (values as mg/l; except where stated)	Ecology 1993 Mean	(Min – Max)	King County 1995 Mean	(Min – Max)
PH	6.94	6.18 – 7.98	8	6.18 – 11.25
Conductivity (umhos/cm)	364	184 – 1110	480	129 – 10,100
Hardness (mg/l CaCO3)	234	73 – 762		
Fecal Coliform (MPN/100 ml)	3,000			
BOD	151	28 – 1,250		
COD	900	120 – 26,900		
Oil and 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 C.9. Catch Basin Decant Values Following Settling.[1]

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	7
Nonpolar fat, oil and grease	5.7 – 25	5 – 22	100
Ph (std)	6.1 – 7.2	6.74 – 8.26	5.0 – 12.0
Total Suspended Solids	2.8 – 1,310		
Recorded Total Monthly Flow; Gallons	Data not available	31,850 – 111,050	
Recorded Max. Daily Flow; Gallons	Data not available	4,500 – 18,600	25,000 GPD
Calculated Average Daily Flow; GPD	Data not available	1,517 – 5,428	

[1] Data from King County's Renton Facility (data from 1998 – 199) and the City of Portland's Inverness Site (data from 1999 – 2001); detention times not provided.

Thurston County Drainage Design and Erosion Control Manual

Volume V
Stormwater BMPs

Prepared by:
Thurston County Water Resources Division,
Department of Resource Stewardship

December 2016

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Chapter 1 - Introduction to Volume V

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* provides best management practices (BMPs) for designing and maintaining permanent stormwater management facilities.

BMPs are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. As described in Volume I, BMPs for long-term stormwater management at developed sites can be divided into three categories:

1. **Flow control**: BMPs that address the volume and timing of stormwater flows including BMPs best suited for meeting the Low Impact Development core requirement (CR #5).
2. **Source control**: BMPs that address prevention of pollution from potential sources
3. **Runoff treatment**: BMPs that address treatment of runoff to remove sediment and other pollutants

This volume addresses flow control and runoff treatment, and includes BMPs to meet the low impact development (LID) requirements of CR#5. Source control BMPs are described in Volume IV. Temporary BMPs for erosion and sediment control are found in Volume II.

BMPs included in this volume are summarized in Table 1.1.

The check mark (√) in the column(s) next to each BMP indicates the BMP type (low impact development, flow control, or runoff treatment) and the level of treatment (basic, enhanced, phosphorus, or oil control). The BMP selection process, which explains each of these categories in detail and helps the manual user to select BMPs depending on project and site characteristics, is provided in Volume I.

Where a BMP type or level of runoff treatment has been indicated with an asterisk (*), the standard BMP meeting minimum design criteria does not provide the level of runoff treatment noted, but the standard design may be modified to provide the additional treatment indicated. Refer to the individual BMP design guidelines for more information.

Many of the BMP design guidelines have been adapted from design criteria from *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2005), the *King County, Washington Surface Water Design Manual* (King County DNRP 2009), and the *Pierce County Stormwater Management and Site Development Manual* (Pierce County Surface Water Management 2008).

Table 1-1 Thurston County Stormwater BMPs

BMP No.	Title	Type of BMP					
				Runoff Treatment			
		LID	Flow Control	Basic	Enhanced	Phosphorus	Oil Control
LID Stormwater Management BMPs							
LID.01	Native Vegetation Protection, Reforestation, and Maintenance	√					
LID.02	Post-Construction Soil Quality and Depth	√					
LID.03	Reduce Effective Impervious Areas Associated with Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas	√					
LID.04	Downspout Infiltration Systems	√					
LID.05	Downspout Dispersion Systems	√					
LID.06	Sheet Flow Dispersion	√					
LID.07	Concentrated Flow Dispersion	√					
LID.08	Bioretention Facilities	√	√	√	√		
LID.09	Alternative Paving Surfaces	√					
LID.10	Vegetated Roofs	√					
LID.11	Full Dispersion	√					
LID.12	Rural Roads Natural Dispersion	√					
LID.13	Rural Roads Engineered Dispersion	√					
LID.14	Tree Planting and Tree Retention	√	√				
LID.15	Minimal Excavation Foundation Systems	√					
Infiltration BMPs							
IN.01	Infiltration Basins		√	*	*	*	
IN.02	Infiltration Trenches		√	*	*	*	
IN.03	Infiltration Vault		√	*	*	*	
Detention BMPs							
D.01	Detention Ponds		√				
D.02	Detention Tanks		√				
D.03	Detention Vaults		√				
D.04	Use of Parking Lots for Detention		√				
Biofiltration BMPs							
BF.01	Basic Biofiltration Swale			√			
BF.02	Wet Biofiltration Swale			√			
BF.03	Continuous Inflow Biofiltration Swale			√			

BMP No.	Title	Type of BMP					
				Runoff Treatment			
		LID	Flow Control	Basic	Enhanced	Phosphorus	Oil Control
BF.04	Basic Filter Strip/CAVFS			✔	*		*

Table 1.1 (continued). Thurston County Stormwater BMPs.

BMP No.	Title	Type of BMP					
				Runoff Treatment			
		LID	Flow Control	Basic	Enhanced	Phosphorus	Oil Control
Wet Pool BMPs							
WP.01	Stormwater Treatment Wetland			√	√		
WP.02	Wet Pond			√		*	
WP.03	Wet Vault			√			*
WP.04	Combined Detention/Wet Pool Facilities		√	√	*	*	
WP.05	Presettling Basin						
Media Filtration BMPs							
MF.01	Sand Filter Basin			√	*	*	
MF.02	Sand Filter Vault			√	*	*	
MF.03	Linear Sand Filter			√	*	*	√
MF.04	Media Filter Drain			√	√	√	
Oil and Water Separation BMPs							
OW.01	API (Baffle type) Separator Bay						√
OW.02	Coalescing Plate (CP) Separator Bay						√
OW.03	Oil Containment Booms						√

√ Meets criteria
* Design option allows BMP to meet criteria

1.2 How This Volume is Organized

Volume V is organized as follows:

Chapter 1: Introduction

Chapter 2: Low Impact Development (LID)

Chapter 3: Infiltration BMPs

Chapter 4: Detention BMPs

Chapter 5: Biofiltration BMPs

Chapter 6: Wet pool BMPs

Chapter 7: Media filtration BMPs

Chapter 8: Oil and water separation BMPs

Chapter 9: Emerging Technologies

Appendix V-A: Control structures, including flow control structures, bypass/diversion manholes, and emergency overflows

Appendix V-B: Facility liner design guidance

Appendix V-C: Maintenance guidelines

Appendix V-D: Access roads and ramps

Appendix V-E: Site design elements, including setbacks, landscaping, fencing, and signage.

1.3 How Do I Get Started?

First, consult Chapter 2 of Volume I to determine core requirements for stormwater treatment and flow management (Core Requirements #4 through #8) and selection of stormwater BMPs. After determining core requirements for your project and selecting BMPs, use this volume (V) to design BMPs. Consult Volume III (Hydrologic Analysis and Stormwater Conveyance) for guidance on methods to appropriately size flow management facilities. These facilities can then be included in any required stormwater submittals (see Volume I, Chapter 3).

Chapter 2 - Low Impact Development (LID)

Low Impact Development (LID) is a development approach that seeks to minimize the stormwater impacts of development by mimicking natural hydrologic processes.

The LID BMPs in this chapter can help you comply with Core Requirement #5 (Onsite Stormwater Management), #6 (Runoff Treatment), and #7 (Flow Control). Core Requirement #5 requires the use of onsite stormwater BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible, without causing flooding or erosion impacts. For more information about Core Requirement #5, see Volume I.

2.1 LID Site Design BMPs

Site design plays an important role in the amount of stormwater runoff generated by a project site. Reductions in impervious areas result in smaller runoff treatment and flow control facilities, thereby reducing stormwater control and treatment requirements and management costs.

This section describes LID site design practices that can reduce impervious areas and improve infiltration and treatment capacity of soils. LID planning and design considerations are also described in Volume I of this manual and in the *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2012).

The following BMPs are described in this section:

- LID.01: Native Vegetation Protection, Reforestation, and Maintenance
- LID.02: Post-Construction Soil Quality, and Depth
- LID.03: Minimize Impervious Areas.

2.1.1 LID.01 Native Vegetation Protection, Reforestation, and Maintenance

Preserving native vegetation onsite to the maximum extent feasible will minimize the impacts of development on stormwater runoff. Per the Applicability section below, it is preferable that 65 percent or more of the project site be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors. The following sections present the strategies and practices for meeting the native vegetation preservation requirements. Additional details on flow dispersion to native vegetation areas are presented under Section 2.3, 65/10 Dispersion.

The goal of preserving and restoring native vegetation in low impact development is to promote infiltration for overland flow generated in adjacent developed portions of the site and more closely mimic the site's natural hydrologic function. This BMP can be highly effective when used in conjunction with BMP LID.03, reducing effective impervious areas.

In areas where development or disturbance has occurred, the goal is to restore the hydrologic functions of a native forested site, including infiltration, evapotranspiration, and canopy interception.

2.1.1.1 Applicability

Preserving existing native vegetation shall be the first priority whenever feasible. Preserving vegetation is much easier than restoring it. Restoring native vegetation may be used in situations where an applicant wishes to convert a previously developed surface to a native vegetated surface for purposes of meeting dispersion requirements or code requirements for forest retention. Restoring native vegetation may also be required in cases where an area designed for native vegetation preservation such as a critical area buffer has been disturbed and requires restoration.

Native vegetation preservation and restoration areas should be incorporated to the maximum extent possible, and where most effective (i.e., where there is intact native vegetation and soils and/or unconcentrated flow from developed areas). Where possible, the goal for native vegetation preservation or restoration shall be as follows:

Rural and large lot development: 65 percent minimum

Medium density (4 to 6 dwelling units per acre): 50 percent minimum

High density (more than 6 dwelling units per acre): Protect or restore native vegetation to the maximum extent practical.

On lots that are one acre or greater, preservation of 65 percent or more of the site in native vegetation will allow the use of full dispersion techniques presented in BMP LID.11. Sites that can fully disperse are not required to provide runoff treatment or flow control facilities.

Native vegetation retention areas may be required as part of a plan of development for any of the following reasons:

Stormwater dispersion areas reserved for stormwater quality and quantity treatment as part of on-site measures

Wetland and other critical area buffers required by Code

Riparian areas and buffers and habitat areas

Minimum native vegetation areas required by zoning codes (for example in the Green Cove Basin).

2.1.1.2 Limitations

Preserving or restoring native vegetation depends heavily on establishing optimal soil and moisture conditions for the vegetation. A moisture-loving plant, even if native, will not thrive in an environment turned dry by rerouting of watershed flows.

Careful selection of areas for native tree preservation should be made with the advice of a landscape architect or tree arborist. Items to consider in this process include:

Impact of removal of adjacent vegetation on survivability of trees during wind storms

The health of tree stands including incidence of disease or infestation

Conifers with live crown ratios of 50 percent or greater have better survivability in wind and sun exposure

Trees and native vegetation that developed in forests are best retained in groups of sufficient size to maintain adequate growing space characteristics and maintain the integrity of the unit.

Avoid areas around structures, roadway intersections or immediately adjacent to the roadway where trees may create a future danger, sight distance or clear zone issue and may result in future removal of trees for safety reasons.

Prioritize native vegetation and soil protection areas by location and type of area as follows:

1. Large tracts of riparian areas that connect and create contiguous riparian protection areas

2. Large tracts of critical and wildlife habitat area that connect and create contiguous protection areas

3. Tracts that create common open space areas among and/or within developed sites

4. Protection areas on individual lots that connect to areas on adjacent lots or common protection areas

5. Protection areas on individual lots.

2.1.1.3 Submittals and Approval

Clearing limits and areas for vegetation restoration shall be shown on the drainage plans for the project. Clearing limits shall be marked in the field and verified by Thurston County prior to clearing. Protective fencing shall be installed to protect native areas to be preserved; examples include orange construction fencing, temporary chain link fence, or equivalent. For revegetation areas, a plants list shall be provided indicating the type of plant, quantity, any planting requirements and location of plantings.

Areas designated to be preserved as native vegetation for stormwater dispersion shall be designated as separate tracts or shall be protected by easement. The areas shall be protected from disturbance by signage and/or fencing. A signage and fencing plan shall be prepared and included in the drainage report submittal.

Permanent signs shall explain the purpose of the area, the importance of vegetation and soils for managing stormwater and that the removal of trees or vegetation and compaction of soil is prohibited.

2.1.1.4 Design Criteria

During construction protect native tree preservation areas from disturbance. See Volume II for additional requirements related to site clearing and protecting native vegetation.

At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.

Vegetation restoration and planting methods shall conform to published standards. The following guidance documents are provided as an example:

2.1.1.4.1 Riparian Areas

Restoring the Watershed A Citizen's Guide to Riparian Restoration in Western Washington, Washington State Department of Fish and Wildlife, 1995

Streamside Planting Guide for Western Washington, Cowlitz County Soil and Water Conservation District

Plant It Right: Restoring Our Streams, WSU Cooperative Extension, 2002

Integrated Streambank Protection Guidelines, Washington State Department of Fish and Wildlife, 2000.

2.1.1.4.2 Marine Bluff

Surface Water and Groundwater on Coastal Bluffs: A Guide for Ecology, Washington State Department of Ecology, Shorelands and Coastal Zone Management Program Publication No. 95-107, 1995

Vegetation Management: A Guide for Puget Sound Bluff Property Owners, Washington State Department of Ecology, Shorelands and Coastal Zone Management Program Publication No. 93-31, 1993.

Tree conservation areas should be designated for the site in areas not adjacent to or impacting structures (one tree height separation) or sight distance/clear area for roadways and shall be protected, or restored to follow natural successional patterns and to develop diverse multilayer canopy structure, snags, large woody debris, understory vegetation, and forest duff.

2.1.1.4.3 Conversion of Previously Developed Surfaces to Native Vegetation

Conversion of a previously developed surface to native vegetated landscape or restoration of disturbed areas required to be native vegetation requires the removal of impervious surface and ornamental landscaping, 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, etc.) 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 according to the specifications in Table 2.1. Species must be selected as appropriate for the site shade and moisture conditions, and in accordance with the following requirements:

Table 2-1 Selected Native Vegetation, Size, and Spacing Requirements

Species	Type	Sun and Moisture Preferences	Planted Size	Spacing
Trees (Plant 2 species minimum, at least one of which is a conifer)				
Douglas fir (*Pseudotsuga menziesii*)	Conifer	Sun, dry to moist soil	5 gallon, 6'-7' B&B	12' o.c.
Western red cedar (*Thuja plicata*)	Conifer	Sun or shade, moist to wet soil	5 gallon, 6'-7' B&B	12' o.c.
Western hemlock (*Tsuga heterophylla*)	Conifer	Sun or shade, well-drained soil	5 gallon, 6'-7' B&B	12' o..c.
Sitka spruce (*Picea sitchensis*)	Conifer	Sun or shade, moist mineral soils to wet soils	5 gallon, 6'-7' B&B	12' o.c.
Red alder (*Alnus rubra*)	Tree	Sun, a nitrogen fixer	5 gallon, 5'-6' B&B	12' o.c.
Bigleaf maple (*Acer macrophyllum*)	Tree	Sun or shade, dry to moist soil	5 gallon, 5'-6' B&B	12' o.c.
Black cottonwood (*Populus trichocarpa*)	Tree	Sun, wet soil	5 gallon, 5'-6' B&B	12' o.c.
Cascara buckthorn (Frangula purshiana)	Tree/shrub	Sun to partial shade, dry to moist soil	5 gallon, 5'-6' B&B	8' o.c.
Pacific willow (*Salix lucida*)	Tree/shrub	Sun, damp soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Shrubs (Plant 2 species minimum)				
Sitka willow (*Salix sitchensis*)	Shrub	Sun or shade, dry to damp soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Vine maple (*Acer circinatum)*	Shrub	Shade, moist to damp soils	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Filbert (hazelnut) (*Corylus cornuta)*	Shrub	Sun to shade, dry soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Salmonberry (*Rubus spectabilis)*	Shrub	Sun to shade, moist to wet soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Thimbleberry (*Rubus parviflorus)*	Shrub	Sun to partial shade, dry to moist soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Ocean spray (*Holodiscus discolor)*	Shrub	Sun to partial shade, dry	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.

Table 2.1 (continued). Selected Native Vegetation, Size, and Spacing Requirements

Species	Type	Sun and Moisture Preferences	Planted Size	Spacing
Shrubs (continued)				
Hollyleaved barberry (Mahonia aquifolium)	Shrub	Sun to shade, dry to moist soil	1 gallon	4' o.c.
Snowberry (*Symphoricarpos albus)*	Shrub	Sun to shade, dry to wet soil	1 gallon, 30-36"	4' o.c.
Service berry (*Amelanchier alnifolia)*	Shrub	Sun to shade, dry to wet soil	1 gallon	6' o.c.
Indian plum (*Oemleria cerasiformis)*	Shrub	Sun to shade, moist soil	1 gallon	4' o.c.
Twinberry (*Lonicera involucrate)*	Shrub	Sun to partial shade, moist soil	1 gallon	4' o.c.
Ground Cover (Plant 2 species minimum).				
Evergreen huckleberry (*Vaccinium ovatum)*	Groundcover	Sun to partial shade, moist soil	1 gallon	2' o.c.
Kinnikinick (*Arctostaphylos uva-ursa)*	Groundcover	Sun to partial shade, dry soil	1 gallon	2' o.c.
Salal (*Gaultheria shallon)*	Groundcover	Sun to shade, dry to moist soil	1 gallon	18" o.c.
Low Oregon graps (*Mahonia repens)*	Groundcover	Sun to partial shade, dry to moist soil	9-12"	18" o.c.
Sword fern (*Polystichum munitum)*	Groundcover	Sun to deep shade, dry to moist soil	2 gallon	3' o.c.

Source: King County Surface Water Design Manual (King County DNRP 2009).

Note:

B&B: Balled and Burlapped

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 the spacing given in Table 2.1.

b. Shrubs: a minimum of two species of shrubs shall 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 shall be planted. Space plants so as to cover the entire landscape area, excluding points where trees or shrubs are planted.

Note: *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 3 years.

7. The plantings must be well established on at least 80 percent of the converted area after 2 years in order to be considered a native vegetated surface.

2.1.1.4.4 Materials

Developments shall use native trees for replacement in areas separate from residential lots, or storm drainage areas adjacent to roadways or parking lots. Species selection shall be based on the underlying soils and the historic, native indigenous plant community type for the site, if existing conditions can support the plant community.

Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system. Coniferous and broad leaf evergreen trees shall be no less than 3 feet in height at time of planting. Deciduous trees shall be a minimum of 5 feet in height or have a minimum caliper size of 1 inch at time of planting.

Note: Avoid the use of a single species of tree for replacement purposes. No individual species of replacement tree should exceed 50 percent of the total, and no individual species should be less than 10 percent of the total.

2.1.1.5 Construction and Maintenance

Maintenance of native vegetation restoration areas shall include monitoring the survival of planted species, weed control and soil amendment as necessary to ensure the establishment of the native vegetation. A minimum 80 percent survival of all planted vegetation at the end of 2 years is required. Ongoing maintenance shall include weeding and watering for a minimum of 3 years from installation.

If during the 2-year period survival of planted vegetation falls below 80 percent, additional vegetation shall be installed as necessary to achieve the required survival percentage. The likely cause of the high rate of plant mortality shall also be determined and corrective actions taken to ensure plant survival. If it is determined that the original plant choices are not well suited to site conditions, these plants shall be replaced with plant species that are better suited to the site.

Native vegetation and soil protection areas serve as stormwater management facilities and should be managed as are other stormwater facilities. The Maintenance Plan for the stormwater facilities shall include a written vegetation management plan and protection mechanisms as necessary to maintain the benefit of these areas over time.

Permanent signs shall be installed indicating that removal of trees or vegetation is prohibited within the native vegetation retention areas. If a ISA certified arborist determines that dangerous and diseased trees are present, then removal of those trees are allowed. If trees are removed, each tree shall be replaced with a minimum of 6 trees, or the area covered by the drip line(s) of the tree(s) shall be revegetated, whichever is greater, in accordance with Conversion of Previously Developed Surfaces to Native Vegetation above.

Permanent fencing is required around the limits of the vegetation retention areas. The type, size, and location of the fencing shall be approved by county review staff and should be made of materials that blend in with the natural surroundings (e.g., wood split-rail, pinned if necessary) and located in such a manner as to not impede the movement of wildlife within the vegetation retention areas.

2.1.2 LID.02 Post-Construction Soil Quality and Depth

Most projects require that site soils meet minimum quality and depth requirements at project completion. Requirements may be achieved by either retaining and protecting undisturbed soil or restoring the soil (e.g., amending with compost) in disturbed areas.

Naturally occurring, undisturbed soil and vegetation provides important stormwater functions, including:

- Water infiltration
- Nutrient, sediment, and pollutant adsorption
- Sediment and pollutant biofiltration
- Water interflow storage and transmission
- Pollutant decomposition.

These functions are largely lost when development removes native soil and vegetation and replaces it with minimal topsoil and sod. And not only are these stormwater functions lost, but such landscapes then become pollution-generating pervious surfaces, due to increased use of pesticides, fertilizers and other landscaping and chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

Reestablishing a minimum soil quality and depth after development regains some of these stormwater functions, providing increased treatment of pollutants and sediments from development and habitation and minimizing the need for some landscaping chemicals, thus reducing pollution.

2.1.2.1 Applicability

This BMP is required in projects subject to Core Requirement #5, Onsite Stormwater Management. When used in combination with other onsite stormwater management BMPs, soil preservation and amendment can help achieve compliance with the Performance Standard option of Core Requirement #5. The following surfaces of a project site shall be required to implement this BMP:

- Areas that are to be incorporated into the stormwater drainage system such as surface BMPs. Note that BMP LID.08 – Bioretention has alternate soil requirements.
- All new lawn and landscape areas. Except that the areas of the project implementing BMP LID.11, “Full Dispersion” are not required to implement this BMP, however, it is still recommended.
- Disturbed areas that are to be restored to native vegetation (See BMP LID.01).

On sites that are underlain by cemented till layers, which are nearly impermeable, the upper soil horizon (native topsoil) processes the majority of stormwater on the site. Ensure that the existing depth of the upper soil horizon is either left in place or removed and replaced (according to the requirements herein) during the grading process. On sites which are underlain by outwash soils, the existing topsoil is not usually as deep (as with till soils), but must still be preserved or replaced.

Establishing 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 onsite management of stormwater flow and water quality.

If soils must be amended to increase the organic content, several sources of organic matter (e.g., compost, composted woody material, biosolids, and forest product residuals) can be used. It is important that the materials used to meet the soil quality and depth requirements be appropriate and beneficial to the plant cover being established. It is also important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

2.1.2.2 Limitations

Native soils with robust native landscapes must be protected from disturbance whenever possible. See the Thurston County Code for more information.

In designated Well Head Protection Areas (WHPA) for public water systems with over 1,000 connections, compost used within the site shall be comprised entirely of vegetative materials only. Biosolids and animal manure components can result in large concentrations of nitrates leaching into groundwater aquifers and are consequently prohibited within the WHPA.

Portions of a site comprised of till soils with slopes greater than 33 percent or other areas a geotechnical engineer indicates are unsuitable for post-construction soils restoration need not implement this BMP.

2.1.2.2.1 Poorly Draining Sites

If the site being considered for turf establishment does not drain well, consider an alternative to planting a lawn. If the site is not freely draining, and turf replacement is still being attempted, compost amendment will still provide stormwater benefits but should be incorporated into the soil at a reduced ratio of no more than 30 percent by volume. This upper limit is suggested in the Pacific Northwest because the region’s extended saturated winter conditions may create water logging of the lawn. The landscape professional should also provide a drainage route or subsurface collection system as part of their design.

2.1.2.2.2 Existing Steep Slope Areas

Increasing soil moisture content may increase soil instability in areas with steep slopes. However, the Washington State Department of Transportation (WSDOT) has incorporated compost-amendment in almost all of its vegetated sites since 1992 without problems, even on the steepest sites (33 percent slope), as a result of the increased moisture holding capacity within the soils. (See design criteria below for requirements of steep slope soil amendment.)

Onsite steep slope areas with native soils and robust native landscapes should be protected from disturbance, which is preferable to re-grading and augmenting the disturbed soil with soil amendment. Also, steep slope areas may be subject to critical area protection per TCC 17.15 or TCC Title 24, which outlines criteria for classification of erosion and active landslide hazard areas.

Where native soils and vegetation is sparse, steep slopes that remain on site that are not constructed as part of the development, should be amended by planting deep rooting vegetation. Plant vegetation in native soil and mulch with 2 inches of compost with 2-3 inches of bark mulch over the top of the compost..

2.1.2.3 Submittals and Approvals

A site specific Soil Management Plan (SMP) shall be submitted and must be approved as part of the permitting process for the project (for Abbreviated and Engineered Abbreviated Drainage Plans the soils restoration information can be shown on the Plot Plan). The SMP shall be prepared per the Soils for Salmon guidance document (see Design Guidelines below) and includes:

- A scale-drawing (11” x 17” or larger) identifying area where native soil and vegetation will be retained undisturbed, and which soil treatments will be applied in landscape areas.
- A completed SMP form identifying treatments and products to be used to meet the soil depth and organic content requirements for each area.
- Computations of compost or topsoil volumes to be imported (and/or site soil to be stockpiled) to meet “pre-approved” amendment rates; or calculations by a qualified professional to meet organic content requirements if using custom calculated rates. Qualified professionals include certified Agronomists, Soil Scientists or Crop Advisors; and licensed Landscape Architects, Civil Engineers or Geologists.
- Copies of laboratory analyses for compost and topsoil products to be used, documenting organic matter contents and carbon to nitrogen ratios.

The steps involved in preparing the SMP include the following:

- Step 1: Review site Landscape Plans and Grading Plans
    - Assess how grading and construction will impact soil conditions
    - Identify which areas are to receive which type of soil treatment options (1 through 4).
- Step 2: Visit Site to Determine Soil Conditions

- Identify compaction of subgrade by digging down to a level 12 inches below finished grade and use a shovel or penetrometer to determine compaction.
- Assess condition of native areas that are to remain undisturbed.
- Assess soil conditions in each area to be cut, filled, or otherwise disturbed and establish scarification and amendment recommendations for each area.

- Step 3: Select Amendment Options
  - Identify areas where each amendment option will be applied and outline these areas on the SMP site plan and on the SMP form.
  - Assign each area an identifying number or letter on the SMP site plan and on the SMP form.
- Step 4: Identify Compost, Topsoils, and Other Organic Materials for Amendment and Mulch.
  - Products for soil amendment must be identified on the SMP form and recent product test results provided showing they meet the requirements of the Soil for Salmon guidance document (see Design Guidelines below).
  - Compost shall meet requirements of WAC 173-350- 220 "Composted Materials".
- Step 5: Calculate Amendment, Topsoil and Mulch Volumes on SMP Form
  - Calculate required cubic yards of amendment for the pre-approved amendment areas.
  - Compute custom calculated amendment rates to achieve the target Soil Organic Matter content (10 percent for landscape beds, 5 percent for turf areas).

2.1.2.4 Hydrologic and Hydraulic Design Considerations

2.1.2.4.1 Flow Credit for Dispersion

Lawn and landscaped areas that meet the requirements of this section may be modeled, using approved runoff models, as "pasture" rather than "lawn" surface over the underlying soil (till or outwash).

In addition, flow control credit is given in runoff modeling when soil preservation and amendment BMP requirements are met and used as part of a dispersion design under the conditions described in:

- BMP LID.05 Downspout Dispersion

- BMP LID.06 Sheet Flow Dispersion
- BMP LID.07 Concentrated Flow Dispersion
- BMP LID.11 Full Dispersion
- BMP LIS.12 Rural Roads Natural Dispersion
- BMP LID.13 Rural Roads Engineered Dispersion.

2.1.2.5 Design Guidelines

This section describes the implementation options and design requirements for soil preservation and amendment. Typical cross-sections of compost-amended soil in planting bed and turf applications are shown in Figure 2.1. Design criteria are provided in this section for the following elements:An applicant can demonstrate compliance with this BMP by following the guidance provided in the most current edition of "*Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*". This document is available at no charge from the following web sites: <www.SoilsforSalmon.org> and <www.BuildingSoil.org>.

2.1.2.5.1 Soil Retention

The duff layer and native topsoil should be retained in an undisturbed state 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.

2.1.2.5.2 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:

A topsoil layer meeting these requirements:

- Turf areas: Place 1.75 inches of compost and till in to an 8 inch depth. Achieve an organic matter content, as measured by the loss-on-ignition test, of a minimum 4 percent (target 5 percent) organic matter content.1
- Planting beds: Place 3 inches of compost and till in to an 8 inch depth. Achieve an organic matter content, as measured by the loss-on-ignition test, of a minimum 8 percent (target 10 percent) dry weight.[1]

[1] Acceptable test methods for determining loss-on-ignition soil organic matter include the most current version of ASTM D2974 "Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils" and TMECC 05.07A "Loss-On-Ignition Organic Matter Method"

- A pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil.
- A minimum depth of 8 inches.

Root zones where tree roots limit the depth of incorporation of amendments are exempted from this requirement. Fence and protect these root zones from stripping of soil, grading, or compaction to the maximum extent practical.

Scarify (loosen) subsoils below the topsoil layer at least 4 inches for a finished minimum depth of 12 inches of uncompacted soil. Incorporate some of the upper material to avoid stratified layers, where feasible.Planting beds must be mulched with 2 to 4 inches of organic material such as arborist wood chips, bark, shredded leaves, compost, etc. Do not use fine bark because it can seal the soil surface.

For turf installations: water or roll to compact to 85 percent of maximum. dry density, rake to level, and remove surface woody debris and rocks larger than 1 inch in diameter. (Building Soil manual [Stenn et al. 2012] or web site <www.buildingsoil.org>).

The resulting soil should be conducive to the type of vegetation to be established.

2.1.2.5.3 Materials

Quality requirements for compost and other materials include the following:

- The organic content for "pre-approved" amendment rates can be met only using compost that meets the definition of "composted materials" in WAC 173-350-220. This code is available online at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-350-220.
- The compost must also have an organic matter content of 35 percent to 65 percent, 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.
- Calculated amendment rates may be met through use of composted materials as defined above; or other organic materials amended to meet the carbon to nitrogen ratio requirements; "pre-approved" amendment rates can only be met using compost meeting the compost specification for bioretention (see Section 2.2.5), with the exception that the compost may have up to 35 percent biosolids or manure.

2.1.2.5.4 Implementation Options

The soil quality design guidelines listed above can be met by using one of the methods listed below which are described in detail in the Soils for Salmon guidance document (see Design Guidelines above):

- Option 1. Leave undisturbed native vegetation and soil, and protect from compaction during construction. Identify areas of the site that will not be stripped, logged, graded or driven on, and fence these areas to prevent impacts during construction (see BMPs C101, C100, and C103 in Volume II). If neither soils nor vegetation are disturbed, these areas do not require amendment.

- Option 2. Amend existing site topsoil or subsoil in place at default "pre-approved" rates, or at custom calculated rates based on tests of the soil and amendment. Scarify or till the subgrade to a depth of 8 inches (or depth needed to achieve a total depth of 12 inches of uncompacted soil after calculated amount of amendments are added). Amend soil to meet required organic content dependent on the use (Planting area or Turf see Figure 2.1) and whether the pre-approved or calculated rate method is used.

- Option 3. Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default "pre-approved" rate or at a custom calculated rate. If placed topsoil plus compost or other organic material will amount to less than 12 inches, then the subgrade will be scarified or tilled to achieve 12 inches of loosened soil after amendment. Replace stockpiled topsoil prior to planting. Amend stockpiled topsoil if needed to meet required organic content dependent on the use (Planting area or Turf) and whether the pre-approved or calculated rate method is used.

- Option 4. Import topsoil mix of sufficient organic content and depth to meet the requirements. Scarify or till subgrade in two directions to 6 inches depth. Imported soils should not contain excessive clay or silt fines (more than 5 percent passing the US #200 sieve) because that could restrict stormwater infiltration. Use topsoil mix suitable for proposed use (planting bed or turf area). Place topsoil in layers per recommendations of Soils for Salmon guidance documents (see Design Guidelines above).

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. See the Soils for Salmon (2009) website for further discussion of implementation and for pre-approved rates of soil amendment.

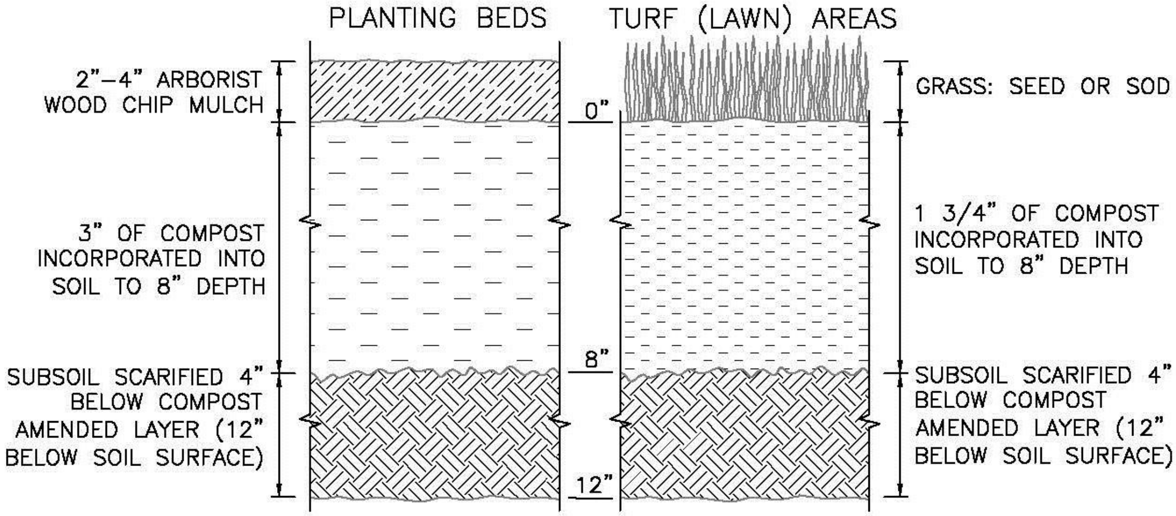


Figure 2.1. Typical soil amendment sections Source: City of Seattle (reproduced with permission)

2.1.2.6 Construction and Maintenance

See the Soils for Salmon website and the guidance provided in the most current edition of "*Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*" (available at www.buildingsoil.org) for details on implementing the Post-Construction Soil Quality and Depth BMP.

2.1.2.6.1 Maintenance

Soil quality and depth should be established near the end of construction and, once established, protected from compaction (e.g., by large machinery use) and from erosion.

Soil should be planted and mulched after installation.

Plant debris or its equivalent should be left on the soil surface to replenish organic matter.

Reduce irrigation and the application of fertilizers, herbicides and pesticides.

Table 2.2. Soil Management Plan for BMP LID.02

PROJECT INFORMATION **Page # ____ of ____ pages**

Complete all information on page 1; only site address and permit number on additional pages.

Site Address / Lot No.:____	
Permit Type:	**Permit Number:**
Permit Holder:	**Phone:**
Mailing Address:____	
Contact Person:	**Phone:**
Plan Prepared By:	

ATTACHMENTS REQUIRED (*Check off required items that are attached to this plan*)

___ **Site Plan showing, to scale:**	___ Areas of undisturbed native vegetation (no amendment required) ___ New planting beds and turf areas (amendment required) ___ Type of soil improvement proposed for each area
___ **Soil test results (required if proposing custom amendment rates)**	
___ **Product test results for proposed amendments**	

AREA #________ (*should match Area # on Site Plan*)

PLANTING TYPE ___ Turf ___ Planting Beds	___ Undisturbed native vegetation ___ Other: ________________________	
SQUARE FOOTAGE OF THIS AREA: _______ square feet		
SCARIFICATION ___ Subsoil will be scarified	___ inches (depth) of scarification needed to achieve finished total 12" loosened depth.	
PRE-APPROVED AMENDMENT METHOD: ___ Topsoil import ___ Amend with compost ___ Stockpile and amend (____ cu. yds. stockpiled)	____inches of compost or imported topsoil applied X 3.1 (*conversion factor, inches to cubic yards*) _____= cu. yards per 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → → (*needed to cover this area to designated depth*)	PRODUCT:________________________ ________________________________ QUANTITY:________CU. YDS.
CUSTOM AMENDMENT ___ Topsoil import ___ Topsoil & compost lift ___ Amend ___ Stockpile and amend (____ cu. yds. stockpiled)	**Attach test results and calculations.** ____ inches organic matter or topsoil import X 3.1 _____= cu. yards / 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → →	PRODUCT:________________________ ________________________________ QUANTITY:________CU. YDS.
MULCH	___ ,000 sq.ft. X 6.2 (*conversion, to give 2 inch mulch depth*) ____ = cubic yards of mulch → → → → → →	PRODUCT:________________________ QUANTITY:________CU. YDS.

TOTAL AMENDMENT/TOPSOIL/MULCH FOR ALL AREAS (*complete on page 1 only, totaling all areas/pages in this Plan*)

- ❑ **Product #1:**____ ❑ **Quantity:** _________**cu. yds.**
- ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

- ❑ **Product #2:**____ ❑ **Quantity:** _________**cu. yds.**
- ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

- ❑ **Product #3:**____ ❑ **Quantity:** _________**cu. yds.**
- ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

Date:	**Inspector:**	**Accepted:**	**Revisions Required:**

COMMENTS:

2.1.3 LID.03 Minimize Impervious Areas

Roads, shared accesses, alleys, sidewalks, driveways, and parking areas are a substantial portion of total urban impervious area and usually have highly efficient drainage systems. Reducing the effective amount of these impervious areas and the amount of runoff they generate is a key concept of LID.

2.1.3.1 Applicability

The following sections describe strategies for reducing the impacts of impervious surfaces associated with transportation and mobility related networks.

2.1.3.2 Limitations

Road designs must comply with the latest edition of Thurston County Road Standards for projects outside of Urban Growth Areas. Within Urban Growth Areas, . . the associated city may request more stringent standards than the Thurston County Road Standards depending on the project location. Road Standards include maximum grade, minimum roadway width, emergency access, compliance with the Americans with Disabilities Act (ADA), permeable pavement, and safety restrictions (clear zone, stopping sight distance, etc.). If a developer or designer is interested in deviating from the road standards, they will need to request a variance. Contact Thurston County Public Works for information on variances.

Because appropriate strategies for reducing impervious areas are different in rural and urban areas, they are broken out as “urban strategies” and “rural strategies” under design criteria, below.

2.1.3.3 Submittals and Approval

As noted above, a variance is required for road design changes that deviate from the governing road standards. Several techniques are listed under “design criteria”. Those that are likely to require a variance are noted. Requests for variance from road standards shall be in a form and contain the information required by the most current version of the Thurston County Road Standards.

2.1.3.4 Design Criteria

2.1.3.4.1.a Urban Strategies

Urban areas in Thurston County are normally under the jurisdiction of cities (Olympia, Lacey, Tumwater, Yelm) with the exception of Grand Mound and some Urban Growth Areas. Depending on your project location and the proposed road design strategies, a variance may be required. Contact Thurston County and the appropriate jurisdiction for additional information.

2.1.3.4.1.b Reduce Roadway Widths

Design roads with the minimum width permissible under the applicable road design standards.

2.1.3.4.1.c Permeable Pavement

The use of permeable paving surfaces (see BMP LID.09) are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing infiltration, treatment and storage of stormwater. Permeable paving surfaces are a good strategy for reducing impervious areas associated with transportation facilities. For projects that trigger Core Requirements #1 through #5 or #1 through #11 (see Volume I, Chapter 2), permeable pavement is one option that must be evaluated for onsite stormwater management for roads with very low traffic volumes and very low truck traffic (see Volume V, Section 2.2.6 for additional details). If permeable pavement surfaces are used adjacent to conventional impervious road sections for sidewalks or pullout parking, use design techniques described in Volume V, Section 2.2.6.9 to prevent saturation of the impervious road section and migration of aggregate base material from the impervious to the permeable section.

For private roads, porous paving surfaces may be used adjacent to the traveled lane (e.g., in pull-out parking, shoulders, and sidewalks) with acceptance by Thurston County and the local jurisdiction. Use of porous pavement on County-maintained roads is not allowed.

2.1.3.4.1.d Cul-de-sacs

Where cul-de-sacs are used, techniques should be used to reduce or disconnect the impervious turnaround area. This can be accomplished by increasing the diameter of the cul-de-sac and including a pervious or bioretention landscaped area in the center where stormwater can be directed.

2.1.3.4.1.e Sidewalks

2.1.3.4.1.f Sidewalks on Single Side of the Road

Thurston County road standards require sidewalks on both sides of arterials, collectors, and local roads. Where pedestrian safety, ADA-compliance, and access are not compromised, developers may request a variance from this standard, proposing sidewalks on only one side of the roadway, to reduce the impervious area associated with sidewalks. To be considered for a variance, the developer must demonstrate that every lot will have pedestrian access to an abutting trail or to a sidewalk located on at least one side of the road.

2.1.3.4.1.g Reverse Slope Sidewalks

Sidewalks and trails should be disconnected from the traveled way portion of the road, when possible. Where feasible, sidewalks should be "reverse slope", where they slope *away* from the road and onto adjacent vegetated areas. If a sidewalk drains onto a vegetated area that is greater than or equal to 10 feet in width and the soils are either native soils or meet the criteria of BMP LID.02, "Post Construction Soil Quality and Depth" then the sidewalk area may be modeled as landscaped area over the underlying soil type.

2.1.3.4.1.h Sidewalk Materials

Sidewalks and trails may be constructed of porous materials for private developments and roadways. Porous sidewalks within the public right-of-way would require Thurston County acceptance and a variance from the Road Standards. Porous materials for sidewalks and trails shall be ADA-compliant. See BMP LID.09, "Alternate Paving Surfaces" for guidance on these materials.

2.1.3.4.2 Parking

2.1.3.4.2.a Parking Lots

Use the minimum off-street parking requirements outlined in Thurston County Code Titles 20 to 23, as applicable for non-residential uses. Pervious materials should be considered for parking lots where feasible.

2.1.3.4.2.b Shared Parking

The total amount of impervious area can be reduced by utilizing shared parking. This strategy is appropriate for land uses with non-competing hours of operation, such as a church and a school or office. See Thurston County Code Title 20 (Non-North County UGA), Title 21 (Lacey UGA), Title 22 (Tumwater UGA), or Title 23 (Olympia UGA) for restrictions and requirements on shared parking.

2.1.3.4.2.c Driveways

Driveways are typically constructed with impervious surfaces and should be considered in the total stormwater runoff reduction strategy. The following are methods to reduce the amount of impervious driveway surfaces (variances may be required):

- Minimize driveway width
- Reduce driveway length where possible. This may be achieved by locating the house closer to the road or by using alley access directly into a garage.
- When possible, design clusters of homes to use shared driveways. On lots that accommodate multiple family dwellings, such as townhouses, the courtyard between garages and the stem of the driveway can be shared space.
- Consider constructing driveways using pervious materials.

2.1.3.4.3 Rural Strategies

Thurston County has well-draining outwash soils in many areas. The County has adopted strategies to preserve existing drainage and take advantage of the infiltration and treatment capacity of existing soils by avoiding curb and gutter where possible to promote dispersion and infiltration into roadside ditches. For rural roads, special sheet flow dispersion BMPs are provided for sites that meet specific conditions (see BMP LID.12 and BMP LID.13).

2.2 LID Stormwater Management BMPs

BMPs in this chapter include:

- LID.04 Downspout Infiltration Systems (Trenches, Drywells)
- LID.05 Downspout Dispersion Systems
- LID.06 Sheet Flow Dispersion
- LID.07 Concentrated Flow Dispersion
- LID.08 Bioretention Facilities
- LID.09 Alternative Paving Surfaces
- LID.10 Vegetated Roofs
- LID.11 Full Dispersion
- LID.12 Rural Road Natural Dispersion
- LID.13 Rural Road Engineered Dispersion
- LID.14 Tree Planting and Tree Retention (for Flow Control Credit)

2.2.1 LID.04 Downspout Infiltration Systems

Downspout infiltration systems are used for infiltrating runoff from roof downspouts and include infiltration trenches and drywells.

2.2.1.1 Applicability

Application of rooftop downspout controls (this BMP, BMP LID.05, "Downspout Dispersion Systems") is required to meet Core Requirement #5. This BMP is the preferred method of rooftop downspout control, and must be considered before the other measures.

2.2.1.2 Limitations

Downspout infiltration systems may not be used to directly infiltrate runoff from pollutant-generating impervious surfaces, such as uncoated metal roofs.

Downspout infiltration systems are not allowed for properties along the Marine Bluff without special acceptance.

2.2.1.3 Submittals and Approval

2.2.1.3.1 UIC Registration

Infiltration drywells are considered underground injection chambers (UIC) and are therefore subject to Ecology UIC registration requirements, as noted in Chapter 3, with the following exceptions:

- Infiltration trenches are not considered UICs, unless they include perforated pipe used to disperse and inject flows (see Chapter 3).
- Infiltration drywells for single family residences which only infiltrate clean roof runoff are not currently required to register as a UIC.

2.2.1.3.2 Soil Testing and Report

See Volume III, Chapter 3 for general soil testing requirements for infiltration.

2.2.1.3.3 Pretreatment

No pretreatment is required.

2.2.1.4 Hydraulic, Hydrologic and Soil Design Considerations

2.2.1.4.1 Flow Credit for Roof Downspout Infiltration

If roof runoff is infiltrated according to the requirements of this section, the roof area may be discounted from the project area used for sizing stormwater facilities and determining the effective impervious area thresholds of Core Requirements #7 (Flow Control).

2.2.1.4.2 Hydraulic Design Elements

A structure with a sump (see Figure 2.1) shall be located upstream of the infiltration trench or drywell, which provides a minimum of 12 inches of depth below the outlet riser. The outlet riser pipe bottom shall be designed so as to be submerged at all times, and a screening material shall be installed on the pipe outlet.

2.2.1.5 Design Criteria for Downspout Infiltration Systems

2.2.1.5.1 Downspout Infiltration Trench

Figure 2.2 and Figure 2.3 present alternative design options for the downspout infiltration trench systems. These systems are designed as specified below.

2.2.1.6 Geometry

Length of trench must not exceed 100 feet from the inlet sump

Minimum spacing between distribution pipe centerlines must be 6 feet.

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.

Course sands and cobbles 20 LF
Medium sand 30 LF
Fine sand, loamy sand 75 LF
Sandy loam 125 LF
Loam 190 LF

2.2.1.6.1 Materials

The aggregate material for the infiltration trench shall consist of ¾” to 1-½ “diameterwashed round rock that meets WSDOT Specification 9-03.12(5).

Geotextile filter fabric shall be wrapped entirely around trench drain rock prior to backfilling EXCEPT that a 6-inch layer of sand below the trench bottom may be used in-lieu of a filter fabric liner on the bottom.

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 if the measured infiltration rate is at least 8 inches per hour. Trench length in fill shall be 60 linear feet per 1,000 square feet of roof area. Infiltration rates can be tested using the methods described in Volume III.

2.2.1.7 Other Design Criteria

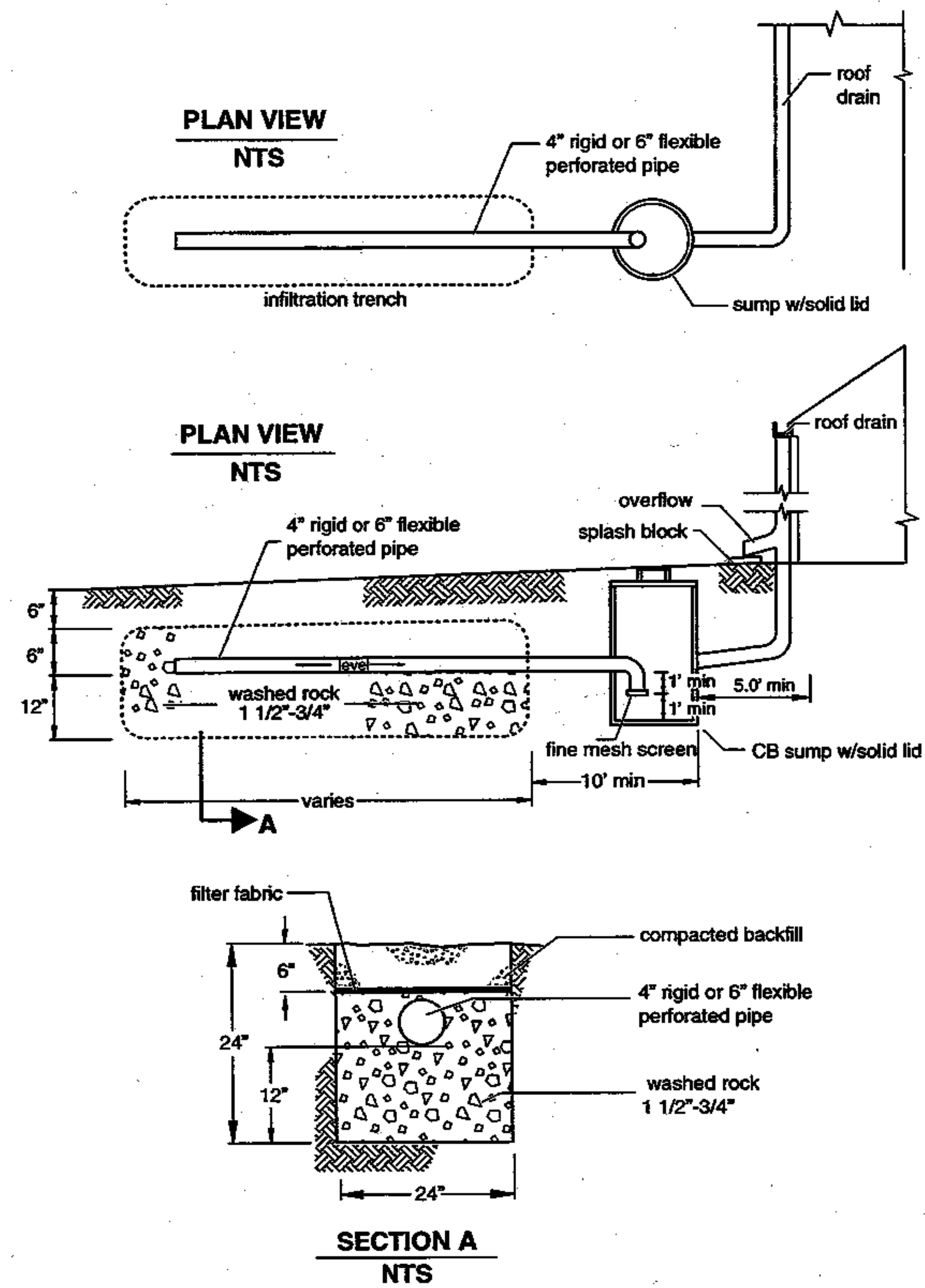
Infiltration trenches shall not be built on slopes steeper than 25 percent (4:1). A geotechnical analysis and report may be required on slopes over 15 percent or if located within 300 feet of the top of a or geologic hazard area.

Trenches shall be covered the same day they are opened.

Trenches shall be no wider than can be excavated by a backhoe straddling the trench.

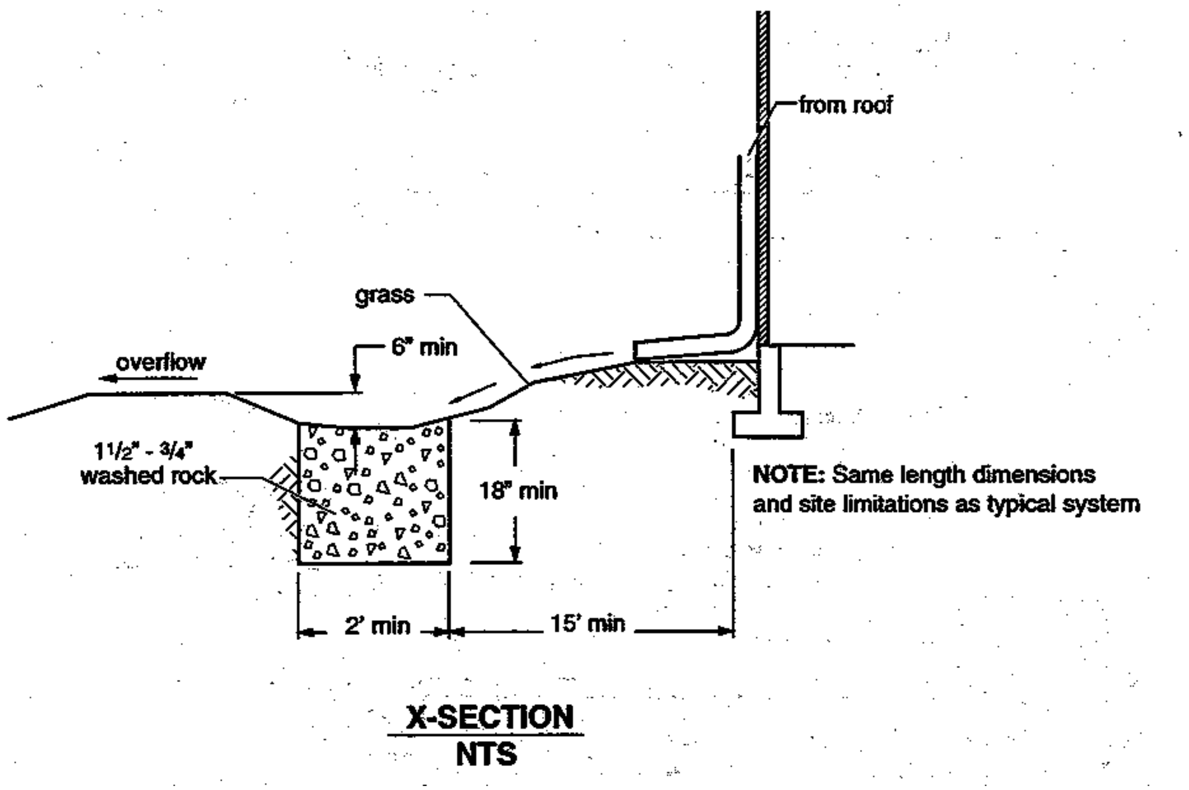
Parallel trenches shall be spaced no closer than 6 feet except that trenches whose target for discharge is the interflow zone. If hardpan is less than 6 feet below finished grade, or the trench is excavated to closer than 3 feet of hardpan (whatever the depth), then the target for infiltration is the interflow zone and:

- Trenches must, as nearly as practical, follow a contour line.
- Parallel trenches shall be spaced no closer than 25 feet apart.



Source: King County

Figure 2.2 Typical Downspout Infiltration Trench



Source: King County

Figure 2.3 Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel

2.2.1.7.1 Design Criteria for Infiltration Drywell Systems

Two alternatives are available for infiltration drywells, Figure 2.4 presents the design of a typical downspout infiltration drywell system. For systems conforming to this typical design each drywell may serve up to 1,000 square feet of impervious surface for either medium sands or course sands. The simplified sizing for drywells as shown in Figure 2.3 may use alternative configurations such as shown in Figure 2.2 and be used for other soil types, but is limited to those projects located in rural areas (i.e. outside of the NPDES Phase II permit boundary and UGA's) or projects in urban areas that are not subject to Core Requirement #7. The drywells shall include a catch basin (as shown in Figure 2.2), or its equivalent upstream of the drywell for particulate removal. These systems are designed as specified below:

2.2.1.7.2 Simplified Sizing for Drywells

The following table (Table 2-2) may be used for drywell sizing for projects that are not subject to Core Requirement #7 (Flow Control – see Volume I, Chapter 2).

Table 2-2 Roof Drywell Sizes by Soil Hydrologic Group

Soil Hydrologic Group	Total Volume Required Per 1,000 Square Feet of Roof [1]
A or B (Sand, loamy sand, sandy loam, loam)	125 cubic feet
C (Silt loam, sandy clay loam, "till" soils with Group A or B surface horizons)	250 cubic feet
D (Silts, clays, rock outcroppings, "till" soils with Group C or D surface horizons) [2]	750 cubic feet

Source: Thurston County 1994.

[1] Volume includes rock backfill. Trench size may be reduced if pipe or other open structure replaces a portion of the rock backfill; contact Thurston County for guidance.

[2] Drywells are not recommended for Hydrologic Group D soils due to extremely slow percolation rates. Drywells should be used only if other reasonable alternatives are infeasible.

2.2.1.7.3 Geometry

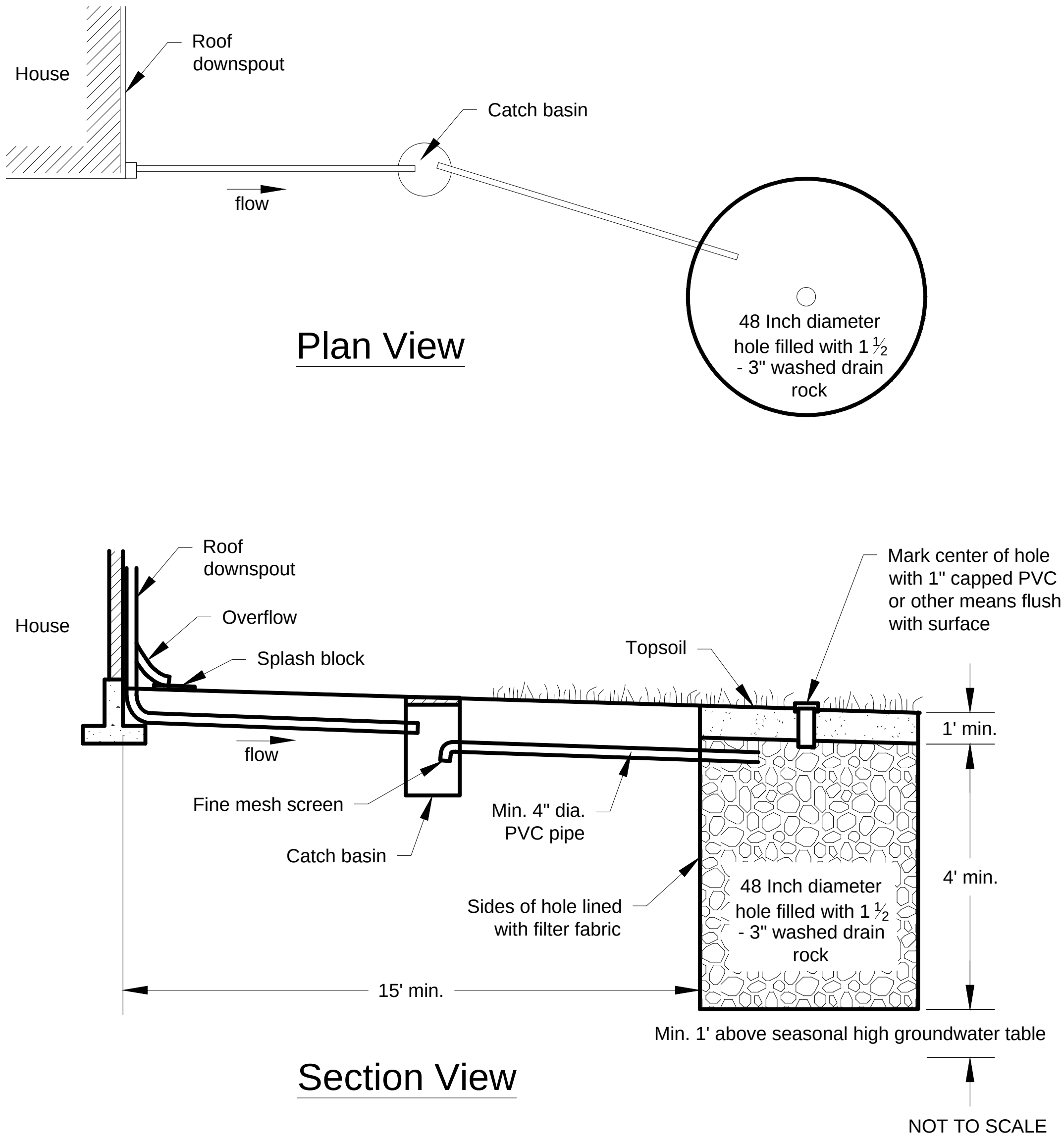
Drywell bottoms must be a minimum of 1 foot above seasonal high groundwater level or impermeable soil layers.

Drywells shall be 48 inches in diameter (minimum) and have a depth of 5 feet (4 feet of gravel and 1 foot of suitable cover material).

Spacing between drywells shall be a minimum of 4 feet.

2.2.1.7.4 Materials

Filter fabric (geotextile) must be placed on top of the drain rock and on trench or drywell sides prior to backfilling. See Appendix V-B (Facility Liners).



Source: Department of Ecology

Figure 2.4 Typical Downspout Infiltration Drywell

Note: Catch Basin (yard drain) sump for infiltration drywells shall be consistent with CB Sump detail of Figure 2.1

2.2.1.8 Structural Design Considerations

Trenches may be located under pavement, if designed by a professional engineer. Trenches must include an overflow at least 1 foot below the pavement, and be in a location that can accommodate overflow without creating a significant adverse impact to downhill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure. The trench depth must be measured from the overflow elevation, not the ground surface elevation.

2.2.1.9 Site Design Elements

See Appendix V-E (Site Design Elements) for setbacks for infiltration facilities.

Downspout infiltration drywells must not be built on slopes greater than 25 percent (4H:1V) without evaluation by a professional engineer with geotechnical expertise, or a licensed geologist, hydrogeologist, or engineering geologist, and with Thurston County acceptance.

Where individual lot drywells are to be installed in a residential subdivision, the project engineer shall determine the required size of each drywell for each lot or group of lots with similar soils. The project engineer shall then record these sizes as necessary to ensure that they become restrictions for future building applications (e.g., record written conditions for lots and/or dictate drywell size on the face of the final plat mylar, etc.).

2.2.1.9.1 Verification of Performance

The project engineer or designee shall inspect infiltration systems before, during, and after construction as necessary to ensure facilities are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. See Sections 3.1.5 and 3.1.6 below for all applicable requirements.

2.2.1.10 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. **Error! Reference source not found.** 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.

2.2.1.10.1 Applications & Limitations

Perforated stub-outs are not appropriate when seasonal water table is less than one foot below trench bottom. In projects subject to Minimum Requirement #5 (see Volume I), perforated stub-out connections may be used only when all other higher priority on-site stormwater management BMPs are not feasible, per the criteria for each of those BMPs.

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 Appendix V-E – Site Design Elements.

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 professional engineer 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.

2.2.1.10.2 Design Criteria

Perforated stub-out connections consist of at least 10 feet of perforatedpipe 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 **Error! Reference source not found.**).

2.2.1.10.3 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.

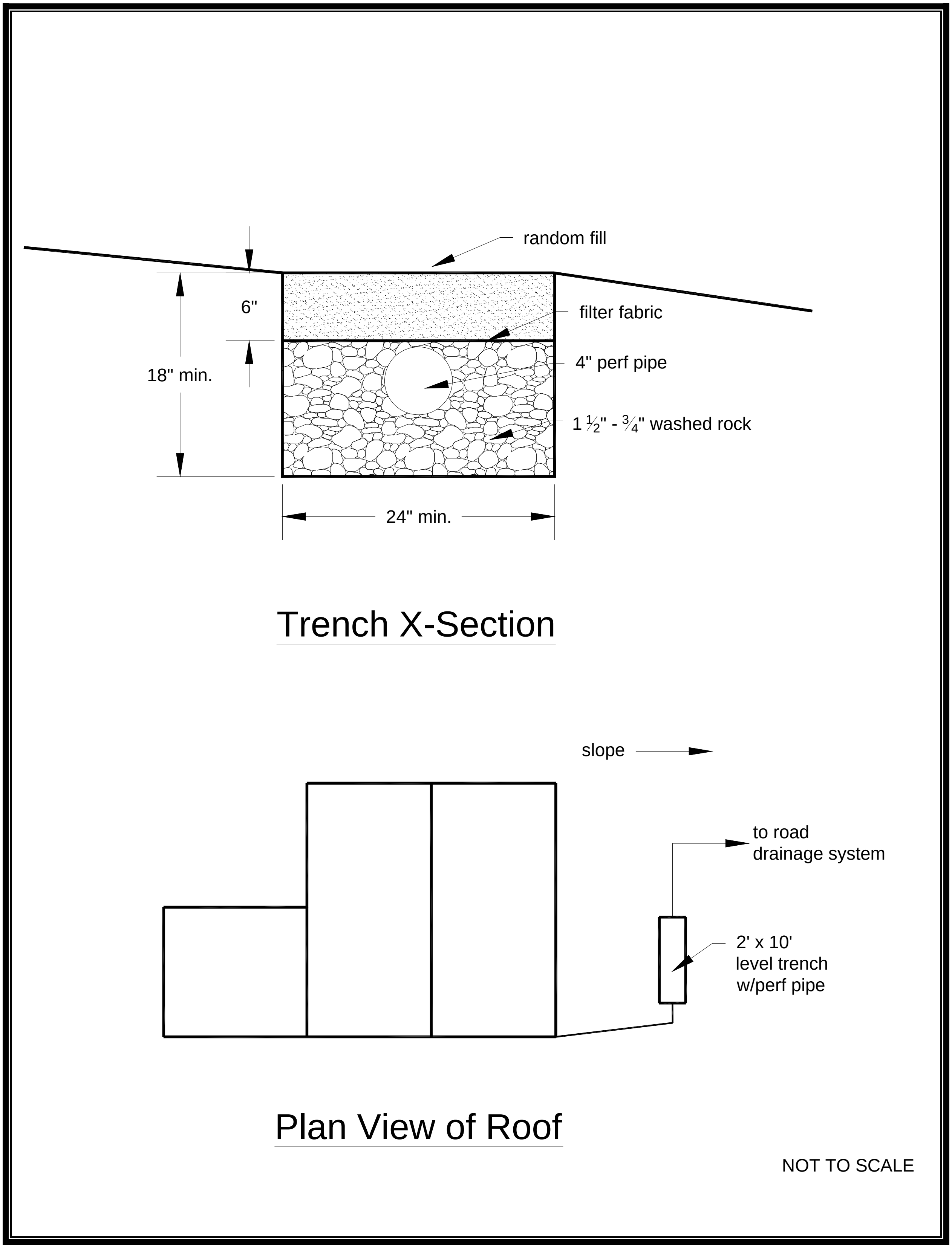


Figure 2.5 Perforated Stub-Out, Source: Department of Ecology

2.2.2 LID.05 Downspout Dispersion Systems

Downspout dispersion systems are gravel-filled trenches or splash blocks that spread roof runoff over vegetated, pervious areas. Dispersion attenuates peak flows by slowing entry of runoff into the conveyance system, allowing some infiltration and providing some water quality benefits, such as filtration and vegetative uptake.

2.2.2.1 Applicability

Rooftop downspout controls (this BMP, BMP LID.04, "Downspout Infiltration Systems", or BMP LID.08, "Bioretention Facilities") are required to meet Core Requirement #5. Downspout Infiltration (BMP LID.04) is the preferred rooftop downspout control. If infiltration is not feasible, bioretention facilities (BMP LID.08) are preferred over downspout dispersion.

Downspout dispersion shall be used in all single-family lots that meet one of the following criteria:

1. Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Section 2.2.1.

2. Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration (as determined in Section 2.2.1) and where the design criteria in Section 2.2.2.3 below can be met.

3. Downspout dispersion can be used to help meet the flow control standards of Core Requirement #7.

4. When used in combination with other onsite stormwater management BMPs, downspout dispersion can also help achieve compliance with Core Requirement #5

2.2.2.2 Limitations

No erosion or flooding of downstream properties may result.

Dispersion should be used only where runoff can be directed away from structures to a flat portion of the lot and where lot size is such that runoff would be expected to be contained onsite (use 10,000 square feet as a guideline). Dispersion is not well suited to small lots, steep slopes, or lots with poor soils and/or a high groundwater table.

Note that for projects that are underlain by hydrologic soil group A soils[2], downspout dispersion systems designed per the requirements of this section may be considered as part of Option #1 in List #1 and List #2 for managing runoff from roof areas.

[2] As defined by the NRCS Web Soil Survey and field verified by a qualified professional.

2.2.2.3 Hydrologic and Hydraulic Design Considerations

If roof runoff is dispersed over a vegetative flow path 25 feet or longer for trenches and 50 feet or longer for splash blocks through undisturbed native landscape or a lawn/landscape area that meets the soils criteria outlined in BMP LID.02, the roof area may be modeled as landscape surface for determining thresholds for Core Requirement #7, Flow Control, and sizing stormwater facilities.

2.2.2.4 Design Criteria

2.2.2.4.1 Dispersion Trenches

Dispersion trenches shall be designed as shown in Figure 2.6.

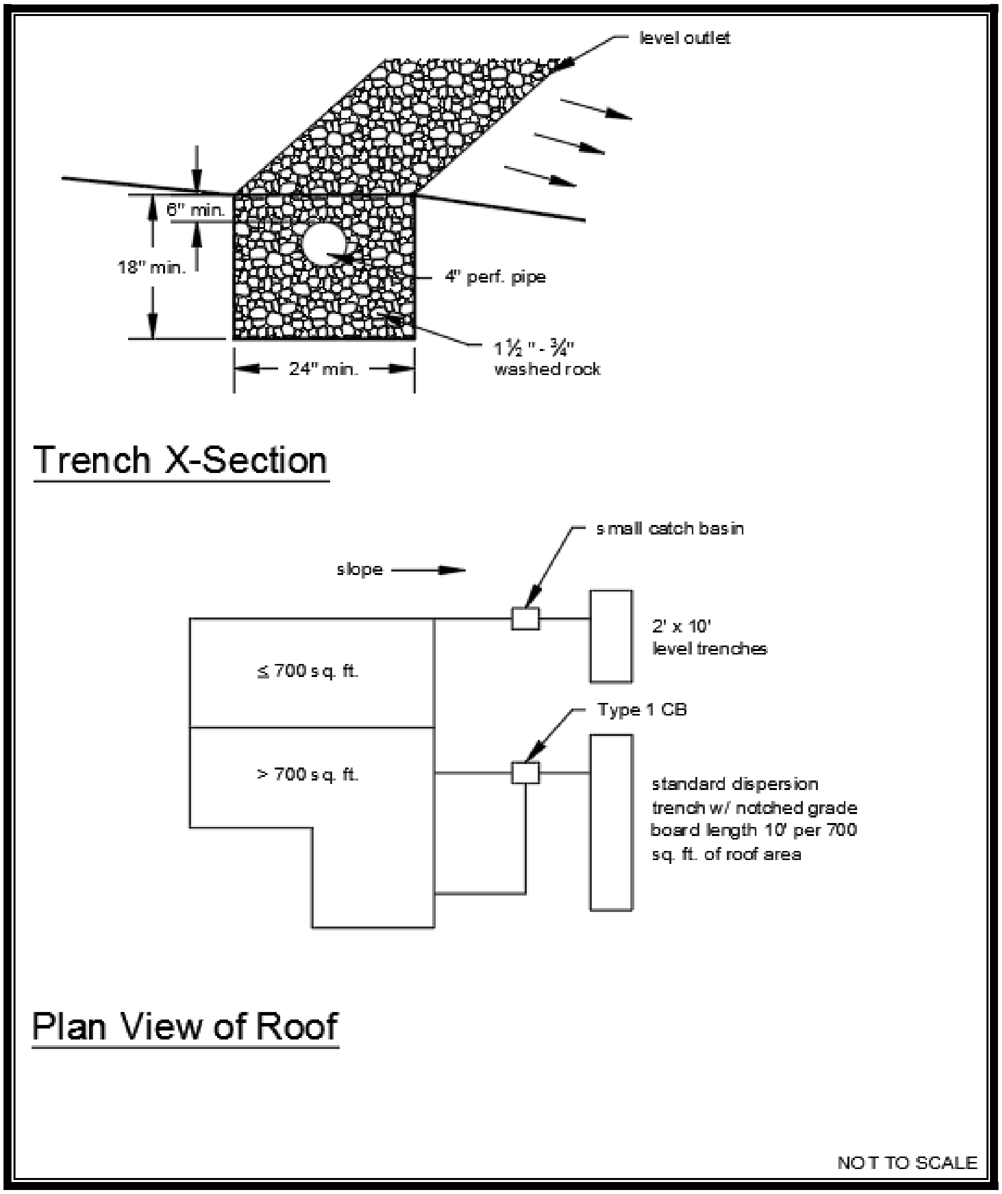


Figure 2.6 Typical Downspout Dispersion Trench

Note: Catch Basin or yard drain sump for downspout dispersion trench shall be consistent with CB Sump detail of Figure 2.1

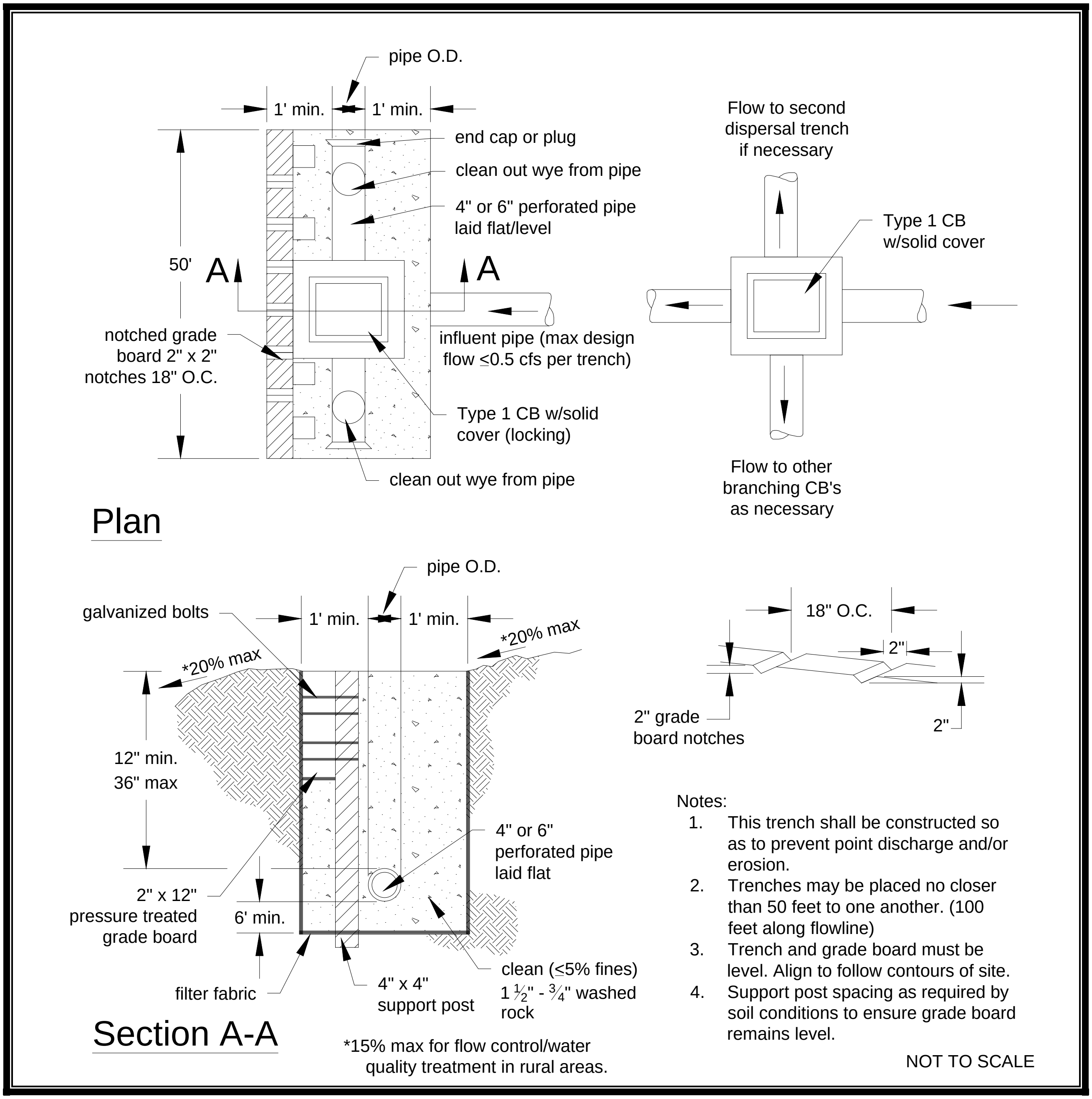


Figure 2.7 Standard dispersion trench with Notched Grade Board. Source: Department of Ecology

A vegetated flow path at least 25 feet in length must be maintained between the outlet of a trench and any property line; structure; critical area (i.e., stream, wetland), or impervious surface. Critical area buffers may count towards flow path lengths. However, the critical area buffer must be permanently protected from modification through a covenant or easement, or a tract dedicated by the proposed project. This does not include steep slopes. See steep slope setbacks below. Trenches serving up to 700 square feet of roof area must be 10 foot long by 2 foot wide gravel filled trenches as shown in Figure 2.4. For roof areas larger than 700 square feet, a dispersion trench with notched grade board shall be used. The total length of this design must not exceed 50 feet, and must provide at least 10 feet of trench per 700 square feet of roof area. In both designs, it is important to include a cleanout structure prior to discharge into the dispersal area. Although the figures refer at times to a Type 1 catch basin, it is also acceptable to use an equivalent type structure which includes a lid, 1 foot minimum sump, and T type outlet with screen.

If hydrologic modeling of the flows from a roof area are performed, the maximum flow to a 50-ft dispersion trench shall not exceed 0.5 cfs for the 100-year event.

2.2.2.4.2 Splash Blocks

Splash blocks shall be designed as shown in Figure 2.8

Splash blocks may be used for downspouts discharging to a vegetated flow path at least 10 feet in width and 50 feet in length as measured from the downspout to the downstream property line, structure, critical areas (i.e., stream, wetland), or other impervious surface. Flow path measurement may traverse a property line into an adjacent critical area buffer, provided that the critical area buffer is permanently protected through a covenant, easement, or a tract dedicated as part of the proposed project. This does *not* include steep slopes. See *limitations*.

A maximum of 700 square feet of roof area may drain to each splash block. When flow paths of multiple splash blocks are combined, the vegetated flow path width shall increase by 50 percent with each additional splashblock.

2.2.2.5 Site Design Elements

2.2.2.5.1 Vegetated Flow path

For both dispersion trenches and splashblocks, the vegetated flow path must be covered with well-established vegetation to prevent erosion and promote partial infiltration. Vegetated flow paths shall consist of undisturbed native landscape area, or an area that meets the requirements of BMP LID.02, Soil Amendments, Quality and Depth.

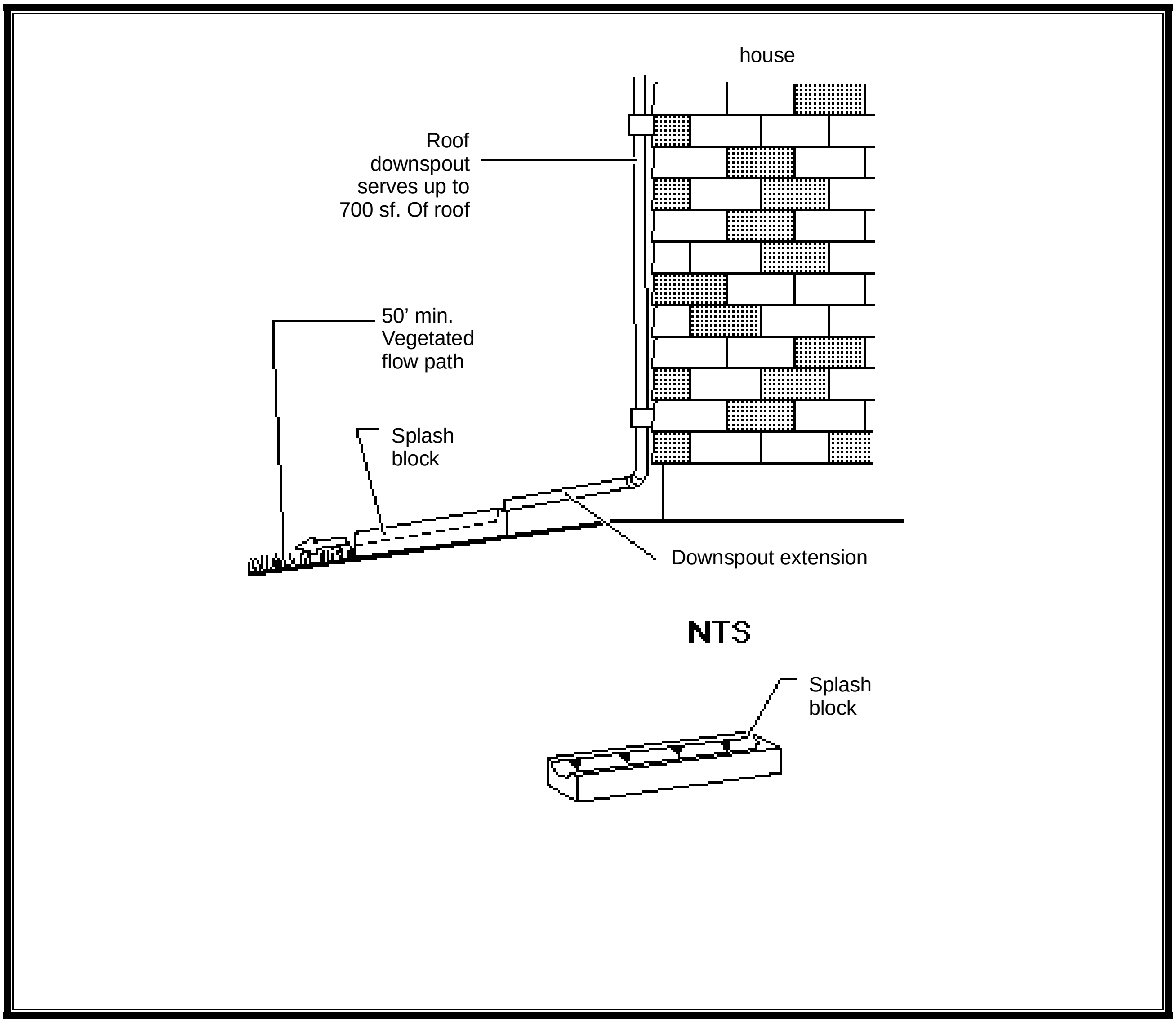


Figure 2.8 Typical Downspout Splashblock Dispersion

2.2.2.5.2 Setbacks

Dispersion systems shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report may be required to address the potential impact of the facility on the slope. Increased setbacks or prohibition of infiltration facilities may result from this report. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

For sites with septic systems, the discharge point 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.

A setback of at least 5 feet shall be maintained between the edge of a dispersion trench and any structure or property line.”

2.2.3 LID.06 Sheet Flow Dispersion

Sheet flow dispersion is the simplest method of runoff control, and can be used with any graded impervious or pervious surface to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

2.2.3.1 Applicability

Flat or moderately sloping (less than 15 percent) impervious surfaces such as driveways, private roadways, sport courts, patios, roofs without gutters, sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, or pasture, or any situation where concentration of flows can be avoided.

When used in combination with other onsite stormwater management BMPs, sheet flow dispersion can also help achieve compliance with the Performance Standard option of Core Requirement #5.

This BMP can be used to disperse unconcentrated site runoff when the project site cannot meet the requirements for full dispersion (see BMP LID.11) in terms of maximum impervious surface and native vegetation retention. If the minimum requirements of BMP LID.11 can be met for a project, then the less restrictive sheet flow dispersion criteria of that BMP can be used.

If the project is a roadway or other linear project and is in the rural area of Thurston County (outside an UGA or the NPDES Phase II permit boundary), then BMP LID.12 (Rural Roads Natural Dispersion) or BMP LID.13 (Rural Roads Engineered Dispersion) for rural roadways may be used for flow dispersion.

2.2.3.2 Limitations

No erosion or flooding of downstream properties may result.

2.2.3.3 Hydrologic and Hydraulic Design Considerations

Flow Credit for Sheet Flow Dispersion

Where sheet flow dispersion is used to disperse runoff into an undisturbed native landscape area, or an area that meets the requirements of BMP LID.02, “Soil Amendments, Quality and Depth”, the impervious area may be modeled as landscaped area for determining thresholds for Core Requirements #6 (Runoff Treatment) and #7 (Flow Control) and for designing stormwater facilities.

2.2.3.4 Design Criteria

See Figure 2.9 for details for driveways.

A transition zone (2-foot minimum) to discourage channeling shall be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material approved by Thurston County and shall be lower than the adjacent impervious surface by approximately 1-inch.

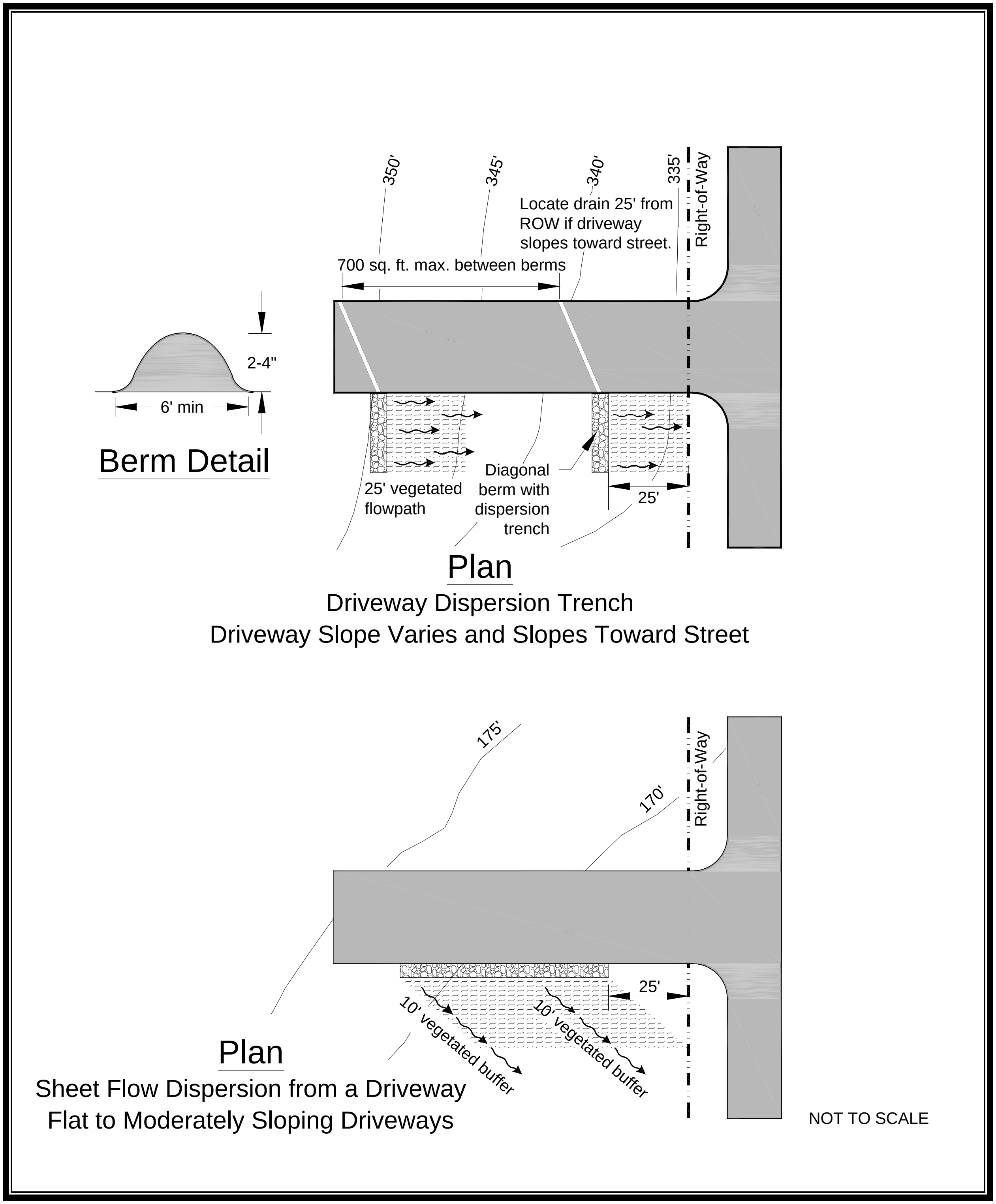


Figure 2.9 Sheet Flow Dispersion for Driveways

A vegetated buffer width of 10 feet must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width (or fraction thereof).

A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, or pasture). Slopes within the 25-foot minimum flow path through vegetation must be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flow path length must be increased 1.5 feet for each percent increase in slope above 8 percent, although the allowable slope shall not exceed 15 percent.

2.2.3.5 Site Design Elements

Sheet flow dispersion may not be appropriate where the drainage discharges toward slopes steeper than 15 percent or geologic hazard areas as defined by TCC 17.15 or TCC Title 24. The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of dispersion toward the slope may result from this report. The geotechnical analysis and report shall address the potential impact of dispersion on the slope.

2.2.4 LID.07 Concentrated Flow Dispersion

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of runoff into the conveyance system, providing some infiltration and water quality benefits (i.e., sedimentation, filtration and vegetative uptake). See Figure 2.10.

2.2.4.1 Applicability

This BMP can be used to disperse concentrated site runoff when the project site cannot meet the requirements for full dispersion (see BMP LID.11) in terms of maximum impervious surface and native vegetation retention. If the minimum requirements of BMP LID.11 can be met for a project, then the less restrictive concentrated flow dispersion criteria of that BMP can be used.

If the project is a roadway or other linear project and is in the rural area of Thurston County (outside an UGA or the NPDES Phase II permit boundary), then BMP LID.12 (Rural Roads Natural Dispersion) or BMP LID.13 (Rural Roads Engineered Dispersion) may be used for flow dispersion.

Concentrated flow dispersion is appropriate for any situation where concentrated flow can be dispersed through vegetation.

When used in combination with other onsite stormwater management BMPs, concentrated flow dispersion can also help achieve compliance with the Performance Standard option of Core Requirement #5.

Figure 2.7 shows two possible ways of spreading flows from steep driveways.

2.2.4.2 Limitations

Dispersion for driveways is usually effective only for single-family residences on large lots and in rural short plats. Lots proposed by short plats in urban areas are usually too small to provide effective dispersion of driveway runoff.

No erosion or flooding of downstream properties may result.

2.2.4.3 Submittals and Approval

Runoff discharged towards geologic or landslide hazard areas as defined by TCC 17 and 24 must be evaluated by a geotechnical engineer or qualified geologist. The discharge point shall not be placed on or above natural slopes greater than 15 percent and 10 feet in height, or above erosion or landslide hazard areas without evaluation by a geotechnical engineer or qualified geologist and acceptance by Thurston County.

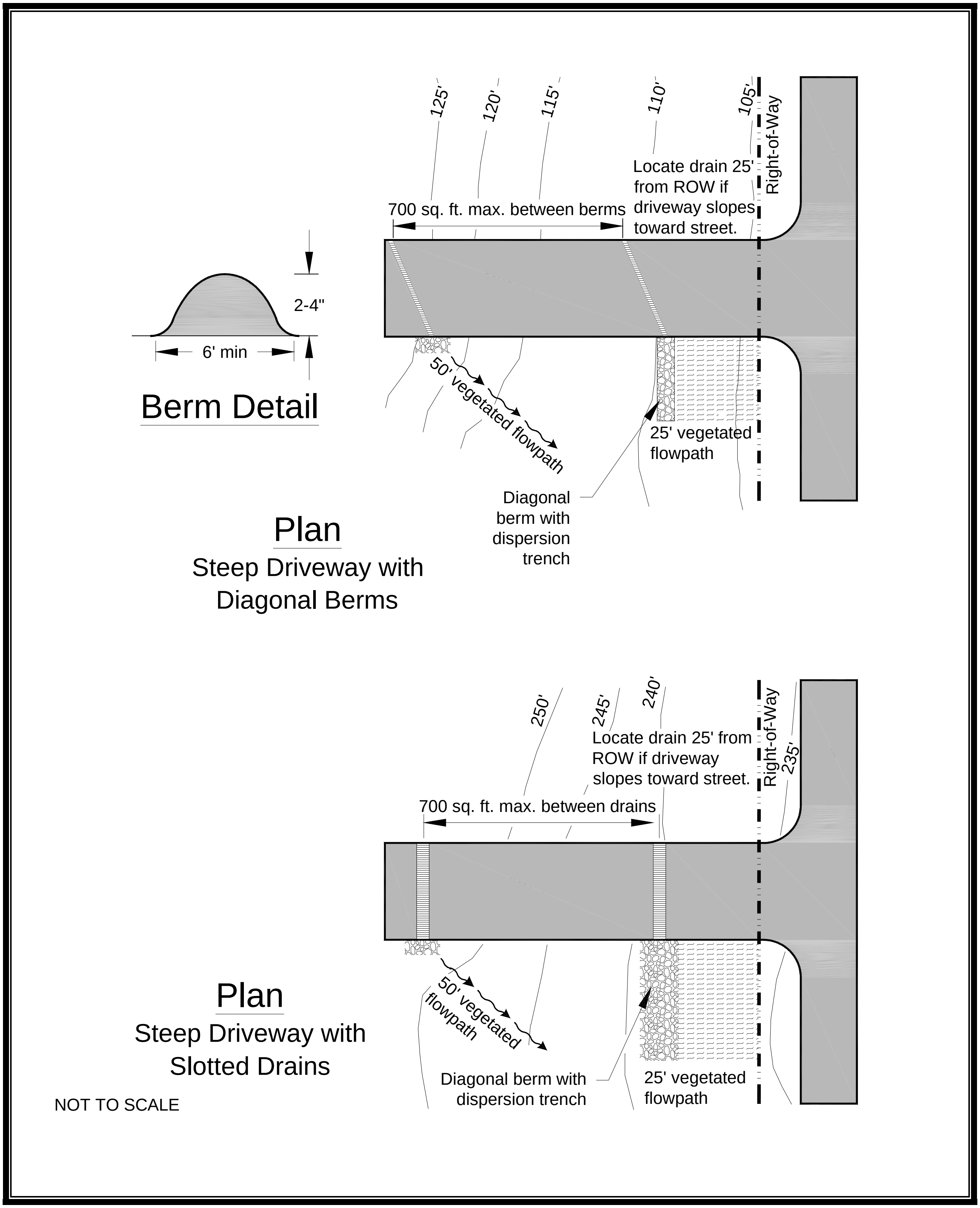


Figure 2.10 Typical Concentrated Flow Dispersion for Steep Driveways

Native vegetation areas or landscape areas designed to meet BMP LID.02 (Post-Construction Soil Quality and Depth) which are used for dispersion of concentrated flows shall be identified on plans and plat maps and easements, tracts, or other means established to ensure their perpetual protection and maintenance of the dispersion area. Signage shall be provided to identify the extent of the area and the purpose of the area as a stormwater facility.

2.2.4.4 Hydrologic and Hydraulic Design Considerations

2.2.4.4.1 Flow Credit for Concentrated Flow Dispersion

Where concentrated flow dispersion is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP LID.02 – Soil Amendments, Quality and Depth, and the vegetated flow path is at least 50 feet, the impervious area may be modeled as landscaped area for establishing thresholds for Core Requirements #6 (Runoff Treatment and #7 (Flow Control) and for stormwater facility design.

2.2.4.5 Design Criteria

Maintain a vegetated flow path of at least 50 feet between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface. The flowpath length is measured perpendicular to site contours.

A maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion BMP. If hydrologic modeling of flows is conducted, flow to a single concentrated flow dispersion point is limited to 0.2 cfs for the 100-year event.

A pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.

2.2.4.6 Site Design Elements

For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by Thurston County if site topography clearly prohibits flows from intersecting the drainfield.

2.2.5 LID.08 Bioretention Cells, Swales, and Planter Boxes

2.2.5.1 Description

Bioretention areas are shallow stormwater systems with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Bioretention areas are designed to mimic a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. Bioretention areas also provide water quality treatment through sedimentation, filtration, adsorption, and phytoremediation.

Bioretention areas function by storing stormwater as surface ponding before it filters through the underlying amended soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil.

The terms bioretention and rain garden are sometimes used interchangeably. Bioretention areas and rain gardens are applications of the same LID concept and can be highly effective for reducing surface runoff and removing pollutants. However, in Thurston County (in accordance with the Department of Ecology's distinction), the term bioretention is used to describe an engineered facility that includes designed soil mixes and perhaps underdrains and control structures. The term, rain garden, is used to describe a shallow landscaped depression on small project sites that only trigger Minimum Requirements

#1-#5. Rain gardens have less restrictive design criteria for the soil mix and do not include underdrains or other control structures. See ~~Section 3.8~~ *Rain Garden Handbook for Western Washington Homeowners* (WSU, 2007 or as revised) for more information on rain garden design.

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:** Designed 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.

Note: Ecology has approved use of certain patented treatment systems that use specific, high rate media for treatment. Such systems are not considered onsite stormwater management BMPs and are not options for meeting the requirements of Minimum Requirement #5. The Ecology approval (General Use Level Designations only) is meant to be used to meet Minimum Requirement #6, where appropriate.

Figure 2.11 Bioretention Area (shown with optional underdrain) - Source Pierce County provides an example illustration of a bioretention area. See Attachments Section A, Details 26.0, 26.1, and 26.2 for examples of bioretention areas in various configurations and site settings.

Typo correction 01/05/2017

2.2.5.2 Applications and Limitations

Bioretention provides effective removal of many stormwater pollutants by passing stormwater through a soil profile that meets specified characteristics. Bioretention areas that infiltrate stormwater into the ground can also serve a significant flow reduction function.

- **Bioretention areas are an onsite stormwater management BMP option for 1) projects that only have to comply with Minimum Requirements #1 through #5, and 2) projects that trigger Minimum Requirements #1 through #10**

- **Bioretention can achieve the Performance Standard option or can be applied from List #1 or List #2 option of Minimum Requirement #5.**

Bioretention areas may meet the Minimum Requirement #6 requirements for basic and enhanced treatment (see Volumes I and V) when the bioretention soil meets the requirements outlined in Section 3.4.6.

- **Bioretention can be designed to fully meet the flow control duration standard of Minimum Requirement #7. Because they typically do not have an orifice restricting overflow or underflow discharge rates, they typically don't fully meet Minimum Requirement #7. However, their performance contributes to meeting the standard, and that can result in much smaller flow control facilities at the bottom of the project site.**

- **Because bioretention areas use an imported soil mix that has a moderate design infiltration rate, they are best applied for small drainage areas, and near the source of the stormwater. Cells may be scattered throughout a subdivision; a swale may run alongside the access road; or a series of planter boxes may serve the road.**

- **Bioretention areas are particularly effective where the underlying soil has a high infiltration rate. Where the native soils have low infiltration rates, underdrain systems can be installed and the facility used to filter pollutants and detain flows that exceed infiltration capacity of the surrounding soil. However, designs utilizing underdrains provide less flow control benefits.**

- **Bioretention areas are applicable to new development, redevelopment and retrofit projects. Typical applications with or without underdrains include:**
    - Individual lots for rooftop, driveway, and other on-lot impervious surface.
    - Shared facilities located in common areas for individual lots.
    - Areas within loop roads or cul-de-sacs.
    - Landscaped parking lot islands (i.e., situated lower than the height of the parking lot surface so that stormwater runoff is directed as sheet flow into

the bioretention area.). This application, in concert with permeable surfaces in the parking lot, can greatly attenuate stormwater runoff.

- Within rights-of-ways along roads (often linear bioretention swales and cells).
- Common landscaped areas in apartment complexes or other multifamily housing designs.
- Planters on building roofs, patios, and as part of streetscapes.

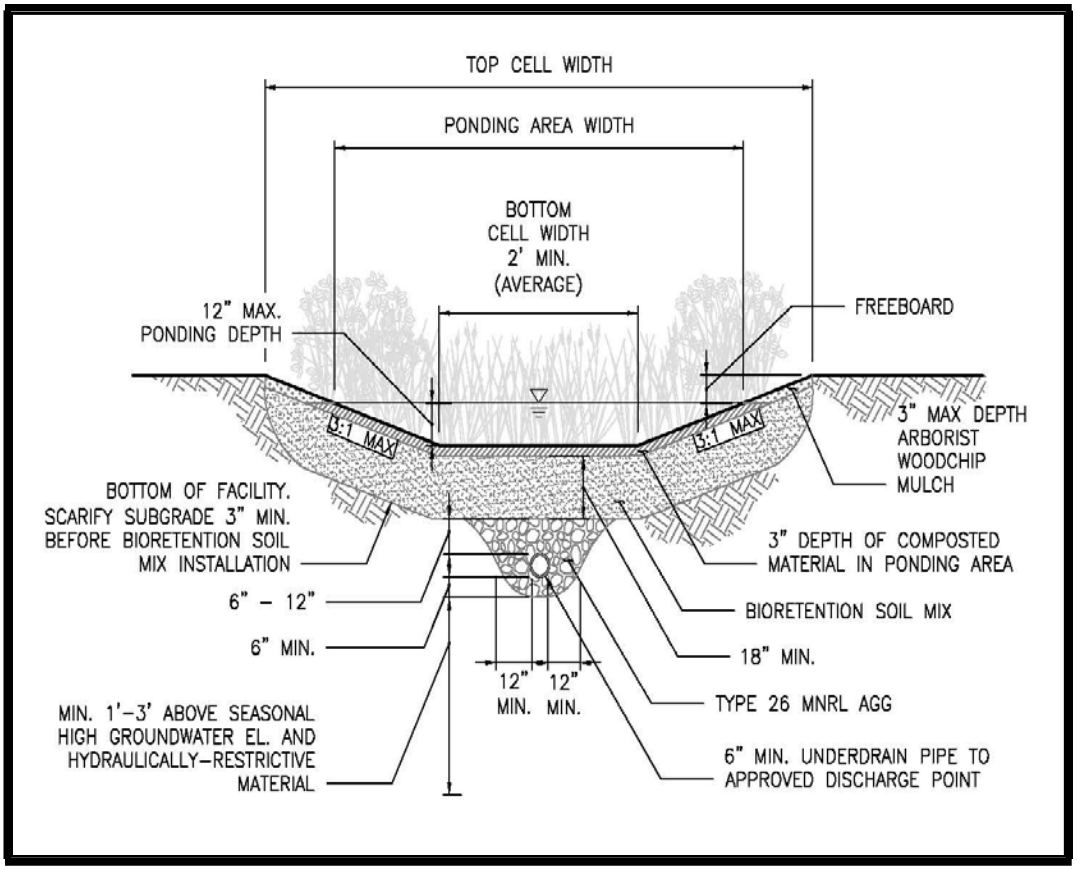


Figure 2.11 Bioretention Area (shown with optional underdrain) - Source Pierce County

2.2.5.3 Infeasibility Criteria

See Appendix III-D in Volume III for infeasibility criteria. The criteria describe conditions that make bioretention not required for consideration in the List #1 or List #2 option of Minimum Requirement #5. In addition, other bioretention design criteria and site limitations that make bioretention areas infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the county. If a project proponent wishes to use a bioretention BMP though not required to because of these feasibility criteria, they may propose a functional design to the county.

2.2.5.3.1 Other Site Suitability Factors:

- **Utility conflicts:** Consult Thurston County requirements for horizontal and vertical separation required for publicly-owned utilities, such as sewer. Consult the appropriate franchise utility owners for separation requirements from their utilities, which may include communications, water, power, 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 the County's 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.

- **Impacts of surrounding activities:** Human activity influences the location of the facility in the development. For example, locate bioretention areas away from traveled areas on individual lots to prevent soil compaction and damage to vegetation or provide elevated or bermed pathways in areas where foot traffic is inevitable and provide barriers, such as wheel stops, to restrict vehicle access in roadside applications.

- **Visual buffering:** Bioretention areas 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 to 3 years irrigation for establishment. Invasive species control may be necessary.

2.2.5.4 Modeling and Sizing

Bioretention areas receiving runoff from roads or a combination of roads and other impervious/pervious surfaces will be larger than rain gardens. For bioretention areas designed to meet Minimum Requirement #5, the bioretention area shall have a horizontally projected surface area below the overflow which is at least 5 percent of the total surface area draining to it. If lawn/landscape area will also be draining to the bioretention area, the horizontally projected surface area below the overflow shall be increased by 2 percent of the lawn/landscape area. For bioretention areas designed to meet Minimum Requirement #6 or #7, the bioretention area must be sized using an approved continuous simulation model.

When using continuous modeling to size bioretention areas, the assumptions listed in Table 2-3 shall be applied. It is recommended that bioretention cells be modeled as a layer of soil (with specified infiltration rate) with infiltration to underlying soil, ponding, and overflow. The bioretention soil is designed in accordance with the treatment soil requirements outlined in the design criteria below. To meet Minimum Requirement #6, at least 91 percent of the influent runoff file produced using a continuous simulation model must be infiltrated. Applicable water quality design storm volume drawdown requirements must also be met.

If 91 percent of the influent runoff file cannot be infiltrated, the percent infiltrated may be subtracted from the 91 percent volume that must be treated, and downstream treatment facilities may be significantly smaller as a result.

The tributary areas, cell bottom area, and ponding depth should be iteratively sized until the duration curves and/or peak values meet the applicable flow control requirements (see Volume I). For additional guidance on bioretention modeling and sizing see the 2014 Ecology Stormwater Management Manual for Western Washington, Volume III, Appendix III-C.

At the time of publication of this volume, the professional version of WWHM includes a bioretention module that can be used to size the cell with or without an underdrain as a function of tributary area, land use type, native soil infiltration rate, side slopes, etc. Other models may have this functionality and can be used if approved by the DDECM Administrator.

Refer to Appendix III-C in Volume III of the Ecology Manual for additional modeling and design guidance for bioretention areas.

Infiltration rates of the native soil (i.e., the undisturbed soil below the imported and/or amended facility soil) and bioretention soil mix infiltration rate must be used when sizing and modeling bioretention areas. The native infiltration rate shall be determined using the methods outlined above. The method for determining infiltration rate of bioretention soil mix is described in Volume III, Section 2.3.4.

Table 2-3 Continuous Modeling Assumptions for Bioretention Cells

Variable	Assumption
Precipitation Series	Thurston County
Computational Time Step	15 minutes
Inflows to Facility	Surface flow and interflow from drainage area routed to facility
Precipitation and Evaporation Applied to Facility	Yes. If model does not apply precipitation and evaporation to facility, include the facility area in the basin area (note that this will underestimate the evaporation of ponded water).
Bioretention Soil Mix Measured Infiltration Rate	For imported soil, rate is 6.0 inch per hour before applying the correction factor.
Bioretention Soil Porosity	30 percent
Bioretention Soil Depth	Minimum of 18 inches
Native Soil Infiltration Rate	Measured infiltration rate, including applicable safety factors (see Volume III, Appendix III-A)
Infiltration Across Wetted Surface Area	Only if side slopes are 3:1 or flatter
Underdrain (optional)	If an underdrain is placed at bottom extent of the bioretention soil layer, all water that filters through the bioretention soil must be routed through the underdrain (i.e., no losses to infiltration). If there is no liner or impermeable layer and the underdrain is elevated above the bottom extent of the bioretention soil or aggregate layer, water stored in the bioretention soil or aggregate below the underdrain invert may be allowed to infiltrate.
Overflow	Overflow elevation set at maximum ponding elevation (excluding freeboard). May be modeled as weir flow over riser edge or riser notch. Note that the total facility depth (including freeboard) must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

2.2.5.5 Field and Design Procedures

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. This section includes infiltration testing requirements and application of appropriate safety factors specific to bioretention areas.

Refer to Appendix III-A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix III-A may not apply to bioretention (additional details provided below).

If the bioretention area includes a liner and does not infiltrate into the underlying soils, they are not considered infiltration facilities and are not subject the infiltration procedures or the setbacks provided in this section. Adhere to setbacks and site constraints for detention vaults included in Section 4.1.3.5.1 for these facilities.

2.2.5.5.1 Determining Design Infiltration Rate

Determining the infiltration rate of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on site. Infiltration rates are also necessary to estimate bioretention performance using the Western Washington Hydrologic Model (WWHM) or MGS Flood.

Initial (measured) infiltration rates are determined through soil infiltration tests. Infiltration tests should be run at the anticipated elevation of the top of the native soil beneath the bioretention area. The following provides recommended test procedures for analysis of the soils underlying bioretention areas.

- For small bioretention cells (bioretention areas receiving water from 1 or 2 individual lots or < 0.25 acre of pavement or other impervious surface), a small-scale PIT, or other methods outlined in Appendix III-A, should be performed at each potential bioretention site. Tests at more than one site could reveal the advantages of one location over another.

- For large bioretention cells (bioretention areas receiving water from several lots or 0.25 acre or more of pavement or other impervious surface), a small- scale PIT, or other methods outlined in Appendix III-A should be performed every 5,000 square feet. The more test pits/borings used, and the more evidence of consistency in the soils, the less of a safety factor may be used. If soil characteristics across the site are consistent, a geotechnical professional may recommend a reduction in the number of tests.

    - If using the PIT method, multiple small-scale or one large-scale PIT can be used. If using the small-scale test, measurements should be taken at several locations within the area of interest.

- For bioretention swales or long, narrow bioretention areas (i.e., one following the road right-of-way), small-scale Pilot Infiltration Test (PIT), or other methods outlined in Appendix III-A should be performed every 200 lineal feet and within each length of road with varying subsurface characteristics, i.e., groundwater elevation, soils type, infiltration rates. However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high groundwater conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

- Test hole or test pit explorations shall be conducted during mid to late in the wet season (December 1 through April 30) to provide accurate groundwater saturation and groundwater information.

- The soil log shall extend a minimum of 4 feet below the bottom of the subgrade (which is the lowest point of excavation where soil is to be amended).

- Note that only the small-scale or large-scale PIT methods may be used to demonstrate infeasibility for Minimum Requirement #5 (i.e., measured infiltration rate of less than 0.3 inches per hour).

- If a single bioretention area serves a drainage area exceeding one acre, infiltration receptor analysis and performance testing may be necessary. See Volume III Section 2.3.2 for specific requirements for infiltration receptor characterization.

2.2.5.5.1.a Assignment of Appropriate Safety Factor

- If deemed necessary by a qualified professional engineer, a safety factor may be applied to the measured Ksat of the subgrade soils to estimate its design (long-term) infiltration rate. Depending on the size of the facility, the variability of the underlying soils, and the number of infiltration tests performed, a safety factor may be advisable. (Note: This is a separate design issue from the assignment of a safety factor to the overlying, designed bioretention soil mix. See the "Bioretention Soil Mix" subsection below).

- The overlying bioretention soil mix provides excellent protection for the underlying native soil from sedimentation. Accordingly, a safety factor for the native soil (i.e., Fplugging used in Appendix III-A) does not have to take into consideration the extent of influent control and clogging over time.

2.2.5.5.2 Prepare Soils Report

A soils report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington that summarizes site characteristics and demonstrates that sufficient permeable soil for infiltration exists at the proposed facility location. At a minimum, the report must contain the following:

- Figure showing the following:
    - Topography within 500 feet of the proposed facility
    - Locations of any water supply wells within 500 feet of the proposed facility
    - Location of groundwater protection areas, aquifer recharge areas, or 1-, 5-, and 10-year times of travel zones for wellhead protection areas
    - Locations of test pits or test holes. A minimum of one soil log or test pit is required at each bioretention area location.

- Results of soils tests including but not limited to: detailed soil logs, visual grain size analysis, grain-size distribution (required if using the grain size analysis method to estimate infiltration rates), percent clay content (include type of clay, if known), color/ mottling, variations and nature of stratification.

- Description of local site geology, including soil or rock units likely to be encountered at soil sampling depths and the seasonal high groundwater elevation.

- Detailed documentation of the design infiltration rate determination, as specified above.

- State whether location is suitable for infiltration and recommend a design infiltration rate.

- A primary pathway for stormwater discharge from a bioretention area with less permeable (Type C) soils can be through interflow in the upper soil structure. The soil investigation should include a detailed description of the condition of the upper soil structure, including the pathway the discharged stormwater will take.

2.2.5.5.3 Estimate Volume of Stormwater

Use the Western Washington Hydrologic Model (WWHM), MGSFlood, or other approved continuous runoff model to generate an influent file that will be used to size the bioretention area. The facility must infiltrate either all of the flow volume as specified by the influent file, or a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Minimum Requirement #7. In addition, the overflow/bypass must meet the LID performance standard if it is the option chosen to meet Minimum Requirement #5, or if it is required of the project.

2.2.5.6 Bioretention Design Criteria

The following provides a description, recommendations, and requirements for the components of bioretention. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for facility review must include documentation of the following elements, discussed in detail below:

- Setbacks and site constraints

- Flow entrance / presettling

- Ponding area

- Overflow

- Bioretention soil mix

- Underdrain (if included

- Setbacks and site constraints

- Flow entrance / presettling

- Ponding area

- Overflow
- Bioretention soil mix
- Underdrain (if included

2.2.5.6.1 Setbacks and Site Constraints

For setbacks and site constraints for non-infiltrating bioretention (lined bioretention cells or planter boxes), refer to the setbacks for detention vaults in Section 3.12.3. See

Infeasibility Criteria in Section 3.4.3 for setbacks and site constraints used to evaluate the bioretention option of List #1 and List #2 (Minimum Requirement #5). (See also Appendix III-D for a summary of infeasibility criteria for all BMPs.) The following minimum setbacks and site constraints apply to all infiltrating bioretention areas (bioretention without a liner or planter box).

- All bioretention areas shall be a minimum of 1 foot positive vertical clearance from any open water maximum surface elevation to structures within 25 feet.
- All bioretention areas shall be a minimum of 10 feet away from any structure or property line. This setback may be reduced by the county for facilities within or adjacent to the right-of-way.
- All bioretention areas shall be set back at least 50 feet from top of slopes steeper than 20 percent and greater than 10 feet high. A geotechnical assessment and soils report must be prepared addressing the potential impact of the facility on the slope. The soils report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.
- All bioretention areas shall be a minimum of 5 feet from septic tanks and distribution boxes.
- For sites with onsite or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the drainfield primary and reserve areas (per WAC 246-272A-0210). This requirement may be modified by the Thurston County Health Department 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.
- All bioretention areas shall be a minimum of 3 feet from the lowest elevation of the bioretention soil, or any underlying gravel layer, and the seasonal high groundwater elevation or other impermeable layer if the area tributary to the facility meets or exceeds any of the following limitations:
    - 5,000 square feet of pollution-generating impervious surface (PGIS)
    - 10,000 square feet of impervious area

- 0.75 acres of lawn and landscape.

- For bioretention systems with a contributing area less than the above thresholds, a minimum of 1 foot of clearance from seasonal high groundwater or other impermeable layer is acceptable.

- Bioretention is prohibited within 300 feet of an erosion hazard, or landslide hazard area (as defined by PCC Title 18E.80) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

- In no case should bioretention areas be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.

  - Where water supply wells exist nearby, it is the responsibility of the applicant's engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration facility on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the facility design, or relocation of the facility should be considered.

  - Bioretention areas upgradient of drinking water supplies and within 1, 5, and 10-year time of travel zones must comply with Washington State Wellhead Protection Program Guidance Document, DOH, 6/2010. Infiltration systems that qualify as Underground Injection Control Wells must comply with Chapter 173-218 WAC and follow the Washington Department of Ecology's "Guidance for UIC Wells that Manage Stormwater," Publication No. 05-10-067.

  - The soils report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- Bioretention constructed with imported composted materials should not be used within one-quarter mile of phosphorus-sensitive waterbodies if the underlying native soil does not meet the soil suitability criteria for treatment in Volume V, Chapter 6. Preliminary monitoring indicates that new bioretention areas 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.

- In the event that the downstream pathway of infiltration, interflow, and/or the infiltration capacity is insufficient to handle the contributing area flows (e.g., a facility enclosed in a loop roadway system or a landscape island within a parking lot), an underdrain system can be incorporated into the bioretention area. The underdrain system can then be conveyed to a nearby vegetated channel, another stormwater facility, or dispersed into a natural protection area. See the underdrain section below for additional information.

2.2.5.6.2 Flow Entrance/Presettling

The design of flow entrance to a bioretention area will depend upon topography, flow velocities, flow volume, and site constraints. Flows entering a facility should have a velocity of less than 1 foot per second to minimize erosion potential. Vegetated buffer strips are the preferred entrance type because they slow incoming flows and provide initial settling of particulates.

Minimum requirements associated with the flow entrance/presettling design include the following:

- If concentrated flows are entering the facility, engineered flow dissipation (e.g., rock pad or flow dispersion weir) must be incorporated
- A minimum 2-inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance, or 5 percent slope from the outer curb face extending to a minimum of 12 inches beyond the back of curb, is required.

Four primary types of flow entrances can be used for bioretention:

1. Dispersed, low velocity flow across a grass or landscape area – this is the preferred method of delivering flows to the facility and can provide initial settling of particulates. Landscape areas and vegetated buffer strips slow incoming flows and provide an initial settling of particulates and are the preferred method of delivering flows to the bioretention cell. Dispersed flow may not be possible given space limitations or if the facility is controlling roadway or parking lot flows where curbs are mandatory.
2. Dispersed flow across pavement or gravel and past wheel stops for parking areas.
3. Drainage curb cuts for roadside, driveway, or parking lot areas – curb cuts shall include rock or other erosion protection material in the channel entrance to dissipate energy. Curb cuts shall be according to Thurston County Standard Plan

- Parking lots that incorporate bioretention into landscaped areas should use concrete curb blocks as wheel stops to protect the bioretention area from traffic intrusion while also allowing the parking lot runoff to flow somewhat unobstructed to the bioretention area.
- The minimum 12-inch drainage curb cut results in a 12-inch opening measured at the curb flow line and will require a 3-foot cut in an existing curb. An 18 inch curb cut is recommended for most applications. Avoid the use of angular rock or quarry spalls and instead use round (river) rock if needed. Removing sediment from angular rock is difficult. Curb cut flow entrances must have either a minimum of 5 percent slope from the outer curb face extending to a minimum of 12 inches beyond the back of curb, or provide a minimum of a 2-inch vertical drop from the back of curb to the vegetated surface of the facility. Provide an area

for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the cell.

- Curb cuts used for bioretention areas in high-use parking lots or roadways require 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 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.

4. Pipe flow entrance – piped entrances shall include rock or other erosion protection material in the facility entrance to dissipate energy and/or provide flow dispersion.

    - 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: 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 should not be placed directly in the entrance flowpath as they can restrict or concentrate flows and can be damaged by erosion around the root ball.

2.2.5.6.3 Ponding Area

Bioretention ponding area may be an earthen depression (for bioretention cells and swales), or a planter box (for bioretention planters or planter boxes). The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the facility. Ponding depth and draw-down rate requirements are 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 1) restore hydraulic capacity of system, 2) maintain infiltration rates, 3) maintain adequate soil oxygen levels for healthy soil biota and vegetation, 4) provide proper soil conditions for biodegradation and retention of pollutants, and 5) prevent conditions supportive of mosquito breeding.

Minimum requirements associated with the bioretention ponding area design include the following:

- The ponding depth shall be a maximum of 12 inches
- The surface pool drawdown time (surface ponding volume) shall be a maximum of 24 hours (drain time is calculated as a function of ponding depth and native soil design infiltration rate).

For projects subject to Minimum Requirement #5 and choosing to use List #1 or List #2 of that requirement, the bioretention area shall have a horizontally projected surface area below the overflow which is at least 5 percent of the total impervious surface area draining to it. If lawn/landscape area will also be draining to the bioretention area, the horizontally projected surface area below the overflow be increased by 2 percent of the lawn/landscape area.

The minimum freeboard measured from the invert of the overflow pipe or earthen channel to facility overtopping elevation shall be 2 inches for drainage areas less than 1,000 square feet and 6 inches for drainage areas 1,000 square feet or greater.

If berming is used to achieve the minimum top elevation needed to meet ponding depth and freeboard needs, maximum slope on berm shall be 3H:1V, and minimum top width of design berm shall be 1 foot. Soil used for berming shall be imported bioretention soil or amended native soil and compacted to a minimum of 90 percent dry density.

2.2.5.6.4 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:

- The maximum planted side slope shall be 3H:1V. If steeper side slopes are necessary rockeries, concrete walls, or soil wraps may be effective design options.
- The bottom width shall be no less than 2 feet.

Bioretention areas should have a minimum shoulder of 12 inches between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should be 90 percent proctor.

2.2.5.6.5 Overflow

An overflow route must be identified for stormwater flows that overtop the bioretention area when infiltration capacity is exceeded or the facility becomes plugged and fails. The overflow route must be able to convey the 100-year recurrence interval developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

Overflow can be provided by a vertical drain pipe installed at the designed maximum ponding elevation (12 inches) and connected to a downstream BMP or an approved discharge point. 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. See also Attachments Section A Detail 26.2.

2.2.5.6.6 Bioretention Soil Mix

Unlike infiltration basins, and trenches, native soil underlying bioretention areas is not subject to the soil infiltration treatment requirements discussed in Volume V (i.e., soil suitability criteria #1 and soil suitability criteria #2). Bioretention areas meet the requirements for basic and enhanced treatment, when the bioretention soil mix meets the requirements of the bioretention soil mix design criteria (see bioretention soil mix criteria below).

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.

The minimum requirements associated with the bioretention soil mix include the following:

- Minimum depth of treatment soil must be 18 inches
- Projects can either use a default bioretention soil mix or can create a custom bioretention soil mix.
    - Projects which use the default bioretention soil mix do not have to test bioretention soil mix infiltration rate. They may assume the rates specified in the next subsection.
    - Projects which create a custom bioretention soil mix rather than using the default requirements must demonstrate compliance with the specific design criteria and must test the bioretention soil mix infiltration rate as described in the “Custom Bioretention Soil Mix” section below.

2.2.5.6.6.a Default Bioretention Soil Mix

Bioretention soil shall be a well-blended mixture of mineral aggregate and composted material measured on a volume basis. Bioretention soil shall consist of two parts fine compost (approximately 35 to 40 percent) by volume and three parts mineral aggregate (approximately 60 to 65 percent), by volume. The mixture shall be well blended to produce a homogeneous mix.

- **Mineral Aggregate:**

- Percent Fines: A range of 2 to 4 percent passing the US #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to ASTM D422.

- **Mineral Aggregate Gradation:**
  - Mineral Aggregate shall be free of wood, waste, coating, or any other deleterious material. The aggregate portion of the Bioretention Soil Mix (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 (Cu = D60/D10) equal to or greater than 4, and
    - Coefficient of Curve (Cc = (D30)2/D60 x D10) greater than or equal to 1 and less than or equal to 3.

Aggregate shall be analyzed by an accredited lab using the US sieve numbers and gradation noted in Table 2-4.

Table 2-4 Aggregate for Bioretention Soil Mix

US Sieve Number	Percent Passing
0.375 inch	100
4	95-100
10	75-90
40	24-40
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, Cation Exchange Capacity

- **Compost to aggregate ratio**: 60-65 percent mineral aggregate, 35–40 percent compost.

- **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.

Composted Material

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.

Compost material must comply with Section 9-14.4(8) of the *WSDOT Standard Specifications, M 41-10, 2016 Edition, Amended April 4, 2016*.

Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall be immediately removed from the project and replaced.

Acceptable compost product sources include those listed on the WSDOT Qualified Products List.

2.2.5.6.6.b Custom Bioretention Soil Mixes

Projects which prefer to create a custom bioretention soil mix rather than using the default requirements above must demonstrate compliance with the following criteria using the specified test method:

- CEC ≥ 5 meq/100 grams of dry soil; USEPA 9081.
- pH between 5.5 and 7.0.
- 5-8 percent organic matter content before and after the saturated hydraulic conductivity test; ASTM D2974 (Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils).
- 2-5 percent fines passing the US #200 sieve; TMECC 04.11-A.
- If compost is used in creating the custom mix, it must meet all of the specifications listed above for compost, except for the gradation specification. An alternative gradation specification must indicate the minimum percent passing for a range of similar particle sizes.
- Measured (Initial) saturated hydraulic conductivity of less than 12 inches per hour; ASTM D 2434 (Standard Test Method for Permeability of Granular Soils (Constant Head)) at 85 percent compaction per ASTM D 1557 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use Appendix III-A, Recommended Modifications to ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes.
- Design (long-term) saturated hydraulic conductivity between 1 and 3 inches per hour. A long-term infiltration rate correction factor of 4 shall be used for the bioretention soil if the area tributary to the facility meets or exceeds any of the below limitations (for bioretention areas with a contributing area less than the

below thresholds, a long-term infiltration rate correction factor of 2 for the bioretention soil mix is acceptable):

- o 10,000 square feet of impervious area
- o 5,000 square feet of PGIS
- o 0.75 acres of lawn and landscape.

2.2.5.6.7 Underdrain (Optional)

Where the underlying native soils have an estimated initial infiltration rate between 0.3 and 1.6 inches per hour, bioretention areas without an underdrain, or with an elevated underdrain directed to a surface outlet, may be used to satisfy List 2 of Minimum Requirement 5. Underdrained bioretention areas that drain to a retention/detention facility must meet the following criteria if they are used to satisfy List 2 of Minimum Requirement 5.

- 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.
- The distance between the bottom of the bioretention soil mix and the crown of the underdrain pipe must be not less than 6 or more than 12 inches.
- The aggregate bedding layer must run the full length and the full width of the bottom of the bioretention area.
- The facility must not be underlain by a low permeability liner that prevents infiltration into the native soil.

Underdrain systems should be installed only if the bioretention area is located where infiltration is not permitted and a liner is used, or where subgrade soils have infiltration rates that do not meet the maximum pool drawdown time. In these cases, underdrain systems can be installed and the facility can be used to filter pollutants and detain flows. However, designs utilizing underdrains provide less infiltration and flow control benefits.

The volume above an underdrain pipe in a bioretention area provides pollutant filtering and some flow attenuation; however, only the void volume of the aggregate below the underdrain invert and above the bottom of the bioretention area (subgrade) can be used in the WWHM or MGSFlood for dead storage volume that provides flow control benefit.

Assume a 40 percent void volume for the filter material aggregate specified below.

Elevating the underdrain 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.

The minimum requirements associated with the underdrain design include:

- Slotted, thick-walled plastic pipe must be used:
    - o Minimum pipe diameter: 4 inches (pipe diameter will depend on hydraulic capacity required, 4 to 8 inches is common).
    - o Slotted subsurface drain PVC per ASTM D1785 SCH 40.
    - o 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 one-half of the circumference of the pipe. See Filter Materials section for aggregate gradation appropriate for this slot size.
- Pipe must have a minimum diameter of 4 inches
- Underdrain pipe slope must be no less than 0.5 percent
- Pipe must be placed in filter material and have a minimum cover depth of 4 inches
- Filter material shall meet the requirements of WSDOT Standard Specifications 9-03.12(4) (gravel backfill for drains)
- A 6-inch non-perforated cleanout must be connected to the underdrain every 300 feet minimum.
    - o The underdrain can be connected to a downstream BMP such as another bioretention/rain garden area as part of a connected system, or to an approved discharge point. A geotextile fabric (specifications in Volume V, Appendix V-A) must be used between the soil layer and underdrain.

2.2.5.6.8 Check Dams and Weirs

For sloped bioretention areas, check dams are necessary to provide ponding, reduce flow velocities and reduce the potential for erosion. Typical check dam 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 performance (modeling) and cost considerations. See the *Low Impact Development Technical Guidance Manual for Puget Sound* for typical designs.

2.2.5.6.9 Planting

The design intent for bioretention plantings is to replicate, to the extent possible, the hydrologic function of a mature forest including succession plants and groundcover. Plant roots aid in the physical and chemical bonding of soil particles that is necessary to form stable aggregates, improve soil structure, and increase infiltration capacity.

The minimum requirements associated with the vegetation design include the following:

- The design plans must specify that vegetation coverage of selected plants will achieve 80 percent coverage within 2 years or additional plantings will be provided until this coverage requirement is met

- For facilities receiving runoff from 5,000 square feet or more impervious surface, plant spacing and plant size must be designed to achieve specified coverage by a certified landscape architect

- The plants must be sited according to sun, soil, wind, and moisture requirements

- At a minimum, provisions must be made for supplemental irrigation during the first two growing seasons following installation.

Refer to Appendix V-E, Planting and Landscaping Requirements and the *LID Technical Guidance Manual for Puget Sound* for guidance on plant selection and recommendations for increasing survival rates.

2.2.5.6.10 Mulch Layer

Bioretention areas should be designed with a mulch layer or a dense groundcover. Properly selected mulch material also reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to soil. Mulch should be:

- Compost in the bottom of the facilities (compost is less likely to float than wood chip mulch and is a better source for organic materials).

- Wood chip mulch composed of shredded or chipped hardwood or softwood on cell 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 trunk or branch wood and bark.

- A maximum of 3 inches thick (thicker applications can inhibit proper oxygen and carbon dioxide cycling between the soil and atmosphere).

Mulch shall not include weed seeds, soil, roots and other material that are not from the above ground components of a tree, 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 1.5 inch gravel (rounded) decorative rock is typical. The area covered with aggregate mulch must not exceed one third of the facility bottom area.

As an alternative to mulch, a dense groundcover may be used. Mulch is required in conjunction with the groundcover until groundcover is established.

2.2.5.6.11 Hydraulic Restriction Layer

For infiltrating bioretention areas adjacent to roads, foundations or other sensitive infrastructure, it may be necessary to restrict lateral infiltration pathways to prevent excessive hydrologic loading using a restricting layer (for the sides of the bioretention area only).

Two types of restricting layers can be incorporated into bioretention designs:

- Clay (bentonite) liners are low permeability liners
- Geomembrane liners completely block infiltration. The liner should have a minimum thickness of 30 mils and be ultraviolet (UV) resistant.

Note: only the infiltrating bottom area (i.e., unlined) may be used in sizing calculations or hydrologic modeling.

If it is necessary to prevent infiltration to underlying soils (e.g., contaminated soils or steep slope areas), the facility must include a hydraulic restriction layer across the facility. The facility may be composed of a low permeability (e.g., concrete) container with a closed bottom, or may be lined with a low permeability material (e.g., clay, geomembrane liner) to prevent infiltration. In these cases, underdrains are required.

Signage

Thurston County that bioretention installations include informational signage upon completion of the installation to help identify the vegetated area as a stormwater BMP and to inform maintenance crews and the general public about protecting the facility's function.

2.2.5.6.12 Bioretention Construction Criteria

Minimum requirements associated with bioretention area construction include the following:

- Bioretention areas that infiltrate into the underlying soil (i.e., do not include a liner) rely on water movement through the surface soils as infiltration and interflow to underlying soils. Therefore, it is important to always consider the pathway of interflow and assure that the pathway is maintained in an unobstructed and uncompacted state. This is true during the construction phase as well as postconstruction.
- During construction, it is critical to prevent clogging and over-compaction of the subgrade and bioretention soils. See Volume II, Section 3.3 for infiltration facility

construction requirements. Specific construction criteria for bioretention areas are provided below.

- Place bioretention soil per the requirements of bioretention soil mix requirements specified in this section, and amend the soil per Section 3.1.

2.2.5.6.12.a Verification of Performance

The project engineer or designee shall inspect bioretention areas before, during, and after construction as necessary to ensure facilities are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. Prior to placement of the Bioretention Soil Mix, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate. Before release of the financial guarantee, the project engineer shall perform a sufficient number of modified falling-head percolation tests (a minimum of two) after construction to determine that the facility will operate as designed. The county must be notified of the scheduled infiltration testing at least 2 working days in advance of the test. See Appendix III-A for testing requirements. If the tests indicate the facility will not function as designed, this information must be brought to the immediate attention of the county along with any reasons as to why not and how it can be remedied.

2.2.5.6.13 Operations and Maintenance Criteria

See Core Requirement 9 in Volume I, Section 3. 8.4; and Volume I, Appendix I-E for information on maintenance requirements.

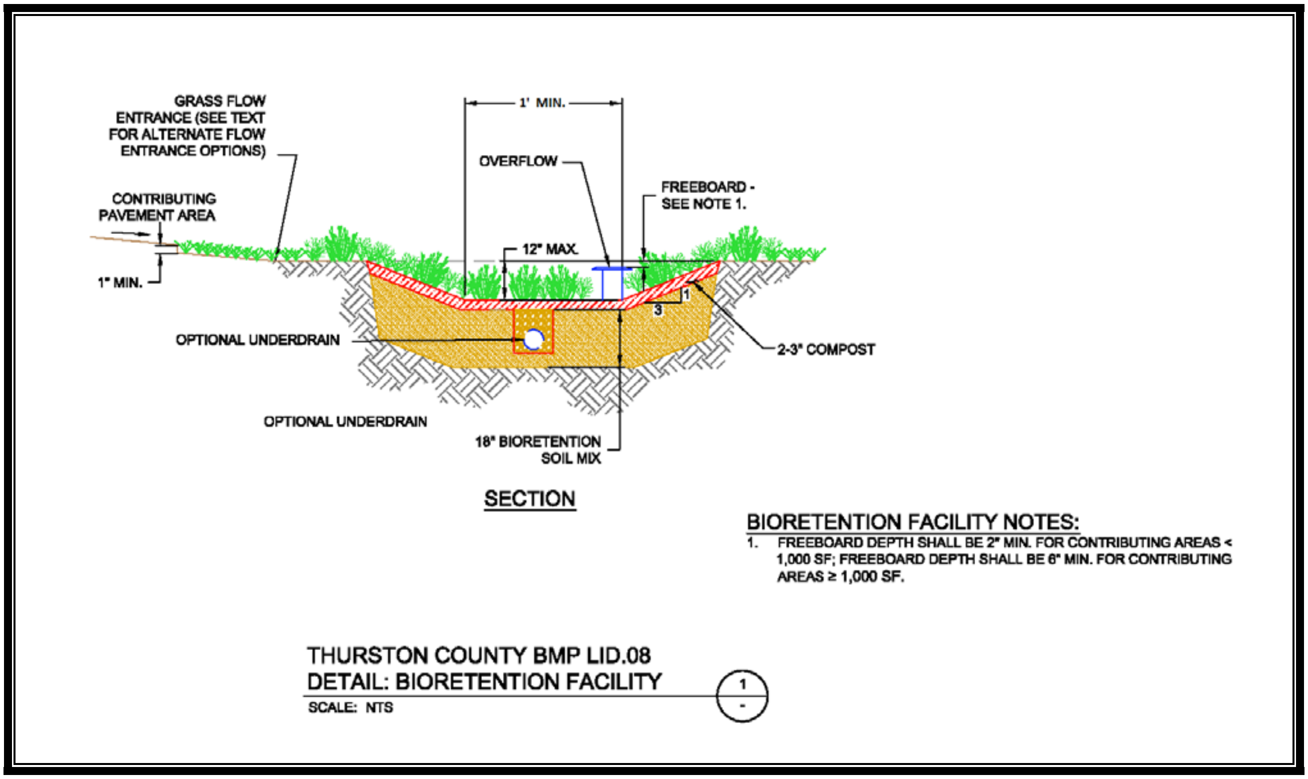


Figure 2.12 Bioretention Area (typical)

2.2.5.6.14 Submittals and Approval

The applicant should consult with Thurston County at the pre-submittal meeting and the scoping report/meeting for the project to discuss the suitability of and requirements for a bioretention facility if one is proposed for the project.

Project submittals shall include the following in addition to the requirements of other sections:

- Source of bioretention soil mix and testing results of treatment soil including test results from the individual components (compost and aggregate components).
- Description of method used and results of infiltration testing of base soils and bioretention soil mix
- Hydrologic modeling results for the bio-retention facility demonstrating that the water quality treatment design storm is handled by the facility and how volumes greater than the water quality design flow are managed
- Project drawings shall include a typical cross-section of the facility and specifications for installation of treatment soils, seeding, sodding and other construction requirements

- Maintenance Plan shall include a discussion of maintenance requirements for the bio-retention facility

The bioretention soils mix shall be tested for infiltration capacity using the following test method:

  - ASTM 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 80 percent using ASTM 1557 (Modified Proctor).

Include in the Soils Management Plan prepared per BMP LID.02 the bioretention soils mix for any proposed bioretention facilities included in the project.

2.2.6 LID.09 Permeable Paving

Permeable pavement is designed to accommodate pedestrian, bicycle, and auto traffic while allowing infiltration and storage of stormwater. Permeable paving surfaces include:

- Porous hot or warm-mix asphalt pavement is a flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate together. However, the fine material (sand and finer) is reduced or eliminated and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

- Pervious Portland cement concrete is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

- Permeable concrete pavers 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 pervious concrete pavers. 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 permeable concrete pavers, 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.

2.2.6.1 Applicability

- Permeable pavement is an onsite stormwater management BMP option for projects that have to comply with Core Requirement #5.

- Permeable pavement can also achieve compliance with the Performance Standard option or can be applied from the List #1 or List #2 option of Core Requirement #5.

- Permeable pavement can meet water quality treatment requirements of Core Requirement #6 when the underlying soil meets the treatment soil requirements outlined in Volume V, Section 6.3, or a water quality treatment course is included.

- Permeable pavement can meet the flow control duration standard of Core Requirement #7. The flow control performance is typically a function of the infiltration rate of the underlying subgrade soil and the depth of the aggregate storage reservoir that stores stormwater until it is infiltrated.

- Appropriate applications for permeable pavement include parking lots, low volume roads, alleys, access drives, pedestrian and bike trails, and patios. The application of permeable pavement on roads shall be limited to those roadways that receive very low-traffic volumes (i.e., ADT less than or equal to 400).

2.2.6.2 Limitations

Because permeable pavement can clog with sediment, permeable pavement is not recommended under the following conditions:

- Excessive sediment contamination is likely on the pavement surface (e.g., construction areas, landscaping material yards)

- It is infeasible to prevent stormwater runon to the permeable pavement from unstabilized erodable areas without pre-settling

- Sites where the risk of concentrated pollutant spills are more likely (e.g., gas stations, truck stops, car washes, vehicle maintenance areas, industrial chemical storage sites).

- Roads subject to high sediment loadings (such as roads that are sanded for deicing purposes in the winter). Application of sand and other gritty substances can clog the pavement, impeding the infiltration of stormwater and resulting in hazardous ponded water conditions.

- Areas with water quality concerns related to stormwater with high concentrations of oils or other contaminants infiltrating through the surface and contaminating groundwater. These include, but are not limited to, gas stations, commercial fueling stations, autobody shops, automobile repair services, and automobile wash services.

- To reduce the potential of clogging, runoff generated from unstabilized pervious surfaces may not be directed onto a permeable pavement surface. If runoff comes from minor or incidental pervious areas (including lawns), those areas must be fully stabilized.

- ADA compliance is required if the pavement is part of an accessible route, and should be a consideration in all other cases, in determining where to use alternative paving surfaces. Sidewalk designs incorporate truncated domes, near the curb ramp to indicate an approaching traffic area for the blind. The rougher surface of permeable paving may obscure this transition. Therefore use standard concrete with truncated domes for curb ramps.

- Permeable pavement is not intended to receive "run-on" stormwater from other areas. Runon from non-pollution generating roof surfaces can be directed to permeable pavement provided that the permeable pavement section area is designed to handle the additional water. Sheet flow from up-gradient impervious areas is not recommended, but permissible if the permeable pavement area is > the impervious pavement area.

The aggregate within the cells of permeable pavers can settle or be displaced from vehicle use. As a result, paver installations for disabled parking spaces and walkways should use solid pavers or standard concrete or asphalt.

Permeable pavement surfaces are suitable for use in Type A through C soils and are not recommended for Type D soils. However, with an adequate storage course, the application can be beneficial for encouraging infiltration.

2.2.6.3 Infeasibility Criteria

See Appendix III-D for the conditions that make permeable pavement not required for consideration in the List #1 or List #2 option of Core Requirement #5. These criteria also apply to impervious pavements that would employ stormwater collection from the surface of impervious pavement with redistribution below the pavement. In addition, other permeable pavement design criteria and site limitations that make permeable pavement infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the county.

Citation of any of the 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).

2.2.6.4 Hydrologic and Hydraulic Design Considerations

Permeable paving surfaces differ greatly in infiltration capacity. Base materials of permeable pavement systems can be designed to infiltrate vertically into outwash soils.

Where cemented till layers of soil exist under a parking lot, a permeable pavement system can still be effective to attenuate peak flows. In small area applications, the subgrade of the parking lot can be built up with porous base material and graded to direct runoff through this material to a controlled outfall, such as bioretention areas.

2.2.6.4.1 Flow Credit/Modeling of Alternative Paving Surfaces

Permeable pavement surfaces designed in accordance with this section for infiltration should be modeled as indicated in Table 2-5. Note that permeable paving surfaces should not be receiving "run on" from other surfaces; however, run-on per Section 2.2.6.2 is acceptable if the permeable pavement area can handle the additional waterThis section includes infiltration testing requirements and application of appropriate safety factors specific to permeable pavement surfaces.

Refer to Appendix III-A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix III-A may not apply to permeable pavement. All test hole or test pit explorations outlined below shall be conducted during mid to late in the wet season (December 1 through April 30) to provide accurate groundwater saturation and groundwater information.

Table 2-5 Continuous Modeling Assumptions for Alternative Paving Surfaces

Variable	Assumption
Computational Time Step	15-minutes
Inflows to Facility	Model pavement area as impervious basin routed to a gravel-filled trench with infiltration to underlying soil. Additional areas draining to the pavement (surface flow and interflow), if any, are also routed to the gravel trench.
Precipitation Applied to Facility	No (applied to basin before routing to trench)
Evaporation Applied to Facility	Yes. While evaporation is applied to the impervious basin before routing to the trench, additional evaporation occurs when water is stored in the storage reservoir
Storage Reservoir Depth	Average maximum subsurface water ponding depth in the storage reservoir (average across the facility) before berm overtopping or overflow. Note: The maximum ponding depth in the storage reservoir shall be a minimum of 6 inches below the surface of pavement.
Storage Reservoir Porosity	Assume maximum 20 percent unless test is provided showing higher porosity for aggregate compacted and in place
Native Soil Design Infiltration Rate	Measured infiltration rate with correction factor applied (see Volume III)
Infiltration Across Wetted Surface Area	No (bottom area only)
Underdrain (optional)	If underdrain is placed at bottom extent of the storage reservoir, all water which enters the facility must be routed through the underdrain. If there is no liner or impermeable layer and the underdrain is elevated within the storage reservoir, water stored in the reservoir below the underdrain may be allowed to infiltrate.
Outlet Structure	Overflow elevation set at average maximum subsurface ponding depth. May be modeled as weir flow over riser edge or notch. Note that freeboard must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

2.2.6.4.2 Determining Initial Subgrade Infiltration Rates

- Projects subject to Core Requirements #1 - #5:
    - A small-scale Pilot Infiltration Test (PIT), or other methods outlined in Appendix III-A, should be performed for every 5,000 square feet of permeable pavement, but not less than 1 test per site.

- Note that only the small-scale or large-scale PIT methods may be used to demonstrate infeasibility for Core Requirement #5 (i.e., measured infiltration rate of less than 0.3 inches per hour).

- Projects subject to Core Requirements #1 - #10:

  - On commercial property: a small-scale Pilot Infiltration Test (PIT), or other methods outlined in Appendix III-A, should be performed for every 5,000 square feet of permeable pavement, but not less than 1 test per site.

  - On residential developments: a small-scale Pilot Infiltration Test (PIT), or other methods outlined in Appendix III-A, 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 groundwater conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

  - 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.

2.2.6.4.3 Assignment of Appropriate Safety/Correction Factors

- If deemed necessary by a qualified professional engineer, a safety factor may be applied to the measured Ksat of the subgrade soils to estimate its design (longterm) infiltration rate. Depending on the size of the facility, the variability of the underlying soils, and the number of infiltration tests performed, a safety factor may be advisable.

- A safety factor for the subgrade (i.e., Fplugging used in Appendix III-A) does not have to take into consideration the extent of influent control and clogging over time, unless deemed necessary by a professional engineer.

- The quality of pavement aggregate base material may be compromised if the aggregate base is not clean washed material, and has more than 1 percent fines passing the US #200 sieve. In these cases, a correction factor (Faggregate) may be necessary. Faggregate ranges from 0.9 (not clean or washed aggregate, greater than 1 percent fines passing the US #200 sieve) to 1 (aggregate base meets specifications).

2.2.6.5 Soil Suitability Criteria Confirmation

- Where permeable pavements are used for pollution-generating hard surfaces (primarily roads, driveways, and parking lots), there must be a determination whether the soil suitability criteria of Volume III, Section 2.3 are met. This requirement does not apply to projects that trigger only Core Requirement #1 through #5.

- Sites not meeting these criteria should be considered infeasible for permeable pavements for pollution-generating hard surfaces, unless a treatment layer is provided.

- The information to make this determination may be obtained from various sources: historic site information, estimated qualities of a general soil type, laboratory analysis of field samples.

2.2.6.6 Prepare Soils Report

A soils report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington that summarizes site characteristics and demonstrates that sufficient permeable soil for infiltration exists at the proposed facility location. See Volume I, Section 3.8 and Appendix I-F for submittal requirements.

2.2.6.7 Sizing Storage Course

Use the Western Washington Hydrologic Model (WWHM), MGSFlood, or other approved continuous runoff model to generate an influent file that will be used to size the storage course of the permeable pavement facility. The facility must infiltrate either all of the flow volume as specified by the influent file, or a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Core Requirement #7. In addition, the overflow/bypass must meet the LID performance standard if it is the option chosen to meet Core Requirement #5, or if it is required of the project.

2.2.6.8 Design Criteria

The following provides a description, recommendations, and requirements for the components of permeable pavement. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for facility review must include documentation of the following elements, discussed in detail below:

- Setbacks and site constraints
- Permeable wearing course
- Drainage conveyance
- Flow entrance/presettling requirements
- Leveling course
- Aggregate storage reservoir

- Lateral subsurface impermeable barriers
- Nonwoven geotextile (optional)
- Subgrade
- Water quality treatment layer
- Signage
- Strucural design considerations

Typical cross-sections of permeable pavement consist of a top layer (permeable wearing course) underlain by a leveling course (if required), aggregate storage reservoir, geotextile fabric (optional), treatment layer (if required) and subgrade. See Figures 3.7 and 3.8 for example permeable surface cross-sections.

2.2.6.8.1 Setbacks and Site Constraints

See Infeasibility Criteria in Appendix III - D for setbacks and site constraints used to evaluate the permeable pavement option of List #1 and List #2 (Core Requirement #5). The following minimum setbacks and site constraints apply to all permeable pavement areas.

- All permeable pavement surfaces shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope. If the permeable pavement is within 200 feet of a slope exceeding 15 percent or within 300 feet of a Geologic Hazard Area, the Administrator or designee may require a geotechnical report to evaluate if a slope exceeding 20% is a landslide hazard area.
- For sites with onsite or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the drainfield primary and reserve areas (per WAC 246-272A-0210. This requirement may be modified by the Thurston County 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.
- Permeable pavement should not be located where seasonal high groundwater or an underlying impermeable/low permeable layer would create saturated conditions within 1 foot of the bottom of the lowest gravel base course.
- In no case should permeable pavement surfaces be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.
    - Where water supply wells exist nearby, it is the responsibility of the applicant’s engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration facility

on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the facility design, or relocation of the facility should be considered.

- o Pollution generating permeable pavement surfaces located within the 1-year capture zone of any well must meet the soil suitability criteria for providing treatment or provide a six-inch layer of media meeting the soil suitability criteria or sand filter specification. Permeable pavement surfaces upgradient of drinking water supplies and within 1-, 5-, and 10-year time of travel zones must comply with Washington State Wellhead Protection Program Guidance Document, DOH, 6/2010.

- o The soils report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- Permeable pavement surfaces are prohibited within 300 feet of a marine bluff hazard, or landslide hazard area (as defined by Thurston County Code Title 17.15 or Title 24) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

2.2.6.8.2 Permeable Wearing Course

The wearing course or surface layer of the permeable pavement surface may consist of porous asphalt, pervious concrete, interlocking concrete pavers, or open-celled paving grid with vegetation or gravel.

- Maximum wearing course slopes for permeable paving surfaces are 5 percent (porous asphalt), 10 percent (pervious concrete), 12 percent (interlocking pavers), and up to 12 percent (grid and lattice systems) (check with manufacturer or local supplier).

- Manufacturer's recommendations on design, installation, and maintenance shall be followed for each application.

- For all surface types, a minimum initial infiltration rate of 20 inches per hour is required. To improve the probability of long-term performance, significantly higher initial infiltration rates are desirable. Use ASTM C1701 to measure initial surface infiltration rates for porous asphalt, pervious concrete, or permeable interlocking concrete pavers. For grid systems, refer to manufacturers testing recommendations.

- Porous Asphalt: Products must have adequate void spaces through which water can infiltrate and must meet performance grade (PG) 70-22. See the LID

Technical Guidance Manual for the Puget Sound Basin for additional specifications.

- Pervious Concrete: Products must have adequate void spaces through which water can infiltrate and must meet the most current version of American Concrete Institute (ACI) 522. See the LID Technical Guidance Manual for the Puget Sound Basin for additional specifications.

- 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. Fill media for grid systems with grass vary per manufacturer from coarse sand to topsoil. Consult manufacturer to confirm that the fill media will provide adequate infiltration capacity and, at that rate, support healthy plant growth.

- Permeable Interlocking Concrete Pavement and Aggregate Pavers: See the LID Technical Guidance Manual for the Puget Sound Basin for specifications and installation procedures published by the Interlocking Concrete Pavement Institute.

- Permeable pavement systems that utilize pavers need to be confined with a rigid edge system to prevent gradual movement of the paving stones.

- Both gravel and soil with vegetation can be used to fill the openings in paver and rigid grid systems and manufacturer recommendations should be followed to apply the appropriate material for each application.

Manufacturer's recommendations on design, installation, and maintenance shall be followed for each application.

2.2.6.8.3 Drainage Conveyance

An overflow route must be identified for stormwater flows that overtop the facility when infiltration capacity is exceeded or when the facility becomes plugged and fails. The overflow route must be able to convey the 100 year developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

2.2.6.8.4 Flow Entrance/Presettling Requirements

Runon to permeable pavement system can be effective to attenuate peak flows, preferably dispersed as sheet flow or delivered subsurface to the storage reservoir. If subsurface delivery is used, primary settling is required (e.g., via catch basin, hooded outlet, sump) followed by distribution to storage reservoir (e.g., via perforated drain pipe).

Runon from up-gradient adjacent impervious paved surfaces is not recommended, but permissible if:

- The permeable pavement area is at least twice the area of the impervious area,

- The length of sheet flow from the impervious paved surface is no greater than half the length across the permeable pavement section, and

- The permeable pavement area section is designed to accommodate and infiltrate the additional water.

2.2.6.8.5 Runoff Treatment

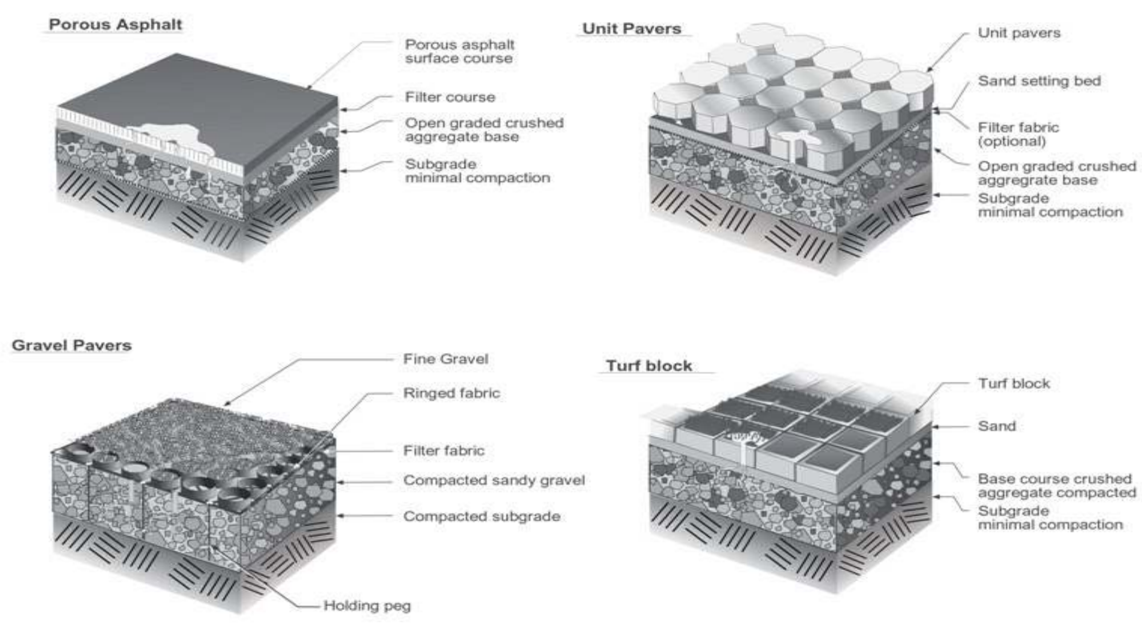
The subgrade must have an infiltration rate of less than 2.4 inches per hour and a cation exchange capacity of 5 milliequivalents CEC/100 grams dry soil or greater to provide water quality treatment that satisfies Core Requirement #6 requirements. Runoff treatment does not apply to alternative paving surface facilities with an underdrain. For more information see Water Quality Treatment Layer below.

2.2.6.8.6 Geometry

Positive surface drainage shall be provided to eliminate risk of ponding on pavement surface (minimum surface slope of 1 percent).

2.2.6.8.7 Materials

Figure 2.13, Figure 2.14, Figure 2.15, and Figure 2.16 show examples of typical cross-sections of porous paving sections. They typically consist of a top layer (porous wearing course), an aggregate subbase, an optional leveling course and geo-textile fabric.



Not to Scale

Figure 2.13 Alternative Paving Surfaces

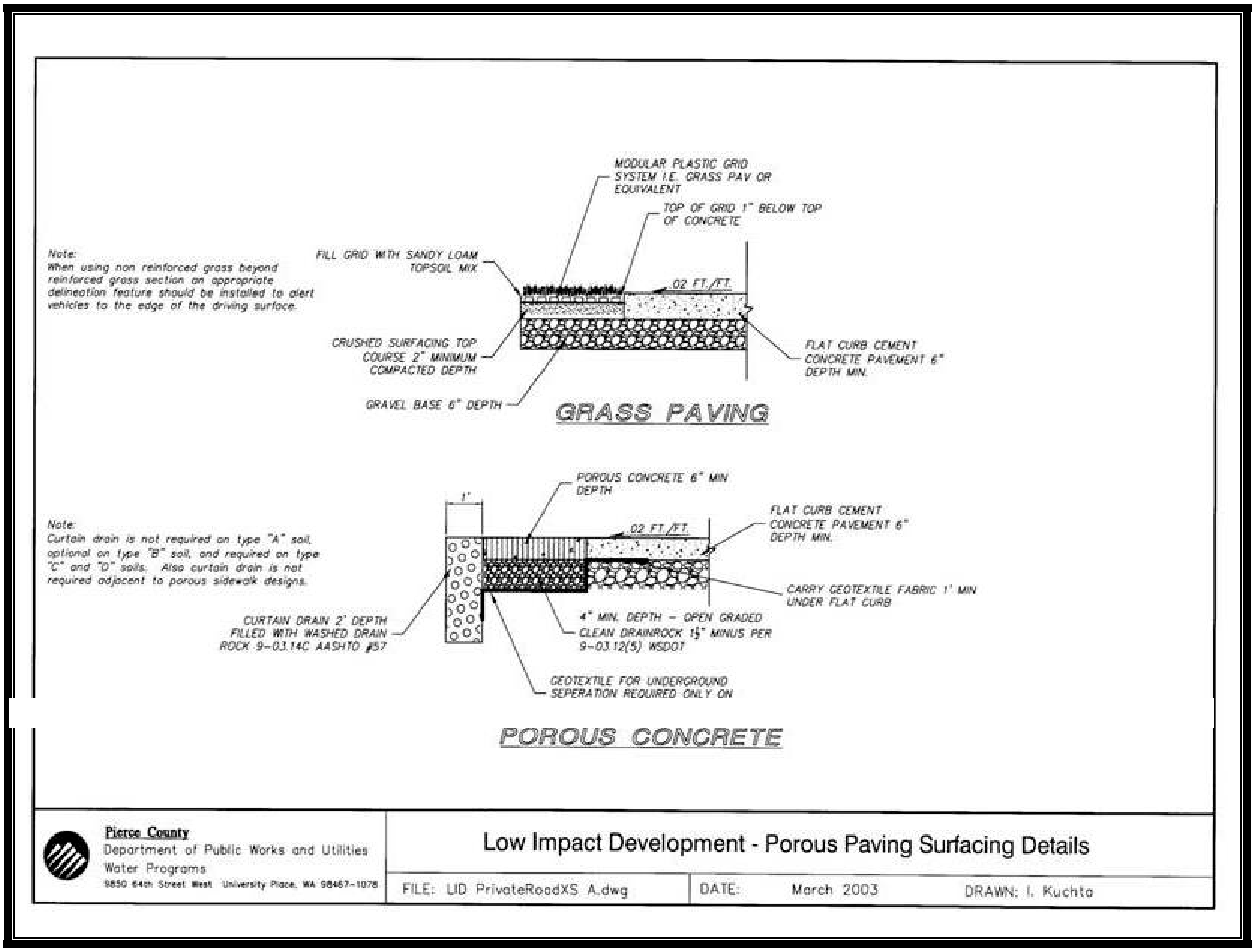


Figure 2.14 Porous Paving Surfacing Details

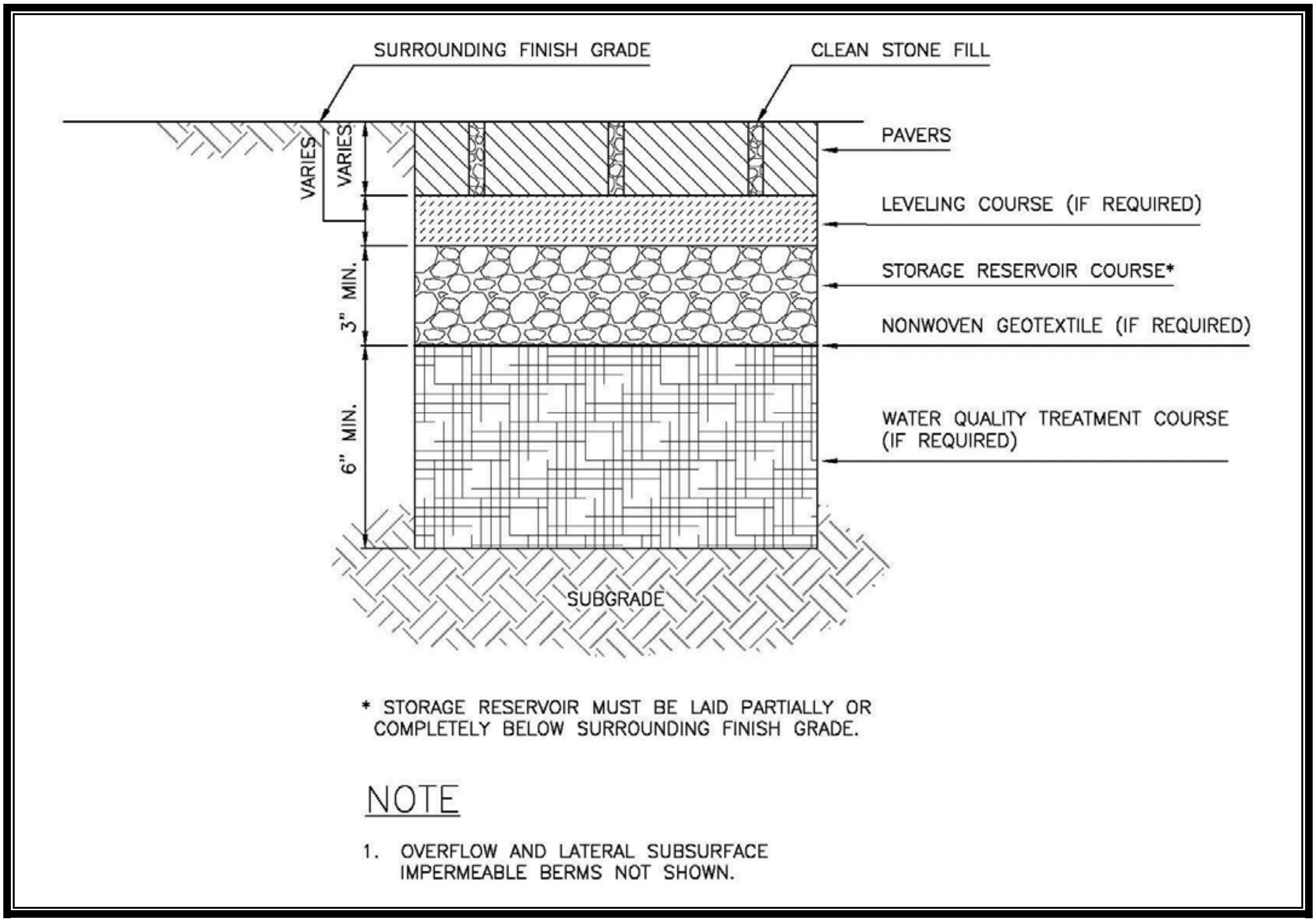


Figure 2.15 Permeable Paver Section

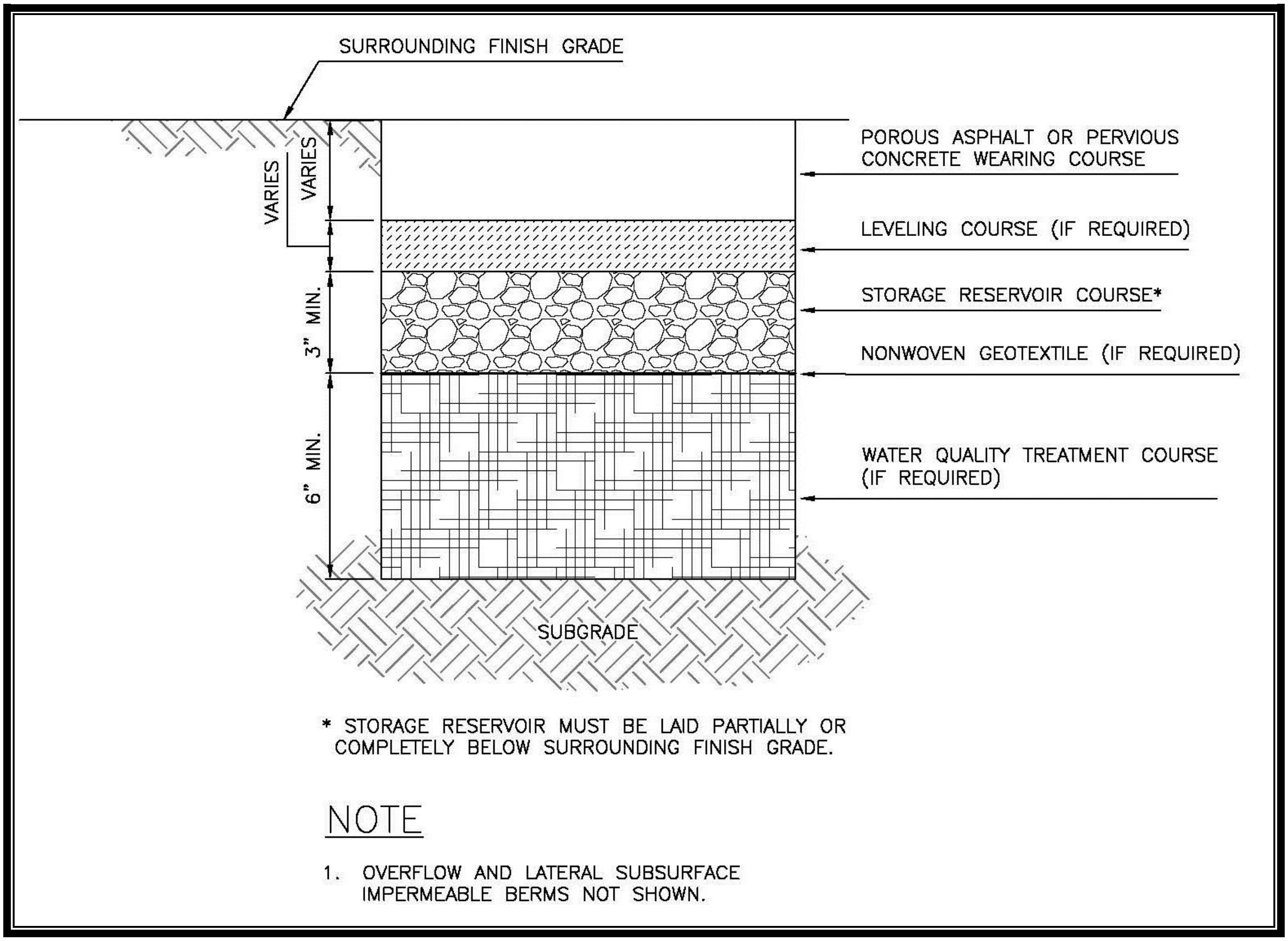


Figure 2.16 Porous Asphalt or Pervious Concrete Section

2.2.6.8.8 Leveling Course

Depending upon the type of permeable pavement installation, a leveling course (also called a bedding or choker course) may be required (per manufacturer recommendations). A leveling course is often required for porous asphalt, open-celled paving grids, and interlocking concrete pavers. This course is a layer of aggregate that provides a more uniform surface for laying pavement or pavers and consists of crushed aggregate smaller in size than the underlying aggregate storage reservoir. Course thickness will vary with permeable pavement type.

Leveling course material and thickness shall be included as required per manufacturer recommendations. Leveling course material must be compatible with underlying aggregate storage reservoir material and shall also have at least a 20 in/hour design infiltration rate. .

2.2.6.8.9 Aggregate Storage Reservoir

Stormwater passes through the wearing and leveling courses to an underlying aggregate storage reservoir, also referred to as “base material,” where it is filtered and stored prior to infiltration into the underlying soil. The aggregate storage reservoir also serves as the support base and must be designed to support the expected loads and be free draining. The aggregate shall meet the following criteria:

- Material must be free draining.

- A 6-inch minimum depth of aggregate storage reservoir is recommended under the permeable wearing course and leveling course (if any) for water storage

- Aggregate storage reservoir shall consist of the leveling course and the storage course. WSDOT Standard Specification 9-03.12(5) is recommended for the storage course. If other gradations are used, the fines (<#200 sieve) shall be less than 2% passing.

Designs utilizing an underdrain that is elevated within the aggregate base course to protect the pavement wearing course from saturation are still considered an LID BMP and can be used to satisfy Core Requirement #5, so long as the underdrain invert is set at or above the maximum design ponding depth.

See Chapter 6 of the "Low Impact Development: Technical Guidance Manual for Puget Sound" for more detailed information for storage courses.

2.2.6.9 Lateral Subsurface Impermeable Barriers

Sloped permeable pavement surfaces have an increased potential for lateral flows through the aggregate storage reservoir along the top of relatively impermeable subgrade soil. This poses a risk of subsurface erosion and reduces the storage and infiltration capacity of the pavement facility. To address this, the subgrade must be designed to create subsurface ponding to detain subsurface flow, increase infiltration, and reduce structural problems associated with subgrade erosion on slopes.

Ponding must be provided using periodic lateral impermeable barriers (e.g. check dams, impermeable liners, or low conductivity geotextiles) oriented perpendicular to the subgrade slope when the slope of the permeable pavement is 3 percent or greater. While the frequency of the barriers is calculated based on the required subsurface ponding depth and the subgrade slope, typical designs include barriers every 6 to 12 inches of grade loss. See Attachments Section A, Details 27.1 for an example of subsurface permeable pavement check dams.

Minimum requirements associated with lateral impermeable barriers include the following:

- Lateral impermeable barriers must be installed at regular intervals perpendicular to the subgrade slope to provide the average subsurface ponding depth in the aggregate storage reservoir required to meet the desired performance standard

- The barriers must not extend to the elevation of the surrounding ground

- Each barrier must have an overflow, as described below, or allow overtopping to the next downslope aggregate storage reservoir section without causing flows to express from the pavement surface or out the sides of the base materials that are above grade.

2.2.6.10 Non-woven Geotextile Fabric

Generally, geotextiles and geogrids are applied:

- To prevent fines from migrating to more open-graded material and the associated structural instability
- For soil types with poor structural stability to prevent downward movement of the aggregate base into the subgrade.

Geotextiles between the permeable pavement subgrade and aggregate base are not required or necessary for many soil types and, if incorrectly applied, can clog and reduce infiltration capability at the subgrade or other material interface. Therefore, the use of geotextiles is discouraged unless it is deemed necessary.

As part of the pavement section design, the designer should review the existing subgrade or subbase characteristics and determine if a nonwoven geotextile is needed for separation of subbase from underlying soils.

2.2.6.10.1 Subgrade

Compact the subgrade to the minimum necessary for structural stability. Two guidelines currently used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90 to 92 percent Standard Proctor (quantitative). Use small static dual wheel mechanical rollers or plate vibration machines for compaction. Do not allow heavy compaction due to heavy equipment operation. Low ground pressure equipment is required when working on the subgrade. Do not subject the subgrade to truck traffic.

To prevent compaction when installing the aggregate storage reservoir, the following steps (back-dumping) should be followed:

- The aggregate storage reservoir is dumped onto the subgrade from the edge of the installation and the aggregate is then pushed out onto the subgrade
- Trucks then dump subsequent loads from on top of the aggregate storage reservoir as the installation progresses.

The various aggregate storage reservoir materials shall be prevented from intermixing with fines and sediment. All contaminated material must be removed and replaced.

2.2.6.10.2 Water Quality Treatment Layer

If the permeable pavement is being designed to provide water quality treatment, underlying soils must meet the requirements for treatment soil provided in Volume V, Chapter 6. If the existing subgrade does not meet these requirements, a 6-inch water quality treatment course may be included between the subbase and the aggregate storage reservoir. The course must be comprised of a media meeting the treatment soil criteria (Volume V, Section 6.3) or the sand material specification for sand filters in the 2012 Ecology Stormwater Management Manual for Western Washington.

2.2.6.10.3 Signage

Informational signage is required for permeable pavement installations upon completion of the installation to help identify the area as a stormwater BMP and to inform maintenance crews and the general public about protecting the facility's function.

2.2.6.10.4 Structural Design Considerations

Structural designs for porous surfaces shall be per the manufacturer's specifications. If any deviations are made from the manufacturer's recommendations or if the manufacturer's recommendations require engineering judgments, the design shall be stamped by a civil engineer.

Porous systems that utilize pavers must be confined with a rigid edge system to prevent gradual movement of the paving stones.

For more information on structural design considerations see the American Concrete Institute, National Asphalt Pavement Association, or the *Low Impact Development Technical Guidance Manual for Puget Sound.*

2.2.6.11 Construction and Maintenance

2.2.6.11.1 Installation Criteria

Permeable pavement system requires careful preparation of the subgrade and aggregate storage reservoir to ensure success in terms of strength and permeability. The compressive strength of a permeable paver system relies mainly on the strength of the underlying soils, particularly when using modular or plastic units where the pavement itself lacks rigidity. Permeable pavement systems, such as pavers and grids, shall be designed and installed according to manufacturer recommendations.

Install appropriate source and erosion control BMPs to prevent sediment transport from construction activities onto the base material or top course when the porous surface is applied prior to the completion of construction and stabilization of the entire site. See Volume II, Section 3.3 for more information on BMPs to protect LID structures during construction.

If possible, temporary roads should be used during construction and final construction of the aggregate storage reservoir material, and permeable surfacing completed after building construction is complete. This construction method is similar to the installation of leveling courses of asphalt in a subdivision prior to building individual lots and installation of the final wearing course upon completion of building construction.

2.2.6.11.2 Sub-base Infiltration Tests

Field infiltration testing of the subgrade or optional water quality treatment course, as applicable, shall be conducted after any compaction has taken place and prior to placement of overlying courses. See Appendix III-A for testing proceedures. It is recommended hat the same type of tests used to determine the initial infiltration rate be repeated at this time.

Test documentation shall be retained with maintenance records and submitted with the engineer's inspection report at project completion.

2.2.6.11.3 Verification of Performance

For parking lots, roads, or other permeable pavement areas larger than 5000 square feet, the project engineer or designee shall inspect permeable pavement areas before, during, and after construction as necessary to ensure facilities are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. Prior to placing the aggregate storage reservoir, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate. The project engineer shall verify that the aggregate storage reservoir has been adequately installed and protected (e.g., from compaction and sedimentation) per the design specifications, prior to paving.

Prior to the installation of the storage course, the project engineer shall perform tests as outlined in Section 2.2.6.11.2 to determine that the facility will operate as designed. The county must be notified of the scheduled infiltration testing at least 2 working days in advance of the test. See Appendix III-A for testing requirements. If the tests indicate the facility will not function as designed, this information must be brought to the immediate attention of the county along with any reasons as to why not and how it can be remedied.

Field infiltration test of the permeable surface shall be conducted after complete pavement section is installed to verify that it meets the minimum initial uncorrected infiltration rate of 20 inches per hour (see Wearing Course section).

As directed by the Administrator or designee, test the facility using ASTM C1701. For grid systems, refer to manufacturers testing recommendations. Wet the road surface continuously for 10 minutes. Test to determine compliance with the 10 inches per hour minimum infiltration rate.

Test facilities annually.

2.2.6.11.4 Maintenance Criteria

Appendix V-C has maintenance guidelines for alternative paving surfaces. Some general considerations are as follows:

- Clogging is the primary mechanism that degrades infiltration rates. The surface design can have a significant influence on clogging of void space. Where run-on flows onto permeable pavement, these areas shall be identified in the Maintenance Plan as requiring more frequent cleaning and inspection.

- Infiltration rates on moderately degraded porous asphalts and concrete can be partially restored by suctioning and sweeping of the surface. Highly degraded porous asphalts and concrete require high pressure washing with suction.

- Maintenance frequencies of suctioning and sweeping shall be specified in the Maintenance Plan.

Porous pavement systems designed with pavers have advantages of ease of disassembly when repairs or utility work is necessary. However, it is important to note that the paver removal area should be no greater than the area that can be replaced at the end of the day. If an area of pavers is removed, leaving remaining edges unconfined, it is likely that loading in nearby areas will create movement of the remaining pavers thereby unraveling significantly more area than intended.

2.2.7 LID.10 Vegetated Roofs

Vegetated roofs are thin layers of engineered soil and vegetation installed on top of conventional flat or sloped roofs. Vegetated roofs are also known as ecoroofs, green roofs, and roof gardens. Because vegetated roofs are an integral component of the building structure, and the design and construction approaches continue to get refined as this technology evolves, this section primarily focuses on the stormwater elements of vegetated roof design. Other technical resources are referenced in this section for additional guidance and information (such as the *LID Technical Guidance Manual for Puget Sound* 2012). Vegetated roofs also provide habitat, enhance aesthetics, reduce temperature within urban centers, and last longer than traditional roofing materials (mainly due to lessened temperature fluctuation of roofing materials).

There are two general types of vegetated roofs, extensive and intensive. Extensive vegetated roofs have lower weight than intensive roofs, and are typically the most suitable for placement on existing structures.

All vegetated roofs consist of four basic components: a waterproof membrane, a drainage layer, a light-weight growth medium, and vegetation (see Figure 2.17.). 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.

Intensive roofs are deeper installations and have at least 6 inches of growth media and are planted with groundcovers, grasses, shrubs, and (sometimes) trees.

Extensive roofs are shallower installations and have less than 6 inches of growth media and use drought-tolerant, low maintenance groundcovers. Extensive systems are further divided into two types:

- "Single-course" systems, consisting of a single media designed to be freely draining and support plant growth
- "Multi-course" systems that include both a growth media layer and a separate, underlying drainage layer.

The following types of vegetated roofs have some flow attenuation and can be modeled as other than an impervious surface, see Section 2.2.7.4.1:

- Intensive vegetated roofs
- Extensive multi-course systems (and commercially available modular systems) with at least 4 inches of growth medium
- Extensive single-course systems with at least 4 inches of growth medium for areas less than 1,000 square feet.

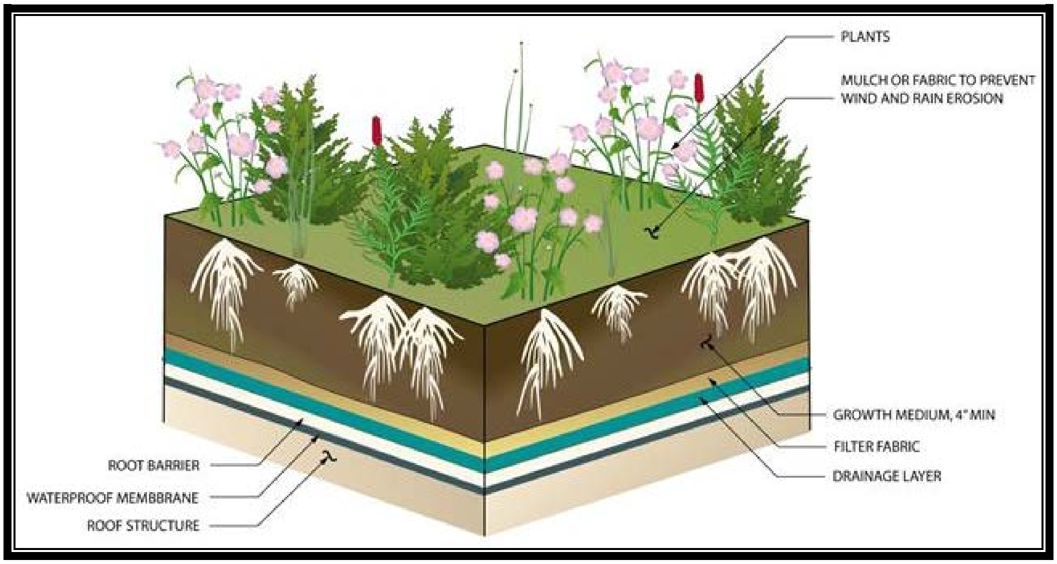


Figure 2.17 Typical Vegetated Roof Section

2.2.7.1 Applicability

Vegetated roofs are applicable in highly developed environments where other LID practices of forest retention or infiltration are not feasible. They are most appropriate for nearly flat roofs. These are the easiest to install and generally provide the greatest stormwater storage capacity per inch of growth medium.

Vegetated roofs can be used to help meet the flow control standards of Core Requirement #7.

- When used in combination with other onsite stormwater management BMPs, vegetated roofs can also help achieve compliance with Core Requirement #5.
- Vegetated roofs are generally applicable to roof slopes between 1 and 22 degrees (0.2:12 and 5:12).
- A primary consideration for the feasibility of vegetated roofs is the structural capability of the roof and building structure. Related factors, including design load, slipping and shear issues, and wind load, are outside the scope of this manual. Refer to Thurston County Building Code, Title 14 and the IBC/IRC for structural requirements.

2.2.7.2 Limitations

Steeper slopes, such as those on single family residences, may result in reduced flow control performance and may trigger additional design requirements (e.g., underlying drainage layer and lateral support measures).

In addition, applications on slopes steeper than 15 percent (5H:1V) will not qualify for flow control credits.

2.2.7.3 Submittals and Approval

Vegetated roofs shall also require acceptance from the Thurston County Fire Marshal to demonstrate adequate ventilation or ability to ventilate in cases of a fire. Other building permit requirements should be investigated by the applicant.

2.2.7.4 Hydrologic and Hydraulic Design Considerations

2.2.7.4.1 Flow Credit for Vegetated Roofs

When using continuous simulation hydrologic modeling to quantify the onsite stormwater management and/or flow control performance of vegetated roofs, the assumptions listed in Table 2-6 must be applied. It is recommended that vegetated roofs be modeled as layers of aggregate with surface flows, interflow, and exfiltrating flow routed to an outlet.

The medium depth can be modified to achieve various degrees of flow control. Because the onsite stormwater management and flow control standards cannot typically be achieved using a vegetative roof, additional downstream flow control measures may be required.

Table 2-6 Continuous Modeling Assumptions for Vegetated Roofs

Variable	Assumption
Precipitation Series	Thurston County
Computational Time Step	15 minutes
Inflows to Facility	None
Precipitation and Evaporation Applied to Facility	Yes
Depth of Material (inches)	Growth medium/soil depth (minimum of 4 inches). Currently, MGSFlood and the Western Washington Hydrology Model (WWHM) are not capable of representing the flow control benefits of the drainage layer or other storage beneath the growth medium.
Vegetative Cover	Ground cover or shrubs. Shrubs are appropriate only when growth medium is at least 6 inches.
Length of Rooftop (ft)	The length of the surface flowpath to the roof drain
Slope of Rooftop (ft/ft)	The slope of the vegetated roof
Discharge from Facility	Surface flow, interflow and exfiltrated flow from vegetated roof module routed to downstream BMP or point of compliance. Note that the exfiltrated flow (flow infiltrated through the media and collected by the drainage layer) is tracked as “groundwater” in MGSFlood and WWHM.

Extensive roofs with 3 to 8 inches of growing media can be represented as 50 percent till landscaped area and 50 percent impervious area in the stormwater hydrologic model.

Intensive roofs with soil/growing media depth of greater than 8 inches can be modeled as 50 percent till pasture and 50 percent impervious area.

For additional guidance on modeling and sizing see the 2014 Ecology Stormwater Management Manual for Western Washington, Volume III, Appendix III-C.

2.2.7.5 Design Criteria

A vegetated roof consists of a system in which several materials are layered to achieve the desired vegetative cover and drainage characteristics (see Figure 2.18 Vegetated Roof).

2.2.7.5.1 Materials

Design components vary depending on the vegetated roof type and site constraints, but typically include a waterproof membrane, a drain system, a drainage layer, a separation fabric, a growth medium (soil), and vegetation.

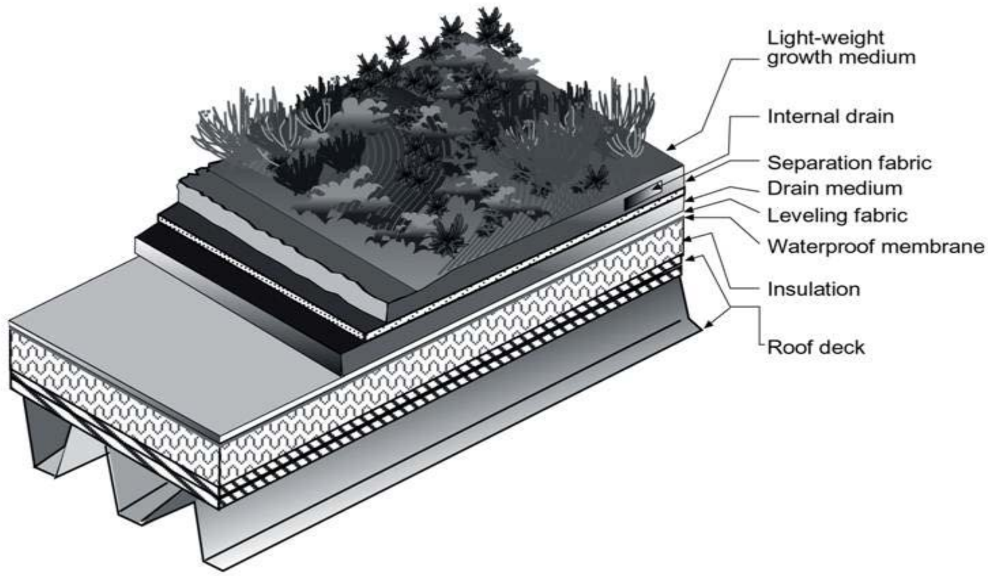
2.2.7.5.1.a Waterproof Membrane

Waterproof membranes are made of various materials, including reinforced polyvinyl chloride (PVC), synthetic rubber (EPDM), thermoplastic polyolefins, high-density polyethylene (HDPE), modified asphalts (bitumens), and hypalon (CPSE). Some waterproofing materials come in sheets or rolls and some are available in liquid form. Each material has different strengths and functional characteristics.

2.2.7.5.1.b Root Barrier

To discourage root damage to the waterproofing membrane, a physical root barrier may be required. The need for a root barrier depends primarily on the particular waterproof membrane selected. Some waterproofing membranes have root barrier capabilities intrinsic to the material. Modified asphalts usually require a root barrier, while EPDM and reinforced PVC typically do not. The manufacturer must be consulted to determine whether a root barrier is recommended for a particular product.

During installation, treatment to prevent root penetration should not be restricted to parts of the roof that will be covered with vegetation, as the roots will extend beyond the areas in which vegetation shows at the surface. Care should be taken to fully treat the areas at joints, borders, and seams.



Not to Scale

Figure 2.18 Vegetated Roof

The root barrier shall not contain leachable water quality contaminants (e.g., herbicides, copper, and zinc), which have sometimes been used in the past to inhibit root growth. To demonstrate this, a material safety data sheet (MSDS) must be submitted.

2.2.7.5.1.c Drainage Layer

For intensive and extensive multi-course vegetated roof systems, a drainage layer must underlie the growth medium. The drainage layer is a multipurpose layer designed to both provide void spaces to hold a portion of the water that passes through the growth medium, and to channel the water to the roof drain system.

The drainage layer can consist of a layer of aggregate or a manufactured mat or board that provides an open free-draining area. Many manufactured products include “egg carton”-shaped depressions that retain a portion of the water for eventual evapotranspiration. Some studies have shown that aggregate drainage layers may provide the better flow control.

For extensive single-course vegetated roofs larger than 1,000 square feet, hydraulic calculations shall be submitted showing that the transmissivity and permeability of the media are sufficient to convey the 25-year recurrence interval peak flow.

For aggregate drainage layers, the drainage media shall meet the following requirements:

- Minimum total pore volume of 25 percent by volume (per American Society for Testing and Materials [ASTM] E2399)
- Minimum saturated hydraulic conductivity of 0.3 centimeters per second, cm/s (per ASTM E2396-05)
- Maximum total organic matter of 1 percent by mass (per loss on ignition testing).

For optimal flow control, an aggregate drainage layer with a saturated hydraulic conductivity of less than 3.2 cm/s is recommended.

2.2.7.5.1.d Separation Fabric

A nonwoven geotextile must be installed between the growth medium (soil) and the drainage layer to prevent fine soil and substrate components from being washed out of the growth medium into the drainage layer (note that this does not apply to single-course extensive vegetated roofs). The fabric must be pervious to allow water to percolate into the drainage layer. If a manufactured drainage layer is used, the separation fabric is typically included.

The separation fabric shall be installed between the growth medium and the drainage layer and between the growth medium and all surrounding areas, roof edges, penetrations, and structures. The fabric also shall have average opening size sufficient to retain media.

2.2.7.5.1.e Growth Medium

Vegetated roofs use a light-weight growth medium with adequate fertility and drainage capacity to support plants and allow infiltration and storage of water. Growth medium composition (fines content and water holding capacity) is the key to flow control performance.

The growth medium typically has a high ratio of mineral to organic material content and can be a mixture of various components including gravel, sand, compost, soil, or light weight aggregate material. Because of their excessive weight, particularly when wet, native soils are not acceptable substrates for vegetated roofs.

The growth medium shall have the following characteristics:

- Must be a minimum of 3 inches deep,
- Minimum total pore volume shall be 45 percent by volume for multi-course systems and 30 percent by volume for single-course systems (per ASTM E2399)
- Water capacity shall be no less than 25 percent for single-course systems, 35 percent for extensive (shallow) multi-course systems, and 45 percent for intensive (deep) multi-course systems (per ASTM E2399)
- Saturated hydraulic conductivity (permeability) should be between 0.01 and 0.85 cm/s for single-course systems and 0.002 and 0.02 cm/s for multi-course systems (per ASTM E2396-05)
- Minimum air content at maximum water capacity should be 5 percent by volume (per ASTM E2396-05), or 10 percent by volume (per FLL method)
- Maximum total maximum organic matter shall be 4 percent by mass for single-course systems, 6 percent by mass for extensive (shallow) multi-course systems, and 8 percent by mass for intensive (deep) multi-course systems (per loss on ignition testing).
- Growth medium depth and characteristics must support growth for selected plant species and must be approved by a licensed landscape architect.
- Mulch, mat, or other measures to control erosion of growth media shall be maintained until 90 percent vegetation coverage is achieved.

2.2.7.5.1.f Vegetation

Vegetation used on extensive vegetated roofs should be drought tolerant, self-sustaining, low maintenance, and perennial or self-sowing. Appropriate plants should also be able to withstand heat, cold, periodic inundation and high winds. Vegetation with these attributes typically includes succulents, grasses, herbs, and wildflowers that are adapted to harsh conditions. Refer to the *LID Technical Guidance Manual for Puget Sound* for additional vegetation guidance for vegetated roofs.

Minimum requirements associated with vegetation design include the following:

- Plans must specify that vegetation coverage of selected plants must achieve 90 percent coverage within 2 years or additional plantings must be provided until this coverage requirement is met

- Plant spacing and plant size must be designed to achieve specified coverage by a licensed landscape architect

Vegetation must be suitable for rooftop conditions (e.g., hot, cold, dry, and windy). Plants must not require fertilizer, pesticides, or herbicides after 2-year establishment period. In the long term, the generation of warm and cold air currents by rooftop heating and air-conditioning vents can cause frost and drought damage to plants. Exhaust gases such as sulfur dioxide or grease from chimneys and exhausts can result in direct damage to vegetation, depending on the species. Therefore, areas that are affected by warm air, variable air currents, and exhaust gasses need to be checked carefully to determine whether they are suitable areas for planting and to identify the type of vegetation that is best suited to the particular conditions. In addition, vegetation must be suitable for harsh (e.g., hot, cold, wet and windy) rooftop conditions.

An additional consideration is the effect of providing a vegetated roof habitat. Habitat may be enhanced by using diverse planting and including some larger plants. Some projects sites may not want to encourage wildlife (e.g., birds near air fields).

2.2.7.5.2 Drain System and Overflow

Vegetated roofs must be equipped with a roof drainage system capable of collecting subsurface and surface drainage and conveying it safely to a downstream BMP or an approved discharge. To facilitate subsurface drainage, interceptor drains are often installed at a regular spacing to prevent excessive moisture build up in the media and convey water to the roof drain.

Roof outlets must be protected from encroaching plant growth and loose gravel, and must be constructed and located so that they are permanently accessible.

2.2.7.6 Structural Design Considerations

Extensive vegetated roofs have the lowest weight and are the most suitable for placement on existing structures.

Vegetated roofs must not be subject to any use that will significantly compact the growth medium. Unless designed for foot traffic, vegetated roof areas that are accessible to the public shall be protected (e.g., signs, railing, and fencing).

2.2.7.7 Construction and Maintenance

2.2.7.7.1 Construction Criteria

The growth medium must be protected from over compaction during construction.

2.2.7.7.2 Irrigation Plan

Provisions must be made for supplemental irrigation during the first two dry seasons after installation to improve plant survival. Subsurface irrigation methods are preferred. If surface irrigation is the only method available, drip irrigation should be used to deliver water to the base of the plant. At a minimum, a water tap should be available on the roof for manual watering.

A permanent irrigation system using potable water may be used, but an alternative means of irrigation, such as air conditioning condensate or another readily available non-potable source should be considered to maximize efficient use of resources. Any non-potable sources must be analyzed to ensure that they do not contain chemicals that might harm or kill the vegetation. Any permanent irrigation system that relies on potable water shall be designed to apply no more than 0.2 inches of water every 14 days from June through September, after the 2-year establishment period. It is recommended that permanent irrigation systems have automatic controls, including a rain shutoff sensor.

Sufficient irrigation shall be provided to achieve and maintain 90 percent plant coverage after 2 years following installation.

2.2.7.7.3 Maintenance Criteria

Vegetated roofs are designed to need very little maintenance. They should also have a longer lifespan than traditional roofs because of the protective nature of the soil structure. Inspections still should be performed regularly to identify any leakage of the membrane system or blockages of the overflow system. A maintenance checklist is included in Appendix V-C and shall be included in the Maintenance Plan for the project.

2.2.8 LID.11 Full Dispersion

2.2.8.1 Purpose and Definition

This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of development sites that preserve the equivalent of at least 65 percent of the site (or a threshold discharge area on the site) in a forest or native condition. Comprehensive LID Site Design projects that meet the requirements outlined below have fully met the requirements of Volume I, Core Requirements #5, #6, and #7, and are not required to demonstrate that additional LID BMPs outlined in Chapter 2 have been considered.

2.2.8.2 Applicability

Full dispersion differs from other LID BMPs described previously in that if minimum native area preservation is adhered to, the limitations on how impervious surfaces are modeled and how concentrated flow can be dispersed are less restrictive.

Full dispersion would be most applicable to developments that desire to or can retain large portions of the site in native conditions such as for critical area buffers, or that concentrate development in a smaller area of a larger site to obtain some benefit from zoning codes (PRRD, Cluster Development, PRD, etc.).

- Projects that retain 65 percent of the site (or a threshold discharge area on the site) in a forested or native condition may use dispersion to avoid triggering the flow control facility requirement (see Volume I, Core Requirements #5 and #7). Areas that are fully dispersed (in accordance with the requirements outlined herein) do not need to perform continuous runoff modeling to demonstrate compliance.

- Preservation of existing vegetation areas must meet the requirements outlined under Section 2.1.1, Preserving Native Vegetation.

- The preserved area may be a previously cleared area that has been replanted in accordance with Section 2.1.1 *LID.01 Native Vegetation Protection, Reforestation, and Maintenance*.

Rural single family residential developments should use this BMP wherever possible to minimize effective impervious surface to less than 10 percent of the development site.

Other types of development that retain 65 percent of the site (or a threshold discharge area on the site) in a forested or native condition may also use this BMP to avoid triggering the flow control facility requirement.

2.2.8.3 Full Dispersion for All or Part of the Development Site

Developments that cannot preserve 65 percent or more of the site in a forested or native condition may disperse runoff into a forested or native area in accordance with the elements of this BMP if:

- The effective impervious surface of the area draining into the native vegetation area is <10 percent; and
- The development maintains ratios proportional to the 65 percent forested or native condition and 10 percent effective impervious surface area. The lawn and landscaping areas associated with the impervious areas may also be dispersed into the native vegetation area. (The lawn and landscaped area must comply with Volume III, Section 3.1 Soil Preservation and Amendment). All design requirements listed also must be met.

Within the context of full dispersion for all or part of the development site the only impervious surfaces that are ineffective are those that are routed into an appropriately sized dry well or into an infiltration basin that meets the flow control standard and does not overflow into the forested or native vegetation area.

2.2.8.4 Limitations

Runoff must be dispersed into native areas per the guidelines and limitations indicated in this BMP.

Additional impervious areas are allowed that exceed the 10 percent threshold, but should not drain to the native vegetation area and are subject to the thresholds, and treatment and flow control requirements of Volume I.

Native vegetation areas must be protected from future development. Protection must be provided through legal documents on record with the local government. Examples of adequate documentation include a conservation easement, conservation parcel, and deed restriction. For residential development projects on a single lot (not a subdivision) this requirement can be met by showing the dispersion area on the final as-built site plan recorded at the end of the project and indicating that the area will be protected from future disturbance.All trees within the preserved area at the time of permit application shall be retained, aside from approved timber harvest activities and the removal of dangerous or diseased trees. Removal of dangerous or diseased trees will require acceptance of Thurston County and may require an arborist to make a written assessment of the trees condition.

The preserved 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, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.

The preserved area may contain utilities and utility easements, but not septic systems. Utilities are defined as potable water and wastewater underground piping, underground wiring, and power and telephone poles.

2.2.8.5 Design Guidelines

Developments that preserve 65 percent of a site (or a threshold discharge area of a site) in a forested or native condition can disperse runoff from the developed portion of the site into the native vegetation area as long as the developed areas draining to the native vegetation do not have impervious areas that exceed 10 percent of the entire site.

Where a development has less than 65 percent of a site available to maintain or create into a forested or native condition, that area may still be used for 65/10 dispersion of a portion of the developed area. The ratio of the native vegetation area to the impervious area, which is dispersed into the native vegetation, must not be less than 65 to 10. The lawn and landscaping areas associated with the impervious areas may also be dispersed into the native vegetation area. (The lawn and landscaped area must comply with Section 2.1.2). All design requirements listed also must be met.

Additional impervious areas above the 10 percent are allowed, but should not drain to the native vegetation area, and are subject to the thresholds, treatment, and flow control requirements of this stormwater manual. The portion of the developed area that is not managed through 65/10 dispersion can be considered a separate project site. In this case, it must be evaluated against the thresholds in Figures 2.1 and 2.2 of Volume I, whichever is appropriate, to determine the applicable core requirements.

Within the context of this dispersion option, the impervious surfaces that are over and above the 10 percent maximum can be routed into an appropriately sized drywell or into an infiltration basin that meets the flow control standard and does not overflow into the forested or native vegetation area.

Dispersion devices are not allowed within 300 feet of Geologic Hazard Areas or within 50 feet of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

The flowpath from contributing impervious areas to the dispersion area must meet all of the following criteria:

- A native vegetation flowpath of at least 100 feet in length (25 feet for sheet flow from a non-native pervious surface) must be available along the flowpath that runoff would follow (upon discharge from an appropriate dispersion device).

- The flowpath must be onsite or in an offsite tract or easement area reserved for such dispersion.

- The slope of the flowpath must be no steeper than 15 percent for any 20-foot reach of the flowpath. Slopes up to 33 percent are allowed where level spreaders are located upstream of the dispersion area and at sites where vegetation can be established.

- The flowpath is not permitted within an erosion hazard, or landslide hazard area (as defined by TCC Titles 17.15 or 24) unless the slope stability impacts of such systems have been analyzed and mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

- The flowpaths for adjacent dispersion devices must be sufficiently spaced to prevent overlap of flows in the flowpath areas.

- For sites with onsite sewage disposal systems, the discharge of runoff from dispersion devices must be at least 30 feet upgradient, or 10 feet downgradient of the primary and reserve drainfield areas (per WAC 246-272A-0210). This requirement may be modified by the Thurston County 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.

- The dispersion of runoff must not create flooding or erosion impacts.

- Runoff from contributing impervious areas must be dispersed into the native vegetation area using the dispersion devices specified below.

2.2.8.5.1 Roof Downspouts

Roof surfaces that comply with the downspout infiltration requirements of BMP LID.04 are considered to be "fully dispersed" (i.e., 0 percent effective imperviousness).

All other roof surfaces are considered to be "fully dispersed" only if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the downspout dispersion requirements of BMP LID.05, and have vegetated flow paths through native vegetation exceeding 100 feet.

2.2.8.5.2 Driveway Dispersion

Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the dispersion BMPs – BMP LID.06 and BMP LID.07 — and have flow paths through native vegetation exceeding 100 feet.

This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

2.2.8.5.3 Roadway Dispersion BMPs

Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the following dispersion requirements:

- Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, disperse driveways to the same standards as roadways to ensure adequate water quality protection of downstream resources.

- Design the road section to minimize collection and concentration of roadway runoff. Use sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) wherever possible to avoid concentration.

- When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event (using approved continuous simulation model).

- 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. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.

- Dispersion trenches shall be designed to accept storm flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flow path, and shall be minimum 2’ x 2’ in section, 50 feet in length, filled with 3/4-inch to 1-1/2-inch washed rock, and provided with a level notched anchor plate flow spreader (see Figure A-12 in Appendix V-A). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to four trenches. Dispersion trenches shall have a minimum spacing of 50 feet.

- After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.

- Flow paths from adjacent discharge points must not intersect within the 100-foot flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flow path shall not exceed 15 percent slope, and shall be located within designated open space.

- Ditch discharge points shall be located a minimum of 100 feet upgradient of slopes steeper than 40 percent, wetlands, and streams.

Where the County determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

2.2.8.5.4 Cleared Area Dispersion BMPs

The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture of up to 25 feet in flowpath length can be considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

- The topography of the non-native pervious surface must be such that runoff will not concentrate prior to discharge to the dispersal area.
- Slopes within the dispersal area should be no steeper than 15 percent. Slopes up to 33 percent are allowed where level spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
- If the flowpath length across the contributing non-native pervious surface is greater than 25 feet, the downstream native vegetation dispersion area flowpath must be extended 1 foot for every 3 feet of contributing flowpath beyond 25 feet (up to a maximum contributing flowpath of 250 feet).

2.2.9 LID.12 Rural Road Natural Dispersion

Natural dispersion is related to sheet flow dispersion (BMP LID.06) and channelized dispersion (BMP LID.07), but only applies to linear projects such as roads, bicycle paths, etc. in rural areas that meet certain criteria. This BMP is derived from the WSDOT's *Highway Runoff Manual* and is principally for use outside of the NPDES Phase II permit boundary and Urban Growth Areas of Thurston County.

Rural road natural dispersion meets Core Requirement #5 (On-site Stormwater Management), basic and enhanced treatment targets of Core Requirement #6 (Runoff Treatment), and Core Requirement #7 (Flow Control).

The key to natural dispersion is that flows from the impervious area must enter the natural dispersion area as sheet flow. Because stormwater enters the dispersion area as sheet flow, it only needs to traverse a narrow band of contiguous vegetation for effective attenuation and treatment. The goal is to have the flows dispersed into the surrounding landscape such that there is a low probability any surface runoff will reach a flowing body of water.

Using natural dispersion on projects will result in benefits when determining applicable core requirements and thresholds. New impervious surfaces that drain to dispersion areas should be accounted for when determining the project's total new impervious surface area, but the area should be counted as noneffective impervious surface (and noneffective PGIS). When modeling the hydrology of the project site and threshold discharge area, the project engineer should treat natural dispersion areas and their tributary drainage areas as disconnected from the project site because they do not contribute flow to other flow control or runoff treatment BMPs.

2.2.9.1 Applicability

Only allowed for roadway and linear projects such as bicycle paths, trails, utility projects in the rural areas of Thurston County (outside UGA's and NPDES Phase II permit boundary). Examples include large lot or short plat access roads through large lot subdivisions and short plats, County or private road widening projects and new construction.

Existing topography, soils and vegetation must be conducive to dispersion (see Design Criteria below).

Natural dispersion helps maintain the temperature norms of stormwater because it promotes infiltration, evaporation, and transpiration and should not have a surface discharge to a lake or stream.

2.2.9.2 Limitations

The effectiveness of natural dispersion relies on maintaining sheet flow to the dispersion area, which maximizes soil and vegetation contact and prevents short-circuiting due to channelized flow. If sheet flow cannot be maintained, natural dispersion will not be effective.

Natural dispersion areas must be protected from future development. For public projects, purchase of additional right-of-way or easements may be required to satisfy the criteria for natural dispersion areas. For private projects, dedicated tracts or easements are required to protect natural dispersion areas.

Natural dispersion areas initially may cost as much as other constructed BMPs because rights-of-way or easements often need to be purchased, but long-term maintenance costs are lower. These natural areas will also contribute to the preservation of native habitat and provide visual buffering of the roadway.

Floodplains are not suitable areas for natural dispersion.

The following are additional limitations for sites where runoff is channelized upstream of the dispersion area:

The channelized flow must be redispersed before entering the natural dispersion area. Flow dispersal trenches (see Section 3.8.1 of Volume III) must be used to create sheet flow conditions.

Energy dissipaters in conjunction with flow dispersal trench may be needed to prevent high velocities through the natural dispersion areas.

Channelized flows are limited to on-site flows. Parallel conveyance systems may be needed to separate off-site flows.

2.2.9.3 Submittals and Approvals

Include in the submittals required in Volume I the following:

Calculations demonstrating the flows for the 100-year storm meet the criteria of this BMP

Documentation of easements, tracts or other protective mechanisms for the dispersion area

Identify the location of signage and fencing required to protect the dispersion area from future disturbance/development

Details of dispersion pads, energy dissipators, level spreaders, etc. necessary to construction the project

Identify on a site plan the contributing areas, point of dispersion and dispersion areas

Geotechnical information documenting the underlying soils type and infiltration rate for the dispersion area

Show the location of wells, drainfields, steep slopes and how the design meets the setback criteria for this BMP

Include in the Soils Management Plan prepared per BMP LID.02 the location of the dispersion area and any planting or soils enhancement required.

2.2.9.4 Hydrologic and Hydraulic Design Considerations

Those pollution and non-pollution generating impervious surfaces that are dispersed according to this BMP are considered non-effective impervious surface. They are counted in the total impervious area when applying core requirements (Volume I, Section 2.3), but not towards the individual thresholds of Core Requirement #6 (Runoff Treatment) or Core Requirement #7 (Flow Control).

The size of the natural dispersion area depends on the flow contributing area and the predicted rates of water loss through the dispersion system. The designer should ensure the dispersion area is sufficient to dispose the runoff through infiltration, evaporation, transpiration, and soil absorption.

2.2.9.5 Design Criteria

2.2.9.5.1 Sheet Flow

Sheet flow dispersion criteria for natural dispersion areas are as follows:

The contributing impervious surface flowpath must be less than 75 feet. The contributing pervious flowpath must be less than 150 feet. Pervious flowpaths may include up-gradient road side slopes that run onto the road and down-gradient road side slopes that precede the dispersion area.The sheet flow path is measured in the direction of flow and generally represents the width of the pavement area.

The longitudinal length of the dispersion area should be equivalent to the longitudinal length of roadway that is contributing sheet flow.

The longitudinal pavement slope (i.e., centerline grade) contributing flow to a dispersion area shall be less than 5 percent. The lateral pavement slope (i.e., crown or superelevation) shall be less than 8 percent.

Roadway side slopes leading to natural dispersion areas should be 25 percent (4H:1V) or flatter. Slopes steeper than 25 percent are allowed if the existing side slopes are well vegetated and show no signs of erosion problems. Road side slopes do not count as part of the dispersion area unless native vegetation is re-established and slopes are less than 15 percent. Road shoulders that are paved or graveled count as impervious surface.

The average longitudinal (parallel to road) slope of the dispersion area must be less than 15 percent.

The average lateral slope of the dispersion area must be less than 15 percent.

For any existing slope that will lead to a natural dispersion area, if evidence of channelized flow (rills or gullies) is present, a flow spreading device should be used before those flows are allowed to enter the dispersion area.

Sheet flow dispersion areas are sized based on soil characteristics of the dispersion area as follows:

For sheet flow dispersion on all outwash soils (Type A and some Type B) soils (depending on saturated hydraulic conductivity rates):

For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.

For dispersion areas that receive sheet flow from only disturbed pervious areas (bare soil and non-native landscaping), for every 6 feet (along the sheet flow path) of disturbed pervious area, 1 lateral foot width of dispersion area is required.

The following criteria are specific to sheet flow dispersion on all Type C and D soils and some Type B soils with short-term infiltration rates of 4 inches per hour or less:

For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

The dispersion area shall have a minimum width of native vegetation of 100 feet (measured in the direction of the flow path).

Figure 2.19 illustrates the configuration of a typical natural dispersion area relative to the roadway.

2.2.9.5.2 Channelized Flow

Channelized stormwater can be re-disbursed, per the guidance below, into areas with (a) native vegetation or (b) cleared land in areas outside of urban growth areas that do not have a natural or manmade drainage system.:

Full dispersion credit (i.e., no other treatment or flow control required) is given to projects that meet the following criteria:

- Outwash soils that have an initial saturated hydraulic conductivity rate of4 inches per hour or greater. The saturated hydraulic conductivity must be based on a Pilot Infiltration Test or other methods outlined in Volume III, Appendix III-A.
  - The dispersion area flowpath must be at least half the width of the contributing impervious drainage area.
- Other soils: (Types C and D and some Type B not meeting the criterion in above)
  - The dispersion area must have 6.5 feet of width for every 1 foot width of impervious area draining to it. A minimum distance of 100 feet is necessary.

Other criteria applicable to all soil types:

- Depth to the average annual maximum ground water elevation should be at least three feet.
- Channelized flow must be re-dispersed to produce longest possible flow path.
- Concentrated runoff from the roadway and adjacent upstream areas (such as in a ditch or cut slope) must be incrementally discharged from the conveyance system (such as a ditch, gutter, or storm sewer) via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows must not exceed 0.5 cubic feet per second (cfs) at any single discharge point from the conveyance system for the 100-year runoff event (determined by an approved continuous flow model). Where flows at a particular discharge point are already concentrated under existing site conditions (for example, in a natural channel that cross the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.
- Discharge points with up to 0.2 cfs discharge for the peak 100-year flow may use rock pads or dispersion trenches to disperse flows. Discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow must use only dispersion trenches to disperse flows.

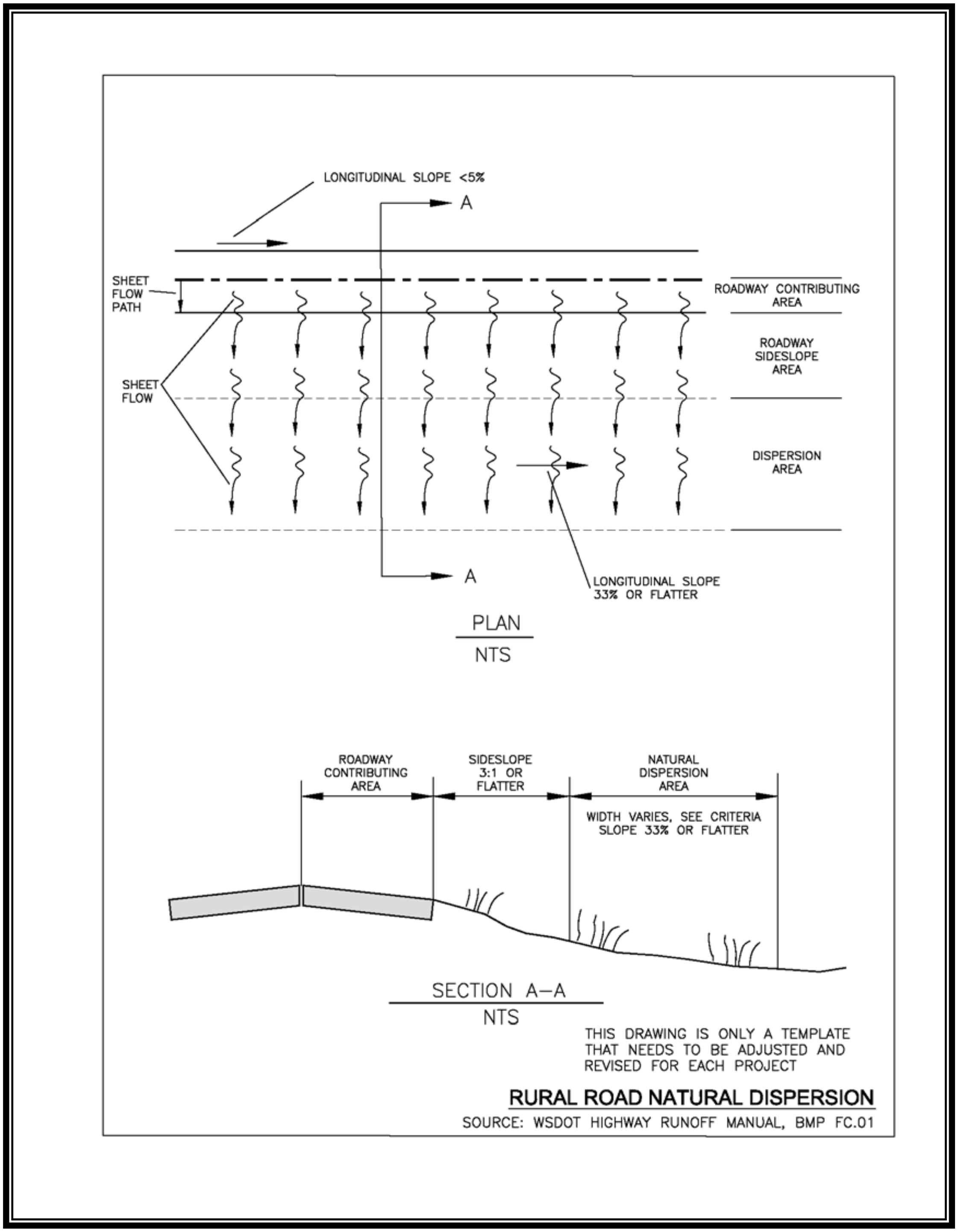


Figure 2.19 Natural Dispersion

Dispersion trenches must be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end; aligned perpendicular to the flow path; a minimum of 2’ x 2’ in section; 50 feet in length; filled with 3/4 to 1-1/2 inch washed rock (WSDOT Standard Specifications 9-03.12(5) or equivalent); and provided with a level notched grade board (see Figure 3-6, Flow Dispersal Trench, in Volume III). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between four trenches (maximum). Dispersion trenches must have a minimum spacing of 50 feet.

After being dispersed with rock pads or trenches, flows from discharge points must traverse the required flow path length of the dispersion area before entering an existing on-site channel carrying existing concentrated flows away from the roadway alignment.

> **Note:** to provide the required flow path length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed.

Flow paths from adjacent discharge points must not intersect within the required flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point.

Ditch discharge points must be located a minimum of 100 feet upgradient of wetlands, streams, or slopes steeper than 40 percent with a vertical change of at least 10 feet.

Where the Administrator or designee determines that there is a potential for significant adverse impacts downstream (such as erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

The following criterion is specific to channelized flow dispersion on all Type A and some Type B soils, depending on infiltration rates.

For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater, the dispersion area should be at least 50 percent of the tributary drainage area.

The following criteria are specific to channelized dispersion on all Type C and D soils and on Type B soils with short-term infiltration rates less than 4 inches per hour:

For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

The dispersion area shall have a minimum width of native vegetation of 100 feet, measured in the direction of the flow path.

2.2.9.5.3 Pipe or Ditch Conveyance System

Flows collected in a pipe or ditch conveyance system require energy dissipation and dispersal at the end of the conveyance system before entering the dispersion area. For flow dispersal and energy dissipation BMPs and techniques, see Section 3.8 of Volume III.

2.2.9.6 Site Design Elements

The key to natural dispersion is having vegetative land cover with a good established root zone where the roots, organic matter, and soil macroorganisms provide macropores to reduce surface compaction and prevent soil pore sealing. The vegetative cover also provides filtration and maintains sheet flow, reducing the chance for erosion. The following areas are considered appropriate candidates for natural dispersion because they are likely to retain these vegetative conditions over the long term:

County right-of-way (for County projects only)

Protected natural areas (critical area buffers, green belts, etc.)

Dedicated tracts in plats for native vegetation protection

Agricultural areas

Parks and nature areas

Commercial or government-owned forest lands

Rural areas with zoned densities of less than one dwelling unit per 5 acres.

While these are generally appropriate areas for natural dispersion, the dispersion area shall still be protected from future development by an easement or dedicated tract. **Note:** Though natural dispersion areas should be adjacent to the project site, they do not have to be immediately adjacent to the length of the roadway.

Natural dispersion area shall have the following attributes:

Be well vegetated with established root zones

Have an average longitudinal slopes of 6H:1V or flatter

Have an average lateral slope of 6H:1V or flatter for both the roadway side slopes and natural area to be part of the natural dispersion area

Have infiltrative soil properties that are verified by a soils professional per Volume III methods.

Natural dispersion areas that have impervious areas (for example, abandoned roads with compacted subgrades) within them shall have those areas tilled and restored using the soil amendments and plantings per BMP LID.01 (Restoring Natural Vegetation).

Natural dispersion areas that are within a landslide hazard area must be evaluated by a geotechnical engineer or qualified geologist.

Natural dispersion areas shall have a separation of at least2 feet between the existing ground elevation and the average annual maximum groundwater elevation. This separation depth requirement applies to the entire limits of the dispersion area. There should be no discernible continuous surface flow paths through the dispersion area.

Intent: Natural dispersion areas are not likely to have a uniform slope across their entire area. As a result, there are ponding areas and uneven terrain. Minor channelization of flow within the dispersion area is expected. However, a continuous flow path through the entire dispersion area disqualifies its use as a BMP because channelized flow promotes erosion of the channel that carries the flow and greatly reduces the potential for effective pollutant removal and peak flow attenuation.

When selecting natural dispersion areas, determine whether there are groundwater management plans for the area and contact the local water purveyors to determine whether the project lies within a designated wellhead protection area or groundwater protection zone, septic drain fields, or aquifer recharge area. There may be additional restrictions within these areas.

2.2.9.6.1 Setback Requirements

Natural dispersion areas can extend beyond the right-of-way provided that documentation ensures (via easements or dedicated tracts) the dispersion area is not developed in the future. Occasionally for public roadway projects, limited right-of-way prevents the securing of the required easements on adjacent properties and limits the ability to construct flow control facilities. In this particular case, the dispersion area can be considered protected if the adjacent land is zoned agricultural, forestry, or rural residential (5-acre parcels or greater). An attempt to obtain a drainage easement for this circumstance should still be made.

Natural dispersion areas shall be setback at least 100 feet from drinking water wells and springs used for public drinking water supplies. Natural dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones for a public water system must comply with the Washington State Department of Health (DOH) requirements.

Natural dispersion areas shall be setback at least 100 feet from septic drainfields. The 100-foot setback is in addition to the required dispersion area. For example if there is a 100-foot width dispersion area, there would be an additional 100-foot setback making a total of 200 feet from the point of discharge of water to the dispersion area to the drainfield area. If the applicant can demonstrate that the dispersion flow path will not intercept the drainfield, this setback requirement may be relaxed.

If the project significantly increases flows to off-site properties, a drainage easement may be required or additional right-of-way purchased.

2.2.9.6.2 Signage

The limits of natural dispersion area shall be marked as a stormwater management facility and also shall be physically marked in the field during and after construction. Signage ensures the natural dispersion area is protected from construction activity disturbance and is adequately protected by measures shown in the temporary erosion and sedimentation control (TESC) plan.

Signage helps ensure the natural dispersion area is not cleared or disturbed after the construction project.

Signage shall be posted at a minimum on all four sides of the dispersion area and at intervals not exceeding 75 feet.

See Appendix V-E for sign specifications.

2.2.9.7 Construction Considerations

For installation of dispersal BMPs and conveyance systems near dispersion areas, the area that needs to be cleared or grubbed should be minimized. Maintaining plant root systems is important for dispersion areas.

The area around dispersion areas should not be compacted.

To the maximum extent practicable, low-ground-pressure vehicles and equipment should be used during construction.

2.2.9.8 Maintenance

Maintenance of natural dispersion areas includes maintaining natural vegetation or restoring natural vegetation disturbed after construction.

Signage and fencing shall be inspected and restored /replaced as required.

Ensure that sheet flow paths are maintained to the dispersion areas, perform hand maintenance to ensure sheet flow.

Maintain energy dissipaters and level spreaders. Cleanout any structures associated with these devices and inspect spreaders to ensure they are functioning correctly. Remove buildup of soil/debris over the surface of level spreader as required to maintain its function.

2.2.10 LID.13 Rural Road Engineered Dispersion

Engineered dispersion is related to Sheet Flow Dispersion (BMP LID.06) and Concentrated Flow Dispersion (BMP LID.07) but only applies to linear projects such as roads, bicycle paths, etc. in rural areas that meet certain criteria. This BMP is derived from the WSDOT's Highway Runoff Manual and is principally for use outside of the NPDES Phase II Permit boundary and Urban Growth Areas of Thurston County.

Engineered dispersion is similar to natural dispersion (BMP LID.13). The distinction between these BMPs is that natural dispersion can take advantage of an existing vegetated area for dispersion, while this dispersion area must be at least partially constructed. This BMP can be used for impervious surfaces that are graded to drain via sheet flow or are graded to collect and convey stormwater to engineered dispersion areas after going through a flow spreading or energy dissipater device. Engineered dispersion uses the existing vegetation or landscaped areas, existing soils or engineered compost-amended soils, and topography to effectively provide flow control and runoff treatment. This type of dispersion may require major or minor construction activity depending on the existing site conditions. Site selection is very important to the success of this BMP. The pollutant-removal processes include infiltration to the existing or engineered soils and through vegetation root zones; evaporation; and uptake and transpiration by the existing vegetation or landscaped areas.

The key to effective engineered dispersion is that flows from the impervious area enter the dispersion area as sheet flow. Because stormwater enters as sheet flows to the dispersion area, it need only traverse a band of contiguous vegetation and compost-amended soils for effective attenuation and treatment. Absorption capacity can be gained by using compost-amended soils to disperse and absorb contributing flows to the dispersion area. The goal is to have the flows dispersed into the surrounding landscape such that there is a low probability that surface runoff will reach a flowing body of water.

Rural road engineered dispersion meets Core Requirement #5 (On-site Stormwater Management), basic and enhanced treatment targets of Core Requirement #6 (Runoff Treatment), and Core Requirement #7 (Flow Control).

2.2.10.1 Applicability

Engineered dispersion is ideal for roadway and other linear projects that collect and convey stormwater to discrete discharge points along the project.

Engineered dispersion maintains temperature norms of stormwater because it promotes infiltration, evaporation, and transpiration and should not have a surface discharge to a lake or stream.

2.2.10.2 Limitations

The effectiveness of engineered dispersion relies on maintaining sheet flow to the dispersion area, which maximizes soil and vegetation contact and prevents short-circuiting due to channelized flow. If sheet flow cannot be maintained, engineered dispersion will not be effective.

Dispersion areas must be protected from future development. For Public projects, purchase of additional right-of-way or easements may be required. For private projects, dedicated tracts or easements are required to protect engineered dispersion areas.

Engineered dispersion areas may cost as much as other BMPs because right of way or easements often need to be purchased and compost-amended soils may need to be added. But long-term maintenance costs are lower.

Floodplains are not suitable areas for engineered dispersion.

Depth to the average annual maximum ground water elevation shall be at least three feet.

2.2.10.3 Submittals and Approvals

Include in the submittals required in Volume I the following:

Calculations demonstrating the flows for the 100-year storm meet the criteria of this BMP

Documentation of easements, tracts or other protective mechanisms for the dispersion area.

Identify the location of signage and fencing required to protect the dispersion area from future disturbance/development

Details of dispersion pads, energy dissipators, level spreaders, etc. necessary to construction the project

Identify on a site plan the contributing areas, point of dispersion and dispersion areas

Geotechnical information documenting the underlying soils type and infiltration rate for the dispersion area

Show the location of wells, drainfields, steep slopes and how the design meets the setback criteria for this BMP

Show areas of engineered dispersion on the Soil Management Plan required as part of BMP LID.02. Include specifications for the soil mix and a planting plan.

2.2.10.4 Hydrologic and Hydraulic Design Considerations

The required size of the engineered dispersion area depends on the area contributing flow and the predicted rates of water loss through the dispersion system. The designer should ensure the dispersion area is able to dispose of (through infiltration, evaporation, transpiration, and soil absorption) stormwater flows predicted by an approved continuous runoff model.

Because a water balance model has not be developed for designing engineered dispersion areas, a set of conservative guidelines similar to those given for natural dispersion have been agreed upon with Ecology (WSDOT 2008). Updates to the engineered dispersion criteria may occur and the project engineer should check with the Administrator to determine if additional criteria have been implemented.

2.2.10.5 Design Criteria

2.2.10.5.1 Geometry

The average longitudinal slope of the dispersion area shall not exceed 6H:1V.

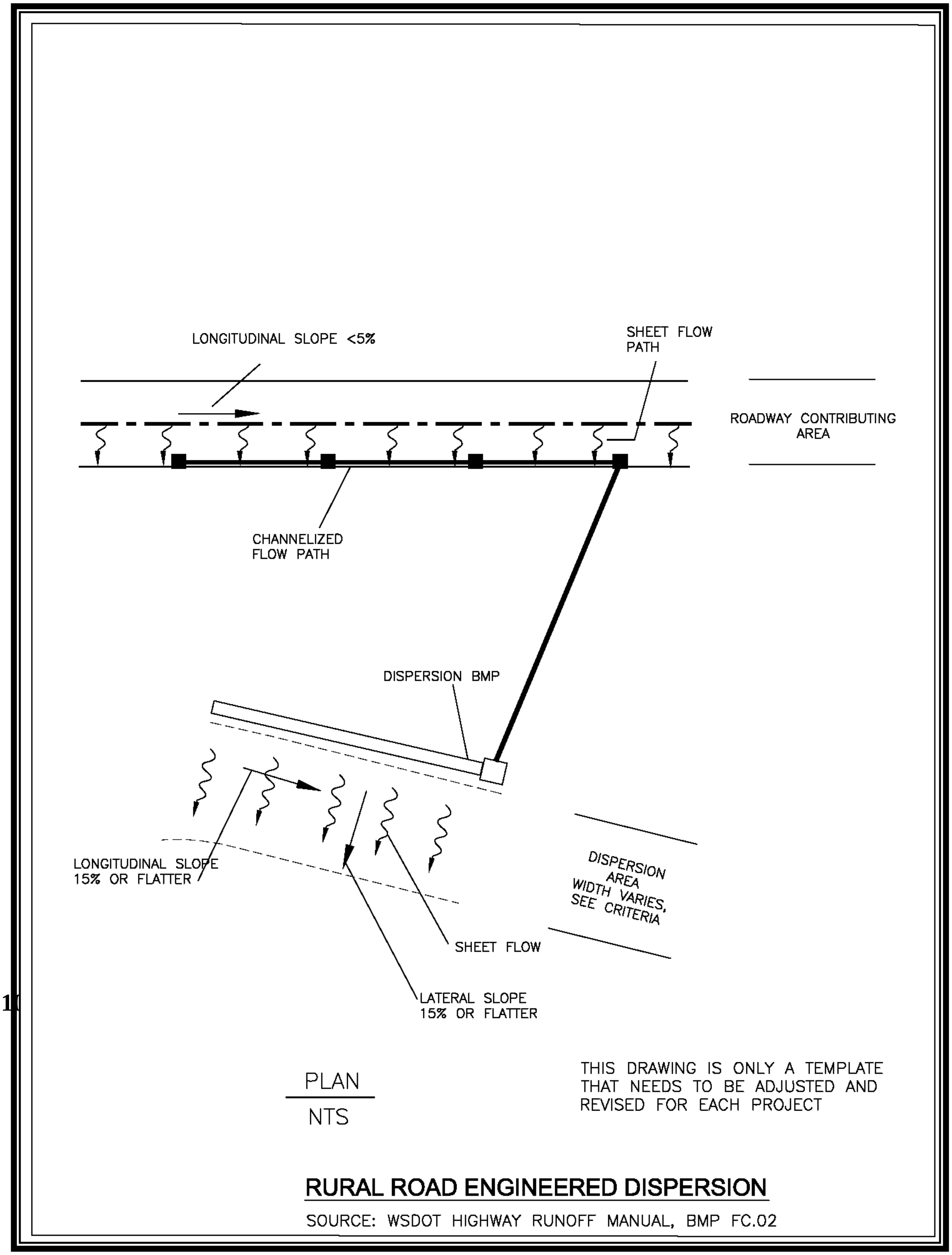
The average lateral slope of the dispersion area shall not exceed 6H:1V.

There should be no discernible flow paths through the dispersion area. A channel or flow path may short circuit the flows and reduce treatment and infiltration ability.

There should be no surface water discharge from the dispersion area to a conveyance system or Category I or II wetlands (as defined by Ecology's Wetland Rating Systems for western Washington).

2.2.10.5.2 Sizing Criteria

Figure 2.20 illustrates a typical engineered dispersion area relative to the adjacent roadway.



2.2.1

Figure 2.20 Engineered Dispersion

Sheet Flow Dispersion

Sheet flow dispersion criteria for Type A, B, C, and D soils are as follows:

The sheet flow path leading to the engineered dispersion area shall not be longer than 150 feet. The sheet flow path is measured in the direction of flow and generally represents the width of the pavement area.

Pervious shoulders and side slopes are not counted in determining the sheet flow path.

The longitudinal length of the dispersion area shall be equivalent to the longitudinal length of the roadway that is contributing sheet flow.

Roadway side slopes leading to engineered dispersion areas should be 25 percent (4H:1V) or flatter. Roadway side slopes that are 25 percent to 15 percent (7H:1V) should not be considered part of the dispersion area. Slopes steeper than 25 percent are allowed if the existing side slopes are well vegetated and show no signs of erosion problems. For any existing slope that will lead to an engineered dispersion area, if evidence of channelized flow (rills or gullies) is present, a flow-spreading device should be used before those flows are allowed to enter the dispersion area.

Roadway side slopes that are 15 percent or flatter are considered part of the dispersion area if engineered dispersion practices are applied to the slope (6.5 feet of compost amended side slope width mitigates for 1 foot of impervious surface). The use of natural or engineered dispersion concepts within one threshold discharge area is acceptable.

The following criteria are specific to sheet flow dispersion on all Type A and some Type B soils, depending on infiltration rates:

For short-term infiltration rates of 4 inches per hour or greater, and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.

For dispersion areas that receive sheet flow only from disturbed pervious areas (bare soil and non-native landscaping), for every 6 feet (along the sheet flow path) of disturbed pervious area, 1 lateral food width of dispersion area is required.

The following criteria are specific to sheet flow dispersion on all Type C and D soils and Type B soils with a short-term infiltration rate less than 4 inches per hour:

For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

The dispersion area shall have a minimum width of 100 feet, measured in the direction of the flow path.

2.2.10.7 Channelized Flow Dispersion

Channelized flow dispersion criteria for Type A, B, C, and D soils are as follows:

Concentrated runoff from the roadway and adjacent upstream areas (such as in a ditch or cut slope) must be incrementally discharged from the conveyance system (such as a ditch, gutter, or storm sewer) via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows must not exceed 0.5 cubic feet per second (cfs) at any single discharge point from the conveyance system for the 100-year runoff event (determined by an approved continuous flow model). Where flows at a particular discharge point are already concentrated under existing site conditions (for example, in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.

Discharge points with up to 0.2 cfs discharge for the peak 100-year flow may use rock pads or dispersion trenches to disperse flows. Discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow must use only dispersion trenches to disperse flows.

Dispersion trenches must be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end; aligned perpendicular to the flow path; a minimum of 2' x 2' in section; 50 feet in length; filled with 3/4 to 1-1/2 inch washed rock; and provided with a level notched grade board, see Figure 2.7. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between four trenches (maximum). Dispersion trenches must have a minimum spacing of 50 feet.

After being dispersed with rock pads or trenches, flows from discharge points must traverse the required flow path length of the dispersion area before entering an existing on-site channel carrying existing concentrated flows away from the roadway alignment.

> **Note:** To provide the required flow path length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed.

Flow paths from adjacent discharge points must not intersection within the required flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point.

Discharge points must be located a minimum of 100 feet upgradient of slopes steeper than 40 percent within a vertical change of at least 10 feet, wetlands, and streams.

Where the County determines that there is a potential for significant adverse impacts downstream (such as erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

The following criterion is specific to channelized flow dispersion on all Type A and some Type B soils, depending on infiltration rates.

For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater, and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.

The following criteria are specific to channelized flow dispersion on all Type C and D soils and Type B soils with a short-term infiltration rate less than 4 inches per hour:

For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

The dispersion area shall have a minimum width of native vegetation of 100 feet, measured in the direction of the flow path.

2.2.10.8 Pipe or Ditch Conveyance System

Flows collected in a pipe or ditch conveyance system require energy dissipation and dispersal at the end of the conveyance system before entering the dispersion area. For flow dispersal BMPs, see Section 3.8 of Volume III.

2.2.10.8.1 Materials

Soils in engineered dispersion areas must meet the requirements of BMP LID.02 (Post-Construction Soil Quality and Depth).

2.2.10.9 Site Design Elements

The following areas are appropriate engineered dispersion areas because they are likely to remain in their existing condition over the long term:

- County right-of-way (for County projects only).
- Protected beautification areas and landscape areas.
- Agricultural areas.
- Parks and nature areas.
- Commercial or government-owned forest lands.
- Rural areas with zoned densities of less than one dwelling unit per 5 acres.

Engineered dispersion areas shall have infiltrative soil properties that are verified by the geotechnical professional using the methods described in Volume III.

Engineered dispersion areas that have impervious areas (for example, abandoned roads with compacted subgrades) within them shall have those areas tilled and reverted using the soil amendments per BMP LID.02 (Post-Construction Soil Quality and Depth).

Engineered dispersion areas that are within a landslide hazard area must be evaluated by a geotechnical engineer or qualified geologist. Engineered dispersion areas should not be sited above slopes greater than 20 percent or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and acceptance by Thurston County.

Engineered dispersion areas shall have a separation of at least 2 feet between the existing ground elevation and the average annual maximum groundwater elevation. This separation depth requirement applies to the entire limits of the dispersion area.

When selecting engineered dispersion areas, determine whether there are groundwater management plans for the area and contact the local water purveyors to determine whether the project lies within a wellhead or groundwater protection zone, septic drain fields, or aquifer recharge area. There may be additional restrictions within these areas.

2.2.10.9.1 Setback Requirements

- Engineered dispersion areas can extend beyond the right-of-way provided that documentation ensures (via easements or dedicated tracts) the dispersion area is not developed in the future.

- Engineered dispersion areas shall be setback at least 100 feet from drinking water wells and springs used for public drinking water supplies. Engineered dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones must comply with the Washington State Department of Health (DOH) requirements.

Engineered dispersion areas shall be setback at least 100 feet from septic drainfields. The 100-foot setback is in addition to the required dispersion area. For example if there is a 100-foot width dispersion area, there would be an additional 100-foot setback making a total of 200 feet from the point of discharge of water to the dispersion area to the drainfield area. If the applicant can demonstrate that the dispersion flow path will not intercept the drainfield, this setback requirement may be relaxed.

If the project significantly increases flows to off-site properties, a drainage easement may be required or additional right-of-way purchased.

2.2.10.9.2 Signage

The limits of engineered dispersion area shall be marked as a stormwater management facility and also shall be physically marked in the field during and after construction. Signage ensures the dispersion area is protected from construction activity disturbance and is adequately protected by measures shown in the temporary erosion and sedimentation control (TESC) plan.

Signage helps ensure the engineered dispersion area is not cleared or disturbed after the construction project.

Signage shall be posted at a minimum on all four sides of the dispersion area and at intervals not exceeding 75 feet.

See Appendix V-E for sign specifications.

2.2.10.10 Construction Considerations

- For installation of dispersal BMPs and conveyance systems near dispersion areas, the area that needs to be cleared or grubbed should be minimized. Maintaining plant root systems is important for dispersion areas.

- The area around dispersion areas should not be compacted.

- To the maximum extent practicable, low-ground-pressure vehicles and equipment should be used during construction.

2.2.10.11 Maintenance

Use the maintenance checklist for vegetated filter strips and energy dissipators for maintenance requirements (Appendix V-C).

Signage and fencing shall be inspected and restored /replaced as required.

Ensure that sheet flow paths are maintained to the dispersion areas, perform hand maintenance to ensure sheet flow.

Maintain energy dissipators and level spreaders. Cleanout any structures associated with these devices and inspect spreaders to ensure they are functioning correctly. Remove buildup of soil/debris over the surface of level spreader as required to maintain its function.

2.2.11 LID.14 Tree Planting and Tree Retention (for Flow Control Credit)

2.2.11.1 Description

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.

2.2.11.2 Applications and Limitations

When used in combination with other low impact development techniques, retained and newly planted trees can help achieve compliance with Core Requirement #5.

When implemented in accordance with the criteria outlined below, retained and newly planted trees receive credits toward meeting the flow control standards of Core Requirement #7. The degree of flow control provided by a tree depends on the tree type (i.e., evergreen or deciduous), canopy area, and proximity to hard surfaces. Flow control credits may be applied to project sites of all sizes.

Site considerations specific to retained and newly planted trees are provided below.

2.2.11.3 Retained Trees

Setbacks of proposed infrastructure from existing trees are critical considerations. Tree protection requirements limit grading and other disturbances in proximity to the tree.

2.2.11.4 Newly Planted Trees

Mature tree height, size, and rooting depth must be considered to ensure that new tree planting locations are appropriate given adjacent above- and below-ground infrastructure. Although setbacks will vary by species, some general recommendations include:

- Minimum 5 foot setback from structures
- Minimum 2 foot setback from edge of any paved surface.

2.2.11.5 Modeling and Sizing

2.2.11.5.1 Retained Trees

Flow control credits for retained trees are provided in Table 2-7 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.

The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.

Table 2-7 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 =
(Σ Evergreen Canopy Area x .2) + (Σ Deciduous Canopy Area x 0.1)

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes.

2.2.11.5.2 Newly Planted Trees

Flow control credits for newly planted trees are provided in Table 2-8 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 2-8 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.)

Tree credits are not applicable to newly planted trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to new trees in planter boxes.

2.2.11.6 Tree Planting and Tree Retention Design Criteria

2.2.11.6.1 Retained Trees

The following design criteria are specific to projects proposing to retain onsite trees for flow control credits:

2.2.11.6.2 Tree Species and Condition

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).

2.2.11.6.3 Tree Size

To receive flow control credit, retained trees shall have a minimum 6 inches diameter at breast height (DBH). DBH is defined as the outside bark diameter at 4.5 feet above the ground on the uphill side of a tree. For existing trees smaller than this, the newly planted tree credit may be applied as presented below.

2.2.11.6.4 Tree Canopy Area

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 (see also Figure 2.21). If trees are clustered, overlapping canopies are not double counted.

2.2.11.6.5 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 shall 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 within half the diameter of the dripline (see also Figure 2.21). 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 tree flow control credit may still be approved.

Minimize the installation of any impervious surfaces in critical root zone areas. Where road or sidewalk surfaces are needed under a tree canopy, un-mortared permeable pavers or flagstone (rather than concrete or asphalt) or bridging techniques should be used (see Figure 2.22).

2.2.11.7 Newly Planted Trees

The following design criteria are specific to projects proposing to plant new onsite trees for flow control credits.

2.2.11.7.1 Tree Species

Consult a landscape architect or other trained professional to guide the plant selection for each unique location and/or application. An approved list of tree species is provided in.

2.2.11.7.2 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.

2.2.11.7.3 Tree Location

Similar to retained trees, flow control credit for newly planted trees depends upon proximity to ground level hard surfaces. To receive a credit, the tree must meet tree location requirements listed in retained tree design criteria above. Distance from hard surfaces is measured from the edge of the surface to the center of the tree at ground level.

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.

To help ensure tree survival and canopy coverage, the minimum tree spacing for newly planted trees shall accommodate mature tree spread. Onsite stormwater management and/or flow control credit must not be given for new trees with on-center spacing less than 10 feet.

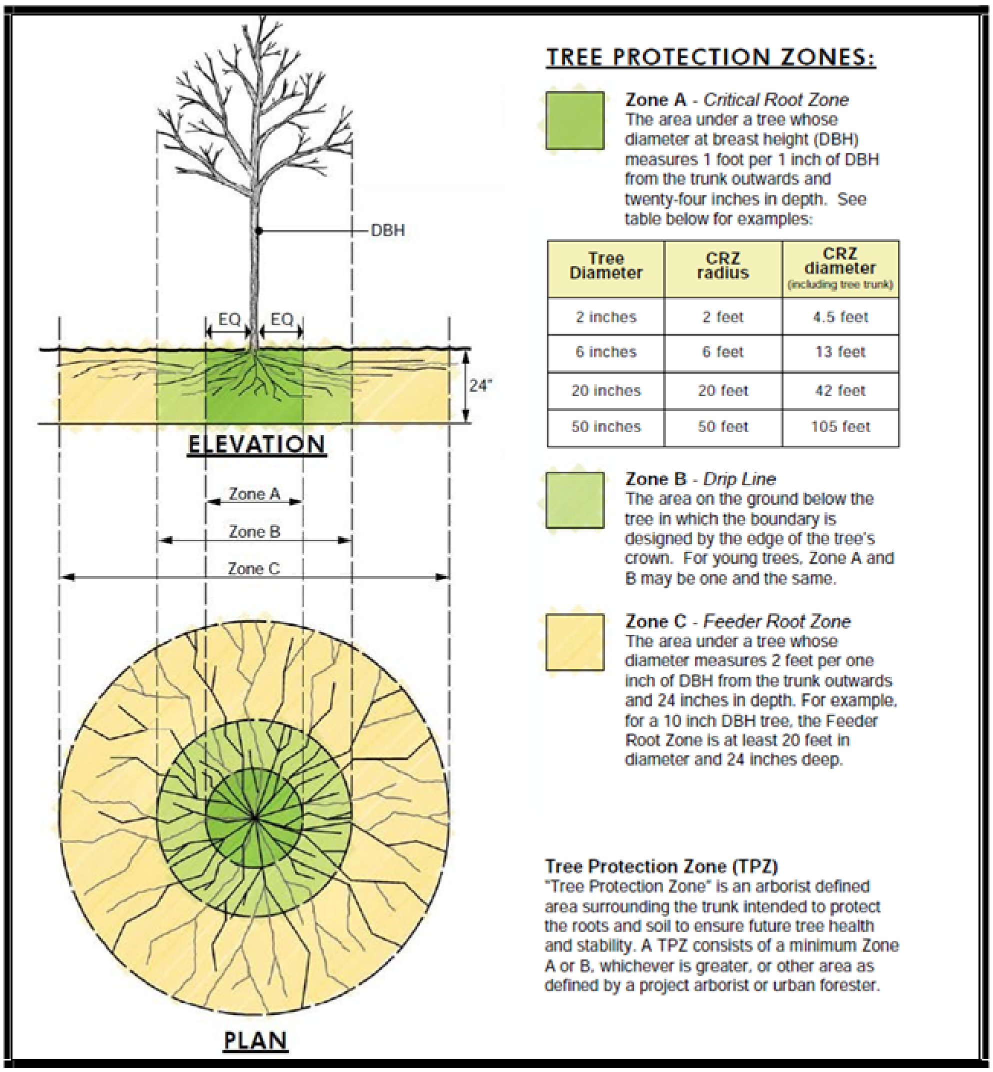


Figure 2.21 Critical Root Zone, Source: Pierce County Stormwater Management Manual

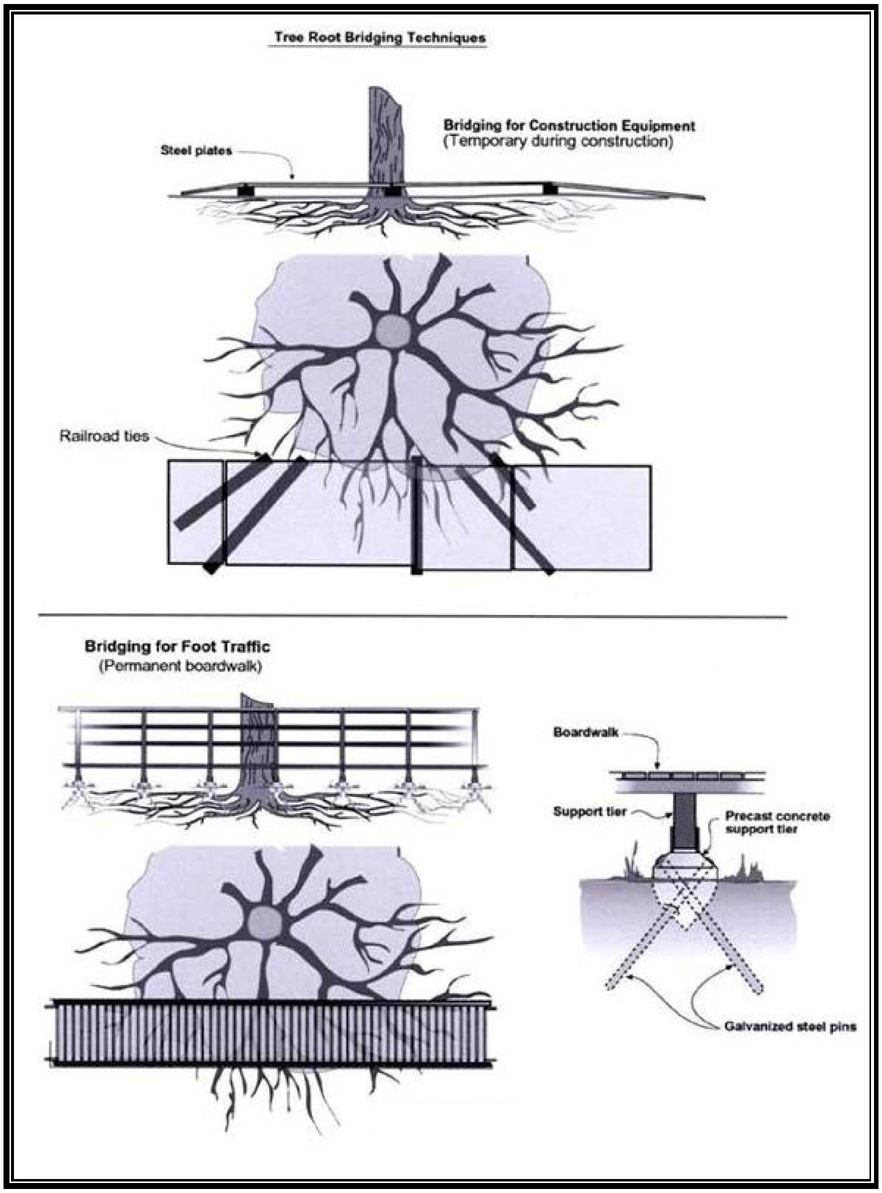


Figure 2.22 Root Bridge, Source: Pierce County Stormwater Management Manual

2.2.11.8 Plant Material and Planting Specifications

Standard practices for planting materials and methods are provided in the WSDOT Standard Specifications Sections 8-02 and 9-14 and WSDOT Standard Plan H-10.10-00.

2.2.11.9 Construction Criteria

Protect trees and tree root systems utilizing the following methods:

- The existing tree roots, trunk, and canopy shall be fenced and protected during construction activities.

- Trees that are removed or die shall be replaced with like species during the next planting season (typically in fall). Trees shall be pruned according to industry standards (ANSI A 300 standards).

- Reduce soil compaction during the construction phase by protecting critical tree root zones that usually extend beyond the trees canopy or drip line. The critical tree root zone should be factored using the tree's diameter breast height (see Figure 2.21).

- Prohibit any excavation within the critical tree root zone.

- Prohibit the stockpiling or disposal of excavated or construction materials in the tree planting areas to prevent contaminants from damaging vegetation and soils.

- Avoid excavation or changing the grade near trees that have been designated for protection. If the grade level around a tree is to be raised, a dry rock wall or rock well shall be constructed around the tree. The diameter of this wall or well should be at least equal to the diameter of the tree canopy plus 5 feet.

- Prevent wounds to tree trunks and limbs during the construction phase.

- Tree root systems tend to overlap and fuse among adjacent trees. Trees or woody vegetation that will be removed and that are next to preserved trees should be cut rather than pushed over with equipment. Where construction operations unavoidably require temporary access over tree root zones or other soil protection areas, provide protection as follows:

- For foot access or similar light surface impacts, apply a 6-inch layer of arborist wood chip mulch and water regularly to maintain moisture, control erosion and protect surface roots.

- For any vehicle or equipment access, apply a minimum 1-inch steel plate or 4-inch thick timber planking over 2-3 inches of arborist wood chip mulch, or a minimum 0.75-inch plywood over 6-8 inches of arborist wood chip mulch to protect roots and root zone soil from disturbance or compaction.

- Prep tree conservation areas to better withstand the stresses of the construction phase by pruning and applying a 1 inch layer of compost covered with a 2 inch layer of mulch around them well in advance of construction activities.

2.2.11.10 Operations and Maintenance Criteria

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. Replace trees that are removed or die with like species during the next appropriate planting season (typically in the fall).

Prune, when necessary for compatibility with other infrastructure and/or to preserve the health and longevity of trees. Meet industry standards for pruning (ANSI A300 standards).

For newly planted trees, provide supplemental irrigation during the first three growing seasons after installation to help ensure tree survival.

See Core Requirement #9 in Volume I; Volume I, Section 3.8.4; and Volume I, Appendix I-E for information on maintenance requirements.

2.2.12 LID.15 Minimal Excavation Foundation Systems

Minimal excavation foundation systems are those techniques that minimize disturbance to the natural soil profile within the footprint of the structure. This preserves most of the hydrologic properties of the native soil. Pin foundations are an example of a minimal excavation foundation. For more information see the *Stormwater Manual for Western Washington* BMP T5.19: Minimal Excavation Foundations.

2.2.12.1 Applicability

- Where minimal excavation foundation systems are used and designed as outlined below, the portion of the rooftop area above minimal excavation foundation systems may be modeled as pasture rather than as impervious surface.

2.2.12.2 Design Criteria

- Minimal excavation foundation systems utilize a pin anchoring system (see Figure 2.23) or a piling/pier foundation which secures the foundation without complete removal and compaction of the surface soil beneath the house. This allows the interflow pathways of runoff under the building structure to be maintained.

- The contributing downspout areas shall be dispersed in accordance with Section 2.2.2. The length of vegetated flow path and setbacks required in Section 2.2.2 are not applicable when using minimal excavation foundation systems.

- To maximize the benefit of minimal excavation foundation systems, the roof runoff shall be dispersed upgradient of the structure. Runoff dispersed upgradient of a garage slab, monolithic poured patio, or driveway may not be included as applicable infiltration areas for these systems.

- Where runoff cannot be dispersed upgradient of the structure, the contributing downspout areas must be dispersed in accordance with the full requirements of Section 2.2.2, including the flow path and vegetated cover requirements. If the design requirements of Section 2.2.2 are met, the tributary roof areas may be modeled as pasture area.

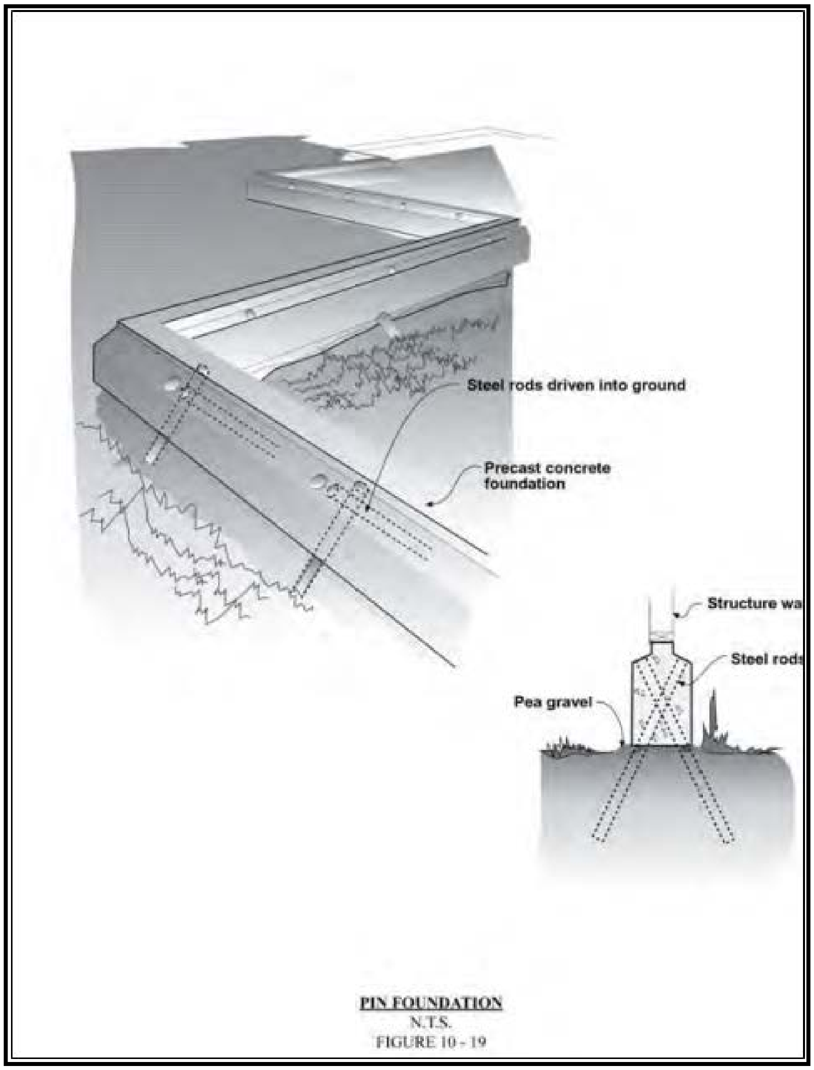


Figure 2.23 Pin Foundations

Chapter 3 - Infiltration BMPs

Infiltration BMPs discharge stormwater into the ground, rather than through a surface or piped outflow. Infiltration can aid in pollutant removal, peak flow control, groundwater recharge, and flood control.

However, to avoid contaminating drinking water sources, infiltration facilities must be sited properly (see site suitability criteria in Volume III) and stormwater runoff must often be pretreated before infiltration. See the individual BMP design guidelines in this chapter for pretreatment requirements.

3.1 General Considerations

3.1.1 Runoff Treatment and Flow Control

Infiltration can be used for both runoff treatment and flow control.

To adequately address groundwater protection when evaluating infiltration, it is important to understand the difference between soils suitable for runoff treatment and soils suitable only for flow control.

Infiltration for runoff treatment treats stormwater by using the filtration, adsorption, and biological decomposition properties of soils. To be used for runoff treatment, soils must include sufficient organic content and sorption capacity to remove pollutants. Examples are silty and sandy loams.

Coarser soils, such as gravelly sands, can provide flow control through rapid infiltration to groundwater, but are not suitable for treating runoff. The use of coarser soils to provide flow control for runoff from pollution generating surfaces must be preceded by treatment in some cases to protect groundwater quality. Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa.

The hydraulic design goal should be to mimic the natural hydrologic balance between surface and ground water, as needed to protect water uses. Frequently infiltration will be used in combination with detention and release to meet Core Requirement #7 (Flow Control). Detention may be provided after infiltration or in combination with infiltration by installing a control structure for controlled release of stormwater for events that exceed the infiltration capacity of the facility.

3.1.2 Site Suitability

Because infiltration facilities release stormwater to groundwater, they must be located and designed to ensure that stormwater discharge will not contaminate drinking water sources or downstream surface waters. Site characterization and suitability criteria are described in Volume III and includes characterization of the soils; locational restrictions and siting criteria; calculating a design infiltration rate; characterization of the infiltration receptor (vadose zone), and underlying aquifer; and mounding analysis requirements.

3.1.3 Underground Injection Control

Infiltration is regulated by the Washington State Department of Ecology (Ecology) and the Underground Injection Control (UIC) Program (Washington Administrative Code [WAC] 173-218).

The following information on Underground Injection Control (UIC) is excerpted from the 2006 Department of Ecology document *Guidance for UIC Wells that Manage Stormwater*. This document is available online at: <http://www.ecy.wa.gov/biblio/0510067.html>.

The UIC program in the state of Washington is administered by the Department of Ecology. In 1984, the Department of Ecology adopted Chapter 173-218 WAC – Underground Injection Control to implement the program. A UIC well is a manmade subsurface fluid distribution system designed to discharge fluids into the ground and consists of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension (WAC 173-218-030).

UIC systems include drywells, pipe or French drains, drain fields, and other similar devices that are used to discharge stormwater directly into the ground. Infiltration trenches with perforated pipe used to disperse and inject flows (as opposed to collect and route to surface drainage, as in an underdrain) are considered to be UIC wells. All stormwater UICs must be registered with Ecology, except residential UICs used for roof runoff control.

The following are not UIC wells; therefore, this guidance does not apply in these situations:

Buried pipe and/or tile networks that serve to collect water and discharge that water to a conveyance system or to surface water.

Surface infiltration basins and flow dispersion stormwater infiltration facilities, unless they contain additional infiltration structures at the bottom of the basin/system such as perforated pipe, or additional bored, drilled, or dug shafts meant to inject water further into the subsurface greater than 20 feet deeper than the bottom of the pond (or deeper than the largest surface dimension per above).

Infiltration trenches designed without perforated pipe or a similar mechanism

A system receiving roof runoff from a single family home.

The two basic requirements of the UIC Program are:

Register UIC wells with the Washington State Department of Ecology unless the wells are located on tribal land. (Those wells should be registered with the Environmental Protection Agency.)

Make sure that current and future underground sources of ground water are not endangered by pollutants in the discharge (non-endangerment standard).

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, a permit is not required. Rule-authorization can be rescinded if a UIC well no longer meets the non-endangerment standard. Ecology can also require corrective action or closure of a UIC well that is not in compliance. Additional information on UIC systems can be found online at: <http://www.ecy.wa.gov/biblio/0510067.html>.

In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater facility. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical reports, runoff treatment BMPs, and monitoring may be required including but not limited to groundwater monitoring through a wet season (December 1st through April 30th).

3.1.4 Groundwater Protection Areas

The applicant must check the Critical Aquifer Recharge (CARA) map, sole source aquifer designations, and wellhead protection areas mapped by the Washington State Department of Health and Thurston County to determine if the project lies within a groundwater protection area. A site is not suitable if the infiltration facility will cause a violation of Washington State Ground Water Quality Standards. At a minimum, projects located within groundwater protection areas may be required to meet one of the soil requirements for infiltration for water quality treatment outlined in Volume III, Section 2.3.1. If an infiltration facility is proposed within a designated well head protection area for a public water system serving over 1,000 connections the enhanced treatment is required prior to infiltration.

3.1.5 Verification of Performance

The project engineer or designee shall inspect infiltration facilities before, during, and after construction as necessary to ensure facilities are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. If an engineered or bioretention soil mix will be placed to provide treatment in an infiltration facility, prior to placement of the engineered or bioretention soil mix, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate. The project engineer shall notify Thurston County at (360) 754-4681 two days before placement of treatment soils, if any, to verify subgrade.

Verification testing of the completed full-scale infiltration facility (BMPs IN.01, IN.02, or IN.03) is required during the first 1 to 2 years of operation and prior to release of any financial assurance instruments (bonds, letters of credit, assignment of funds). Verification testing is required to ensure that the completed full-scale infiltration facility operates as designed including confirmation of estimated design infiltration rates.

The applicant shall submit a facility monitoring and evaluation report to document the results of the verification testing. A licensed civil engineer shall prepare and seal the report. The report shall document work and assess stormwater infiltration facility performance versus design.

All field work shall be done under the engineer’s direction and supervision. Testing shall consist of automated continuous water level monitoring over a sufficient number of storms to provide an accurate “long-term” infiltration rate. Testing shall either have a minimum of 30 days’ test results with two or more events exceeding 30 percent of facility volume, or one full wet season’s data (November 1 to March 30). An alternative, with Administrator or designee acceptance, is to simulate storm events using hydrant or trucked water. The report shall specify any actions needed to restore performance, such as sediment removal or facility expansion.

A program for monitoring of groundwater quality may be required and if so it shall be prepared by the site professional. Instances in which groundwater monitoring may be required include shallow groundwater, infiltration facilities at commercial or industrial sites, and infiltration facilities located within critical, sensitive or sole-source aquifer areas as designated by Thurston County. For those facilities required to conduct groundwater monitoring, the ground water monitoring wells installed during site characterization may be used for this purpose. At a minimum at least one up-gradient and one down-gradient groundwater sample will be collected per year and analyzed for pollutants such as metals, nitrogen, phosphorous and dissolved solids.

Long-term (more than 2 years) in-situ drawdown and confirmatory monitoring of the infiltration facility is also strongly recommended, along with a maintenance program that results in achieving expected performance levels. Long term monitoring and groundwater monitoring shall be included in the Maintenance plan for the facility including methods of testing, frequency and reporting requirements.

3.1.6 Contingency Planning

The methods used to estimate infiltration rates described in Volume III are expected to yield relatively accurate estimates of ultimate infiltration rates. However, soils, shallow geology, and groundwater conditions can be extremely complex and highly variable, which may cause inaccuracies. Therefore, it is necessary to have a plan for fixing under performance discovered after facilities are installed (see Section 3.1.5, Verification of Performance).

All projects using infiltration facilities shall provide a contingency plan for under performance. The plan shall include a reasonable “worst-case” project of long-term infiltration performance and describe methods and costs for improving/restoring performance and/or expanding facility size. These costs shall provide one basis for required performance/operation and maintenance bonding (see Volume I).

3.2 Infiltration BMPs

This section includes the following BMPs:

- IN.01 Infiltration Basin
- IN.02 Infiltration Trench
- IN.03 Infiltration Vault
- IN.04 Bio-Infiltration Swale.

3.2.1 IN.01 Infiltration Basins

Infiltration basins are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff.

This section describes design and maintenance criteria for infiltration basins (see schematic in Figure 3.1).

3.2.1.1 Applicability

Infiltration basins for flow control are used to convey stormwater runoff from new development or redevelopment to the ground and ground water after appropriate treatment. Infiltration basins designed to meet runoff treatment criteria of Core Requirement #6 rely on the soil profile or an engineered soil layer to provide pollutant removal. Runoff in excess of the infiltration capacity of the basin must be managed to comply with the flow control requirements in Volume I, Core Requirement #7, if applicable.

Infiltration basins are a good option (and may be required) for flow control where soils have adequate infiltration rates and the site meets the site suitability criteria for infiltration facilities described in Volume III.

Infiltration basins for water quality treatment are capable of achieving performance objectives for water quality treatment. In general, this treatment method can capture and remove or reduce target pollutants to levels that:

- Will not adversely affect public health or beneficial uses of surface and ground water resources, and
- Will not cause a violation of ground water quality standards

Infiltration treatment systems are typically installed:

- As off-line systems, or on-line for small drainages
- As a polishing treatment for street/highway runoff after pretreatment for solids 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 include a pre-settling basin or a basic treatment BMP such as wet pond/vault, biofilter, constructed wetland, media filter, and oil/water separator.

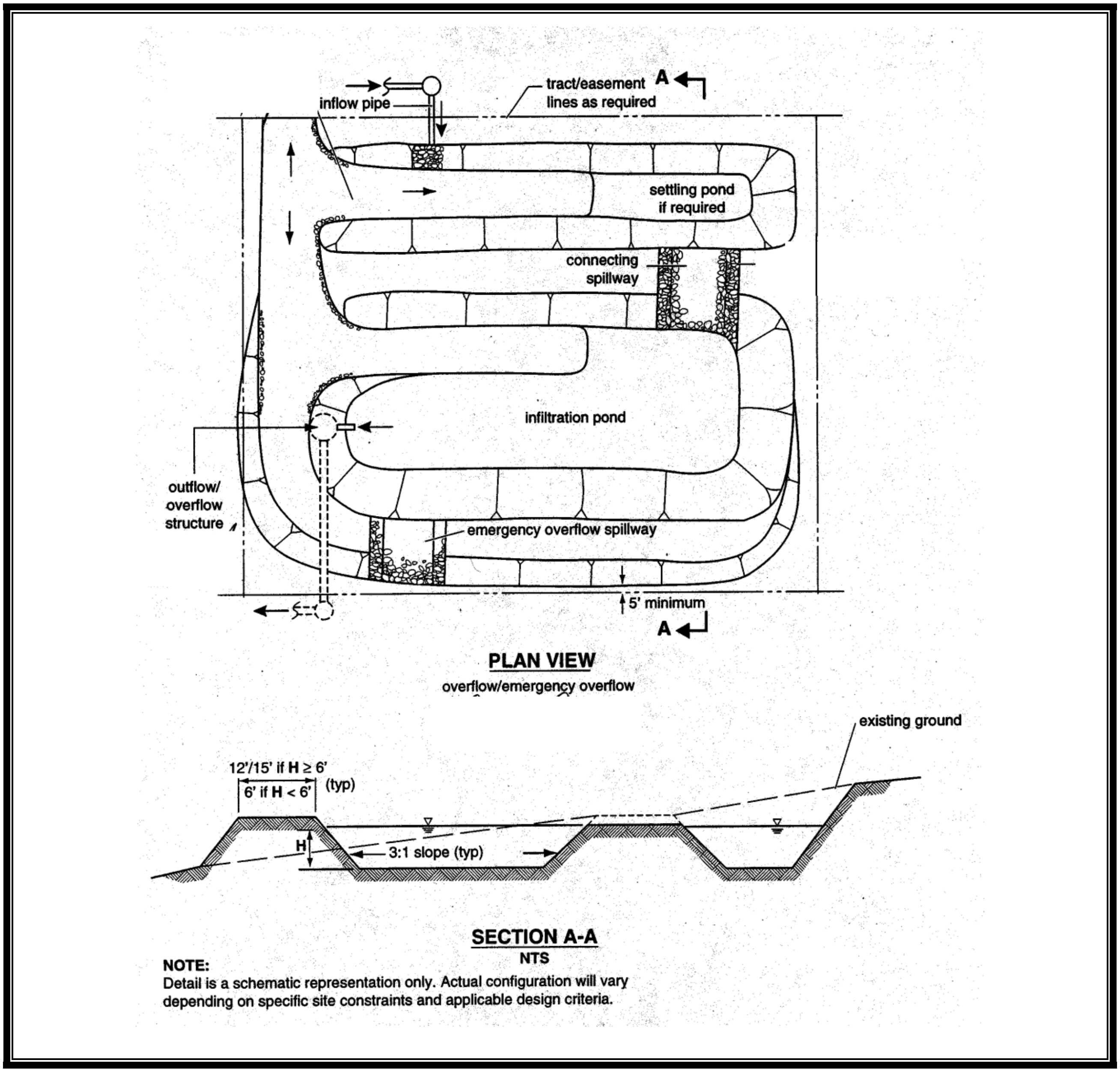


Figure 3.1 Typical Infiltration Pond/Basin

Infiltration basins are preferred over infiltration trenches (BMP IN.02), infiltration vaults (BMP IN.03), and bio-infiltration swales (BMP IN.04). This is primarily because basins are easier and less expensive to construct and maintain.

3.2.1.2 Limitations

See Volume III for soil testing and site suitability criteria.

3.2.1.3 Submittals and Approval

Prepare submittals required by Volume I and include the following information in the submittal:

- Hydrologic modeling results showing the how the facility meets the flow control core requirements
- Show details of all structures and material and construction specifications
- Planting plan showing plant species, quantity, location and any special planting requirements
- Provide at least one cross section of the pond through the control structure
- Provide design calculations for the overflow structures
- Show how the facility location meets setback requirements
- Required contingency planning and performance verification testing information
- Geotechnical report and infiltration rate calculations required by Volume III.

3.2.1.4 Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration system (BMPs BF.01, BF.03, BF.04, or BF.05) or presettling basin (BMP WP.05) for water quality treatment prior to discharge to an infiltration facility. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

3.2.1.5 Hydrologic and Hydraulic Design Considerations

See Volume III for detailed guidance on modeling infiltration basins.

3.2.1.5.1 100-Year Overflow Conveyance

An overflow route must be identified for stormwater flows that overtop the facility when infiltration capacity is exceeded or when the facility becomes plugged and fails. The overflow route must be able to convey the 100-year developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage. The emergency overflow spillway shall be designed in accordance with the requirements for detention pond overflow spillway design criteria (BMP D.01).

3.2.1.5.2 Spill Control Device

All infiltration facilities must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a “tee” section is used for spill control, the top of the spill control riser must be set above the infiltration facility’s 100-year overflow elevation to prevent oils from entering the infiltration facility.

3.2.1.6 Soil Physical and Chemical Suitability for Treatment

(Applies to infiltration facilities used as treatment facilities not to facilities used for flow control only).

The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants. Section 2.3.1 of Volume III discusses the soil properties needed to meet runoff treatment requirements.

Engineered soils may be used to meet infiltration BMP design criteria in Volume V and the performance goals in Core Requirement #6 (Runoff Treatment; Volume I). BMP LID.08 Bioretention provides an acceptable engineered soil specification for runoff treatment. Use of alternate engineered soils must be approved by the County, and requires field performance evaluation(s), using acceptable protocols, to determine effectiveness, feasibility, and acceptability.

3.2.1.7 Design Criteria

3.2.1.7.1 Geometry

The slope of the basin bottom shall not exceed 3 percent in any direction.

A minimum of 1 foot of freeboard is required when establishing the design ponded water depth. Freeboard is measured either from the rim of the infiltration facility to the maximum ponding level, or from the rim down to the overflow point if overflow or a spillway is included.

- Infiltration basins with a maximum depth of 4 feet or more and a minimum storage volume of 5,000 cubic feet are required to include a crest gage that will record maximum basin water surface elevation after a storm event. The designer may submit alternative crest recording device for county acceptance. See WSDOT Standard Plan H-30.10-00, Crest Gage for crest gage details. In addition, project submittals must include a table that identifies the design stage/storage/discharge expected for the 2-, 5-, 10-, 25-, 50, and 100-year recurrence interval flows.

3.2.1.7.2 Materials

Lining material: Basins can be open or covered with a 6- to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric, to help prevent the buildup of impervious deposits on the soil surface. A nonwoven geotextile shall be selected that will function sufficiently without plugging (see geotextile specifications in Appendix V-B). The filter layer can be replaced or cleaned when/if it becomes clogged.

Vegetation: The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas shall be stabilized and planted—preferably with grass—in accordance with the *Drainage Design and Erosion Control Plan* (see Core Requirement #1 of Volume I).

Treatment infiltration basins must have sufficient vegetation established on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Erosion protection of inflow points to the basin must also be provided (e.g., riprap, flow spreaders, energy dissipators. Select suitable vegetative materials for the basin floor and side slopes to be stabilized.

Seed mixtures shall be the same as those recommended in Table E-2 in Appendix V-E. The use of slow-growing, stoloniferous grasses will permit long intervals between mowing (twice a year is usually satisfactory). Fertilizers shall be applied only as necessary and in limited amounts, to avoid contributing to ground water pollution. Consult the local extension agency for appropriate fertilizer types and application rates.

3.2.1.8 Site Design Elements

Access must be provided for vehicles to easily maintain the forebay (presettling basin) area, while not disturbing vegetation or re-suspending sediment any more than absolutely necessary.

3.2.1.8.1 Access Road

An access road to the control structure and at least one access point per cell are needed, and may be designed and constructed as specified in Appendix V-D.

3.2.1.9 Construction Criteria

Initial basin excavation must be conducted to within 2 feet of the final elevation of the basin floor. Excavate infiltration trenches and basins to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation must remove all silt accumulated in the infiltration facility before putting it into service. After construction is completed, prevent sediment from entering the infiltration facility by first conveying runoff water through an appropriate pretreatment system such as a presettling basin, wet pond, or sand filter.

Infiltration basins should not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any silt accumulation in the basin must be removed before putting it into service.

Light-tracked equipment is recommended to avoid compaction of the basin floor. The use of draglines and trackhoes should be considered for constructing infiltration basins. The infiltration area must be flagged or marked to keep heavy equipment away.

The infiltration basin area shall be clearly identified and protected prior to construction to prevent compaction of underlying soils by vehicle traffic.

Infiltration basins shall not begin operation until all erosion-causing project improvements are completed, and all exposed ground surfaces are stabilized by revegetation or landscaping.

3.2.1.10 Maintenance Criteria

Provision shall be made for regular and perpetual maintenance and access (tract, easement, etc., see Volume III) to the infiltration basin/trench. Adequate access, including measures to prevent encroachment into tracts/easements for purposes of inspection, operation and maintenance must be part of infiltration basin and trench design. Provisions must be made for regular and perpetual maintenance of the infiltration basin or trench, including replacement or reconstruction of any media used for treatment purposes. The Operation and Maintenance Plan shall be submitted to and approved by the County to ensure maintenance of the desired infiltration rate.

Debris/sediment accumulation – Removal of accumulated debris/sediment in the basin/trench should be conducted every 6 months or as needed to prevent clogging, or when the measured infiltration rate is significantly less than the design rate.

Vegetation growth should not be allowed to exceed 18 inches in height. Mow the slopes periodically and check for clogging, and erosion.

See Appendix V-C for additional information on maintenance requirements.

3.2.2 IN.02 Infiltration Trenches

This section describes design, construction, and maintenance criteria for infiltration trenches. For trenches associated with roof downspout infiltration, see BMP LID.04.

Figure 3.2 through Figure 3.7 provide different configurations for infiltration trenches. Infiltration trenches are rectangular trenches generally at least 24 inches wide backfilled with a coarse stone aggregate that temporarily stores stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil.

3.2.2.1 Applicability

Infiltration trenches are more appropriate for small contributing areas or the risk of clogging and flooding increases. They are also suited to retrofit situations where limited area is available for infiltration basins.

Infiltration trenches can be used to meet the flow control standards of Core Requirement #7.

When used in combination with other onsite stormwater management BMPs, they can also help achieve compliance with the Performance Standard option of Core Requirement #5.

Infiltration trenches can be used to meet some of the water quality treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Volume III, Section 2.3.1.

3.2.2.2 Limitations

See Volume III for soil testing and site suitability criteria.

3.2.2.3 Submittals and Approval

In addition to submittal requirements of Volume I, complete geotechnical investigations and prepare a site suitability analysis per Volume III. If an infiltration trench includes a perforated distribution pipe, the BMP is subject to the requirements of the Underground Injection Control (UIC) regulations (see Section 3.1.3).

3.2.2.4 Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration swale system, basic filter strip or presettling basin for water quality treatment (see BMP BF.01, BMP BF.04 and BMP WP.05) prior to discharge to an infiltration trench. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

3.2.2.5 Hydrologic and Hydraulic Design Considerations

See Volume III for guidance on determining a design infiltration rate and hydrologic modeling requirements.

Overflow Channel: Because an infiltration trench is normally used for small drainage areas, an emergency spillway is not necessary. However, a non-erosive overflow channel leading to a stabilized watercourse shall be provided.

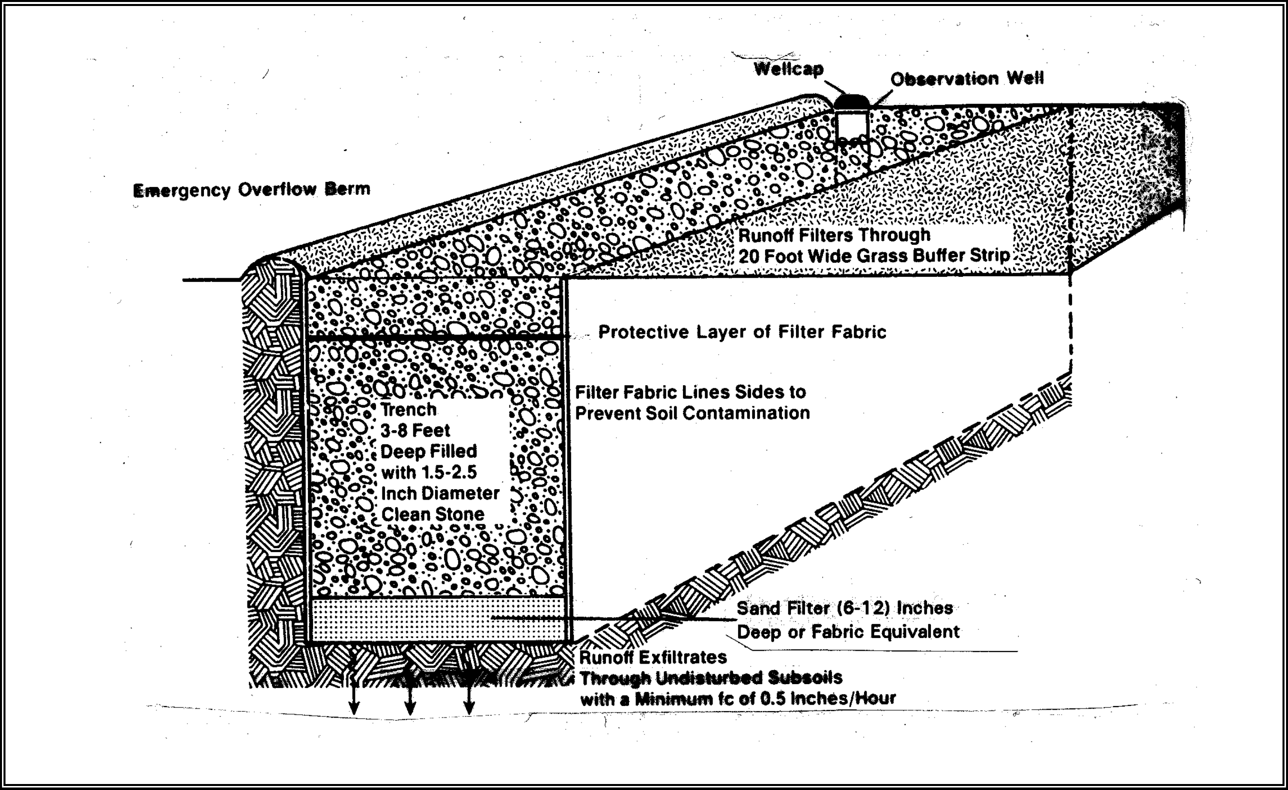


Figure 3.2 Schematic of an Infiltration Trench

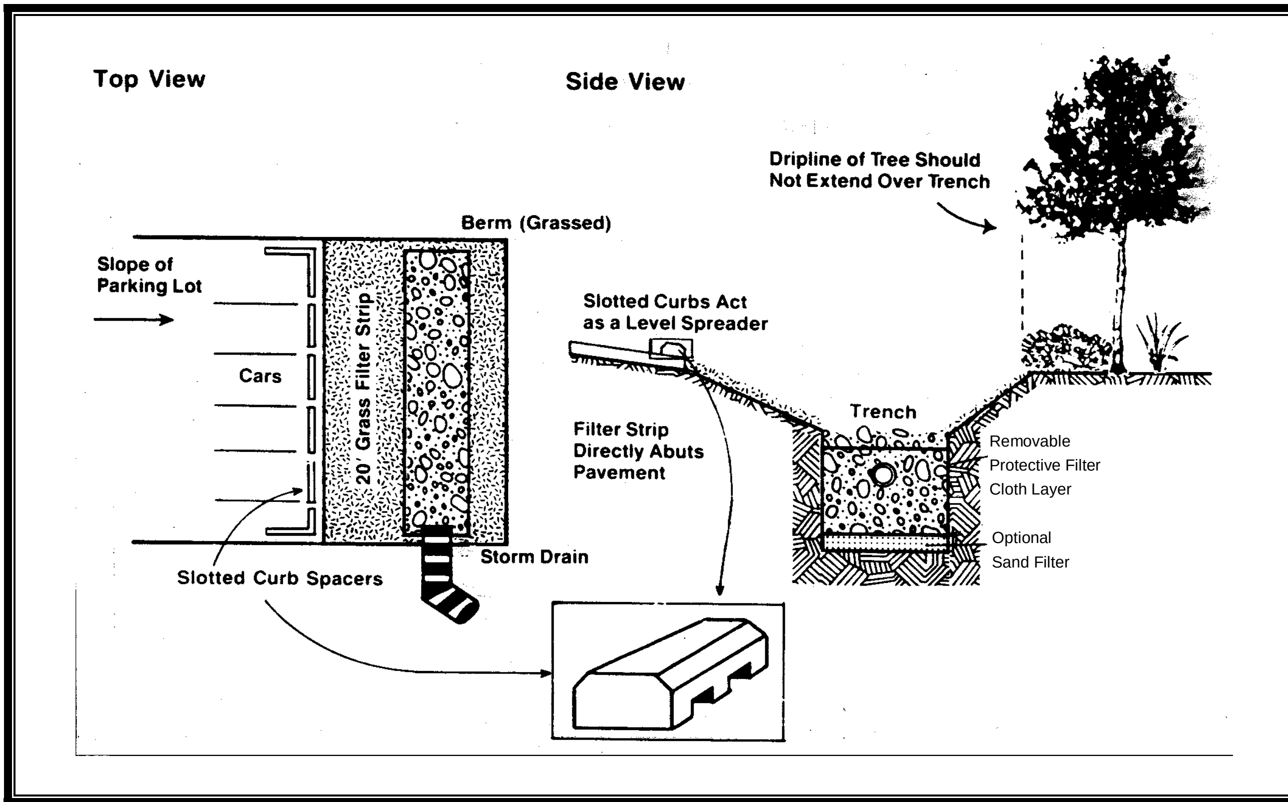
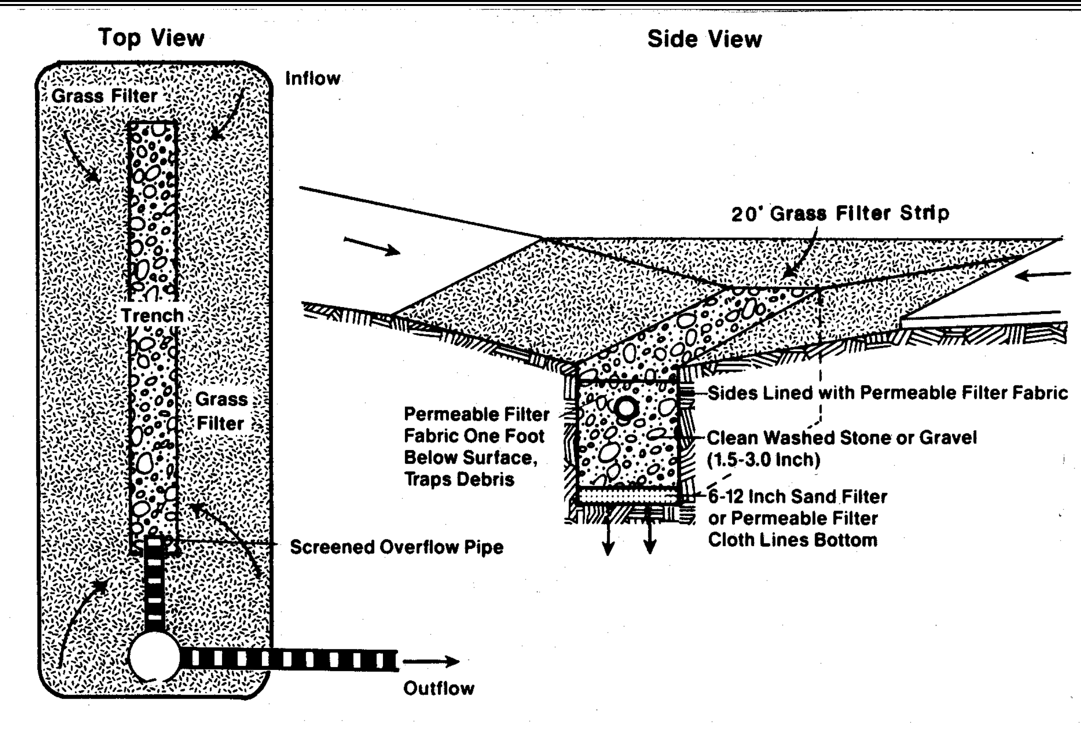


Figure 3.3 Parking Lot Perimeter Trench Design



Source: Schueler (reproduced with permission)

Figure 3.4 Median Strip Trench Design

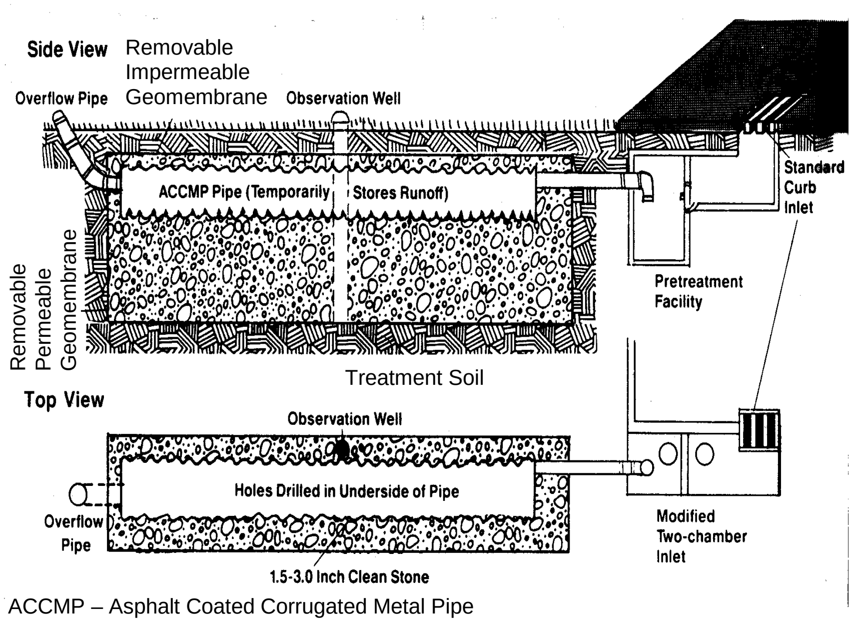


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Figure 3.5 Oversized Pipe Trench Design

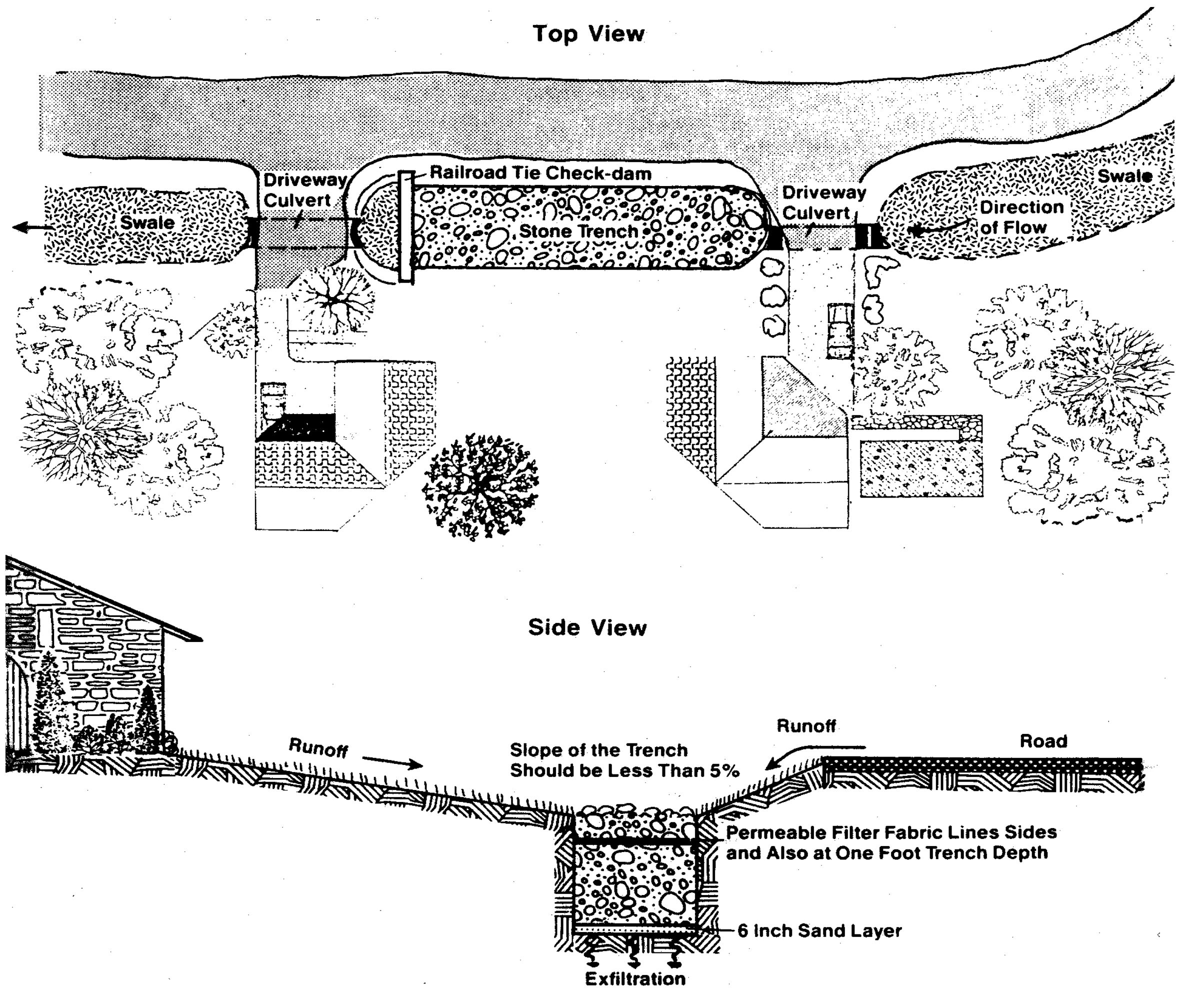

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Figure 3.6 Swale/Trench Design

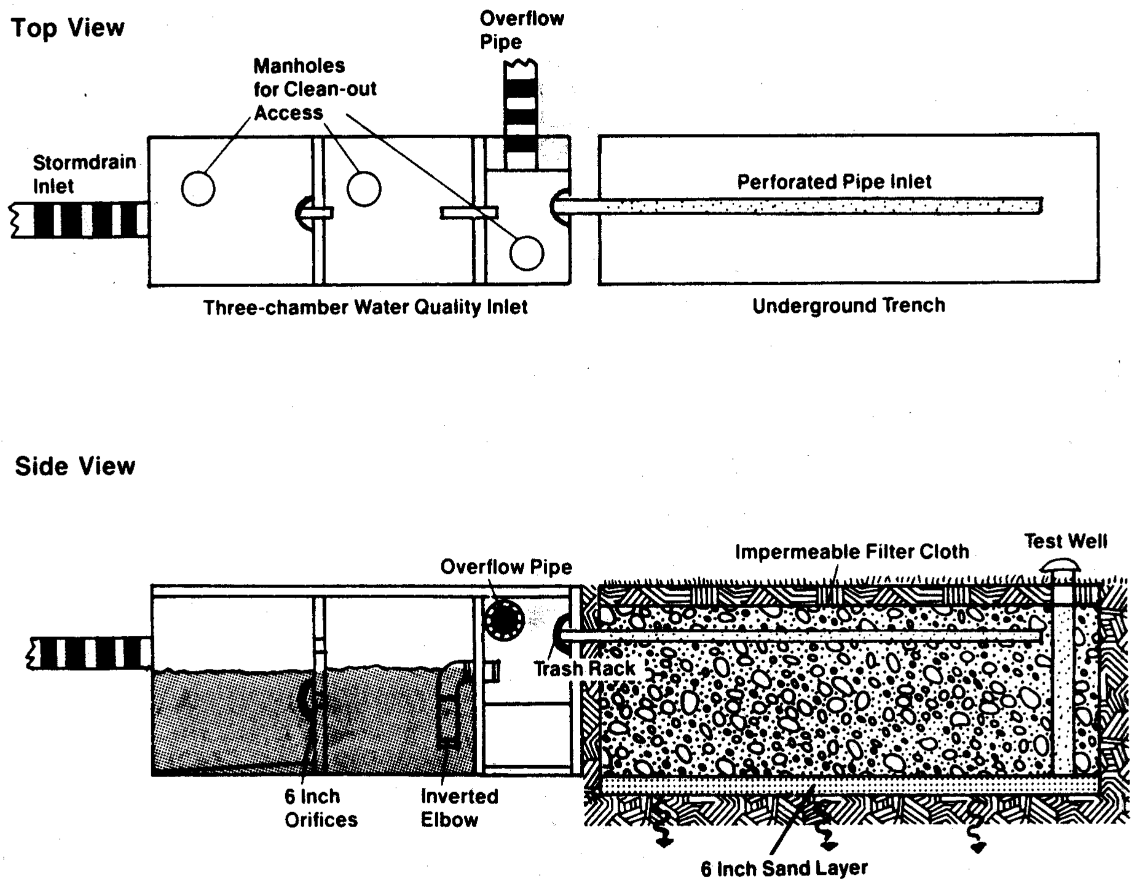

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Figure 3.7 Underground Trench with Oil/Grit Chamber

Surface Cover: A stone-filled trench can be placed under a porous or impervious surface cover to conserve space. If located under an off-street parking lot the following are required:

- Observation wells must be placed no further than 100 feet apart.
- The Maintenance Plan must clearly state that the pavement may have to be removed for maintenance.
- No infiltration facilities shall be allowed under streets or roads, public or private (if more than one parcel is served).

Observation Well: An observation well shall be installed at the lower end of the infiltration trench to check water levels, drawdown time, and sediment accumulation, and to conduct water quality monitoring. Figure 3.2 illustrates observation well details. The well should consist of a perforated PVC pipe 4 to 6 inches in diameter, and be constructed flush with the ground elevation. For larger trenches, a 12- to 36-inch-diameter well can be installed to facilitate maintenance operations (e.g., pumping out sediment). The top of the well shall be capped to discourage vandalism and tampering.

3.2.2.6 Design Criteria

3.2.2.6.1 Trench Cover

The surface of the trench can be covered with grating, or consist of stone, gabion, sand, or a grassed covered area with a surface inlet.

3.2.2.6.2 Distribution Pipe

Perforated rigid pipe at least 8 inches in diameter can also be used to distribute stormwater in the infiltration trench. However, an infiltration trench with distribution pipe is subject to the requirements of the Underground Injection Control (UIC) program (see Section 3.1.3).

3.2.2.6.3 Geometry

Infiltration trenches are generally at least 24 inches wide. However, narrower or wider trenches are allowed if they meet the requirements of this section.

Parallel trenches shall be spaced no closer than 10 feet or based on recommendations of the geotechnical engineer.

Trenches should generally follow a contour line.

3.2.2.6.4 Materials

Backfill Material:

The aggregate material for the infiltration trench must consist of a clean aggregate and meet WSDOT Specification 9-03.12(5) that nominally ranges from 0.75-inch to 1.5-inch diameter. A maximum diameter of 3 inches and a minimum diameter of 1.5 inches may be approved if void space is maintained. Void space for these aggregates must be in the range of 30 to 40 percent.

Geotextile fabric liner: The aggregate fill material shall be completely encased in an engineering geotextile material. Geotextile must surround all of the aggregate fill material except for the top 1 foot, which is placed over the geotextile. Geotextile fabric with acceptable properties must be carefully selected to avoid plugging (see Appendix V-B of Volume V).[3]

A 6-inch minimum layer of sand may be used as a filter media at the bottom of the trench instead of geotextile.

The sand filter shown at the base of the infiltration trenches in the attached figures is optional.

3.2.2.6.5 Spill Control

All infiltration trenches must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a “tee” section is used for spill control, the top of the spill control riser must be set above the infiltration facility’s 100-year overflow elevation to prevent oils from entering the infiltration facility.

3.2.2.7 Construction and Maintenance

Initial trench excavation shall be conducted to within no less than 2 feet of the final elevation of the basin floor. Excavate infiltration trenches to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation must remove all silt accumulation in the infiltration trench before putting it into service. After construction is completed, prevent sediment from entering the infiltration facility by first conveying the runoff water through an appropriate pretreatment system such as a presettling basin, biofiltration swale or filter strip, wet pond, or sand filter.

Infiltration facilities should not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any asilt accumulation in the basin must be removed before putting it into service.

The infiltration facility area shall be clearly identified and protected prior to construction to prevent compaction of underlying soils by vehicle traffic.

Infiltration facilities shall not begin operation until all erosion-causing project improvements are completed and all exposed ground surfaces are stabilized by revegetation or landscaping.

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[3] Refer to the Federal Highway Administration Manual “Geosynthetic Design and Construction Guidelines,” Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications. Refer to the NCHRP Report 367, “Long-Term Performance of Geosynthetics in Drainage Applications,” 1994, for longterm 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.

Trench Preparation: Excavated materials must be placed away from the trench sides to enhance trench wall stability. Care must also be taken to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic (see erosion and sediment control criteria in Volume II).

Stone Aggregate Placement and Compaction: The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.

Potential Contamination: Prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate must be removed and replaced with uncontaminated stone aggregate.

Overlapping and Covering: Following the stone aggregate placement, the geotextile must be folded over the stone aggregate to form a 12 inch minimum longitudinal overlap. When overlaps are required between rolls, the upstream roll must 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. Natural soils should be placed in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. Soil piping, geotextile clogging, and possible surface subsidence will be avoided by this remedial process.

Unstable Excavation Sites: Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.

See Appendix V-C for information on maintenance requirements.

3.2.3 IN.03 Infiltration Vaults, Galleries, and Tanks

This section describes design, construction, and maintenance criteria for infiltration vaults.

Infiltration vaults are typically bottomless underground structures used for temporary storage and infiltration of stormwater runoff to groundwater. Infiltration tanks are large-diameter cylindrical structures with perforations in the base. These types of underground infiltration facilities can be a useful alternative for sites with constraints that make siting an infiltration pond difficult.

3.2.4 Applicability

Infiltration of runoff is the preferred method of flow control following appropriate runoff treatment. Runoff in excess of the infiltration capacity must be detained and released in compliance with the flow control requirement described in Core Requirement 6.

3.2.4.1 Limitations

Because infiltration vaults are difficult to maintain, County acceptance must be gained prior to implementation of this BMP.

Infiltration vaults shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the infiltration vault shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

3.2.4.2 Submittals and Approval

In addition to submittal requirements of Volume I, complete geotechnical investigations and prepare a site suitability analysis per Volume III.

3.2.4.3 Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration swale system, basic filter strip or presettling basin for water quality treatment (see BMP BF.01, BMP BF.04 and BMP WP.05) prior to discharge to an infiltration trench. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

3.2.4.4 Hydrologic and Hydraulic Design Considerations

See Volume III for guidance on determining a design infiltration rate and hydrologic modeling requirements.

Overflow: A primary overflow must be provided to bypass flows over the 100-year postdeveloped peak flow to the infiltration vault.

3.2.4.5 Design Criteria

3.2.4.5.1 Geometry

The maximum depth from finished grade to the vault invert shall be 20 feet.

The minimum internal height shall be 7 feet, measured from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. The minimum internal height requirement may not be needed for any areas covered by removable panels.

3.2.4.5.2 Spill Control

All infiltration vaults must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a "tee" section is used for spill control, the top of the spill control riser must be set above the infiltration facility's 100-year overflow elevation to prevent oils from entering the infiltration facility.

3.2.4.6 Structural Design Considerations

3.2.4.6.1 Materials

Minimum 3,000 psi structural reinforced concrete shall be used for infiltration vaults. All construction joints must be provided with water stops. Pre-cast vaults or vaults made of materials other than concrete may be allowed subject to meeting the requirements of this section and with prior acceptance of the Administrator or designee.

Infiltration vaults may be constructed using material other than reinforced concrete, such as large, perforated, corrugated metal pipe (see Figure 3.8), or plastic provided that the following additional criteria are met:

Bedding and backfill material for the structure must be washed drain rock extending at least 1 foot below the bottom of the structure, at least 2 feet beyond the sides, and up to the top of the structure.

Drain rock must be completely covered with construction geotextile for separation (per the *Standard Specifications*) prior to backfilling. If the drain rock becomes mixed with soil, the affected rock material must be removed and replaced with washed drain rock to provide maximum infiltration effectiveness.

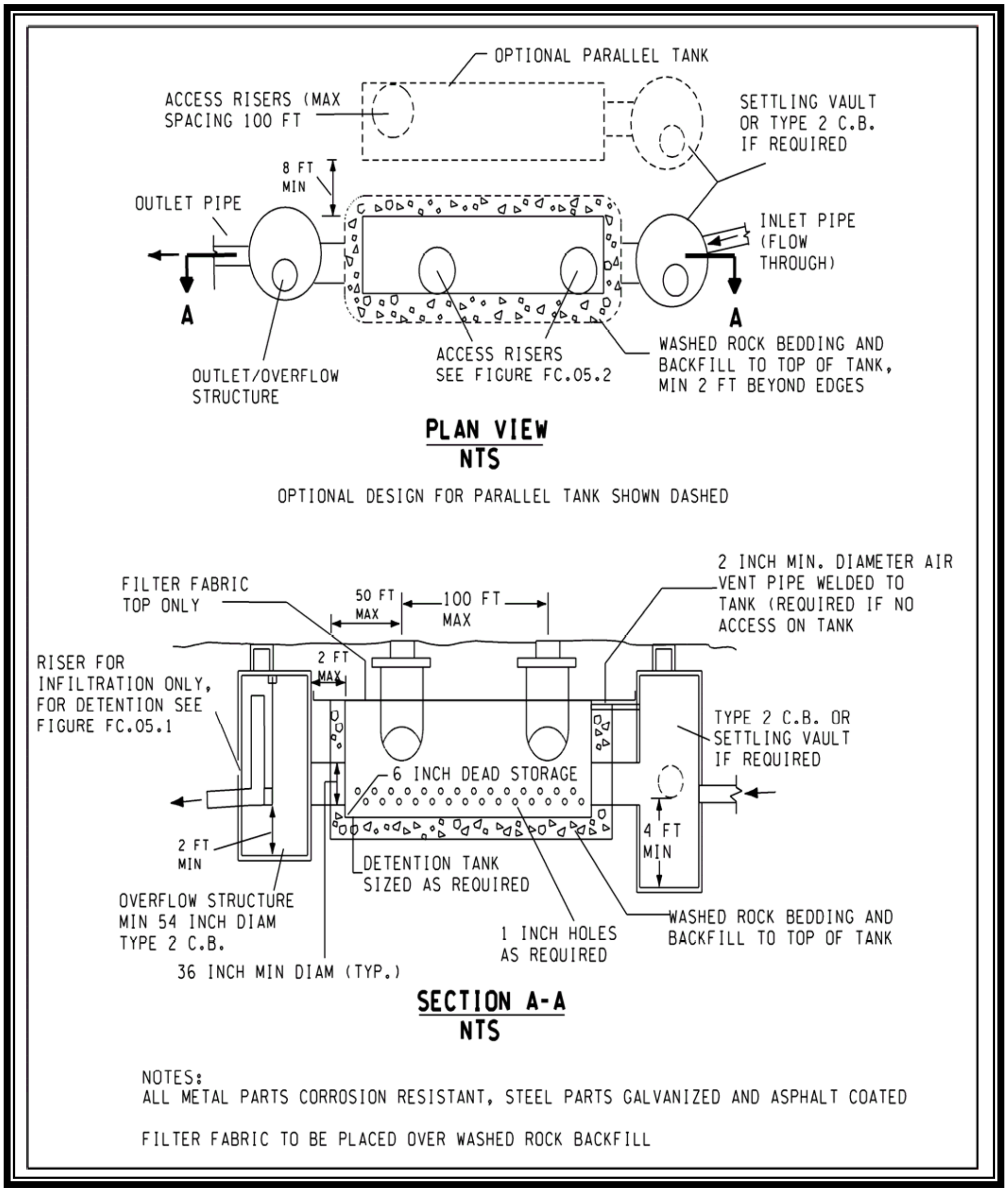


Figure 3.8 Infiltration Vault

The perforations (holes) in the bottom half of the pipe must be 1 inch in diameter and start at an elevation of 6 inches above the invert. The nonperforated portion of the pipe in the lower 6 inches is intended for sediment storage to protect clogging of the native soil beneath the structure.

The number and spacing of the perforations should be sufficient to allow complete infiltration of the soils with a safety factor of 2.0 without jeopardizing the structural integrity of the pipe.

Open bottom stormwater chamber systems may also be used with the construction criteria shown above.

3.2.4.6.2 Structural Stability

All vaults must meet structural requirements for overburden support and H-20 vehicle loading. Vaults located under roadways must meet the live load requirements of the Standard Specifications. Cast-in-place wall sections must be designed as retaining walls. Structural designs for cast-in-place vaults must be stamped by a licensed structural civil engineer. Bottomless vaults must be provided with footings placed on stable, well consolidated native material and sized considering overburden support, traffic loading (assume maintenance traffic, if vault is placed outside right of way), and lateral soil pressures when the vault is dry. Infiltration vaults are not allowed in fill slopes unless a geotechnical analysis approves fill stability. The infiltration medium at the bottom of the vault must be native soil.

3.2.4.6.3 Access

Access must be provided over the inlet pipe and outlet structure. The following guidelines for access shall be used:

- Access openings must be positioned a maximum of 50 feet from any location within the tank. Additional access points may be needed on large vaults. If more than one “v” is provided in the vault floor, access to each “v” must be provided.

- For vaults with greater than 1,250 square feet of floor area, a 5' by 10' removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided as shown in Figure 3.8.

- Ladders and hand-holds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements. Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes as specified below.

- All access openings, except those covered by removable panels, shall have round, solid locking lids, or 3-foot square, locking diamond plate covers.

- Vaults with widths 10 feet or less shall have removable lids.

- Any vault requiring internal structural walls shall provide wall openings sufficient for maintenance access between cells. The openings shall be sized and situated to allow access to the maintenance “v” in the vault floor.

- Vaults must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

- Ventilation pipes (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively removable panels over the entire vault may be provided.

3.2.4.7 Construction and Maintenance

Initial excavation should be conducted to within 1 foot of the final elevation of the infiltration vault base. Final excavation to the finished grade should be deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected. The final phase of excavation should remove all accumulated sediment.

Infiltration vaults, as with all types of infiltration facilities, should generally not be used as temporary sediment traps during construction. If an infiltration vault is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any accumulation of silt in the vault must be removed before the vault is put into service.

Relatively light-tracked equipment is recommended for excavation to avoid compacting the soil beneath the base of the infiltration vault. The use of draglines and trackhoes should be considered. The infiltration area should be flagged or marked to keep equipment away.

See Appendix V-C for information on maintenance requirements.

Chapter 4 - Detention BMPs

4.1 Detention Facility BMPs

Detention facilities temporarily store increased surface runoff from development, meeting performance standards described in Core Requirement #7 for flow control (Volume I). The following types of detention facilities are described in this chapter:

- D.01 Detention Ponds
- D.02 Detention Tanks
- D.03 Detention Vaults
- D.04 Use of Parking Lots for Detention.

4.1.1 D.01 Detention Ponds

Drainage facilities, including detention ponds, should be made attractive features of the urban environment. Pond designers are encouraged to be creative in shaping and landscaping detention ponds and to consider aesthetics as an important design criterion.

4.1.1.1 Applicability

Detention ponds are appropriate for sites large enough for them. Detention ponds are not designed for habitat, in part because they usually drain completely between storms. If a detention facility is needed that provides habitat, flow control and runoff treatment, consider constructed wetlands designed with detention storage (BMP WP.04). Combined constructed wetland and detention ponds occupy a comparable amount of surface area as detention ponds while providing habitat, runoff treatment and a more aesthetically pleasing facility.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the detention pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the detention pond shall be lined. Pond liners may not be used to place detention facilities below the seasonally high groundwater elevation.

4.1.1.2 Limitations

Detention ponds occupy a large amount of surface area, and so are typically not used for sites with a high land cost or dense development.

4.1.1.3 Submittals and Approval

The following information shall be included in required submittals (see Volume I, Chapter 3):

- Hydrologic modeling results showing the how the facility meets the flow control standards (Core Requirement #7 – see Volume I, Chapter 2).
- Details of all structures and material and construction specifications.
- Planting plan showing plant species, quantity, location and any special planting requirements.
- Cross section of the pond through the control structure (additional sections and details may be needed depending on the complexity of the grading).
- Design calculations for the overflow structures.
- Demonstration of how the facility location meets setback requirements.

4.1.1.4 Pretreatment

Pretreatment is not required.

4.1.1.5 Hydrologic and Hydraulic Design Considerations

4.1.1.5.1 General Hydraulic Design Considerations

Detention ponds must be designed as flow-through systems, and a design that maximizes the flow path between inlet and outlet is recommended to promote sedimentation.

Flows must enter the detention pond through a conveyance system separate from the control structure and outflow conveyance system.

4.1.1.5.2 Detention Volume and Outflow

The volume and outflow design for detention ponds must comply with both Core Requirement #7 in Volume I, and hydrologic analysis and design methods described in Volume III. See Appendix V-A for design guidelines for restrictor orifice structures.

4.1.1.5.3 Infiltration Considerations

Detention ponds may be sited on soils that are sufficiently permeable for a properly functioning infiltration system (see Section 3.2). These detention ponds have a surface discharge, and may also use infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements in Section 3.2 for infiltration ponds and Volume III for a soils report, testing, groundwater protection, presettling, and construction techniques.

4.1.1.5.4 Primary Overflow

The detention pond must have a primary overflow (usually a riser pipe within the control structure – see Appendix V-A) 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. The design must provide controlled discharge directly into the downstream conveyance system or other acceptable discharge point.

4.1.1.5.5 Secondary Inlet to Control Structure

A secondary inlet to the control structure must be provided in ponds as additional protection against overtopping if the control structure inlet becomes plugged. A grated opening in the control structure manhole functions as a weir when used as a secondary inlet (see Appendix V-A).

Note: The maximum circumference of this opening must not exceed one-half the control structure circumference. The “birdcage” overflow structure shown in Appendix V-A may also be used as a secondary inlet.

4.1.1.5.6 Emergency Overflow Spillway

Ponds must have an emergency overflow spillway (except as noted in the next paragraph). For impoundments of 10 acre-feet or greater, the emergency overflow spillway must meet the state’s dam safety requirements. For impoundments under 10 acre-feet, ponds must have an emergency overflow spillway 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.

As an alternative to an emergency overflow spillway for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 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 Appendix V-A. 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 toward a steep slope, consideration shall be given to providing an emergency overflow structure in addition to the spillway.

The emergency overflow spillway must be armored with riprap in conformance with the Outlet Protection BMP in Volume II. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows reenter the conveyance system (see Figure 4.2).

Design the emergency overflow spillway to allow a minimum of 1 foot of freeboard above the design water surface elevation.

4.1.1.5.6.a 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 (see Appendix V-A).

4.1.1.6 Design Criteria

See Figure 4.1 and Figure 4.2 for typical detention pond layout.

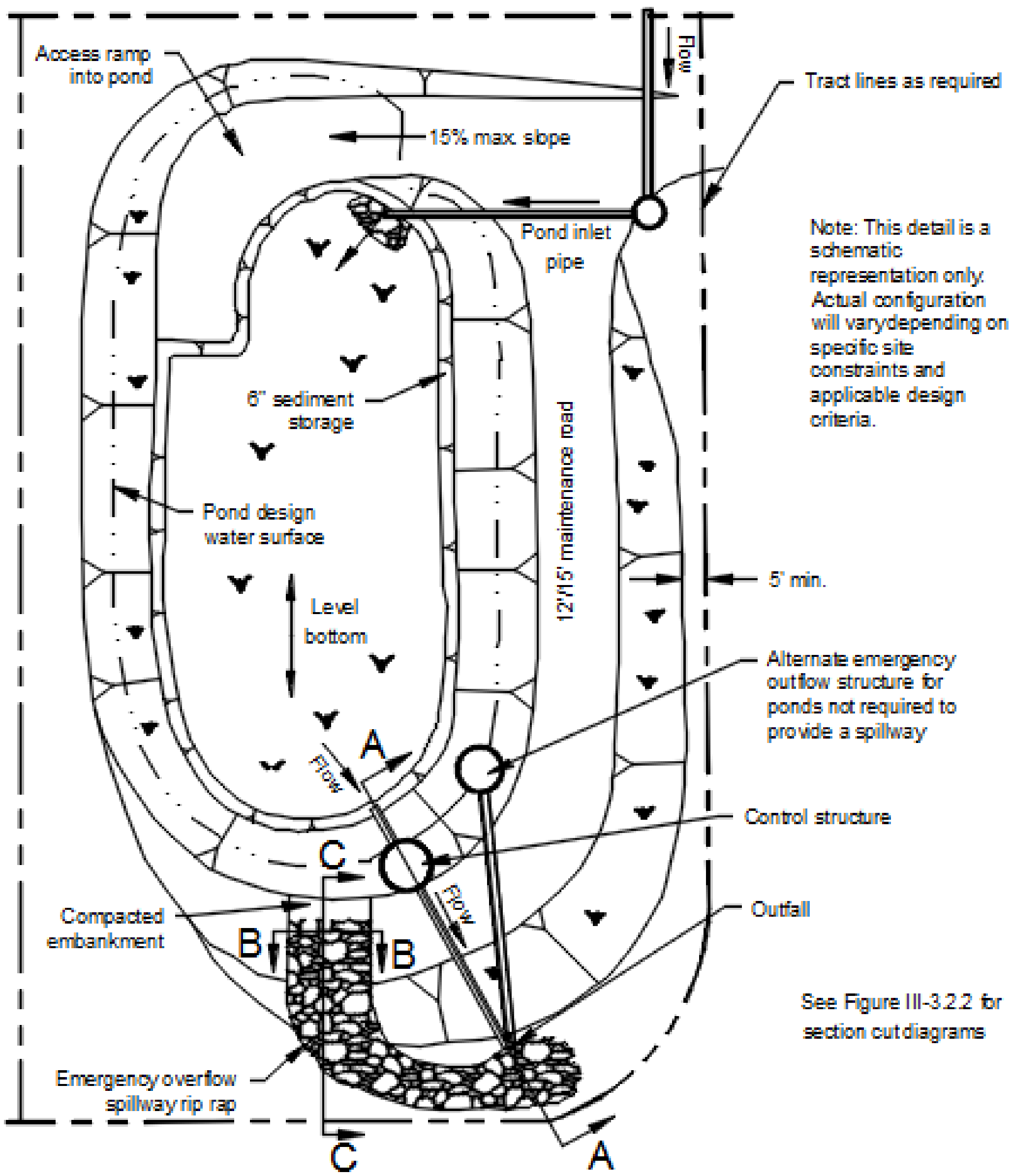


Figure 4.1 Typical Detention Pond

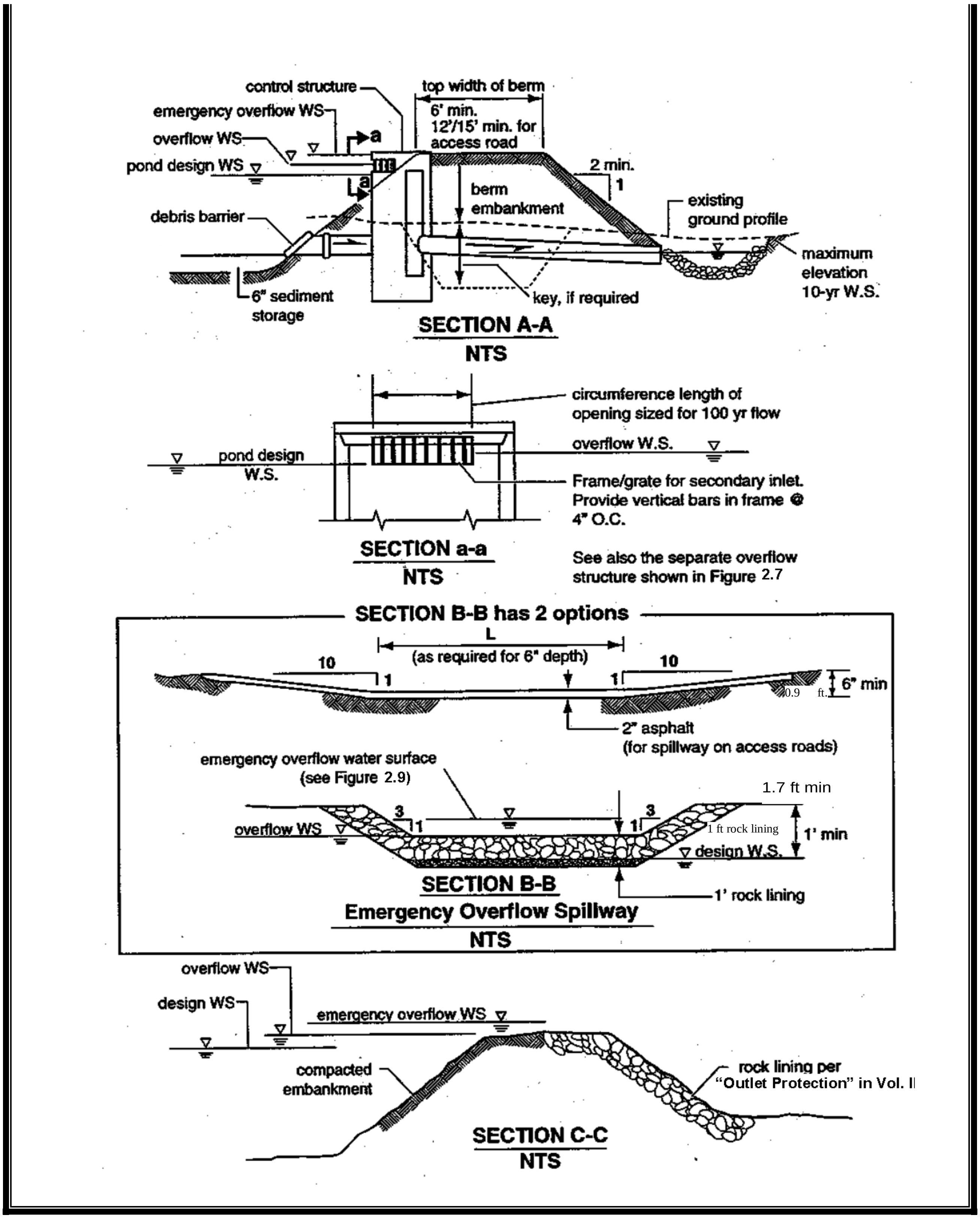


Figure 4.2 Typical Detention Pond Sections

4.1.1.6.1 Geometry

- Pond bottoms must be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.
- Interior side slopes up to the emergency overflow water surface shall not be steeper than 3H:1V unless a fence is provided (see Appendix V-E, Fencing).
- Exterior side slopes must not be steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.

4.1.1.7 Structural Design Considerations

4.1.1.7.1 Ponds Located near Steep Slopes or Landslide Hazard Areas

A geotechnical analysis and report must be prepared for work located within 300 feet of the top of a slope designated a landslide hazard area (as defined in Thurston County Code Title 17.15.600, typically 50 percent, or lesser slopes if seeps are present). The scope of the geotechnical report shall include the assessment of impoundment seepage on the stability of natural slopes where the facility will be located within the setback limits of steep slopes (greater than 15 percent and 10 foot height).

The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or other prohibitions may result from this report. The geotechnical analysis and report shall address the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

4.1.1.7.2 Vertical Side Slopes

Vertical retaining walls including rockeries, concrete, masonry unit walls, and keystone type walls may be used to contain the pond, provided:

- They are designed by a licensed geotechnical engineer or civil engineer with structural experience and account for the saturated conditions of the base and retained soils. Structural calculations are stamped by the professional engineer.
- A fence is provided along the top of the wall (see Appendix V-E)
- The entire 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
- An access ramp to the bottom of the pond is provided.

4.1.1.7.3 Embankments

Pond berm embankments must meet the following requirements:

- Constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report), which is free of loose surface soil materials, roots and other organic debris

- Constructed by excavating a "key" equal to 50 percent of the berm embankment cross-sectional height and width (except on till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till)

- Constructed of compacted soil (a minimum of 95 percent of the maximum dry density, standard proctor method per ASTM D1557) placed in 6 inch lifts, with the following soil characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 30 percent clay, a maximum of 60 percent sand, a maximum of 60 percent silt, with nominal gravel and cobble content or as recommended by a geotechnical engineer. (Note: glacial till is normally well-suited for berm embankment material) The core shall be adequate to make the embankment impervious.

- Anti-seepage collars shall be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth at the design water surface.

- Exposed earth on the pond side slopes shall be sodded or seeded with appropriate seed mixture (see Volume II, Erosion and Sedimentation Control BMPs). Establishment of protective vegetative cover shall be ensured with appropriate surface protection BMPs and reseeded as necessary.

- Where maintenance access is provided along the top of the berm, the minimum width of the top of the berm shall be 15 feet.

- Pond berm embankments greater than 6 feet in height shall require a design by a qualified Professional Engineer licensed in the State of Washington. Berm embankment width shall otherwise vary as recommended by the Professional Engineer.

- Embankments less than 6 feet in height shall have a minimum 6 foot top width and slopes not to exceed 2H:1V. However, maintenance access for mowing and pond access must still be provided.

- Embankments adjacent to a stream or other body of water shall be sufficiently protected with riprap or bio-engineering methods to prevent erosion of the pond embankment. Other control measures may be necessary to protect the embankment.

- Exterior and interior side slopes of retention and detention ponds that are steeper than 2H:1V, must be analyzed for stability by a qualified civil or geotechnical engineer.

- Anti-seepage filter-drain diaphragms must be placed on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Part IV, Section 3.3.B (pages 3-27 to 3-30) of the Dam Safety Guidelines (Ecology 2004). An electronic version of the Dam Safety Guidelines is available in PDF format at <http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html>.

4.1.1.7.4 Dam Safety for Detention BMPs

Stormwater facilities that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level *at the embankment crest* 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 these ponds are typically designed to accommodate.

Electronic versions of dam safety guidance documents in PDF format are available on the Department of Ecology Web site at: <http://www.ecy.wa.gov/programs/wr/dams/dss.html>.

4.1.1.8 Site Design Elements

For planting recommendations, setbacks, signage and fencing, see Appendix V-E.

4.1.1.9 Construction and Maintenance

For access road design information, see Appendix V-D.

4.1.1.9.1 Maintenance

Maintenance can help ensure that detention ponds continue to function as originally designed. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Thurston County, a designated group (such as a homeowner's association) or some individual must accept responsibility for maintaining the structures and the impoundment area. It is Thurston County policy not to accept maintenance responsibility for facilities constructed by a private applicant even if they serve runoff from the public right-of-way.

A maintenance plan must be formulated that outlines the schedule and scope of maintenance operations. See Appendix V-C for information on maintenance requirements for detention ponds.

Any standing water removed during the maintenance operation must be disposed of at an approved discharge location. Any discharge to a sanitary sewer system requires approval of the sewer service provider and is generally not allowed. Pretreatment may be necessary if standing water is not free of pollutants. Residuals must be disposed in accordance with state and local solid waste regulations (see Minimum Functional Standards for Solid Waste Handling, Chapter 173-304 WAC).

4.1.2 D.02 Detention Tanks

Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figure 4.3 and Figure 4.4.

4.1.2.1 Applicability

Detention tanks are appropriate for highly developed sites with limited land available for surface facilities.

4.1.2.2 Limitations

Detention tanks are typically laid flat or at a very low slope, so they are not likely appropriate for steep sections of roadway, due to the large amount of excavation required.

Tanks shall not be located under the travel way in public rights-of-way.

4.1.2.3 Hydrologic and Hydraulic Design Considerations

4.1.2.3.1 General Hydraulic Design Considerations

Tanks may either be designed as flow-through or back-up systems (see Figure 4.3).

4.1.2.3.2 Detention Volume

The volume and outflow design for detention tanks must comply with both Core Requirement #7-Flow Control in Volume I and hydrologic analysis and design methods described in Volume III.

4.1.2.3.3 Control Structures

Details of outflow control structures are given in Appendix V-A.

Tanks may be designed as flow-through systems or may be designed as backup systems if preceded by water quality facilities, 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.

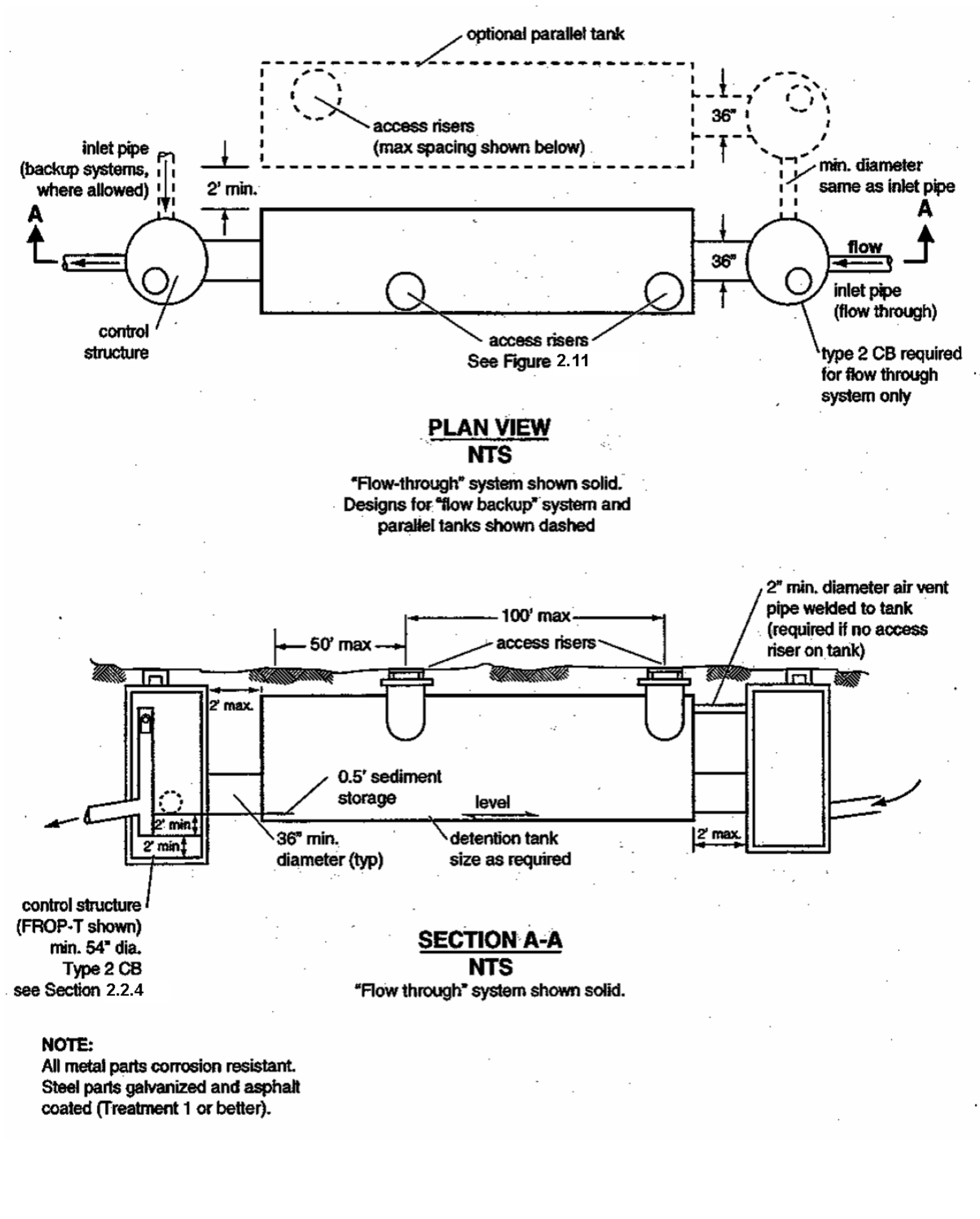
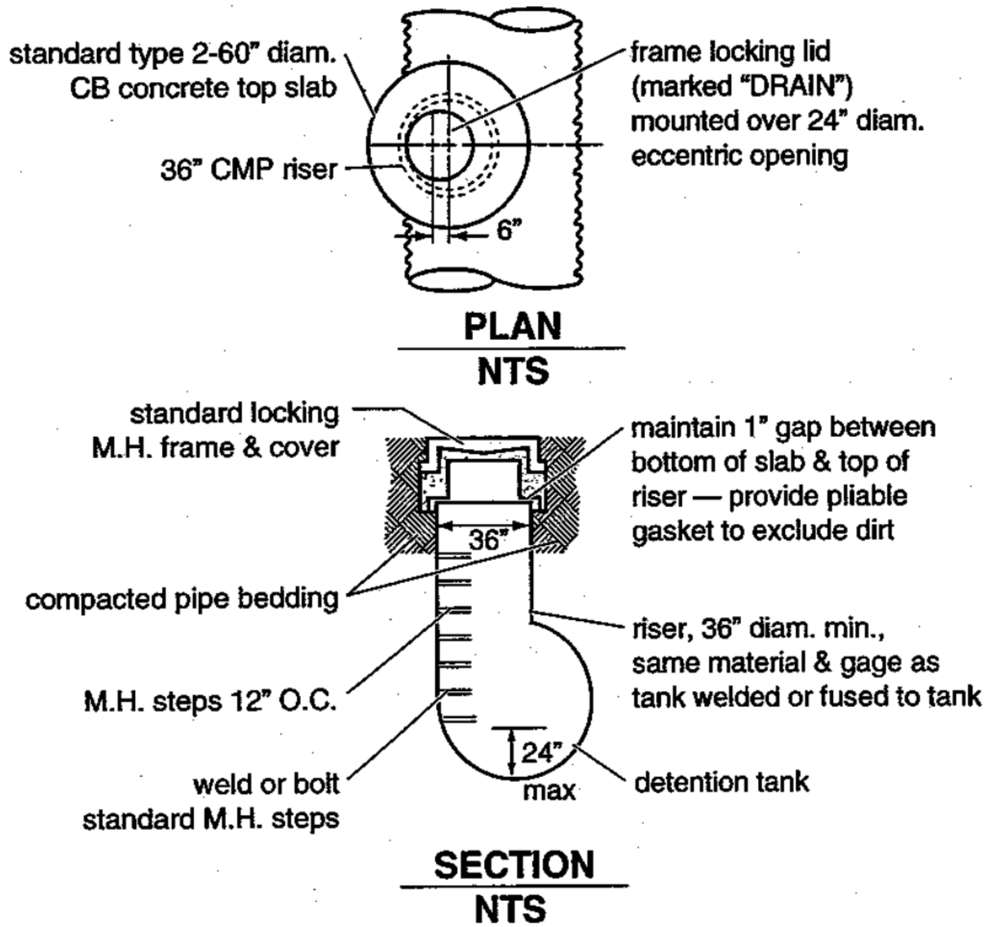


Figure 4.3 Typical Detention Tank



Notes:

1. Use adjusting blocks as required to bring frame to grade.
2. All materials to be aluminum or galvanized and asphalt coated (Treatment 1 or better).
3. Must be located for access by maintenance vehicles.
4. May substitute WSDOT special Type IV manhole (RCP only).

Figure 4.4 Detention Tank Access Detail

4.1.2.4 Design Criteria

4.1.2.4.1 Geometry

The detention tank bottom shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.

The minimum pipe diameter for a detention tank is 36 inches.

Tanks larger than 36 inches shall be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe. These sections will not be considered as access when determining required access points.

The maximum depth to a detention tank invert shall be 20 feet.

4.1.2.4.2 Materials

Materials for underground detention tanks shall conform to requirements for conveyance systems described in Volume III. Materials for pipe shall be limited to:

Aluminum spiral rib pipe (12-gauge minimum)

Corrugated aluminum pipe and pipe arch (12-gauge minimum)

Reinforced concrete pipe

Corrugated high density polyethylene pipe (CPEP) – Smooth interior

Steel reinforced polyethylene (SRPE)

No corrugated iron or steel pipe (galvanized or aluminized) will be allowed. Galvanized metals leach zinc into the environment, especially in standing water situations. This can result in zinc concentrations that are toxic to aquatic life. Therefore, use of galvanized materials in stormwater facilities and conveyance systems is prohibited.

Pipe material, joints, and protective treatment for tanks shall be in accordance with Section 9.05 of the *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction*.

Detention tanks are not to be perforated so as to provide infiltration of stormwater.

4.1.2.5 Structural Design Considerations

4.1.2.5.1 Structural Stability

Tanks must meet structural requirements for overburden support and traffic loading (if appropriate). H-20 live loads shall be accommodated for tanks lying under parking areas and access roads. Metal tank end plates shall be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe, and may require reinforcing ribs. Tanks shall be placed on stable, well-consolidated native material with a suitable bedding. Tanks shall not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

4.1.2.5.2 Buoyancy

Buoyancy calculations shall be required where groundwater may induce flotation. Buoyancy must be balanced by ballasting with backfill or concrete backfill, providing concrete anchors, increasing total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations that demonstrate stability must be documented by the project engineer.

4.1.2.5.3 Access

Access requirements for detention tanks are as follows:

Access must be provided to the upstream terminus of the tank if the tank is designed with a common inlet/outlet (e.g., a backup system rather than a flow through system).

All tank openings must be easily accessible by maintenance vehicles.

The maximum depth from finished grade to tank invert shall be 20 feet.

Access points must support expected wheel loads.

Access openings shall be positioned a maximum of 50 feet from any location within the tank.

All tank access openings shall have round, solid locking lids (usually 1/2- to 5/8-inch diameter Allen-head cap screws).

Thirty six-inch minimum diameter CMP riser-type manholes (Figure 4.4) 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.

Tanks must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

4.1.2.6 Site Design Elements

Detention tanks shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the detention tank shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

4.1.2.7 Setbacks

All stormwater vaults and tanks shall be setback from any structure or property line at least a distance equal to the depth of the ground disturbed in setting the structure. Additional setbacks are listed under BMP D.01 – Detention Pond and Appendix V-E. Vaults and tanks shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Section 3.6 of Volume III.

All facilities must be a minimum of 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

4.1.2.8 Construction and Maintenance

4.1.2.8.1 Maintenance

Provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix V-C for specific maintenance requirements.

4.1.2.8.2 Access Roads

Access roads are needed to all detention tank control structures and risers. The access roads shall be designed and constructed as specified in Appendix V-D. Access shall be provided through a tract or easement connecting to a public right-of-way. See additional access requirements in Volume III.

4.1.3 D.03 Detention Vaults

4.1.3.1 Applicability

Detention vaults are box-shaped underground storage facilities typically constructed with reinforced concrete. Detention vaults are appropriate for highly developed sites with limited land available for surface facilities.

4.1.3.2 Hydrologic and Hydraulic Design Considerations

4.1.3.2.1 Detention Volume and Outflow

Volume and outflow design for detention vaults must comply with both Core Requirement #7 in Volume I, and the hydrologic analysis and design methods described in Volume III.

Restrictor and orifice design are given in Appendix V-A.

Details of outflow control structures are given in Appendix V-A.

4.1.3.3 Design Criteria

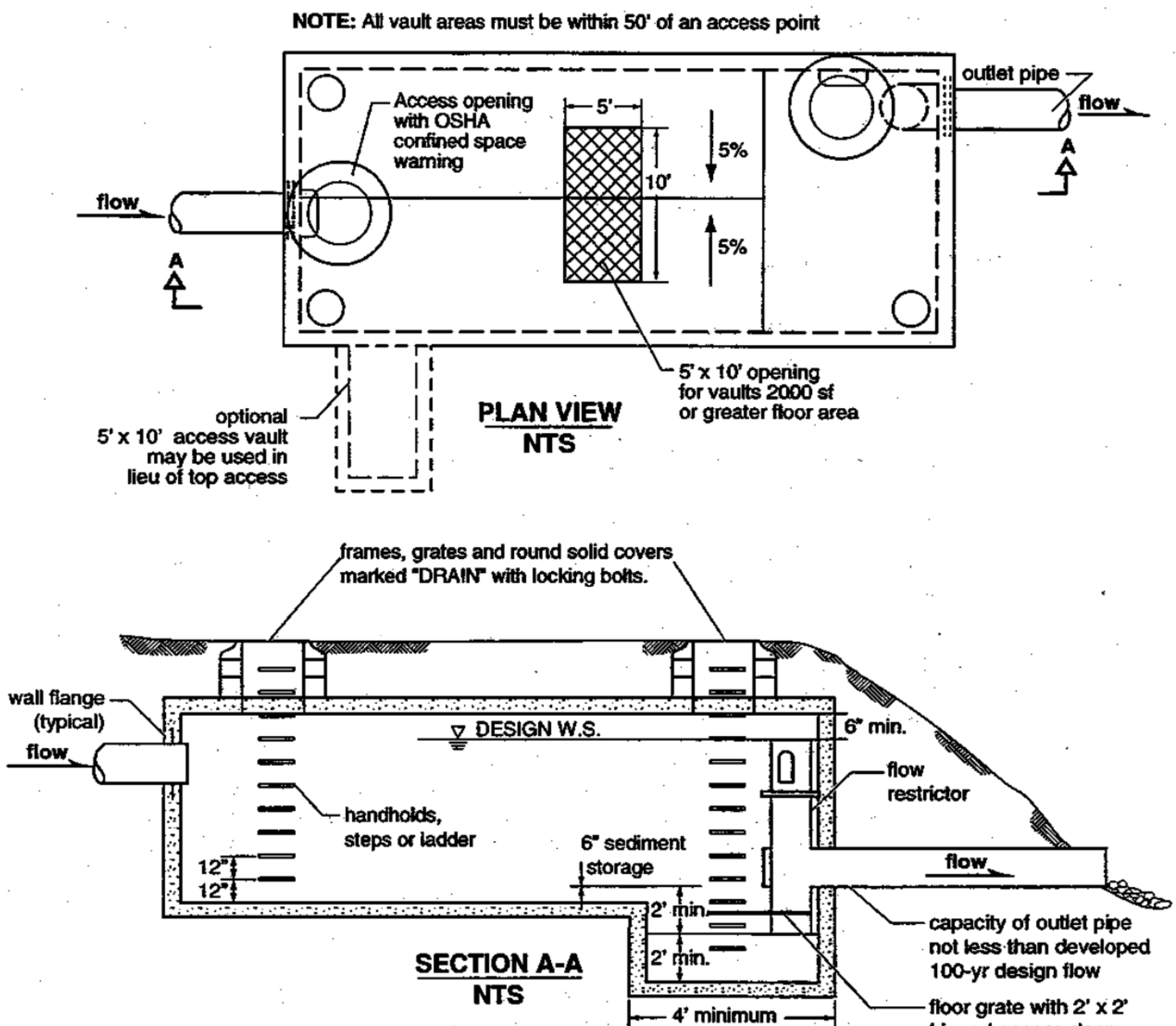
A standard detention vault detail is shown in Figure 4.5. Control structure details are shown in Appendix V-A.

Typical design guidelines are as follows:

Detention vaults may be designed either as flow through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet should be maximized where feasible.

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. Alternatively, the vault bottom may be flat with 0.5 to 1 foot of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

The invert elevation of the outlet shall be elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. The outlet shall also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment I 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.

Figure 4.5 Typical Detention Vault

4.1.3.3.1 Geometry

The maximum depth from finished grade to the vault invert shall be 20 feet

The minimum internal height shall be 7 feet, measured from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. The minimum internal height requirement may not be needed for any areas covered by removable panels.

4.1.3.4 Structural Design Considerations

4.1.3.4.1 Materials

Minimum 3,000 psi structural reinforced concrete shall be used for detention vaults. All construction joints must be provided with water stops. Pre-cast vaults or vaults made of materials other than concrete may be allowed subject to meeting the requirements of this section and with prior acceptance of the Administrator or designee.

4.1.3.4.2 Structural Stability

All vaults shall meet structural requirements for overburden support and H-20 traffic loading (See Standard Specifications for Highway Bridges, 1998 Interim Revisions, American Association of State Highway and Transportation Officials). Cast-in-place wall sections shall be designed as retaining walls. Structural designs for cast-in-place vaults shall be stamped by a licensed civil engineer with structural expertise. Vaults shall be placed on stable, well-consolidated native material with suitable bedding. Vaults shall not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

4.1.3.4.3 Access

Access must be provided over the inlet pipe and outlet structure. The following guidelines for access shall be used:

Access openings must be positioned a maximum of 50 feet from any location within the tank. Additional access points may be needed on large vaults. If more than one “v” is provided in the vault floor, access to each “v” must be provided.

For vaults with greater than 1,250 square feet of floor area, a 5' by 10' removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided as shown in Figure 4.5.

Ladders and hand-holds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements. Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes as specified below.

All access openings, except those covered by removable panels, shall have round, solid locking lids, or 3-foot square, locking diamond plate covers.

Vaults with widths 10 feet or less shall have removable lids.

Any vault requiring internal structural walls shall provided wall openings sufficient for maintenance access between cells. The openings shall be sized and situated to allow access to the maintenance "v" in the vault floor.

Vaults must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Ventilation pipes (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively removable panels over the entire vault may be provided.

4.1.3.5 Site Design Elements

Detention vaults shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the detention vault shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

4.1.3.5.1 Setbacks

All stormwater vaults shall be setback from any structure or property line at least a distance equal to the depth of the ground disturbed in setting the structure. Additional setbacks are listed under BMP D.01 – Detention Pond and in Appendix V-E. Vaults shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Section 3.6 of Volume III.

All facilities must be a minimum of 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

4.1.3.6 Construction and Maintenance

4.1.3.6.1 Maintenance

Maintenance must be a basic consideration in design and in determination of first cost. Provisions to facilitate maintenance operations must be built into the vault, including panels, access openings, and openings between structural interior walls as applicable, as specified under *structural design considerations*, above.

See Appendix V-C for additional information on maintenance requirements.

4.1.3.6.2 Access

An access road must be provided to the control structure, panels, and other maintenance openings. See Appendix V-D for design and construction requirements.

4.1.4 D.04 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 if the following requirements are met:

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.

The gradient of the parking lot area subject to ponding is 1 percent or greater.

The emergency overflow path is identified and noted on the engineering plan. The overflow must not create a significant adverse impact to downhill properties or drainage system.

Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.

No overflow to a public right-of-way occurs.

Chapter 5 - Biofiltration BMPs

5.1 Biofiltration BMPs

Biofiltration provides runoff treatment by combining vegetation with slow and shallow-depth flow. As runoff passes through the vegetation, pollutants are removed by filtration, infiltration, and settling. These effects are aided by the reduction in velocity of stormwater as it passes through the biofilter. Biofiltration facilities include *swales*, designed to convey and treat concentrated runoff at shallow depths and slow velocities, and *filter strips*, broad areas of vegetation for treating sheet flow runoff.

A biofilter can be used as a basic treatment BMP for stormwater runoff from roadways, driveways, parking lots, and other pollution generating pervious and impervious surfaces. It can also be used as the first stage of a treatment train, multiple BMPs in a series for treating contaminated stormwater runoff. Placement of the biofilter “off-line” is preferred to on-line applications to avoid flattening of the vegetation and the erosive effects of high flows.

Generally biofiltration BMPs are suitable for sites that have the following characteristics:

Accessibility for operation and maintenance

Suitable growth environment (soil, exposure to sunlight, etc.) for the vegetation

Adequate change in grade to allow inflow to the biofilter and conveyance to additional treatment/detention facilities located downstream.

The following biofiltration BMPs are described in this section:

BF.01 Basic Biofiltration Swale

BF.02 Wet Biofiltration Swale

BF.03 Continuous Inflow Biofiltration Swale

BF.04 Basic Filter Strip

BF.05 Narrow Area Filter Strip

5.1.1 BF.01 Basic Biofiltration Swale

Biofiltration swale with check dams at Ecology headquarters

5.1.1.1 Applicability

Biofiltration swales are a low-cost, easy to construct and maintain BMP that provides basic treatment or provides pretreatment for an infiltration facility or for another enhanced BMP.

5.1.1.2 Limitations

Basic biofiltration swales require a substantial amount of open space and flat, longitudinal slopes, and so will not work on every site. A site suitable for biofiltration swales should have the following:

Adequate space to accommodate the swale (a minimum of 100 feet long with a bottom width of 2 feet; may be larger depending on flows)

A longitudinal slope between 1.5 percent and 2.5 percent. Shallower slopes would require an underdrain and steeper slopes would require check dams at vertical drops of 12 to15 inches.

Maintenance access.

5.1.1.3 Submittals and Approval

Biofiltration swale calculations as outlined in this section shall be provided for each biofiltration swale included in the project. Include calculations in the submittal completed in accordance with the requirements of Volume I, Chapter 3.

Project drawings shall show the location, slope, and bottom width of each biofiltration swale. Detail sheets shall include a biofiltration swale cross-section and specifications for seeding, amending soils, sodding and other design criteria as described in this section.

5.1.1.4 Pretreatment

Pretreatment is not required.

5.1.1.5 Hydrologic and Hydraulic Design Considerations

Table 5-1 Sizing Criteria Biofiltration Swale

Design Parameter	Requirement
Longitudinal Slope	0.015 – 0.025 (unless underdrain or check dams are included in the design - see note 1.)
Maximum Velocity	1 ft/sec
Maximum velocity for channel stability[2]	3 ft/sec
Maximum water depth	2" – if mowed frequently; 4" if mowed infrequently
Manning coefficient	0.2-0.3 (0.24 if mowed infrequently
Bed width (bottom)	2-10 ft (unless dividing berm and flow spreader are incorporated into the design – see note 3.)
Freeboard height	0.5 ft
Minimum hydraulic residence time at K multiplied by WQ Design Flow Rate	9 minutes (18 minutes for continuous inflow)
Minimum length	100 ft
Maximum sideslope	3H:1V 4H:1V preferred (backslope of 2H:1V allowed for limited right-of-way areas)

Notes:

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 drain 6 inches 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 5 inch Schedule 40 PVC perforated pipe or equivalent with 6 inches of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric.
2. Maximum flowrate for channel stability shall be the 100-year, 24-hour discharge calculated with WWHM using a 15-minute time step, or alternatively the 100-year, 24-hour event using a single event hydrologic model (SBUH or SCS).
3. 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.

5.1.1.5.1 Design Process Overview

To design a biofiltration swale for a project, perform the following per the detailed design guidance included in this section:

Identify the location on the site, available slope constraints, and contributing area to the swale. Determine if swale will be upstream or downstream of detention and whether on-line or off-line. Note: if swale is downstream of detention a "wet biofiltration swale" swale design is required, see BMP BF.02.

If slope is less than 1.5 percent, an underdrain will be required. If slope greater than 2.5 percent check dams will be required.

Perform hydrologic modeling to establish design flows using either a single-event model (SBUH or SCS) or continuous simulation model.

Size the swale to treat the water quality design event. Minimum length is 100 feet.

Check the hydraulic capacity/stability of the swale under the 100-year flow condition (for on-line swale only).

Select vegetation cover suitable for the swale.

Determine need for level spreader and establish spacing/design.

5.1.1.5.2 Design Flow

Biofiltration swales shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (Volume III). If hydrologic calculations are being performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio from Figure 5.1and Figure 5.2 (for online or off-line swales, respectively) to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures. Recent biofiltration sizing recommendations (9 minutes detention at the peak design flow rate estimated by SBUH for a 6-month, 24-hour storm with a Type 1A rainfall distribution) will be maintained until more definitive information on bioswale performance is collected.

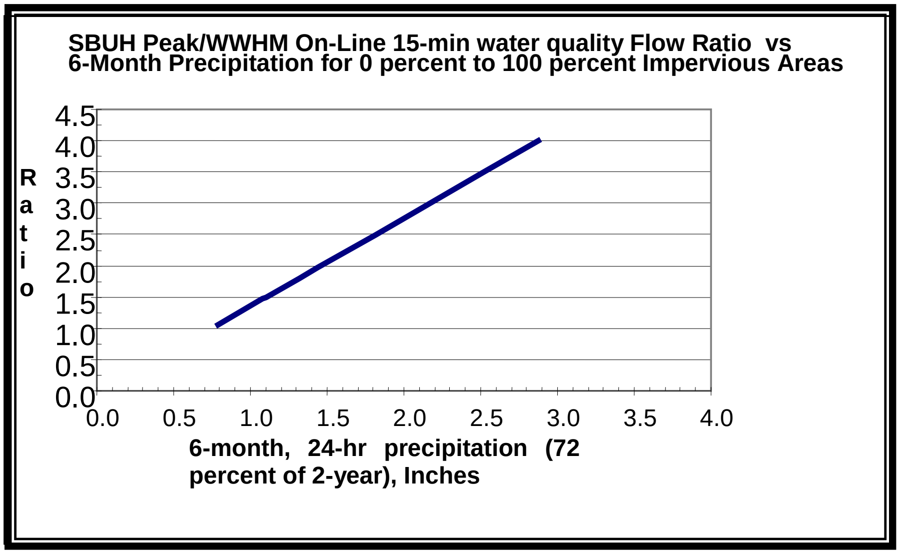


Figure 5.1 Ratio of SBUH Peak/Water Quality Flow

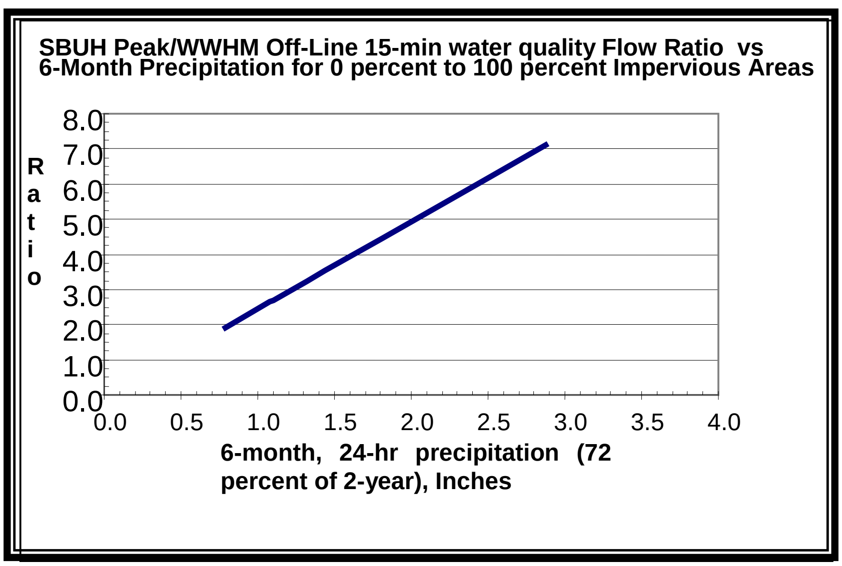


Figure 5.2 Ratio of SBUH Peak/Water Quality Flow

5.1.1.5.3 Guidance for Bypassing Off-line Facilities

Biofiltration swales should be designed as off-line facilities, which receive only the water quality design flow rate, where feasible. For online systems, designers must evaluate the hydraulic capacity/stability for inflows greater than design flows. When designing a swale to be off-line, the stability check described under *Sizing Procedure for Biofiltration Swales* is not required.

Swales designed in an off-line mode shall not engage a bypass until the flow rate exceeds the water quality design flow rate.

5.1.1.5.4 Hydraulic Residence Time

The swale length must be a minimum of 100 feet. Swale length is determined by selecting swale slope and sectional properties that keep velocity below 1.0 feet per second for the water quality design flow rate and provide a minimum 9-minute hydraulic residence time (see Step D-7).

5.1.1.5.5 Velocity

The maximum velocity under the design flow rate is 1.0 feet per second. A velocity greater than 1.0 feet/sec has been found to flatten grasses, thus reducing filtration.

5.1.1.5.6 Sizing Procedure for Biofiltration Swales

This guide provides biofilter swale design procedures in full detail, along with examples.[4]

5.1.1.5.6.a Preliminary Steps (P)

P-1 Determine the Water Quality design flow rate (Q) in 15-minute time-steps using an approved continuous runoff model. Use the correct flow rate, off-line or online, for your design situation. Alternatively, use SBUH (Volume III) to calculate water quality design flow rate (6-month, 24-hour storm), in which case the correction factor, K, will not be required.

P-2 Establish preliminary geometry for your swale depending on your site. For initial calculations, assume the following (note that some of these design criteria may be modified if needed by adding underdrains or check dams but these are good initial assumptions):

Longitudinal slope of 1.5 to 2.5 percent

Minimum length 100 feet

Width of 2 to 10 feet

Side slopes of 3H:1V or flatter. (2H:1V Allows for backslope only in limited right-of-way applications).

[4] WSDOT has developed a biofiltration swale design spreadsheet that available at http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm

5.1.1.5.6.b Design Calculations for Biofiltration Swale

D-1. Select the design depth of flow:

2” if mowed frequently; 4” if mowed infrequently

D-2. Select a value of Manning's n.

The manning coefficient will depend on the vegetation selected and the frequency of mowing. It should be in the range of 0.2 – 0.3. A manning coefficient of no less than 0.24 should be used if the swale will be mowed infrequently.

D-3. Select swale shape-typically trapezoidal.

D-4. Set up a table or spreadsheet relating flow depth to hydraulic radius, flow area, and wetted perimeter. For a trapezoidal channel, the relations will be as follows:

$A = by + (Z_1y^2 + Z_2y^2)/2$

Wetted perimeter, $P = b + d(\sqrt{1+Z_1^{\ 2}} + \sqrt{1+Z_2^2})$

Hydraulic Radius, R = A/P

Where:

A = cross-sectional area of flow (square feet)

b = bottom width of trapezoid (feet)

y = flow depth (feet)

Z_1 = side slope on one side of trapezoid ([ft of horizontal distance]/[ft of vertical distance])*;

Z_2 = side slope on other side of trapezoid ([ft of horizontal distance]/[ft of vertical distance])*

*For example, if a swale has side slopes of 3 (horizontal): 1 (vertical), $Z_1 = Z_2 = 3$.

D-5. Use Chezy-Manning equation (which yields velocity), multiplied by the area to calculate conveyance capacity and determine whether swale has adequate capacity to convey water quality design flow within maximum flow depth and velocity constraints.

$$v = \frac{1.49}{n} R^{2/3} \sqrt{s}, \text{ and}$$

$$Q = vA$$

$Y \leq 0.17$ feet if mowed frequently; $y \leq 0.33$ feet if mowed infrequently.

$V \leq 1$ foot per second.

If the velocity exceeds 1.0 feet/sec, adjust the swale geometry (wider swale bottom, flatter side slopes, and/or flatter longitudinal slope) and repeat steps D-4 and D-5 until the condition is met.

D-7. Compute the swale length (L, feet)

L = Vt

Where: t = hydraulic residence time (seconds), or 540 seconds (9 minutes).

If a biofilter length is greater than the space permits, investigate how Q can be reduced (e.g., use of LID BMPs). Alternatively, reduce velocity by adjusting the swale geometry (wider swale bottom, flatter side slopes, and/or flatter longitudinal slope) and repeat the analysis.

D-8. If there is still not sufficient space for the biofilter, consider the following solutions:

Divide the site drainage to flow to multiple biofilters

Use infiltration to provide lower discharge rates to the biofilter (only if the infiltration requirements in Volume III are met)

Reduce the developed surface area to gain space for biofiltration

Nest the biofilter within or around another BMP.

5.1.1.5.6.c Check for Stability (Minimizing Erosion)

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. Maintain the same units as in the biofiltration capacity analysis.

The maximum permissible velocity for erosion prevention (Vmax) is 3 feet per second.

SC-1. Calculate 100-year recurrence interval flow using 15-minute time steps using an approved continuous runoff model or the 100-year recurrence interval, 24-hour flow from a single event model (SBUH, SCS). If 15-minute time steps are not available in the continuous simulation runoff model, the designer can use the100-year hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps.

SC-2. Estimate the vegetation coverage ("good" or "fair") and height when the biofilter 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.

SC-3. Estimate the degree of retardance from Table 5-2. When uncertain, be conservative by selecting a relatively low degree.

Table 5-2 Guide for Selecting Degree of Retardance [(a)]

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

[a] 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.

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.

SC-5. See Figure 5.2 to obtain a first approximation for VR, VR_{approx}.

SC-6. Compute hydraulic radius, R_{100}, from VR in Figure 5.2 and a Vmax of 3 ft/second,

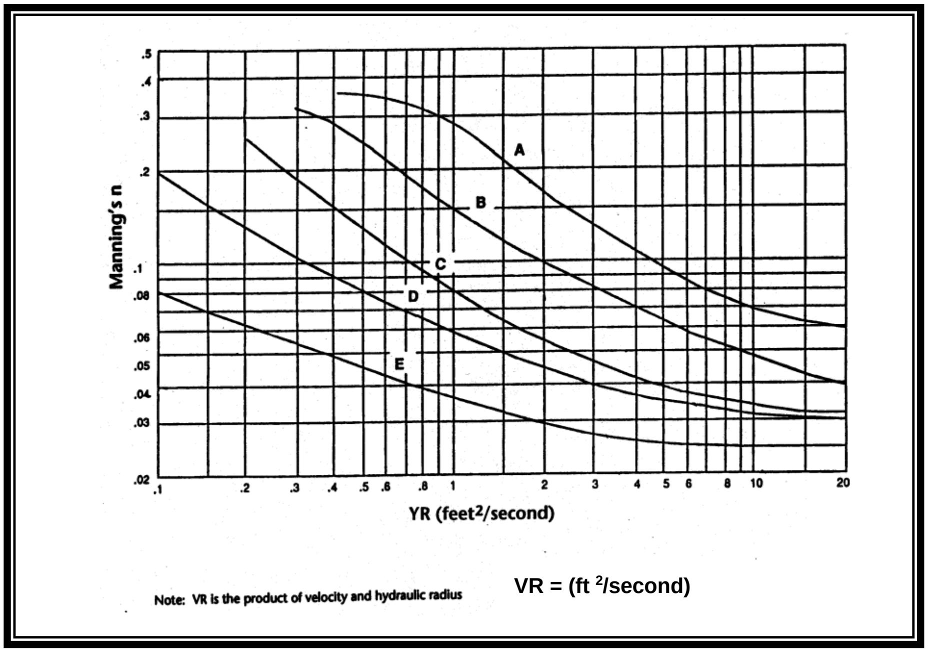
$R_{100} = VR_{approx} / V_{max}$, where VR_{approx} is from Figure 5.2 (step SC-5).

SC-7. Use Chezy-Manning equation multiplied by R to solve for the actual VR:

$$vR = \frac{1.49}{n_{100}} R_{100}{}^{5/3} \sqrt{s} \,,$$

Where n_{100} is as selected in step SC-4; and R_{100} is the hydraulic radius calculated in step SC-6.

Table 5-3 The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E)
Source: Livingston, et al., 1984



SC-8. Compare the actual VR from Step SC-7 and first approximation 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.

SC-9. Compute the actual V for the final design conditions:

Check to be sure $V < V_{max}$ of 3 ft/second.

SC-10. Compute the required swale cross-sectional area, A, for stability:

SC-11. Compare the A, computed in Step SC-10 of the stability analysis, with the A from the biofiltration capacity analysis (Step D-5).

If less area is required for stability than is provided for capacity, the capacity design is acceptable. If not, use A from Step SC-10 of the stability analysis and recalculate channel dimensions.

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.

SC-13. Compare the depth from Step SC-12 to the depth used in the biofiltration capacity design (Step D-1). Use the larger of the two and add 0.5 feet of freeboard to obtain the total depth (y_t) of the swale. Calculate the top width for the full depth using the appropriate equation.

SC-14. Recalculate the hydraulic radius: (use b from Step D-4 calculated previously for biofiltration capacity, or Step SC-11, as appropriate, and y_t = total depth from Step SC-13).

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.

5.1.1.5.6.d Completion Step (CO)

CO. Review all of the criteria and guidelines for biofilter planning, design, installation, and operation above and specify all of the appropriate features for the application.

5.1.1.6 Design Criteria

Figure 5.3, Figure 5.4, Figure 5.5, and Figure 5.6 provide details of biofiltration swales.

5.1.1.6.1 Geometry

5.1.1.6.1.a Length

Biofiltration swales shall have a minimum length of 100 feet but 200 feet is preferable, where feasible.

Use a wide radius curved path to gain length where land is not adequate for a linear swale (avoid sharp bends to reduce erosion or provide for erosion protection).

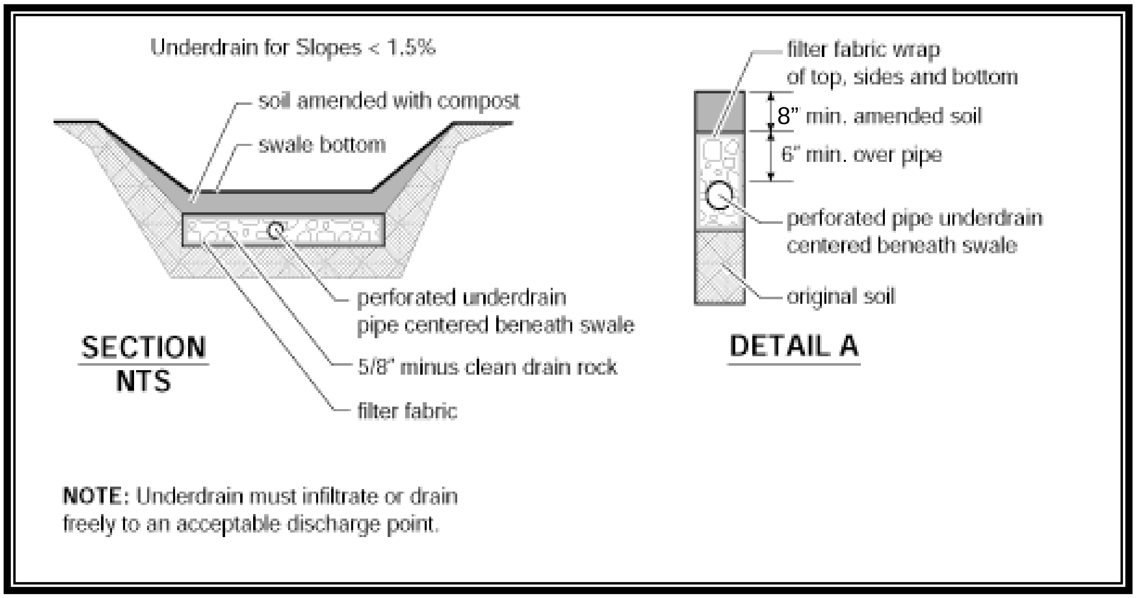


Figure 5.3 Biofiltration Swale Underdrain Detail

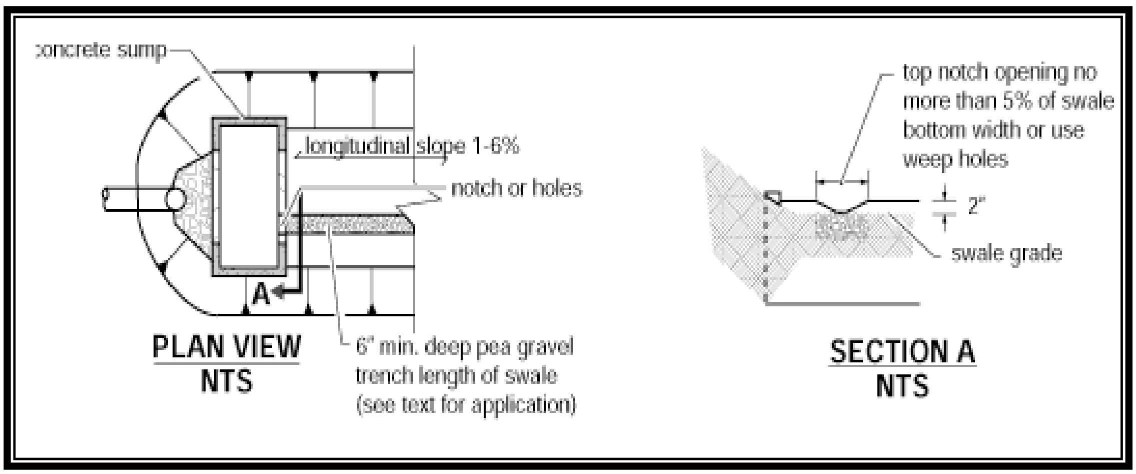


Figure 5.4 Biofiltration Swale Low-Flow Drain Detail

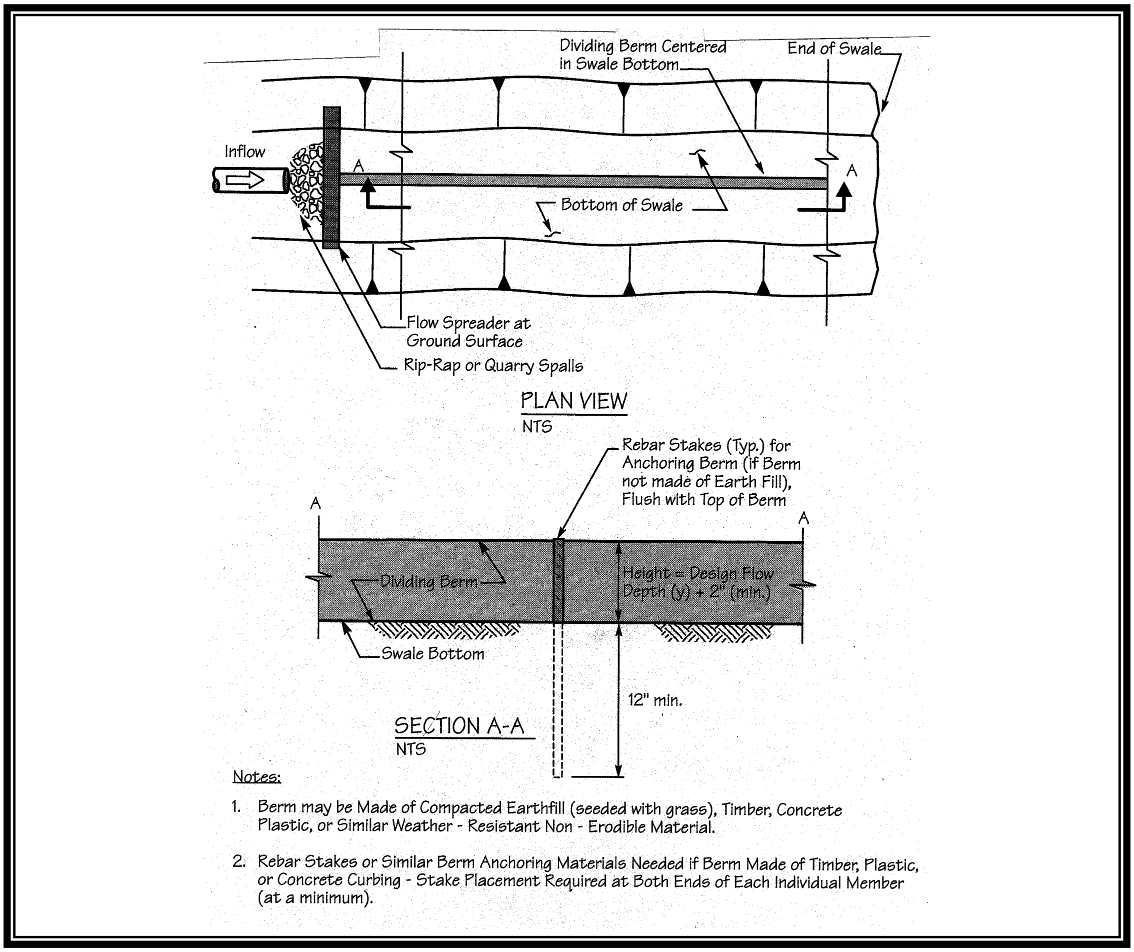


Figure 5.5 Swale Dividing Berm

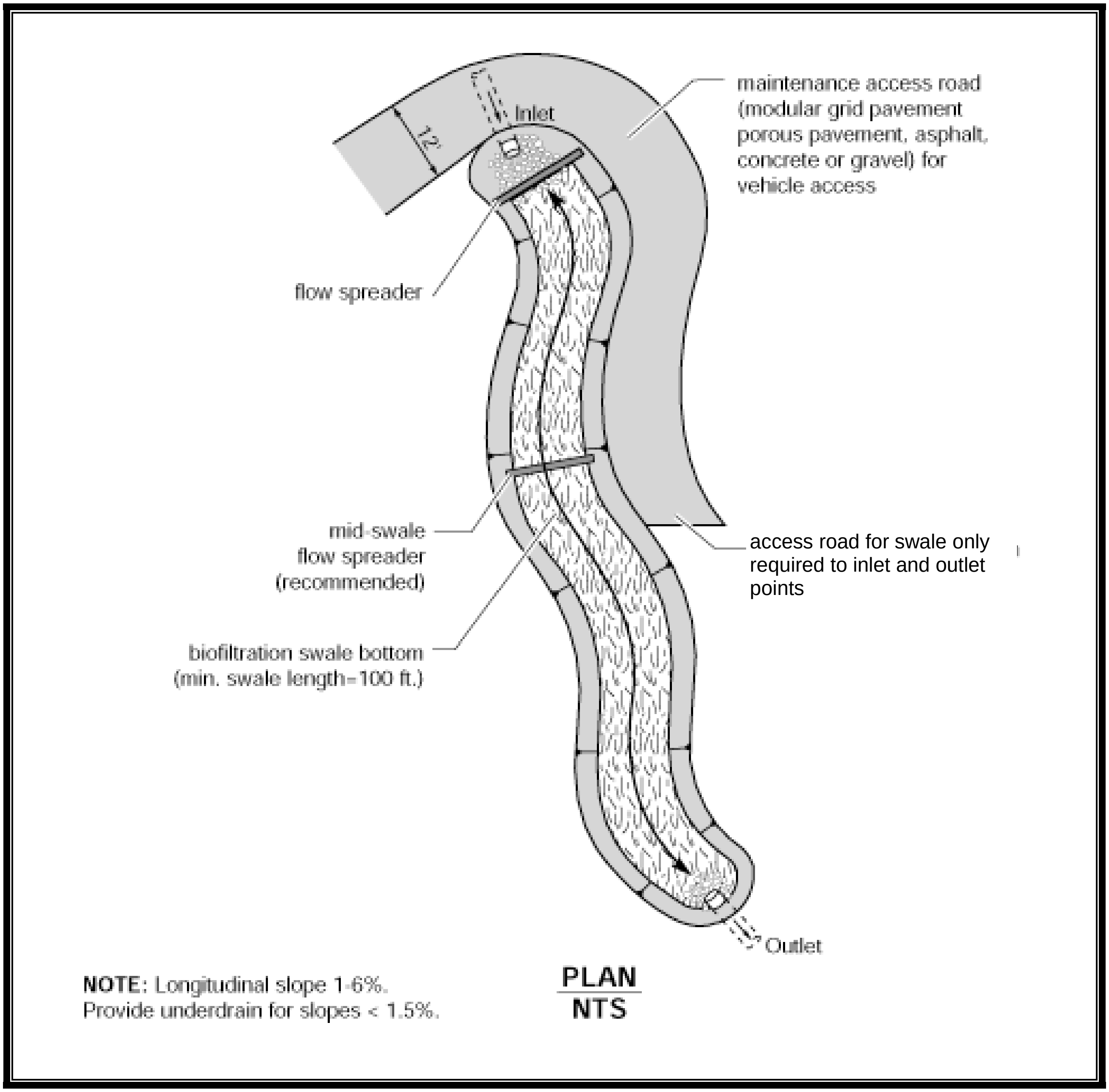


Figure 5.6 Biofiltration Swale Access Features

5.1.1.6.1.b Longitudinal Slope

The longitudinal slopes should be between 1.5 percent and 2.5 percent, where feasible. If a flatter or steeper slope is required, the following requirements apply:

> If the slope is less than 1.5 percent, 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 drain 6 inches deep in the soil.

Underdrains can be made of 6-inch Schedule 40 PVC perforated pipe with 6 inches of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric (see Figure 5.3).

Slopes greater than 2.5 percent need check dams (riprap) at vertical drops of 12 to 15 inches.

Effective treatment depends on flows being dispersed throughout the width of the swale. To avoid channelization, the following design elements are recommended:

Install level spreaders (minimum 1 inch gravel) at the head and every 50 feet in swales of 4 feet width (or greater). Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofilter as needed.

5.1.1.6.1.c Width and Cross Section

Biofiltration swales are typically trapezoidal in shape.

The swale bottom should be between 2 and 10 feet wide, unless a dividing berm is provided. 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 5.5 Swale Dividing Berm).

5.1.1.6.2 Materials

5.1.1.6.2.a Soil Criteria

The swale shall have a minimum 8 inches of topsoil that conforms to the following:

Table 5-4 Soil Recommendations for Swales

Composition	Percentage	Notes
Sandy Loam	60 to 90	A higher percentage of sand is recommended for soils with longitudinal slopes <2 percent to promote infiltration.
Clay	0 to 10	
Composted organic matter	10 to 30	Use compost amended soil where practicable. Shall not include animal waste or toxic materials.

If groundwater contamination is a concern, seal the bed with clay or a treatment liner (see Appendix V-B).

5.1.1.6.2.b Vegetation Criteria

Table 5-5 and Table 5-6present recommended grasses and groundcovers. The following invasive species shall not be used:

Phalaris arundinaceae (reed canarygrass)

Lythrum salicaria (purple loosestrife)

Phragmites spp. (reeds)

Iris pseudocorus (yellow iris)

Typha spp (Cattails).

Table 5-5 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
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight. * based on Briargreen, Inc.

Table 5-6 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 lanceolata*
yellow-root	*Xanthorhiza simplissima*
--	*Genista*
white lawn clover	*Trifolium repens*
white sweet clover*	*Melilotus alba*
-------	*Rubus calycinoides*
strawberry*	*Fragaria chiloensis*
broadleaf lupine*	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
tufted fescue	*Festuca amethystine*
buffalo grass	*Buchloe dactyloides*
red fescue*	*Festuca rubra*
tall fescue grass*	*Festuca arundinacea*
blue oatgrass	*Helictotrichon sempervirens*

Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.

Use sod with low clay content in the bottom of the swale and to a depth of 1 foot to initiate adequate vegetative growth. Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.

5.1.1.7 Construction and Maintenance

The biofiltration swale should not be put into operation until areas of exposed soil in the contributing drainage catchment have been sufficiently stabilized.

Effective erosion and sediment control (ESC) measures should remain in place until the swale vegetation is established (see Volume II for ESC BMPs).

Avoid compaction during construction. Grade biofilters to attain uniform longitudinal and lateral slopes.

Eight inches of top soil meeting soil criteria above shall be tilled into the top 8 inches of native soil. Sod of a type meeting the requirements of Table 5.3 shall be installed in the bottom and to a minimum of 1-foot vertical depth above the swale bottom. (Establishing a stand of grass from seed able to hold up to the flows in the swale usually takes too long to establish.) Top soil shall be placed to provide a smooth transition from the sod area to the upper swale area to be seeded.

The swale may need to be irrigated if moisture is insufficient during dry weather season.

Fertilizing a biofilter should be avoided if at all possible. 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.

Maintain access to biofilter inlet, outlet, and for mowing (Figure 5.6).

If a swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the drainpipes.

Biofiltration swales located within a residential subdivision shall include signage of a type approved by Thurston County indicating that the biofiltration swale is a water quality treatment facility, that no filling, grading, fertilizing or other disturbance of the swale is allowed without prior acceptance of Thurston County. One sign shall be located at a minimum along the frontage of each lot and not greater than 200 feet for lot frontages greater than 200 feet. The signs shall be embedded in concrete or otherwise secured to prevent removal.

See Appendix V-C for additional information on maintenance requirements.

5.1.2 BF.02 Wet Biofiltration Swale

A wet biofiltration swale is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. When saturation exceeds about 2 weeks, typical grasses will die. Vegetation for wet biofiltration swales, however, is specifically adapted to withstand saturated soil conditions.

Wet swale example

5.1.2.1 Applicability

Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable due to any of the following conditions:

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).

5.1.2.2 Limitations

The plants selected for wet biofiltration swales are appropriate for saturated soil conditions. Therefore, this BMP is not appropriate where stormwater is likely to infiltrate rapidly, drain quickly, or when saturated soil conditions are otherwise not expected.

5.1.2.3 Submittals and Approval

As part of submittals made as required in Volume I, include information described under BF.01 for a basic biofiltration swale.

5.1.2.4 Pretreatment

Pretreatment is not required.

5.1.2.5 Hydrologic and Hydraulic Design Considerations

Use the same design approach as for basic biofiltration swales except for the following:

Adjust for Extended Wet Season Flow: If the swale will be downstream of a detention pond providing flow control, multiply the treatment area (bottom width times 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 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 biofilter 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.

High-Flow Bypass: A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line water quality design flow that has been increased by the ratio indicated in Figure 5.1b. 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 basic biofiltration swales 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 basic biofiltration swales except no flow spreader is needed.

5.1.2.6 Design Criteria

5.1.2.6.1 Geometry

Swale Geometry: Same as specified for basic biofiltration swales except for the following modifications:

Criterion 1: 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. *Note: The minimum swale length is still 100 feet.*

Criterion 2: If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of retaining walls, log check dams, or short riprap sections. **No underdrain or low-flow drain is required**.

5.1.2.6.2 Materials

5.1.2.6.2.a Soil Criteria

Same as for basic biofiltration swales (see Table 5-4).

5.1.2.6.2.b Vegetation Criteria

A list of acceptable plants and recommended spacing is shown in Table 5-7. 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.

Table 5-7 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*	6 inches
Small-fruited bulrush	*Scirpus microcarpus*	12 inches

* Good choices for swales with significant periods of flow, such as those downstream of a detention facility.

Note: Cattail (*Typha latifolia*) is not appropriate for most wet swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.

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 two-thirds of the swale after 4 weeks.

5.1.2.7 Site Design Elements

Access is only required to the inflow and the outflow of the swale; access along the length of the swale is not required. Also, wheel strips may not be used for access in the swale.

Intent: An access road is not required along the length of a wet 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.

5.1.2.8 Construction and Maintenance

Construction considerations are the same as for basic biofiltration swales.

Mowing 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.

5.1.3 BF.03 Continuous Inflow Biofiltration Swale

A continuous inflow biofiltration swale is a basic swale modified by increasing its length to achieve an average residence time equivalent to a regular swale. The continuous design is needed where water enters a biofiltration swale continuously along the side slope rather than discretely at the head.

5.1.3.1 Applicability

The continuous inflow biofiltration swale is appropriate where inflows are not concentrated, such as locations along the shoulder of a road without curbs. This design may also be used where frequent, small point flows enter a swale, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts.

5.1.3.2 Limitations

No inlet port should carry more than about 10 percent of the flow

A continuous inflow swale is not appropriate where significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge point, in order to provide adequate treatment for the increased flows.

5.1.3.3 Submittals and Approval

As part of submittals made as required in Volume I, include information described under BF.01 for a basic biofiltration swale.

5.1.3.4 Pretreatment

Pretreatment is not required.

5.1.3.5 Hydrologic and Hydraulic Design Considerations

The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be online facilities.

If only a single design flow is used, the flow rate at the outlet shall be used. The goal is to achieve an average residence time through the swale of 9 minutes as calculated using the online water quality design flow rate multiplied by the ratio, K, in Figure 5.1a. Assuming an even distribution of inflow along the side of the swale, double the hydraulic residence time to a minimum of 18 minutes.

5.1.3.6 Design Criteria

5.1.3.6.1 Geometry

Same as basic biofiltration swale.

5.1.3.6.2 Materials

Same as specified for **basic biofiltration swale**, except for the following:

For continuous inflow biofiltration swales, interior side slopes above the water quality design treatment elevation shall be planted in grass. A typical lawn seed mix or biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale. The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the biofiltration treatment area.

5.1.4 BF.04 Basic Filter Strip

A basic filter strip is flat with no side slopes, see Figure 5.7. Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

Vegetated Filter Strip in Median Along I-5 in Snohomish County

5.1.4.1 Applicability

A basic filter strip is typically used online, adjacent, and parallel to paved areas like parking lots, driveways, and roadways. The filter strip soil and vegetation criteria can also be modified to provide enhanced treatment – see *Materials under the Design Criteria* section.

5.1.4.2 Limitations

Filter strips shall only receive sheet flow. The maximum permissible tributary flow path is 150 feet.

5.1.4.3 Submittals and Approval

No additional submittals (except those described in Volume I as applicable to your project) are required.

5.1.4.4 Pretreatment

Pretreatment is not required.

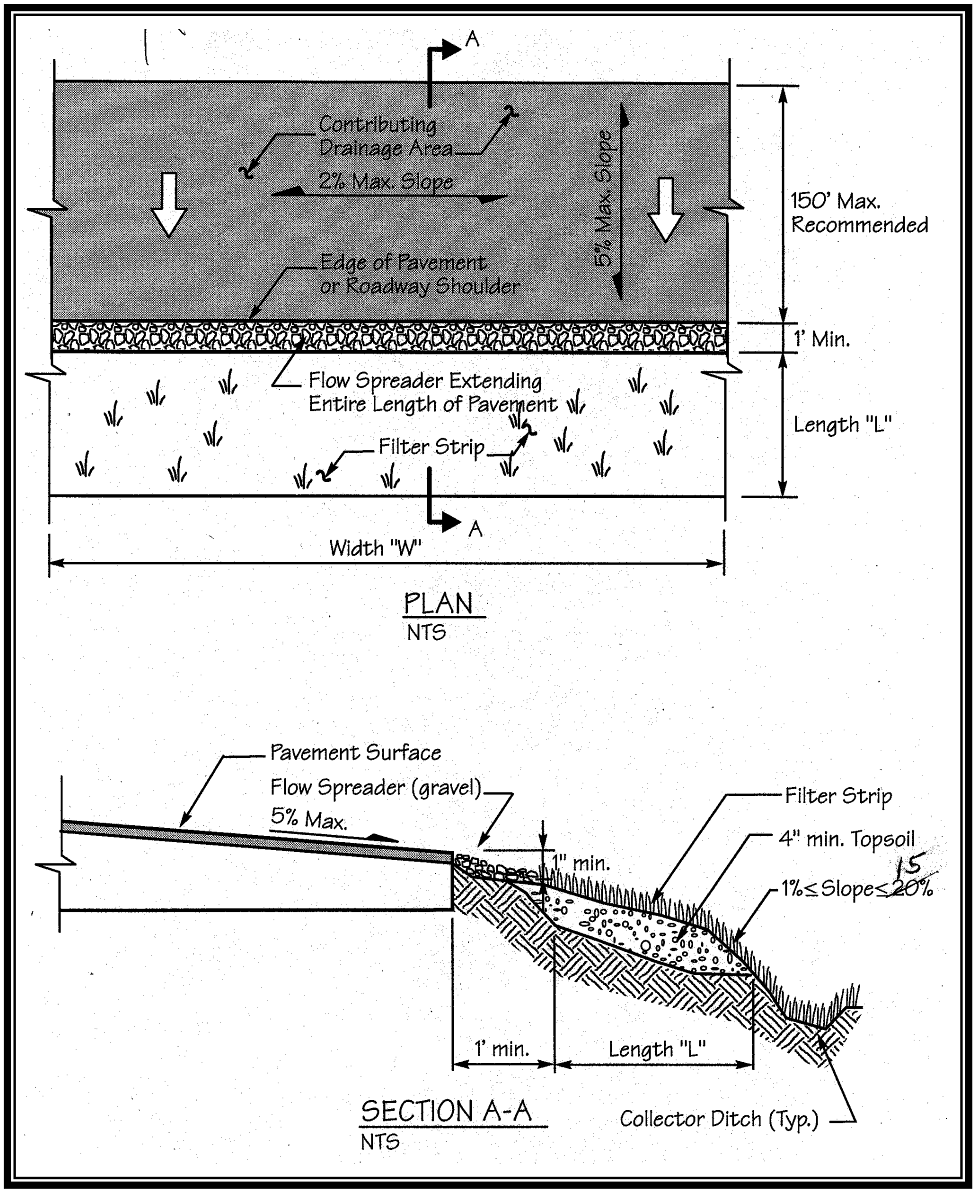


Figure 5.7 Typical Filter Strip

Hydrologic and Hydraulic Design Considerations

5.1.4.4.1 Water Quality Design Flow Rate

Filter strips shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (Volume III). If hydrologic calculations are being performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio from Figure 5.1a or 5.1b to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures.

5.1.4.4.2 Maximum Water Depth

1 inch.

5.1.4.4.3 Maximum Velocity

0.5 feet per second.

5.1.4.4.4 Manning Coefficient

0.35 (0.45 if compost-amended, and mowed to maintain grass height ≤ 4 inches)

5.1.4.4.5 Hydraulic Residence Time

9 minutes.

5.1.4.4.6 Sizing Method

Calculate the design flow depth using Manning's equation as follows:

$$KQ = (1.49A\ R^{0.67}\ s^{0.5})/n$$

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 based on an approved continuous runoff model, ft^3/sec

K = The ratio determined by using Figure 5.1a. If SBUH model is used for water quality design flow rate calculations, K = 1.

n = Manning's roughness coefficient

s = Longitudinal slope of filter strip parallel to direction of flow

T = Width of filter strip perpendicular to the direction of flow, ft.
A = Filter strip inlet cross-sectional flow area (rectangular), ft^2
R = hydraulic radius, ft.

Rearranging for y:

$$y = [KQn/1.49Ts^{0.5}]^{0.6}$$

y must not exceed 1 inch

Note: As in swale design an adjustment factor of K accounts for the differential between the WWHM Water Quality design flow rate and the SBUH design flow.

Calculate the design flow velocity V, ft./sec., through the filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft./sec

Calculate required length, in feet, of the filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$$L = tV = 540V$$

5.1.4.5 Design Criteria

5.1.4.5.1 Geometry

The slope of the filter strip (perpendicular to the roadway or other contributing area) shall be between 1 and 15 percent.

The maximum slope of contributing area flowing toward the filter strip is five percent unless flow spreading and energy dissipation is included in the design (see Figure 5.7). The maximum slope of the contributing area parallel to the filter strip is 2 percent.

The inlet edge shall be a minimum of 1 inch lower than contributing paved area.

For roadways with curbs, curb cuts shall be a minimum 12-inch wide and 1-inch above the filter strip inlet. Curb cuts shall be spaced at 10 feet intervals, maximum.

5.1.4.5.2 Materials

Compost Amended Vegetated Filter strip: The filter strip may be able to provide enhanced treatment where the following are met:

> Where a filter strip area is compost-amended to a minimum of 10 percent organic content in accordance with BMP LID.02;

Hydroseeded grass maintained at 95 percent density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs)

If groundwater contamination is a concern, seal the bed with clay or a treatment liner.

Chapter 6 - Wet Pool BMPs

6.1 Wet Pool BMPs

Wet pools treat stormwater runoff by allowing particulates to settle during stilling conditions (“sedimentation”), by biological uptake of dissolved pollutants, and by vegetative filtration. Wet pool facilities include wet ponds, wet vaults, and stormwater treatment wetlands. Wet pools may be single-purpose facilities, providing only runoff treatment, or may be combined with a detention pond or vault to provide flow control. If combined, the volume for detention can often be included above the wet pool with little further loss of development area.

The following wet pool BMPs are described in this chapter:

WP.01 Stormwater Treatment Wetland

WP.02 Wet Ponds

WP.03 Wet vaults

WP.04 Combined Detention/Wet Pond Facilities

WP.05 Presettling BasinsWP.01 Stormwater Treatment Wetlands

Stormwater treatment wetlands are shallow, man-made ponds designed to treat stormwater using the biological processes of emergent aquatic plants (see stormwater wetland details in Figure 6.1 and Figure 6.2).

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.

Note: Wetlands created to mitigate disturbance impacts (e.g., filling) may not be used as stormwater treatment facilities.

Wm Bush Park wetland in Lacey

6.1.1.1 Applicability

This design occupies about the same surface area as wet ponds, but may be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. Stormwater treatment wetlands are a good water quality facility choice in areas with high winter groundwater levels.

A stormwater treatment wetland may provide treatment only (have a permanent pool with no live storage) or may provide both storage and treatment (have both a permanent pool and live storage). See WP.04, combined detention/wet pond facilities for more information on stormwater treatment wetlands that provide both runoff treatment and detention.

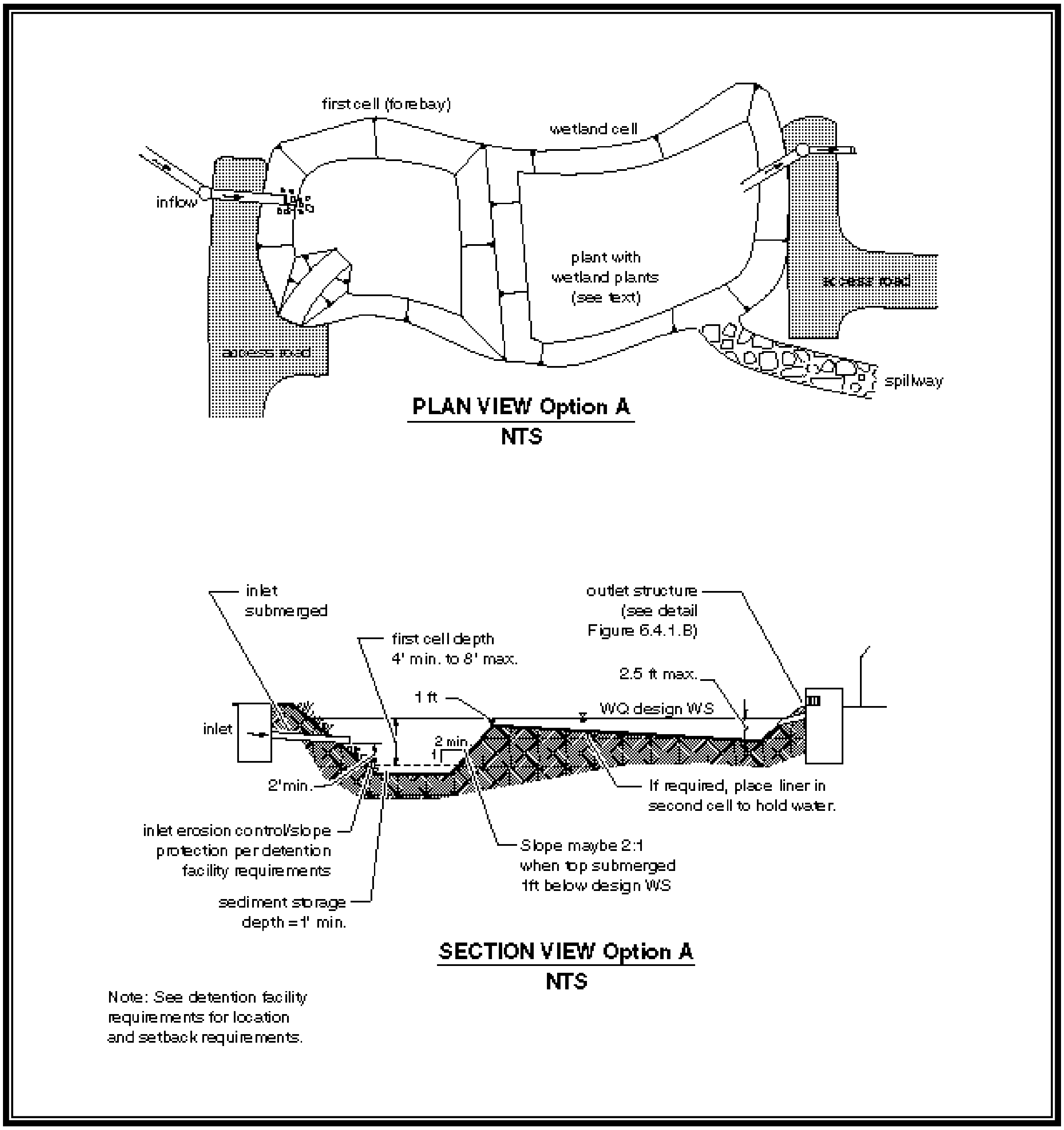
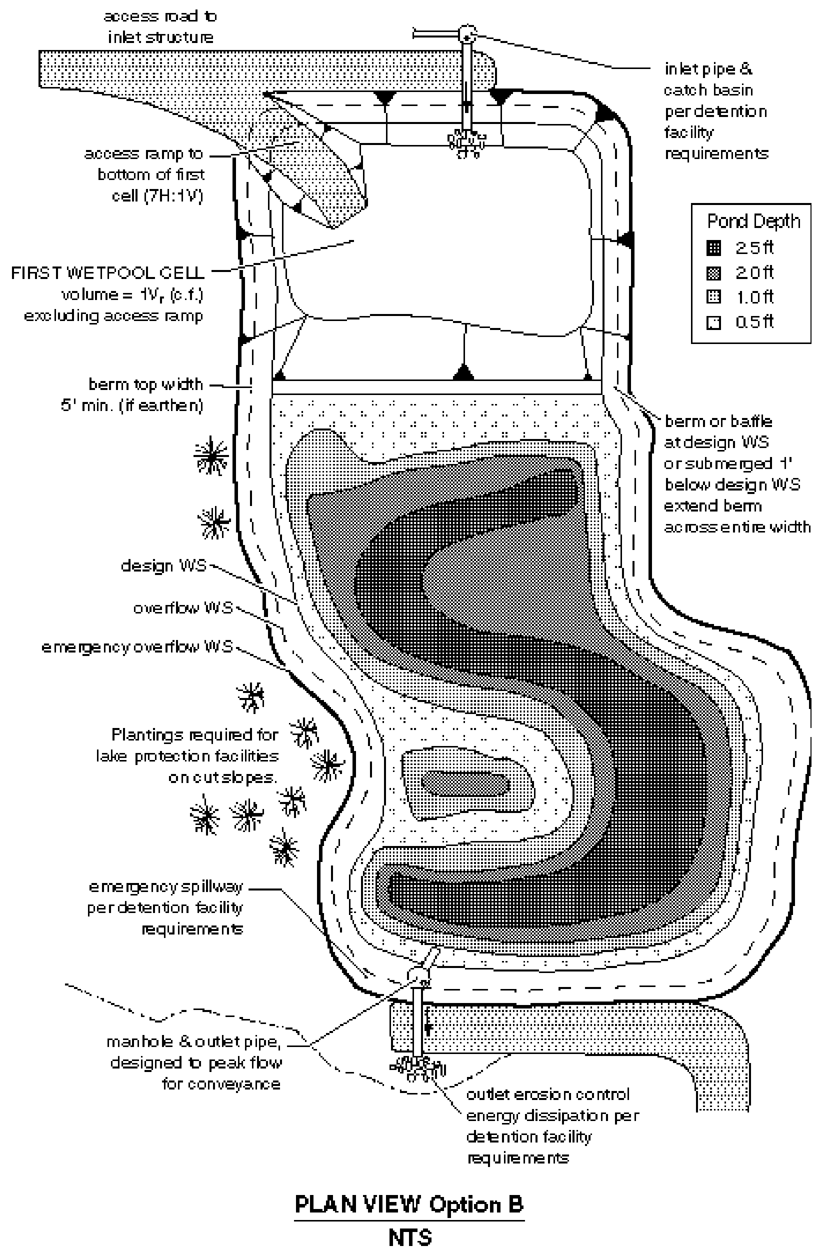


Figure 6.1 Stormwater Wetland – Option One



(**Figure 6.2 Stormwater Wetland — Option Two**

Limitations

The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Since water depths are shallower than in wet ponds, water loss by evaporation is an important concern.

A stormwater treatment wetland placed in soils with a field-saturated percolation rate of greater than 0.5 inches per hour shall be lined.

All constructed wetlands shall be designed by the project engineer in conjunction with a wetland consultant.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the stormwater wetland shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the stormwater wetland shall be lined.

6.1.1.3 Submittals and Approval

Make submittals required by Volume I and include the following information in the submittal:

Detailed planting plan for the wetland to include species, quantity, location, and special planting considerations for all plantings to be incorporated into the wetland

Description of liner material to be used. If lining of the stormwater wetland pond is not proposed, submit documentation from a geotechnical professional demonstrating that the soils have an infiltration rate of less than 0.5 in/hr.

Hydrologic modeling results showing the volume required for the stormwater wetland as well as calculations showing how area and volume requirements are met for each cell

Details of all structures and material and construction specifications

Cross section of the stormwater wetland through the outlet structure

Design calculations for the overflow structures

Document that facility location meets setback requirements.

6.1.1.4 Pretreatment

Pretreatment is accomplished in the presettling cell of the wetland, so a separate pretreatment facility is not required.

6.1.1.5 Hydrologic and Hydraulic Design Considerations

When used for stormwater treatment, stormwater wetlands employ some of the same design features as wet ponds. However, instead of primarily using gravity settling for treatment, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus, when designing wetlands, plant vigor and biomass are primary design concerns, not water volume.

6.1.1.5.1 Inlets and Outlets

Inlets and outlets shall be configured using the requirements of wet ponds (see BMP WP.02).

6.1.1.5.2 Sizing Procedure

Step 1: The volume of a basic wet pond is used as a template for sizing the stormwater wetland. The design volume is the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model.

Step 2: Calculate the surface area of the stormwater wetland. The surface area of the wetland shall be the same as the top area of a wet pond sized for the same site conditions. Calculate the surface area of the stormwater wetland by using the volume from Step 1 and dividing by the average water depth (use 3 feet).

Step 3: Determine the surface area of the first cell of the stormwater wetland. Use the volume determined from Criterion 2 under "Wetland Geometry", and the actual depth of the first cell.

Step 4: Determine the surface area of the wetland cell. Subtract the surface area of the first cell (Step 3) from the total surface area (Step 2).

Step 5: Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to 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 wetland is set to be roughly equivalent to that of a wet pond designed for the same site so as not to discourage use of this option.

Step 6: Choose plants. See Table 6.2 for a list of plants recommended for wet pond water depth zones, or consult a wetland scientist.

6.1.1.6 Design Criteria

6.1.1.6.1 Geometry

Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.

6.1.1.6.1.a Presettling Cell

The presettling cell shall contain approximately 33 percent of the wet pool volume calculated in Step 1 above. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage. One foot of sediment storage shall be provided in the presettling cell.

6.1.1.6.1.b Wetland Cell

The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches).

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 6.1).

The second example is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 6.2). To the extent possible create a complex microtopography within the wetland, and design the flow path to maximize sinuous flow between wetland cells. 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 6-1 below). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by Thurston County.

Table 6-1 *Distribution of Depths in Wetland Cell*

Dividing Berm at Water Quality Design Water Surface		Dividing Berm Submerged 1 Foot	
Depth Range (ft)	**Percent**	**Depth Range (ft)**	**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

6.1.1.7 Berm

The "berm" separating the two cells shall be shaped such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in Figure 6.1). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see previous section - "naturalistic" alternative. In either case the berm design shall meet the requirements of this section.).

The top of berm shall be either at the water quality design water surface or submerged 1 foot below the water quality design water surface, as with wet ponds. Correspondingly, the side slopes of the berm must meet the following criteria:

If the top of berm is at the water quality design water surface, the berm side slopes shall be no steeper than 3H:1V.

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 shall be not greater than 3:1, just as the pond banks shall 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.

6.1.1.7.1 Materials

6.1.1.7.1.a Lining Requirements

Many wetland plants can adapt to periods of summer drought, however the stormwater wetland design should maximize the duration of wet conditions to the extent possible. Therefore, for all constructed wetlands placed in soils with a field-saturated percolation rate greater than 0.5 inches per hour, both cells of the stormwater wetland shall be lined with a low-permeability liner. The criteria for liners given in Appendix V-B must be observed. A minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with three parts native soil) must be placed over the liner. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

6.1.1.7.1.b Vegetation

The wetland cell shall be planted with emergent wetland plants following the recommendations given in ***Table 6-2*** or the recommendations of the 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 wet pool unless they are removed.

Consultation with a wetland consultant (an individual with education and experience in freshwater or wetland biology landscape architecture, or equivalent) is required for stormwater treatment wetlands on sites with contributing areas of greater than 1 acre. The services of a wetland consultant are highly recommended, but not required, on smaller sites (contributing areas of 1 acre or less). On smaller stormwater treatment wetland projects, the project engineer may adapt the following planting approach for use without requiring a wetland consultant.

Table 6-2 Emergent Wetland Plant Species Recommended for Wet Ponds

Species	Common Name	Notes	Maximum Depth
Agrostis exarata (1)	Spike bent grass	Prairie to coast	to 2 ft
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 ft
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	to 2 ft
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 FT			
Agrostis exarata (1)	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	

Species	Common Name	Notes	Maximum Depth
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 FT			
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 ft
Beckmania syzigachne (1)	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus (2)	Hardstem bulrush	Single tall stems, not clumping	to 3 ft
Scirpus validus (2)	Softstem bulrush		
INUNDATION GREATER THAN 3 FT			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 ft
Nymphaea odorata (1)	White waterlily	Shallow to deep ponds	to 6 ft

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: Municipality of Metropolitan Seattle, Water Pollution Control Aspects of Aquatic Plants, 1990. Hortus Northwest, Wetland Plants for Western Oregon, Issue 2, 1991. Hitchcock and Cronquist, Flora of the Pacific Northwest, 1973.

The stormwater treatment wetland bottom and wetted side slopes shall be planted with nursery-grown plants and shrubs. Field-harvested (wild) plants may be used with approval of the wetland consultant and the Administrator or designee. The stormwater treatment wetland bottom must have suitable soil type and be tilled for planting and root establishment. Soil amendments may be necessary. All planting shall occur between the months of October and April unless otherwise approved by the Administrator or designee.

For each 1,500 square feet of stormwater treatment wetland bottom, plant at least 100 open-water or emergent plants in homogeneous groups of 10 or more, on 2-foot centers. In addition, plant at least 30 shrubs on 5-foot centers, midway between the low and high-water level. Shrubs may be from cuttings or stakes if appropriate to the type of plant and proper planting methods are used to improve survival. Plantings used must be from the recommended list in Table 6.2 unless otherwise approved by the Administrator or designee.

The wetland consultant shall monitor performance of the stormwater treatment wetland vegetation for a minimum of 2 years. Monitoring shall occur at least yearly during the summer months. Measures of success are as follows:

1. Minimum survival of shrubs shall be 80 percent. Lesser survivals may be allowed if original planting density exceeded minimums. All plants lost shall be replaced between the months of October and April by like species unless recommended otherwise by the wetland consultant and accepted by the Administrator or designee.

2. Minimum percent vegetated cover of stormwater treatment wetland bottom area, excluding exotic and invasive species, at two years shall be 50 percent. If stormwater treatment wetland cover is less than 50 percent, removal of exotic/invasive species and additional plantings may be required.

A bond or other financial guarantee to ensure the above measures of success are attained may be required.

6.1.1.8 Site Design Elements

6.1.1.8.1 Access and Setbacks

Location of the stormwater wetland relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as described in Appendix V-E for detention ponds.

Access and maintenance roads shall be provided and designed according to the design criteria provided in Appendix V-D. Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp 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.

6.1.1.8.2 Construction and Maintenance

The presettling cell must include a gravity drain for maintenance.

Construction of the naturalistic alternative (Option 2) 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.

The presettling cell of a stormwater treatment wetland may be used as a sedimentation pond during construction. However, any sediment that has accumulated in the pond must be removed after construction is complete and before the stormwater treatment wetland is permanently online.

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 county may require a bypass/ shutoff valve to enable the stormwater treatment wetland to be taken off-line for maintenance purposes.

6.1.2 WP.02 Wet Ponds

A wet pond is a constructed stormwater pond that retains a permanent pool of water ("wet pool") during the rainy season. The larger the volume of the wet pool the more effective the pond in settling particulate pollutants. Peak flow control can be provided in the "live storage" area above the permanent pool (see BMP WP.04). Figures 6.3 and 6.4 illustrate a typical wet pond BMP.

Wetpond along Yelm Hwy in Lacey

6.1.2.1 Applicability

A wet pond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wet pond holds a permanent pool of water that provides an attractive aesthetic feature.

Wet ponds may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wet pond can often be stacked under the detention pond with little further loss of development area. See BMP WP.04 for a description of combined detention and wet pool facilities.

The following design criteria cover two wet pond applications – the basic wet pond and the large wet pond.

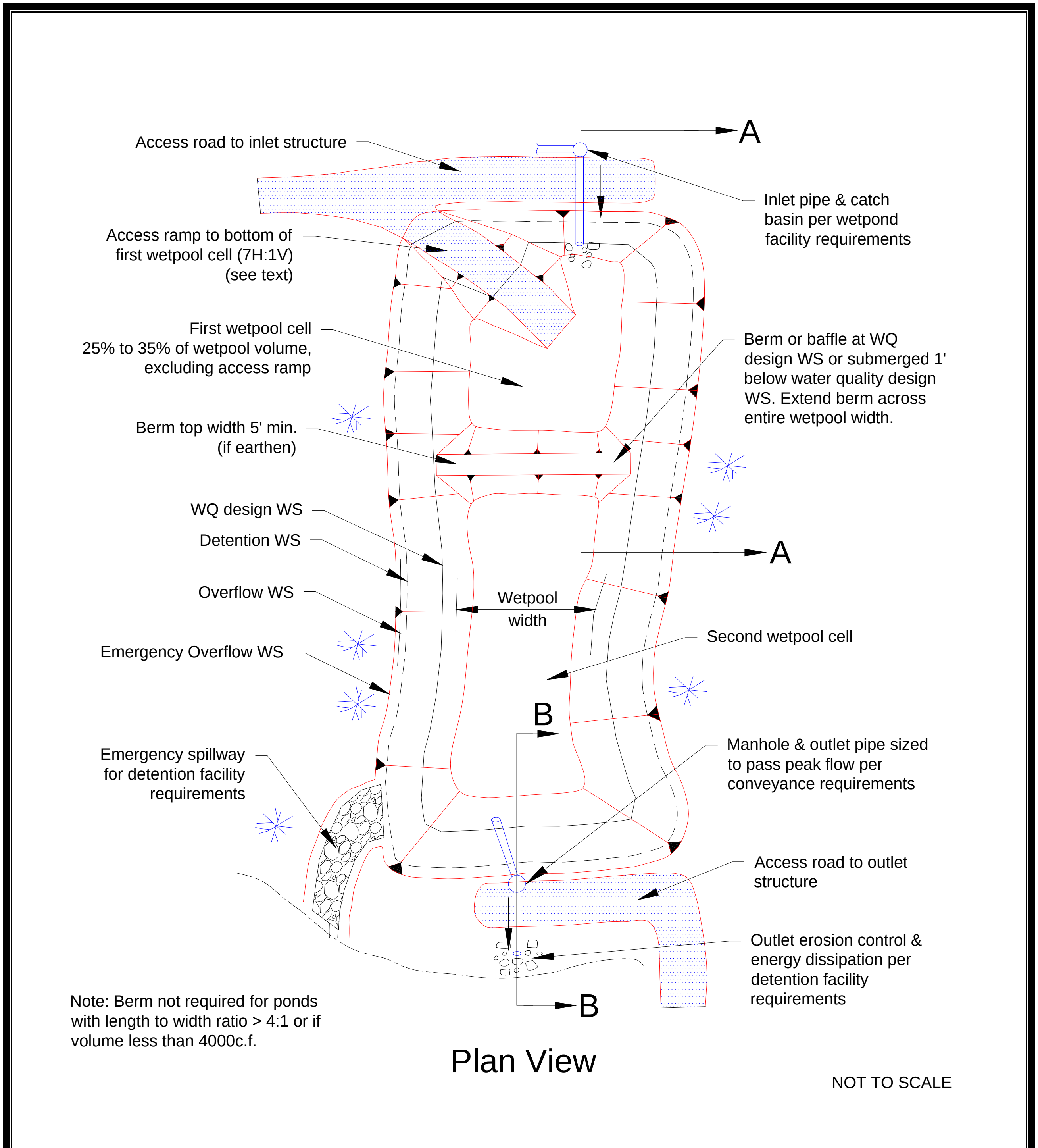


Figure 6.3 Wet Pond

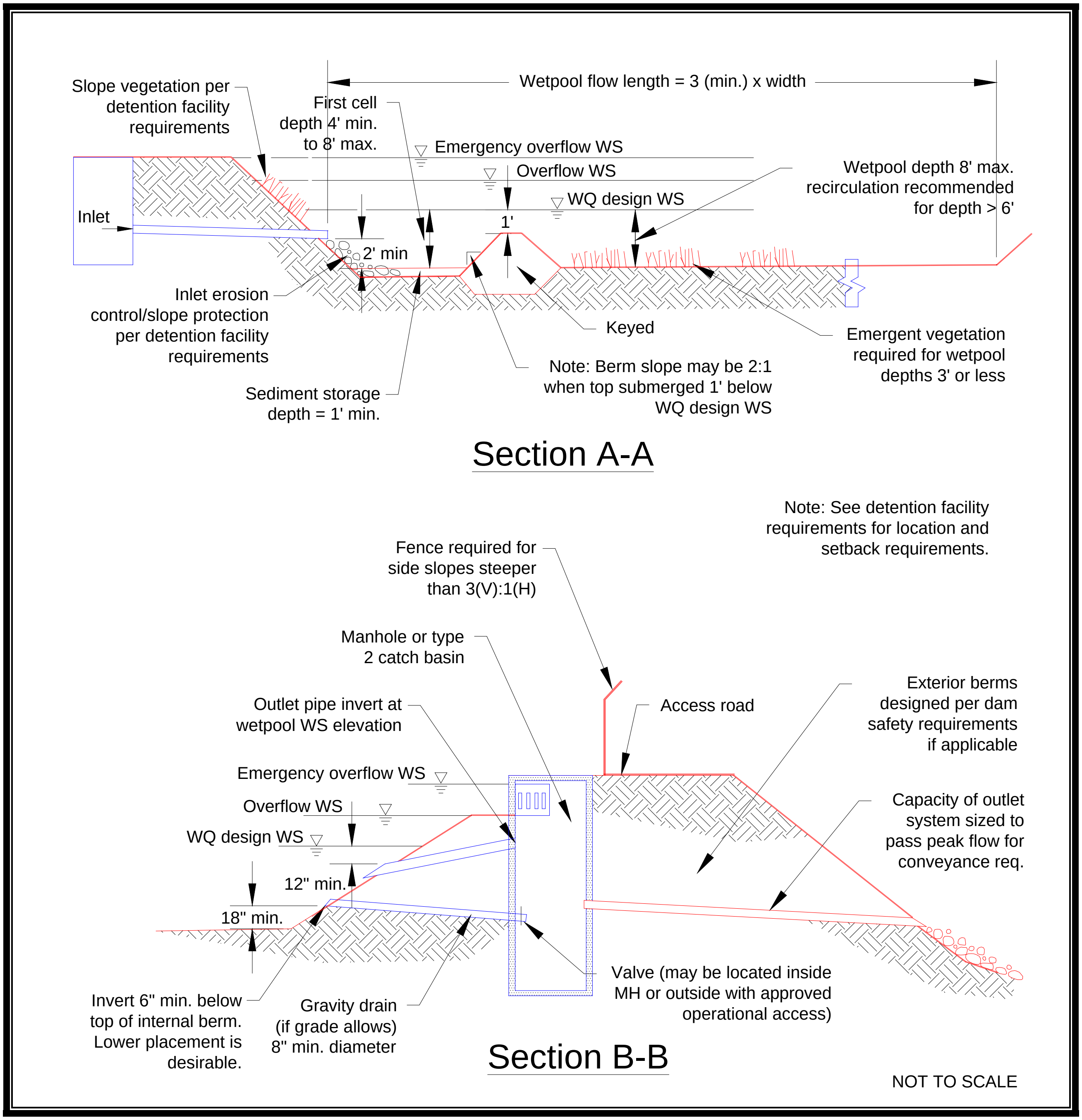


Figure 6.4 Wet Pond

Large wet ponds are designed for higher levels of pollutant removal (phosphorus treatment).

6.1.2.2 Limitations

Wet ponds rely on a permanent pool of water for water quality treatment and aesthetics. Bioretention facilities (BMP LID.07) or infiltration basins (BMP IN.01) are better choices where there are porous soils.

If wet ponds are proposed in areas with porous soils (infiltration rate of greater than than 0.5 inches per hour), the pond will be required to be lined to maintain a permanent wet pool.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the wet pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the wet pond shall be lined.

Wet ponds can attract wild fowl that can be hazardous to air traffic. The Federal Aviation Administration has established perimeters around airports to exclude open water areas that could attract wildlife. See the *Airport Stormwater Guidance Manual* at http://www.wsdot.wa.gov/aviation/AirportStormwaterGuidanceManual.htm if the project is within 10,000 feet of an airport.

6.1.2.3 Submittals and Approval

Complete applicable submittals in accordance with the requirements in Volume I. For projects proposing wet ponds for runoff treatment, provide the following information in the submittal:

> Justification for use of a wet pond. A wet pond is an allowed water quality treatment facility for projects in which a stormwater treatment wetland (BMP WP.01) is not feasible or practicable. The applicant shall explain why a stormwater treatment wetland is infeasible for the project or site, subject to acceptance of the Administrator.
>
> Documentation from a geotechnical professional demonstrating that the soils have an infiltration rate of less than 0.5 inches per hour if lining of the wet pond is not proposed
>
> Hydrologic modeling results showing the volume required for the wet pool. If the facility is a combined wet/detention pond, calculations shall also demonstrate compliance with Core Requirement #7 (Flow Control).
>
> Details of all structures and material and construction specifications
>
> Planting plan showing plant species, quantity, location and any special planting requirements
>
> Cross section of the pond through outlet structure.
>
> Design calculations for the overflow structures
>
> Documentation that facility location meets setback requirements.

6.1.2.4 Pretreatment

Pretreatment is not required for this BMP.

6.1.2.5 Hydrologic and Hydraulic Design Considerations

6.1.2.5.1 Wet Pool Volume

The primary design factor that determines a wet pond's treatment efficiency is the volume of the wet pool. The larger the wet pool volume, the greater the potential for pollutant removal.

Conveyance modeling for the stormwater system leading to the wet pond must be shown to include consideration of the backwater effects of the submerged inlet.

6.1.2.5.1.a Basic Wet Pond

For a basic wet pond, the wet pool volume provided shall be equal to or greater than volume of the 6-month, 24-hour storm or alternatively the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model.

6.1.2.5.1.b Large Wet Pond

A large wet pond requires a wet pool volume at least 1.5 times larger than the basic wet pond.

6.1.2.5.2 Sizing Procedure

Procedures for determining a wet pond's dimensions and volume are outlined below.

Step 1: Identify required wet pool volume using an approved continuous runoff model – the 91st percentile, 24-hour runoff volume. A large wet pond requires a volume at least 1.5 times the 91st percentile, 24-hour runoff volume.

Step 2: Determine wet pool dimensions. Determine the wet pool dimensions satisfying the design criteria outlined below. A simple way to check the volume of each wet pool cell is to use the following equation:

$$V = \frac{h(A_1 + A_2)}{2}$$

where V = wet pool volume (cf)

h = wet pool average depth (ft)

A_1 = water quality design surface area of wet pool (sf)

A_2 = bottom area of wet pool (sf)

Step 3: Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wet pool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

Use the nomographs in Volume III, Appendix III-C to select a trial size for the pond outlet pipe sufficient to pass the online water quality design flow, Q_{wq} indicated by an approved continuous runoff model.

Use the nomographs in Volume III, Appendix III-C to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.

Use the nomographs in Volume III, Appendix III-C to determine the flow area A_c at critical depth.

Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).

Calculate the velocity head V_H ($V_H = V_c^2 / 2g$, where g is the gravitational constant, 32.2 feet per second).

Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + d_c + V_H).

Adjust outlet pipe diameter as needed and repeat Step 3.

Step 4: Determine wet pond dimensions. General wet pond design criteria and concepts are shown in Figure 6.3 and Figure 6.4.

6.1.2.5.3 Velocities

The runoff shall be discharged uniformly and at a velocity below 3 feet per second in Type A and B soils, and 5 feet per second in Type C and D soils or as necessary to prevent erosion and to insure quiescent conditions within the BMP.

6.1.2.5.4 Outlet Structure

The inverted outlet pipe traps oils and floatables in the wet pond.

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 Appendix V-A for an example). 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 shall be back-sloped, or have a turn-down elbow, and extend 1 foot below the water quality design water surface. A floating outlet, set to draw water from 1 foot below the water surface, is also acceptable if vandalism concerns are adequately addressed.

The pond outlet pipe shall be sized, at a minimum, to pass the online water quality design flow. **Note**: The highest invert of the outlet pipe sets the water quality design water surface elevation.

6.1.2.5.5 Overflow

The overflow criteria for single-purpose (treatment only, not combined with flow control) wet ponds are as follows:

- 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.

- 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 through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*

- The grated opening shall be sized to pass the 100-year recurrence interval design flow. The capacity of the outlet system shall be sized to pass the peak flow for the conveyance requirements.

An emergency spillway shall be provided and designed according to the design criteria in Appendix V-A.

6.1.2.5.6 Base Flow

A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.

6.1.2.6 Design Criteria

6.1.2.6.1 Geometry

The wet pond geometry should be designed to avoid short circuiting and promote 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, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding “dead zones” and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are:

- 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

- 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 wet pond 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.

6.1.2.6.1.a Inlets

All inlets shall enter the first cell. The inlet to the wet pond shall be submerged with the inlet pipe invert a minimum of 2 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.

6.1.2.6.1.b Length:width Ratio

Inlets and outlets shall be placed to maximize the flow path through the facility. The ratio of flow path length to width from the inlet to the outlet shall be at least 3:1. The flow path 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

The number of inlets to the facility should be limited; ideally there should be only one inlet. If there are multiple inlets, the length-to-width ratio shall be based on the average flow path length for all inlets.

Wet ponds with wet pool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). The ratio of flow path length to width shall be at least 4:1 in single celled wet ponds, but should preferably be 5:1.

For wet ponds with wet pool volumes greater than 4,000 cubic feet, the wet pool shall be divided into two cells separated by a baffle or berm. Both cells must have level pond bottoms.

The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). For wet pool depths in excess of 6 feet, some form of recirculation shall be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.

6.1.2.6.1.c Pre-settling Cell

The first cell shall contain between 25 to 35 percent of the total wet pool volume. 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.

Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot.

Install a gravity drain in the pre-settling cell.

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 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 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 shall 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.

6.1.2.6.1.d Second Cell

Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Planting requirements).

6.1.2.6.1.e Baffle or Berm

A berm or baffle shall extend across the full width of the wet pool, and tie into the wet pond side slopes.

The baffle or berm volume shall not count as part of the total wet pool volume. The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water 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 Thurston County.

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.

6.1.2.6.1.f Side Slopes

Provide side slopes that are sufficiently gentle to avoid the need for fencing (3H:1V or flatter).

6.1.2.6.1.g Submerged Berm

The top of the berm may extend to the water quality design water surface, or be 1 foot below the water quality design water surface. If at the water quality 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. 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 wet pond.

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.

6.1.2.6.2 Materials

6.1.2.6.2.a Lining

Liners, if required, shall meet the requirements of Appendix V-B.

6.1.2.6.2.b Soils

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.

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.

6.1.2.6.2.c Vegetation

Planting requirements for detention ponds also apply to wet ponds.

Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating. 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.

Large wet ponds intended for phosphorus control shall 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 wet pond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 6.2 for recommended emergent wetland plant species for wet ponds.

> Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

Cattails (*Typha latifolia*) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.

If the wet pond discharges to a phosphorus-sensitive lake or wetland (see Chapter 4 of Volume I), shrubs that form a dense cover should be planted on slopes above the water quality 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*)

Pacific yew (*Taxus brevifolia*)

Numerous ornamental species.

6.1.2.7 Structural Design Considerations

The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged 1 foot below the design water surface to discourage access by pedestrians.

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, then dam safety design and review are required by Ecology.

No trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety.

6.1.2.8 Site Design Elements

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.

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

Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

6.1.2.8.1 Setbacks

Location of a wet pond relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as described in Appendix V-E for detention ponds.

6.1.2.8.2 Access

Access and maintenance roads shall be provided and designed according to the requirements in Appendix V-D. Access and maintenance roads shall extend to both the wet pond inlet and outlet structures. An access ramp shall be provided to the bottom of all cells, unless trackhoe (maximum reach of 20 feet) can reach all portions of the cell and can load a truck parked at the pond edge or on the internal berm of a wet pond or combined pond.

The access and maintenance road could be extended along the full length of the wet pond and could double as play courts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.

If the dividing berm is also used for access, it shall be built to sustain loads of up to 80,000 pounds.

6.1.2.9 Construction and Maintenance

As with other similar BMPs, wet ponds may be used as sedimentation ponds during construction. However, any sediment that has accumulated in the pond must be removed after construction is complete and before the pond is permanently online.

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 County may require a bypass/ shutoff valve to enable the pond to be taken off-line for maintenance purposes.

A gravity drain for maintenance is required where feasible. The engineer must demonstrate why a drain is not feasible and show in the Maintenance Plan how to drain the pond.

6.1.3 WP.03 Wet Vaults

A wet vault is an underground structure similar in appearance to a detention vault, except with a permanent pool of water (wet pool) that dissipates energy and improves the settling of particulate pollutants (see Figure 6.5). Being underground, the wet vault lacks biological pollutant removal mechanisms (e.g., algae uptake) present in surface wet ponds.

Wet vault construction at Bellingham

6.1.3.1 Applicability

A wet vault requires specific acceptance of the Administrator or designee. With acceptance, a wet vault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs. The use of wet vaults for residential development is highly discouraged.

If oil control is required for a project, a wet vault may be combined with an API oil/water separator.

6.1.3.2 Limitations

A wet vault 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.

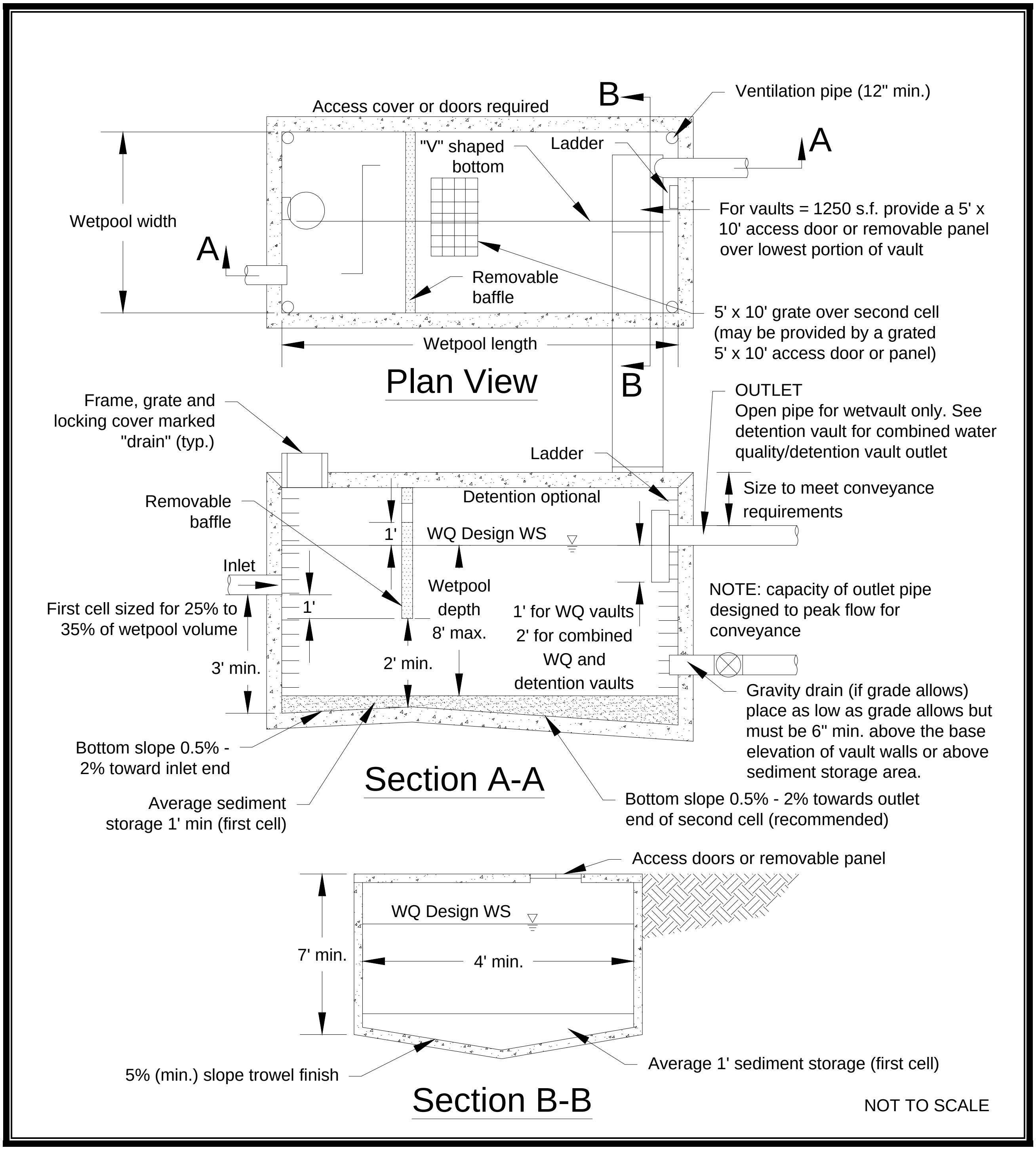


Figure 6.5 Wet Vault

Below-ground structures like wet vaults are difficult and expensive to maintain. The need for maintenance is often not seen and as a result routine maintenance does not occur.

6.1.3.3 Submittals and Approval

The use of a wet vault for runoff treatment is restricted to those circumstances where other alternatives are not feasible of practicable due to situations such as limited space or safety concerns. Its use requires the specific acceptance of the Administrator or designee. The applicant shall submit to the Administrator or designee the justification for using a wet vault for the project and why other runoff treatment facilities are not suitable.

If use of a wet vault is approved for the project, include documentation of acceptance and calculations in the submittal prepared for the project in accordance with the requirements of Chapter 3 of Volume I.

6.1.3.4 Pretreatment

A catch basin structure shall be installed upstream from the wet vault with a minimum sediment storage depth of 2 feet to capture large sediment and debris prior to entry to the vault.

6.1.3.5 Hydrologic and Hydraulic Design Considerations

6.1.3.5.1 Wet Vault Sizing

As with wet ponds, the primary design factor that determines the removal efficiency of a wet vault is the volume of the wet pool. The larger the volume, the more effective the pollutant removal.

The sizing procedure for a wet vault is identical to the sizing procedure for a wet pond. The wet pool volume for the wet vault shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event using a single event hydrologic model (SBUH/SCS). Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used.

6.1.3.6 Design Criteria

Typical design details and concepts for the wet vault are shown in Figure 6.5.

6.1.3.6.1 Geometry

Pollutant removal performance of wet vaults may be improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios (a flow length-to-width ratio greater than 3:1 minimum is desirable), dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

The vault shall be separated into two cells by a wall or a removable baffle.

Where possible, the inlet and outlet should be at opposing corners of the vault to increase the flow path.

6.1.3.6.1.a Inlet

The number of inlets to the wet vault should be limited, and the flow path length should be maximized from inlet to outlet for all inlets to the vault.

The inlet to the wet vault 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.

6.1.3.6.1.b Outlet

Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.

The outlet pipe shall be back-sloped or have tee section, the lower arm of which shall extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.

6.1.3.6.1.c Baffle

If a removable baffle is used, the following criteria apply:

> The baffle shall extend from a minimum of 1 foot above the WQ design water surface to a minimum of 1 foot below the invert elevation of the inlet pipe.
>
> The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
>
> If the vault is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, the baffle or wall may be omitted and the vault may be one-celled.
>
> 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.
>
> *Exception*: Thurston County may allow the vault bottom to be flat if removable panels are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

The highest point of a vault bottom must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.

Provision for passage of flows should the outlet plug shall be provided.

Wet vaults 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.

Wet vaults shall conform to the "Materials" and "Structural Stability" criteria specified for detention vaults (BMP D.03).

Where pipes enter and leave the vault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.

6.1.3.6.1.d Presettling Cell

The sediment storage in the first cell shall be an average of 1 foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

Vault Width	Sediment Depth (from bottom of side wall)
15'	10"
20'	9"
40'	6"
60'	4"

Where feasible, the bottom of the first cell shall be sloped toward the access opening. Slope shall be between 0.5 percent (minimum) and 2 percent (maximum).

6.1.3.6.1.e Second Cell

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.

Where feasible, the floor of the second cell should slope toward the outlet for ease of cleaning.

6.1.3.6.2 Materials

Wet Vaults shall meet the material requirements and structural design considerations for Detention Vaults as listed in BMP D.03, Section 4.1.3 of Volume V.

6.1.3.6.3 Modifications for Combining with a Baffle Oil/Water Separator

If the project site is a high-use site (see Volume I) and a wet vault is proposed, the vault may be combined with a baffle oil/water 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 baffle oil/water separators must be adhered to, in addition to those for a wet vault. This will result in more frequent inspection and cleaning than for a wet vault used only for TSS removal. See Appendix V-C for information on maintenance of baffle oil/water separators.

The following additional design criteria apply to wet vaults combined with baffle oil/water separators:

The sizing procedures for the baffle oil/water separator (Chapter 8) shall be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wet vault size to match.

An oil retaining baffle shall be provided in the second cell near the vault outlet. The baffle shall not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.

The vault shall have a minimum length-to-width ratio of 5:1.

The vault shall have a design water depth-to-width ratio of between 1:3 to 1:2.

The vault shall be watertight and shall be coated to protect from corrosion.

Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.

Wet vaults used as oil/water separators must be off-line and must bypass flows greater than the off-line WQ design flow multiplied by the off-line ratio indicated in Figure 5.1.b. *<u>Intent:</u> This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.*

6.1.3.7 Structural Design Considerations

The two cells of a wet vault shall 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 cells must be positioned so as to lengthen, rather than divide, the flow path. *Intent: Treatment effectiveness in wet pool 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 cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.*

If a wall is used to separate the two cells, a 5-foot by 10-foot removable maintenance access must be provided for both cells.

6.1.3.8 Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03, of this Volume).

6.1.3.9 Construction and Maintenance

Lockable grates instead of solid manhole covers are recommended to increase air contact with the wet pool.

A minimum of 50 square feet of grate shall be provided over the second cell. For vaults in which the surface area of the second cell is greater than 1,250 square feet, 4 percent of the top shall 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.*

Thurston County may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

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.WP.04 Combined Detention and Wet Pool Facilities

Combined detention and water quality wet pool facilities look like detention facilities, but also contain a permanent pool of water. The following design procedures, requirements, and recommendations describe differences in the design of standalone water quality facilities when combined with detention storage.

6.1.3.10 Applicability

The following combination facilities are summarized in this section:

Table 6-3 Combined Detention and Wetpool Facilities

Facility	Flow Control	Level of Treatment
Basic detention/wetpond	Flow control	Basic treatment
Large detention/wetpond	Flow control	Phosphorus treatment
Detention/wetvault	Flow control	Basic Treatment
Detention/stormwater wetland	Flow Control	Basic Treatment

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area.

6.1.3.11 Limitations

The fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone water quality facilities. 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 wet pool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wet pool volume, the live storage component of the facility shall be provided above the seasonal high water table.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the wet pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the wet pond shall be lined.

6.1.3.12 Submittals and Approval

Make submittals required by Volume I and as required for the individual detention or wet pool / wet vault BMP. Include the following information in the submittal:

Hydrologic modeling results showing the volume required for the wet pool as well as calculations demonstrating compliance with flow control core requirements

Justification for not providing a liner, if lining the facility is not proposed

Details of all structures and material and construction specifications

Planting plan showing plant species, quantity, location and any special planting requirements

Cross section of the pond through the control structure

Design calculations for the overflow structures

Documentation of how the facility location meets setback requirements.

6.1.3.13 Pretreatment

No pretreatment is required. Except that if the combined facility is a wet vault/detention vault then a catch basin with a minimum 2-foot sediment depth shall be installed immediately upstream from the vault.

6.1.3.14 Hydrologic and Hydraulic Design Considerations

The sizing procedure for combined detention and wet ponds are identical to those outlined for wet ponds and for detention facilities. The wet pool volume for a combined facility shall be equal to or greater than the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model. Follow the standard procedure specified in Volume III to size the detention portion of the pond.

6.1.3.15 Design Criteria

Typical design details and concepts for a combined detention and wet pond are shown in Figure 6.6, Figure 6.7, and Figure 6.8. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in BMP D.01.

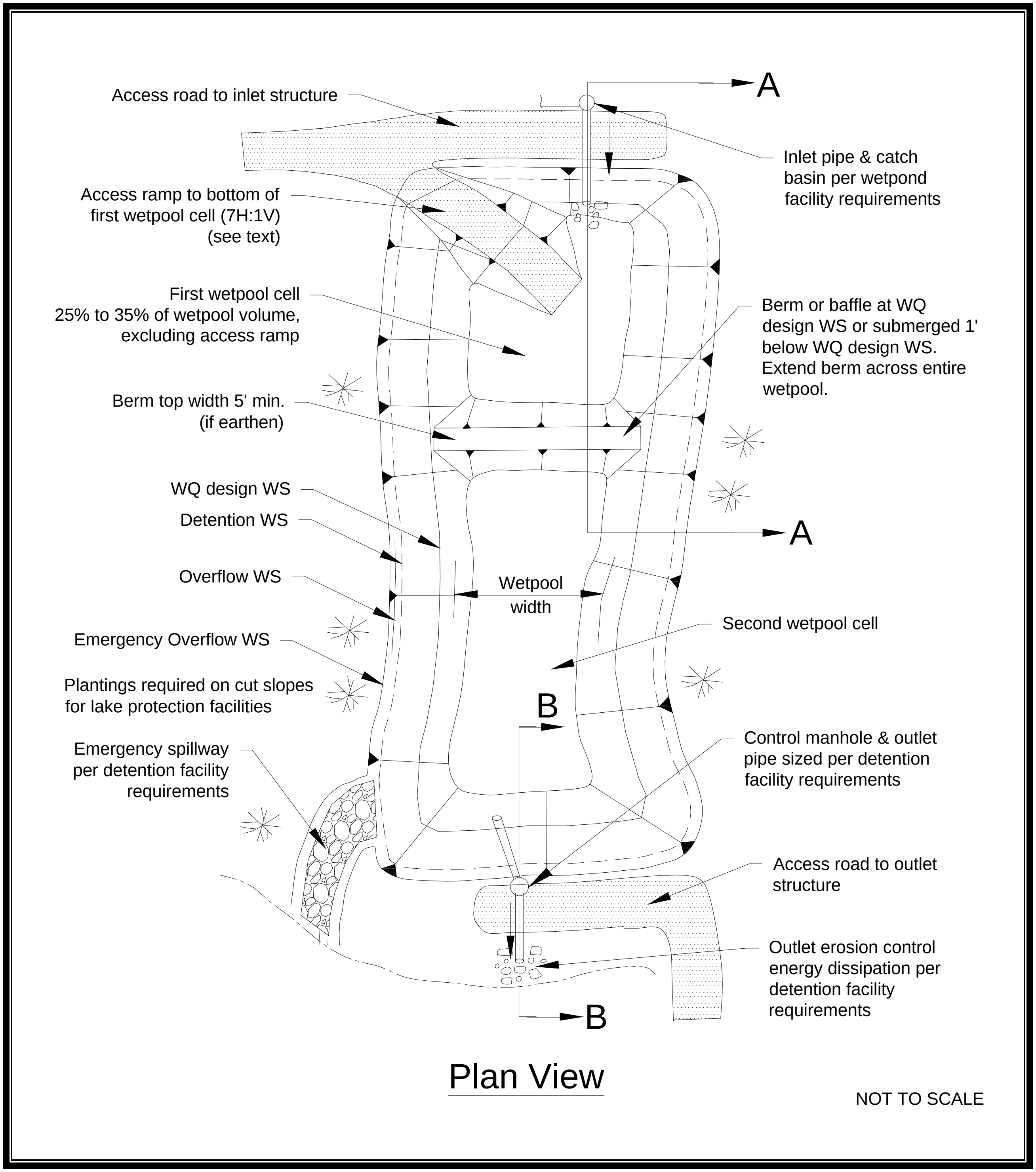


Figure 6.6 Combined Detention and Wetpond

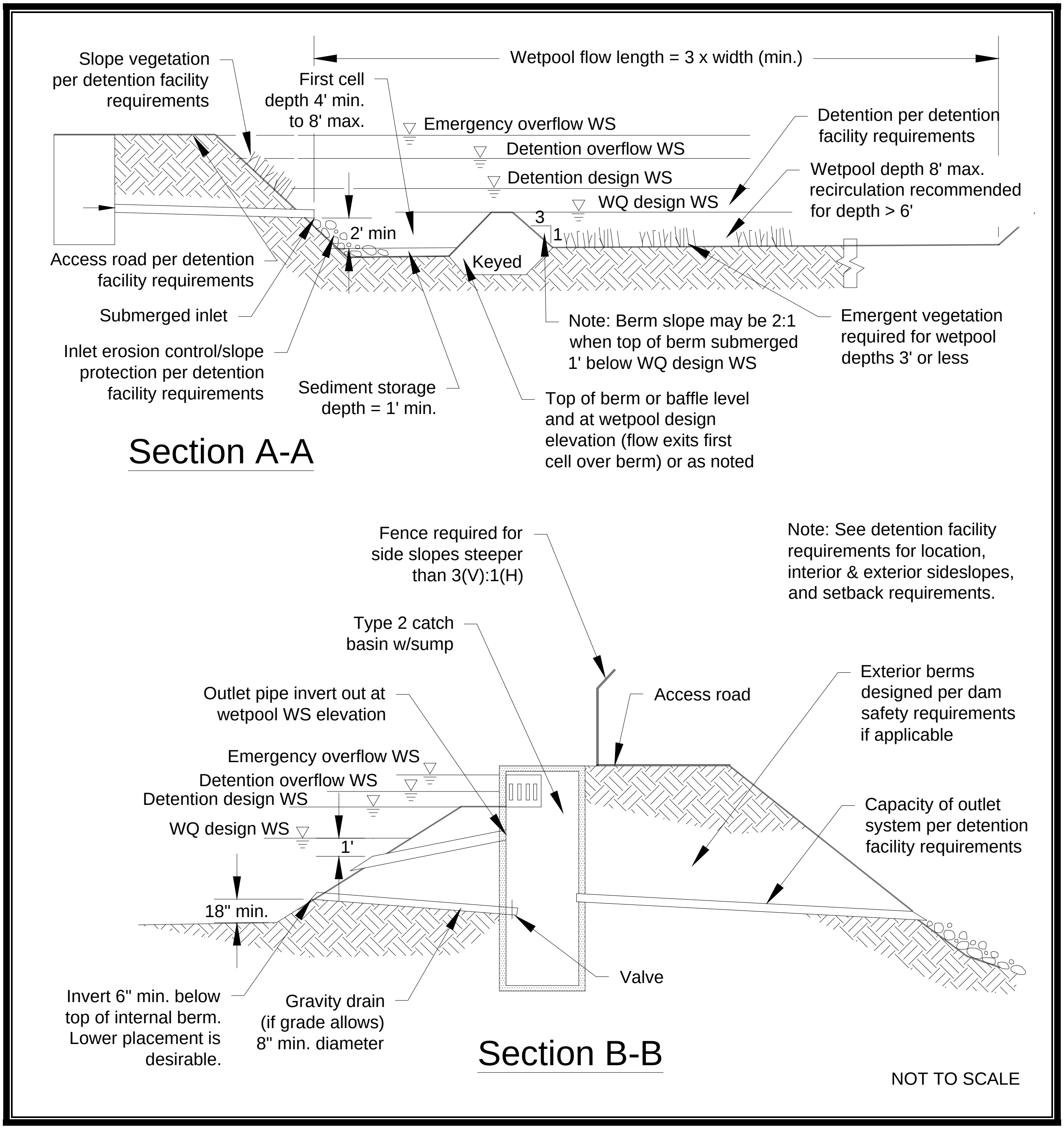


Figure 6.7 Combined Detention and Wetpond (continued)

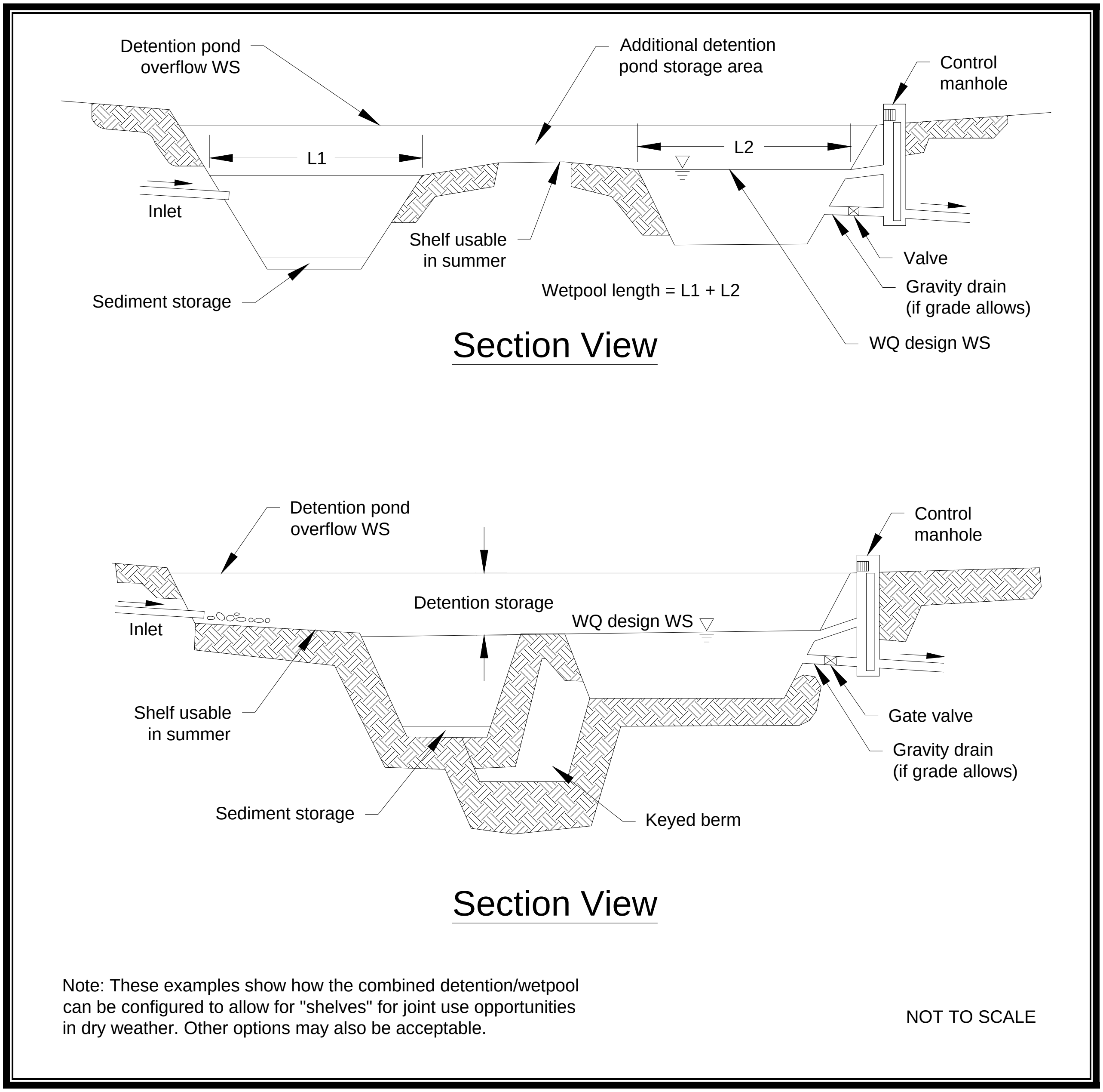


Figure 6.8 Alternative Configurations of Detention and Wetpool Areas

6.1.3.16 Detention Pond and Wet Pond

6.1.3.16.1 Geometry

The wet pool and sediment storage volumes shall not be included in the required detention volume.

The “Wet Pool Geometry” criteria for wet ponds (see BMP WP.02) shall apply with the following modifications/clarifications:

> Criterion 1: The permanent pool 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 wet pool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wet pond criteria governing water depth must, however, still be met. See Figure 6.8 for two possibilities for wet pool 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.
>
> Criterion 2: The minimum sediment storage depth in the first cell is 1 foot. The 6 inches of sediment storage required for detention ponds do 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.

6.1.3.16.1.a Berms, Baffles, and Slopes

Same as for wet ponds (see BMP WP.02).

6.1.3.16.2 Inlet and Outlet

The “Inlet and Outlet” criteria for wet ponds shall apply with the following modifications:

> A sump must be provided in the outlet structure of combined ponds.
>
> The detention flow restrictor and its outlet pipe shall be designed according to the requirements for control structures in Volume V-A.

6.1.3.16.3 Planting Requirements

Same as for wetponds.

6.1.3.16.4 Access and Setbacks

Same as for wetponds.

6.1.3.17 Combined Detention and Wetvault

6.1.3.17.1 Geometry

Minimum sediment storage depth in the first cell shall average 1 foot. The 6 inches of sediment storage required for detention vaults do not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.

The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator.

6.1.3.17.2 Inlet and Outlet

The inlet and outlet criteria for wet vaults shall apply with the following modifications:

> Provide a sump in the outlet structure of the vault
>
> Design the detention flow restrictor and its outlet pipe according to the requirements for detention vaults.

6.1.3.18 Combined Detention and Stormwater Wetland

6.1.3.18.1 Sizing Criteria

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure outlined in BMP WP.01 to determine the stormwater wetland size. Follow the standard procedure for sizing a detention pond for the detention portion of the wetland.

Water Level Fluctuations Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

6.1.3.18.2 Geometry

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

> 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.

6.1.3.18.3 Inlet and Outlet Criteria

The inlet and outlet criteria for wetponds shall apply with the following modifications:

Provide a sump in the outlet structure of combined facilities

Design the detention flow restrictor and its outlet pipe according to the requirements for detention ponds.

6.1.3.18.4 Planting Requirements

The Planting Requirements for stormwater 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 (burrreed)	1 – 2’ depth
Veronica sp. (marsh speedwell)	0 – 1’ depth

In addition, the shrub *Spirea douglasii* (Douglas spirea) may be used in combined facilities.

6.1.3.18.5 Access and Setbacks

Same as for stormwater wetlands.

6.1.4 WP.05 Presettling Basins & Pretreatment

A presettling basin is a structure that provides pretreatment of runoff to remove coarser-grained suspended solids, which can impact other runoff treatment BMPs.

6.1.4.1 Applicability

Removal of suspended solids pretreatment helps prevent clogging or excessive sedimentation in the main water quality facility. Pretreatment is required:

> For sand filters and infiltration BMPs to protect them from excessive siltation and debris
>
> Where the basic treatment facility or the receiving water may be adversely affected by non-target pollutants (e.g., oil), or may be overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids).

Presettling basins are a typical pretreatment BMP used to remove suspended solids. All basic, enhanced, and phosphorus treatment options may be used for pretreatment to reduce suspended solids.

A detention pond sized to meet the flow control standard in Volume I may also be used to provide pretreatment for suspended solids removal.

This remainder of this section discusses Presettling Basins as a BMP.

6.1.4.2 Limitations

Runoff treated by a presettling basin may not be discharged directly to a receiving water or to groundwater because it only removes coarse particulates—not fine-grained or dissolved materials. It must be further treated by a basic or enhanced runoff treatment BMP.

6.1.4.3 Hydrologic and Hydraulic Design Considerations

6.1.4.3.1 Treatment Volume

The total treatment volume of the presettling basin shall be at least 30 percent of the total water quality treatment design volume (e.g., 30 percent of the size of a wetpond designed per BMP WP.02).

6.1.4.3.2 Drawdown Time

Drawdown time of the presettling storage area (excluding wet pool area) must not exceed 40 hours.

6.1.4.4 Design Criteria

6.1.4.4.1 Geometry

A presettling basin shall be designed to include a wet pool sedimentation area at least 6 inches deep at the bottom of the facility.

If the runoff in the presettling basin will be in direct contact with the soil, it must be lined per the liner requirement in Appendix V-B.

The presettling basin shall meet the following requirements:

> The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flow path.
>
> The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
>
> Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at opposite ends of the basin in order to maximize particle-settling opportunities.

6.1.4.5 Structural Design Considerations

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, then dam safety design and review are required by Ecology.

6.1.4.6 Site Design Elements

6.1.4.6.1 Setbacks

Setbacks shall be the same as for wet ponds.

6.1.4.7 Construction and Maintenance

A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation, unless an alternative gauging method is proposed.

Applicable maintenance requirements for a wet pond also apply to a pre-settling basin and are further described in Appendix V-C.

Chapter 7 - Media Filtration BMPs

Media filtration BMPs rely on the physical, biological, and chemical properties of various media such as sand, perlite, zeolite, and activated carbon to remove pollutants. Filter systems are commonly configured as basins, trenches, vaults, or proprietary cartridge filtration systems.

NOTE: Thurston County will not accept ownership of media filtration facilities without prior acceptance. See Appendix V-C for maintenance requirements:

7.1 Media Filtration Design BMPs

The following media filtration BMPs are described in this section:

MF.01 Sand Filter Basin

MF.02 Sand Filter Vault

MF.03 Linear Sand Filter.

MF.04 Media Filter Drain.

Proprietary media filters which have been approved by Ecology with a General Use Level Designation for the required level of treatment may be proposed for some projects with there is insufficient land available for surface facilities. Acceptance by the Manual Administrator or designee is required. For information on current approved proprietary media filters and other emerging technologies, see Ecology's website: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/>.

All media filtration BMPs shall be maintained in accordance with the manufacturer's recommendations and schedules. Owners shall provide the Thurston County Water Resources Unit with maintenance logs annually at the end of each calendar year.

7.1.1 MF.01 Sand Filter Basin

The sand filter basin is a technology adopted from wastewater treatment. Stormwater passes through a sand layer, which filters out particulates—and in the case of amended sand, dissolved substances as well.

7.1.1.1 Applicability

Sand filtration can be used in most types of developments. Applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, high-use sites, high-density multifamily housing, roadways, and bridge decks. They are not recommended in areas undergoing construction or otherwise generating high sediment loads.

Sand filter basins may be designed to provide basic or enhanced treatment, depending on the media:

7.1.1.1.1 Basic Sand Filter

Basic sand filters are expected to achieve the performance goals for basic treatment. Based on experience in King County, Washington and Austin, Texas, basic sand filters should be capable of achieving the following average pollutant removals:

> 80 percent total suspended solids at influent Event Mean Concentrations (EMCs) of 30 to 300 mg/L (King County, 1998) (Chang, 2000)
>
> Oil and grease to below 10 mg/L daily average and 15 mg/L at any time, with no ongoing or recurring visible sheen in the discharge.

7.1.1.1.2 Amended Sand Filter

Sand filters can also be amended to provide enhanced treatment. Use of amended sand filters for enhanced treatment requires prior County and Ecology approval.

7.1.1.1.3 Large Sand Filter

Large sand filters are approved for phosphorus treatment. They are expected to remove at least 50 percent of total phosphorous compounds by collecting and treating 95 percent of the runoff volume (ASCE and WEF, 1998).

7.1.1.2 Limitations

Sand filter basins require a large amount of space, and so are not appropriate for tightly constrained sites.

There must be adequate hydraulic head between the inlet and outlet (see *Hydrologic and Hydraulic Design Considerations*). They are not appropriate for areas subject to large loadings of debris, heavy sediment loads, and oils and greases that could clog or prematurely overload the sand.

7.1.1.3 Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

7.1.1.4 Pretreatment

Pretreatment is necessary to reduce velocities to the sand filter and remove debris, floatables, large particulate matter, and oils. In high water table areas, adequate drainage of the sand filter may require additional engineering analysis and design considerations. An underground filter (BMP MF.02) should be considered in areas subject to freezing conditions (Urbonas, 1997).

7.1.1.5 Hydrologic and Hydraulic Design Considerations

Sand filters may be located either online or off-line, subject to the following:

> ***Online*** sand filters must NOT be placed upstream of a detention facility. This is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.
>
> ***Offline*** sand filters placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at the 15-minute water quality flow rate, as predicted by an approved continuous runoff model, to the sand filter.
>
> ***Offline*** sand filters placed ***downstream*** of a detention facility must have a flow splitter designed to send all flows at the 2-year recurrence interval flow from the detention pond, as predicted by an approved continuous runoff model, to the treatment facility.

7.1.1.5.1 Sand Filter Sizing Procedure

Sand filters must capture and treat the Water Quality Design Storm volume, which is 91 percent of the total runoff volume (95 percent for large sand filter) as predicted by an approved, equivalent, continuous runoff model.

General facility sizing methods are described below, followed by design criteria to be used when designing a sand filter with an approved continuous runoff model.

7.1.1.5.1.a General Design Method

Whether designing the sand filter manually or with an approved model, either method uses Darcy's law for modeling flow through a porous media like sand or soil:

$$Q = KiA$$

Where:

Q = water quality design flow (cfs)

K = hydraulic conductivity of the media (fps)

A = surface area perpendicular to the direction of flow (sf)

i = hydraulic gradient (ft/ft) for a constant head and constant media depth

$$i = \frac{h + L}{L}$$

and:

h = average depth of water above the filter (ft), defined as d/2

d = maximum water storage depth above the filter surface (ft)

L = thickness of sand media (ft).

Darcy's law underlies both the manual and the modeling design methods. V, or more correctly, 1/V, is the direct input in the sand filter design. The relationship between V and K is revealed by equating Darcy's law and the equation of continuity, Q = VA. (Note: When water is flowing into the ground, V is commonly called the filtration rate. It is ordinarily measured via a soil infiltration test.)

Specifically:

$$Q = KiA \quad \text{and} \quad Q = VA \text{ so,}$$
$$VA = KiA \quad \text{or} \quad V = Ki$$

Note that $V \neq K$. The filtration rate is not the same as the hydraulic conductivity, but they do have the same units (distance per time). K can be equated to V by dividing V by the hydraulic gradient i, which is defined above.

The hydraulic conductivity K does not change with head nor is it dependent on the thickness of the media, only on the characteristics of the media and the fluid. The hydraulic conductivity of 1 inch per hour (2.315×10^{-5} fps) specified for sand filter design is based on bench-scale tests of conditioned rather than clean sand.

This design hydraulic conductivity represents the average sand bed condition as silt is captured and held in the filter bed. Unlike the hydraulic conductivity, the filtration rate V changes with head and media thickness, although the media thickness is constant in the sand filter design. ***Table 7-1*** shows values of V for different water depths d (d=2h).

Table 7-1 Sand Filter Design Parameters

	Sand Filter Design Parameters					
Facility ponding depth d (ft)	1	2	3	4	5	6
Filtration rate V (in/hr) [a]	1.33	1.67	2.00	2.33	2.67	3.00
1/V (min/in)	45	36	30	26	22.5	20

[a] The filtration rate is not used directly, but is provided for information. V equals the hydraulic conductivity, K, times the hydraulic gradient, i. The hydraulic conductivity used is 1 inch/hr. The hydraulic gradient = (h + L)/L, where h = d/2 and L = the sand depth (1.5 ft).

7.1.1.5.1.b Modeling Method

When using continuous modeling to size a sand filter, apply the assumptions listed in ***Table 7-2***. Several available modeling programs include built-in modules to size sand filters.

Table 7-2 Sand Filter Design and Sizing Criteria

Variable	Assumption
Computational Time Step	15-minutes
Inflows to Facility	Model output for water quality design
Ponding Depth	Maximum water depth over the filter media
Precipitation Applied to Facility	Checked (always activated when sizing above ground sand filters)
Evaporation Applied to Facility	Checked (always activated when sizing above ground sand filters)
Media depth	18 inches or other as designed
Sand Media Hydraulic Conductivity	1 inch per hour
Use Wetted Surface Area	Only if side slopes are 3:1 or flatter

7.1.1.5.2 Inlet

Inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) shall be designed to capture the applicable design flow rate, minimize turbulence and to spread the flow uniformly across the surface of the sand filter. Stone riprap or other energy dissipation devices shall be installed to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures (see Appendix V-A).

7.1.1.5.3 Overflow

An overflow shall be included in the design of the basic and large sand filter basin (see Appendix V-A). The overflow height shall be at the maximum hydraulic head of the pond above the sand bed.

7.1.1.5.4 Underdrain

The following are design criteria for the underdrain piping: (types of underdrains include: a central collector pipe with lateral feeder pipes, or, a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, or, longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.)

> Upstream of detention underdrain piping shall be sized to handle double the 2-year recurrence interval flow indicated by an approved continuous runoff model (the doubling factor is a safety factor used in the absence of a conversion factor from the 1-hour time step to a 15-minute time step). Downstream of detention the underdrain piping shall be sized for the 2-year recurrence interval flow indicated by an approved continuous runoff model. In both instances there shall be at least 1 foot of hydraulic head above the invert of the upstream end of the collector pipe (King County, 1998).
>
> Internal diameters of underdrain pipes shall be a minimum of 6 inches and two rows of three-eighth-inch holes spaced 6 inches apart longitudinally (maximum), with rows

120 degrees apart (laid with holes downward). Maximum perpendicular distance between two feeder pipes must be 10 feet. Drain piping could be installed in basin and trench configurations.

Main collector underdrain pipe shall be at a slope of 1 percent minimum.

A geotextile fabric (specifications in Appendix V-B) must be used between the sand layer and drain rock or gravel and placed so that 2 inches of drain rock/gravel is above the fabric.

Cleanout wyes with caps or junction boxes must be provided at both ends of the collector pipes. Cleanouts must extend to the surface of the filter.

7.1.1.6 Design Criteria

Figure 7.1, Figure 7.2, Figure 7.3, Figure 7.4, and Figure 7.5 provide details of a sand filter basin.

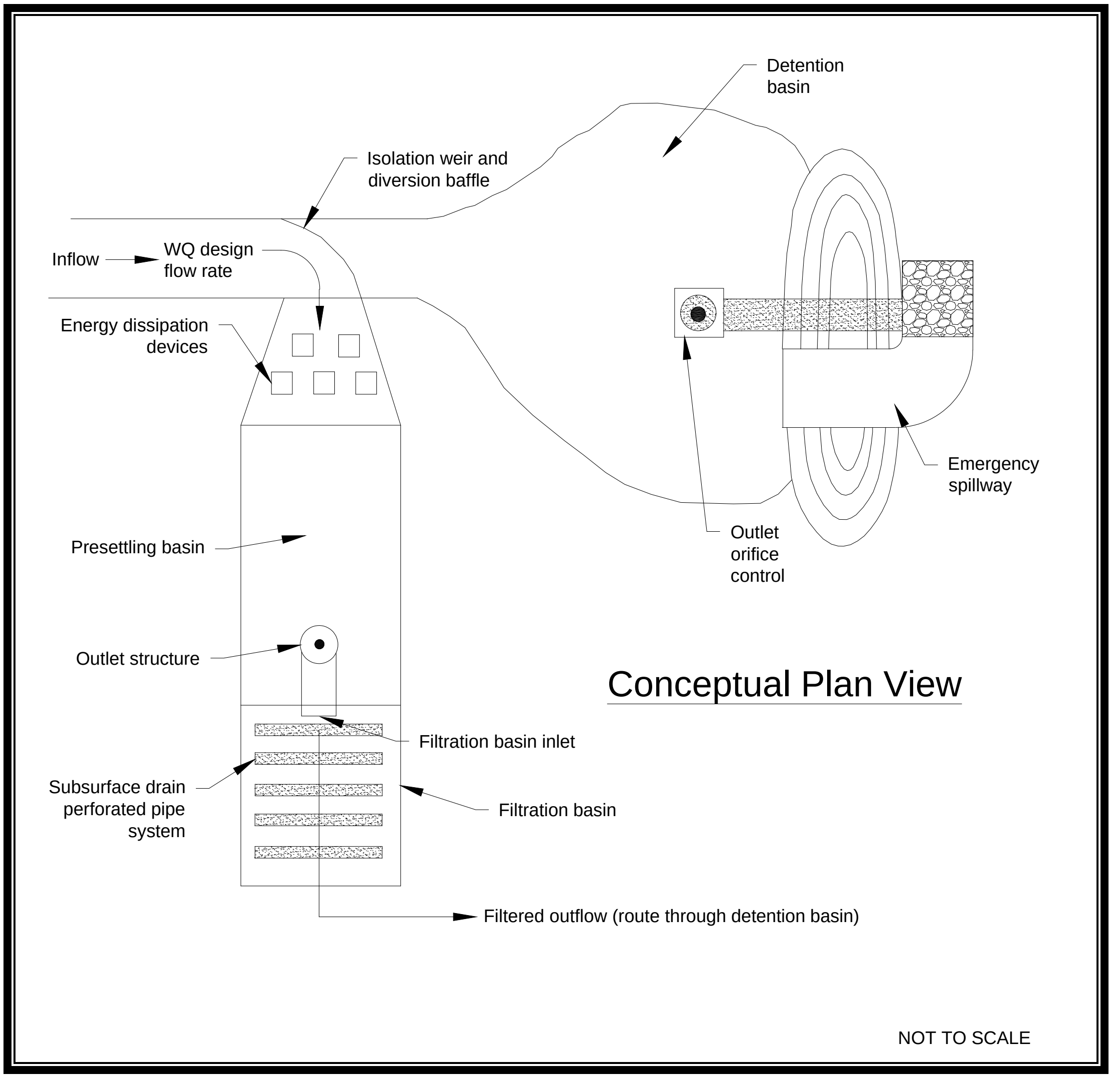


Figure 7.1 Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)

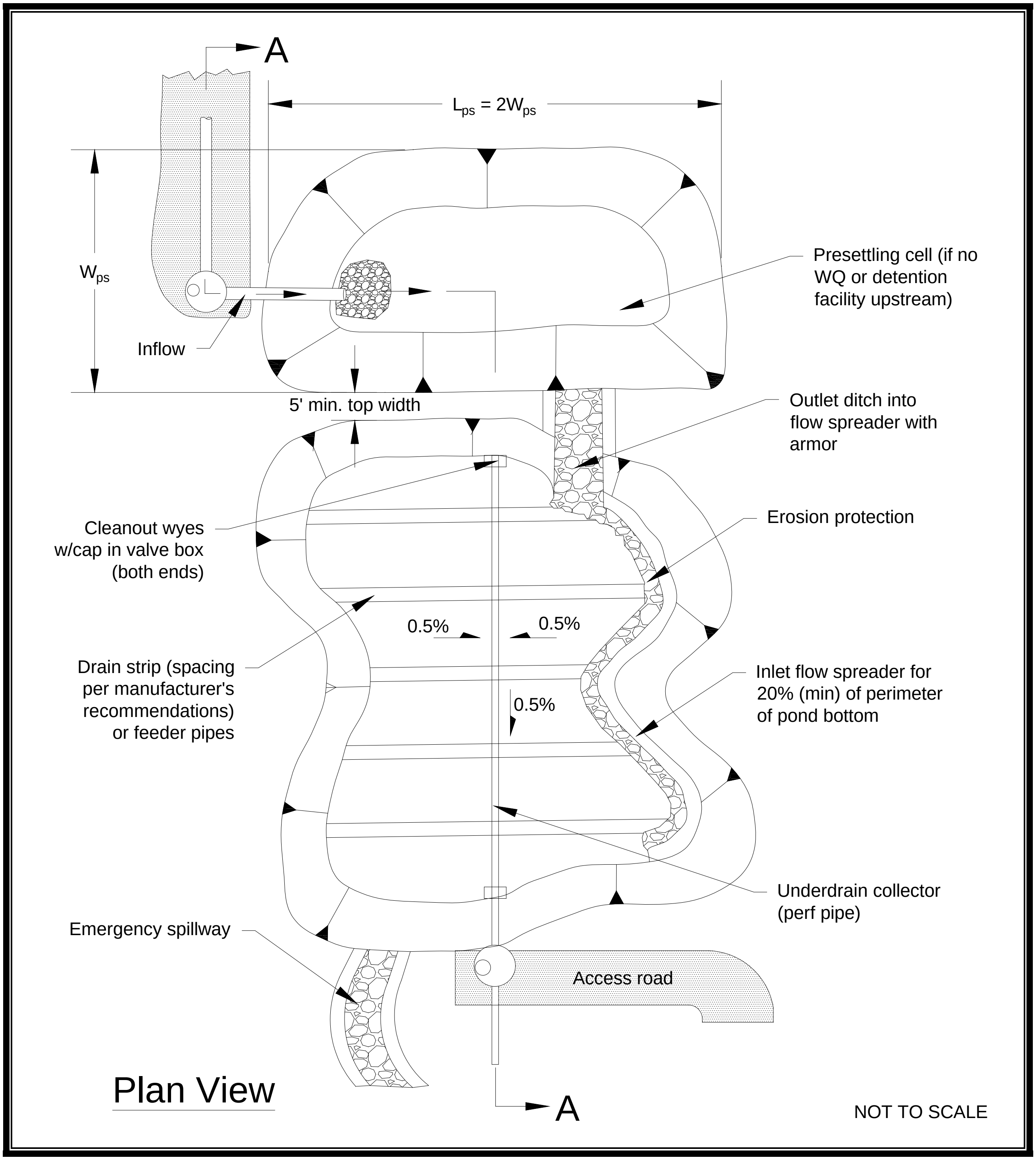


Figure 7.2 Sand Filter with Pretreatment Cell

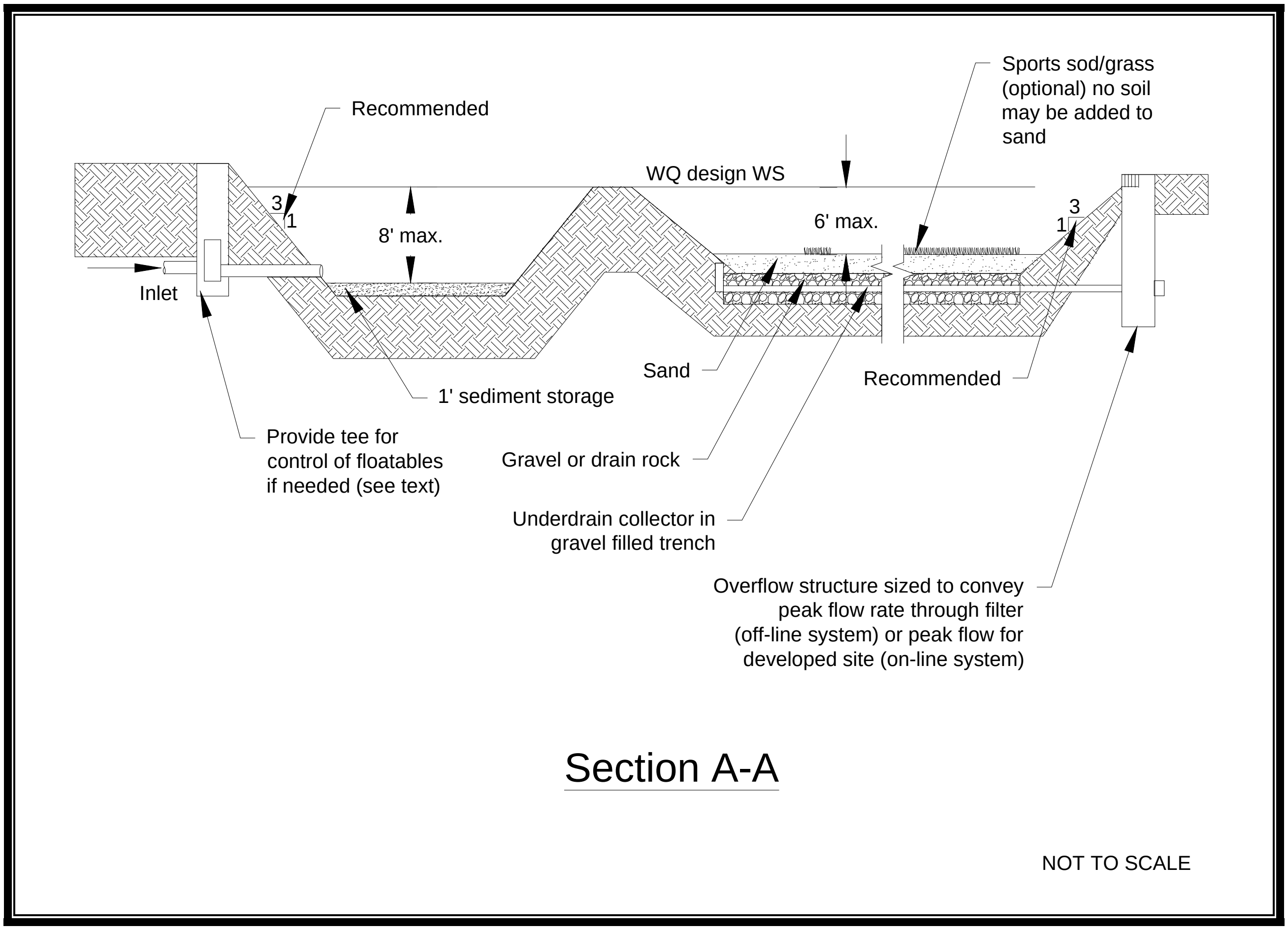


Figure 7.3 Sand Filter with Pretreatment Cell – Section

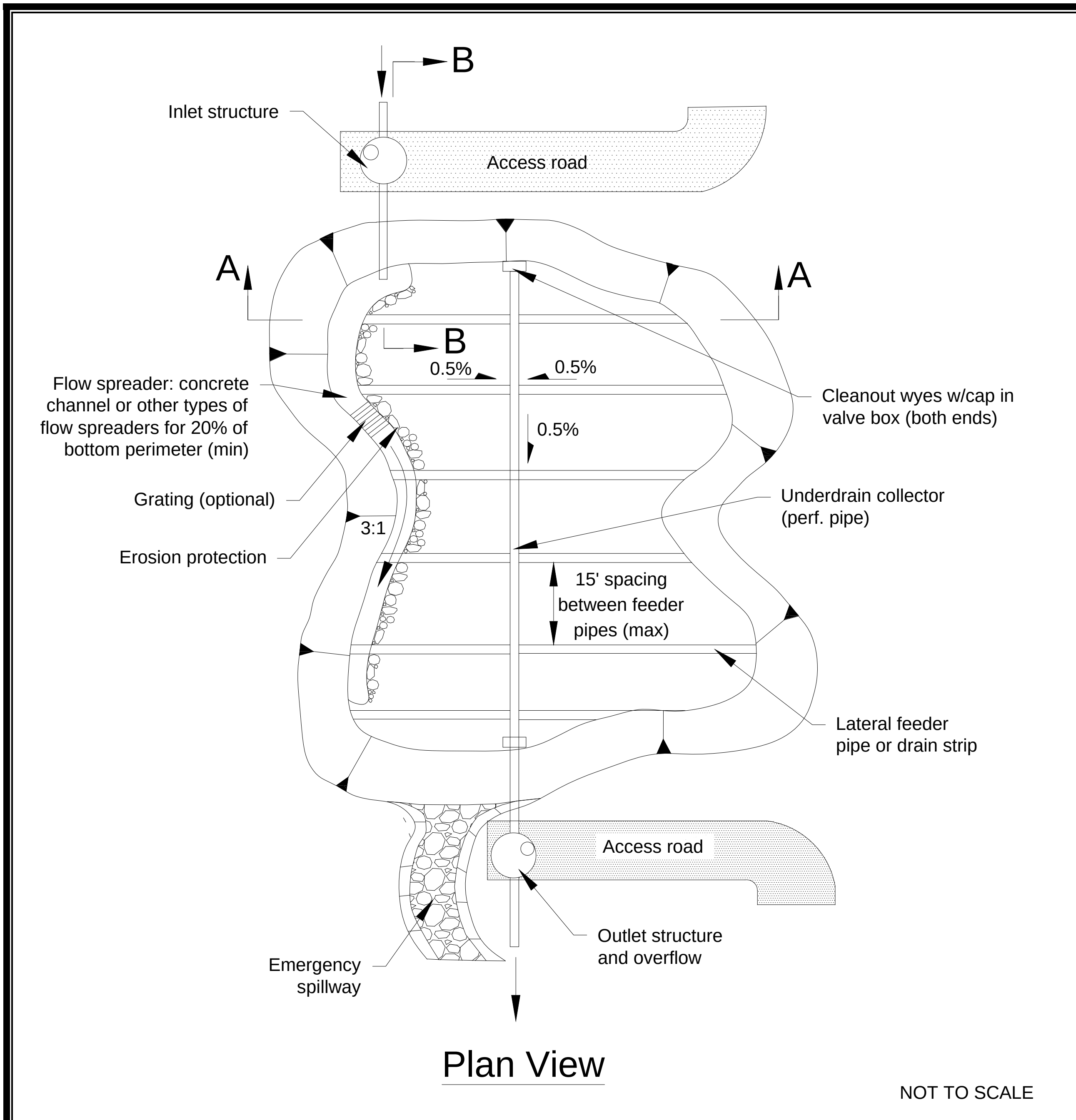


Figure 7.4 Sand Filter with Level Spreader

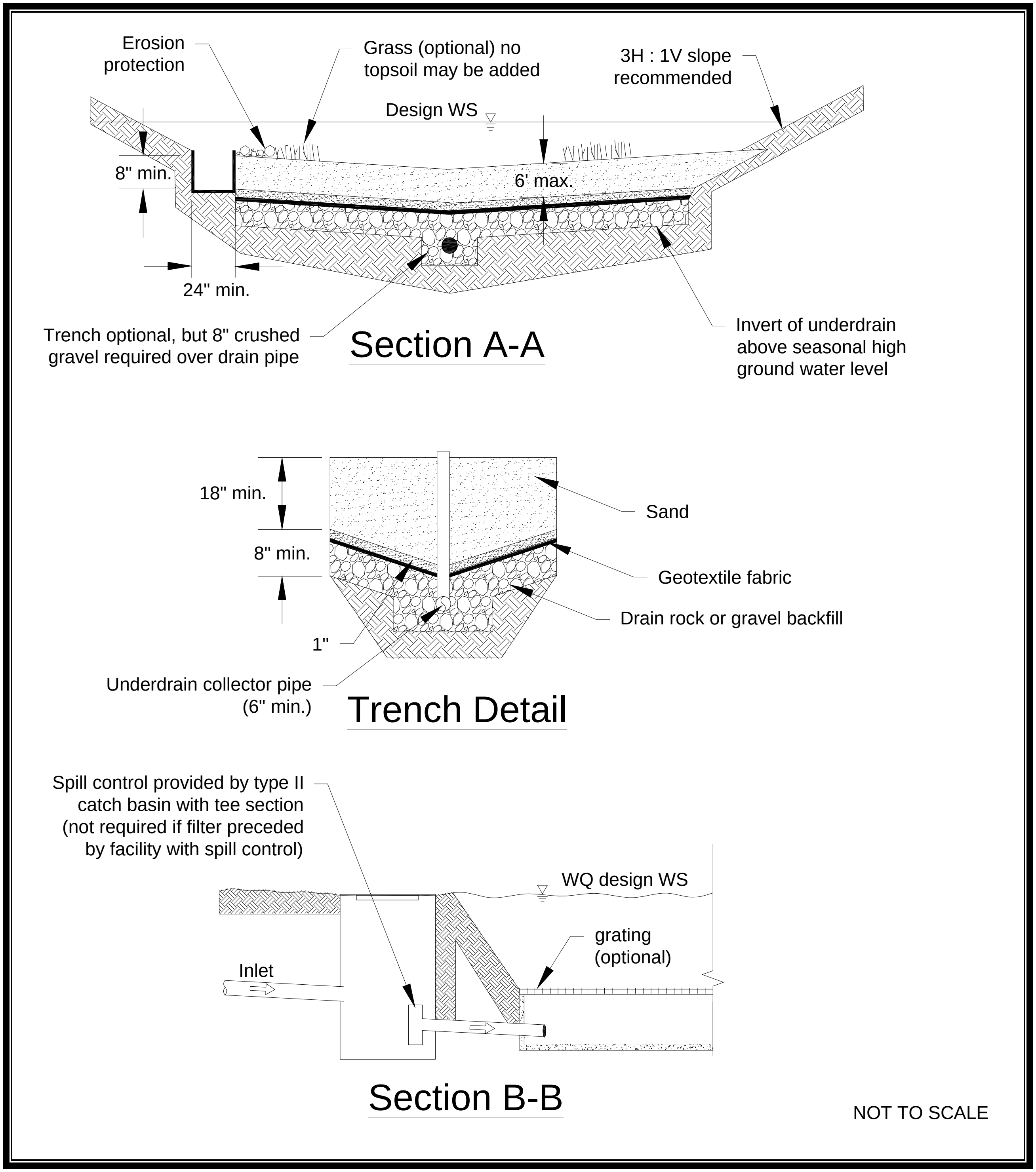


Figure 7.5 Sand Filter with Level Spreader – Sections and Details

7.1.1.6.1 Geometry

Side slopes for earthen/grass embankments must not exceed 3:1 to facilitate mowing.

7.1.1.6.2 Materials

7.1.1.6.2.a Drain Rock

Drain rock shall be 0.75 to 1.5 inch rock or gravel backfill, washed free of clay and organic material.

7.1.1.6.2.b Underdrain Piping

All piping is to be schedule 80 PVC or greater wall thickness.

7.1.1.6.2.c Sand

Sand bed depth shall be a minimum of 18 inches. The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in ***Table 7-3*** below. The contractor must obtain a grain size analysis from the supplier to certify that the No. 100 and No. 200 sieve requirements are met. (**Note**: Standard backfill for sand drains, WA. Std. Spec. 9-03.13, does not meet this specification and shall not be used for sand filters.)

Table 7.3. Sand Medium Specification

Table 7-3 Sand Medium Specification

U.S. Sieve Number	Percent Passing
4	100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

7.1.1.6.2.d Impermeable Liners for Sand Bed Bottom

Impermeable liners are required where the underflow could cause problems with structures. If an impermeable liner is not provided, then an analysis must be provided identifying possible adverse effects of seepage zones on groundwater, and near building foundations, basements, roads, parking lots and sloping sites.

Impermeable liners may be clay, concrete, or geomembrane. Clay liners shall have a minimum thickness of 12 inches and meet the specifications given in ***Table 7-4***. If a geomembrane liner is used it must have a minimum thickness of 30 mils and be ultraviolet resistant. The geomembrane liner must be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane.

Table 7-4 Clay Liner Specifications

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1 x $10^{-6 \text{ max.}}$
Plasticity Index of Clay	ASTM D-423 and 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 percent of Standard Proctor Density

Source: City of Austin, 1988.

If an impermeable liner is not required then a geotextile fabric liner must be installed that retains the sand and meets the specifications listed in Appendix V-A, unless the basin has been excavated to bedrock.

7.1.1.7 Structural Design Considerations

Concrete liners may also be used for sedimentation chambers and for sedimentation and sand filtration basins less than 1,000 square feet in area. Concrete must be 5 inches thick Class A or better and shall be reinforced by steel wire mesh. The steel wire mesh must 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 must 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.

7.1.1.8 Site Design Elements

High groundwater may damage underground structures or affect the performance of filter underdrain systems. There must be sufficient clearance (at least 2 feet) between the seasonal high groundwater level and the bottom of the sand filter to obtain adequate drainage.

Sand filters without impermeable liners shall not be built on fill sites and shall be located at least 20 feet downslope and 100 feet upslope from building foundations.

7.1.1.9 Construction and Maintenance

7.1.1.9.1 Construction Considerations

Until all project improvements which produce surface runoff are completed, and all exposed ground surfaces are stabilized by revegetation or landscaping, sand filtration systems may not be operated, and no surface runoff may be permitted to enter the system.

Careful level placement of the sand is necessary to avoid formation of voids within the sand 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. To enable settling, flood the sand with 10 to 15 gallons of water per cubic foot of sand.

7.1.1.9.2 Maintenance Access

Include a maintenance access ramp with a slope not greater than 7:1 at the inlet and the outlet of a surface filter. Consider installing an access port for inspection and maintenance.

7.1.1.9.3 Cleanouts and Underdrain Piping

A valve box must be provided for access to the cleanouts.

Access for cleaning all underdrain piping shall be provided. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand bed.

7.1.2 MF.02 Sand Filter Vault

A sand filter vault (see Figure 7.6 and Figure 7.7) is similar to a sand filter basin, except that the sand layer and underdrains are installed below grade. A sand filter vault consists of presettling and sand filtration cells.

7.1.2.1 Applicability

A sand filter vault is appropriate where space limitations preclude aboveground facilities or in areas subject to freezing.

7.1.2.2 Limitations

A sand filter vault is not appropriate in high water table areas. There must be adequate hydraulic head (approximately 4 feet) between the inlet and outlet. As with sand filter basins, vaults are not appropriate for areas subject to large loadings of debris, heavy sediment loads, and oils and greases that could clog or prematurely overload the sand.

7.1.2.3 Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

7.1.2.4 Pretreatment

Design shall include a forebay, pre-settling basin or other treatment BMP prior to the sand filter for coarse sediment removal.

7.1.2.5 Hydrologic and Hydraulic Design Considerations

Sand filter sizing is the same as for MF.01 (sand filter basin).

Vaults may be designed as off-line systems or online for small drainages.

7.1.2.5.1 Off-line Systems

In an off-line system a diversion structure (see Appendix V-A) shall be installed to divert the design flow rate into the sediment chamber and bypass the remaining flow to detention/retention (if necessary to meet Core Requirement #7), or to surface water.

7.1.2.5.2 Inlet

Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum of 8-inch distance between the top of the 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.

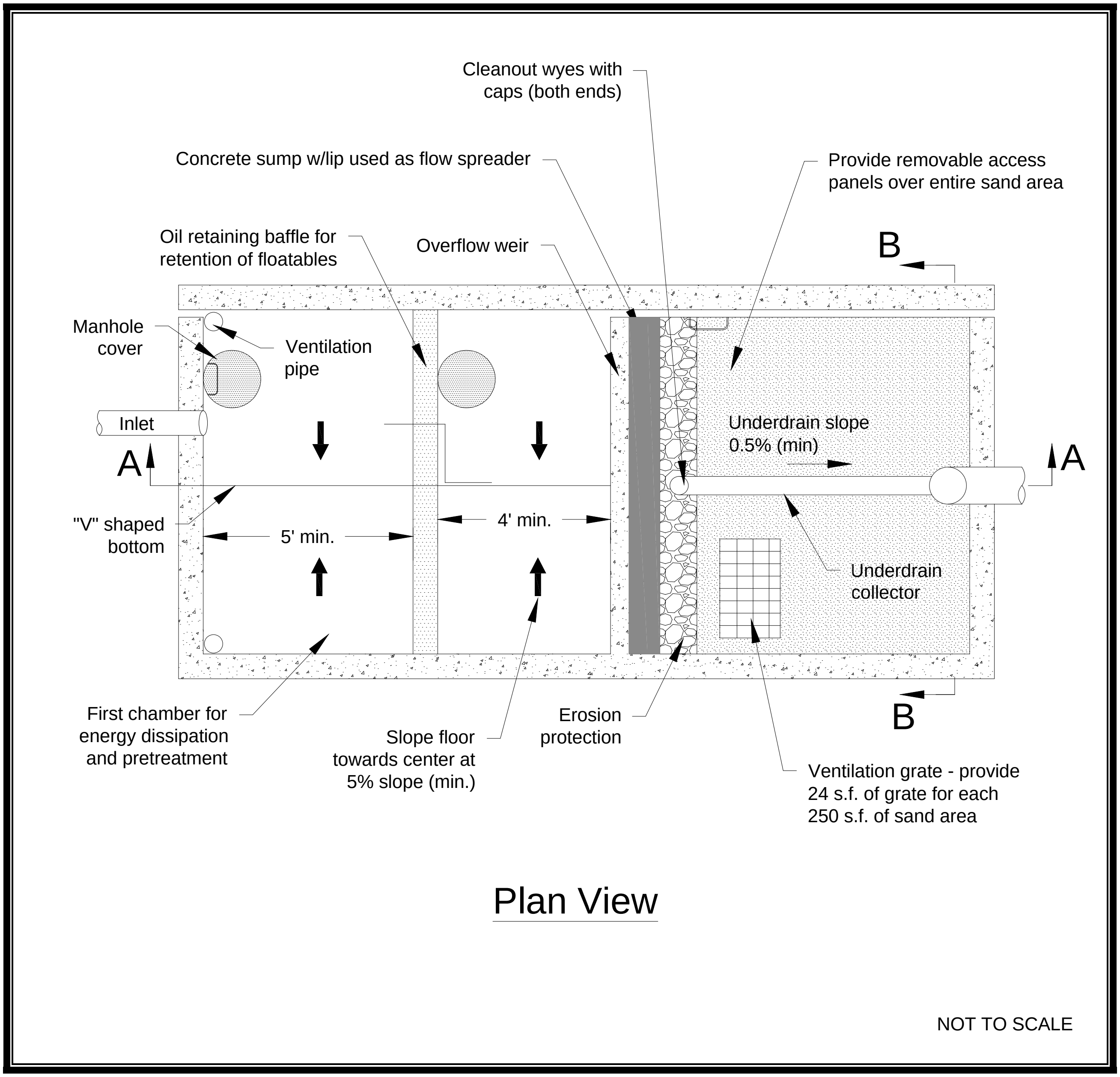


Figure 7.6 Sand Filter Vault

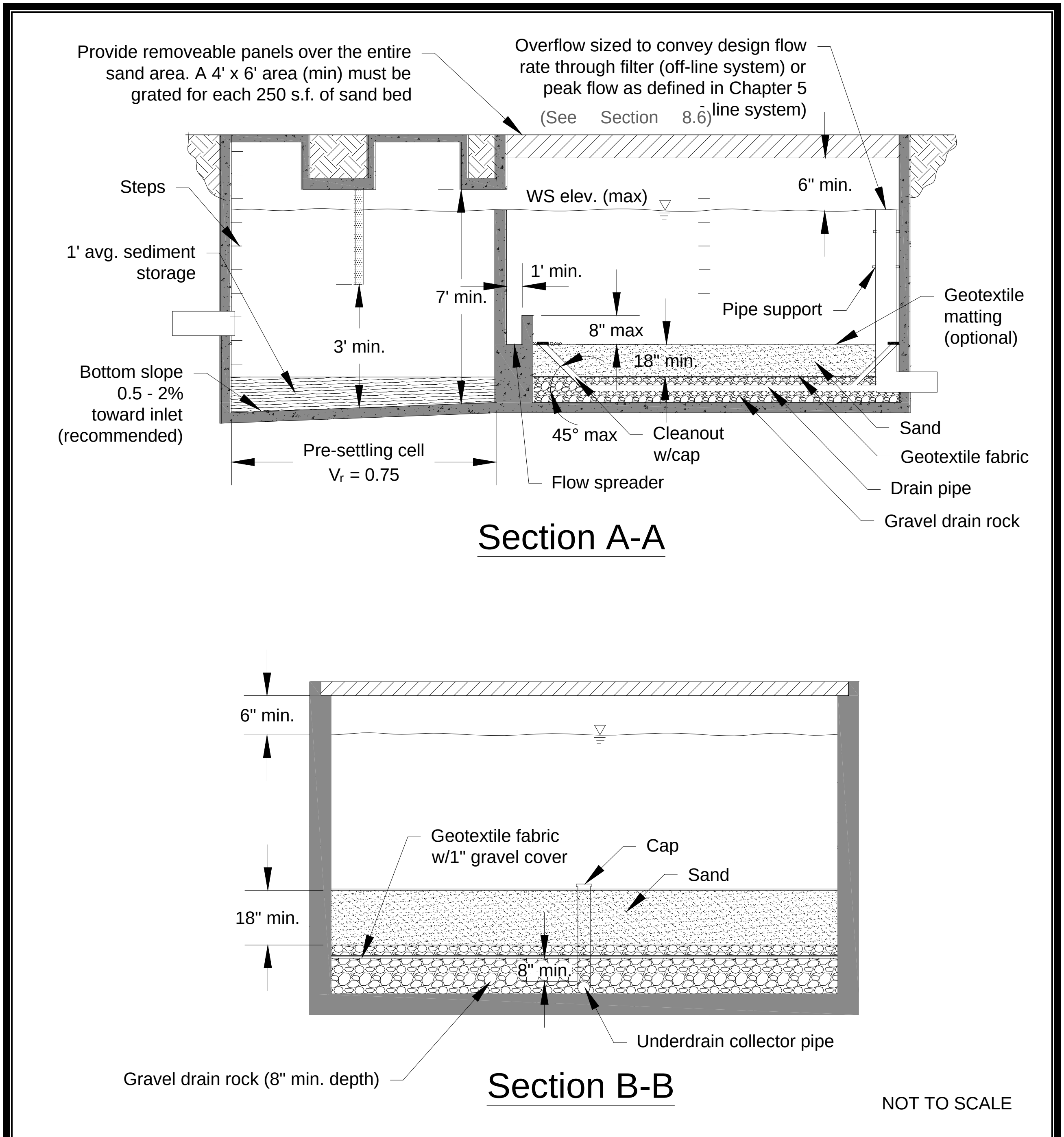


Figure 7.7 Sand Filter Vault: Sections

If an inlet pipe and manifold system is used, the minimum pipe size shall 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 spreader. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used.

7.1.2.6 Design Criteria

The filter bed shall consist of a sand top layer, and a geotextile fabric second layer with an underdrain system.

7.1.2.6.1 Geometry

7.1.2.6.1.a Presettling Cell

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 chamber must be sealed to trap oil and trash. This chamber is usually connected to the sand filtration chamber through an invert elbow to protect the filter surface from oil and trash.

7.1.2.6.1.b Baffle

If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least 1 foot above to 1 foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladder must be provided on both sides of the baffle.

7.1.2.6.2 Materials

Sand filter vaults must conform to the materials and structural suitability criteria specified for wet vaults

A geotextile fabric (see Appendix V-B) 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.

7.1.2.7 Structural Design Considerations

Sand filters vaults shall conform to the structural suitability and materials criteria specified for wetvaults.

7.1.2.8 Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

7.1.2.9 Construction and Maintenance

Provide a sand filter inlet shutoff/bypass valve for maintenance

Provision for access is the same as for wet vaults. Removable panels must be provided over the entire sand bed.

To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate shall 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 filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.

7.1.3 MF.03 Linear Sand Filter

A linear sand filter (see Figure 7.8) is typically a long, shallow, two-celled, rectangular vault. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader.

7.1.3.1 Applicability

Linear sand filters are well-suited to small drainages (less than 2 acres of impervious area), and can fit well into long narrow spaces such as the perimeter of a paved surface.

A linear sand filter can be used to treat runoff from high-use sites for total suspended solids and oil/grease removal or, alternatively, as a part of a treatment train to provide enhanced or phosphorus treatment.

7.1.3.2 Limitations

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.

7.1.3.3 Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

7.1.3.4 Pretreatment

Pretreatment is achieved in the upstream cell of the linear sand filter which provides for settling of coarse particles. Therefore, a separate pretreatment facility is not required.

7.1.3.5 Hydrologic and Hydraulic Design Considerations

Maximum sand bed ponding depth is 1 foot.

Drain pipe must be sloped a minimum of 0.5 percent.

7.1.3.6 Design Criteria

Figure 7.7 shows a plan view and sections of a linear sand filter. The linear sand filter has a sediment chamber and a sand filter chamber.

The two chambers shall be divided by a divider wall that is level and extends a minimum of 12 inches above the sand bed.

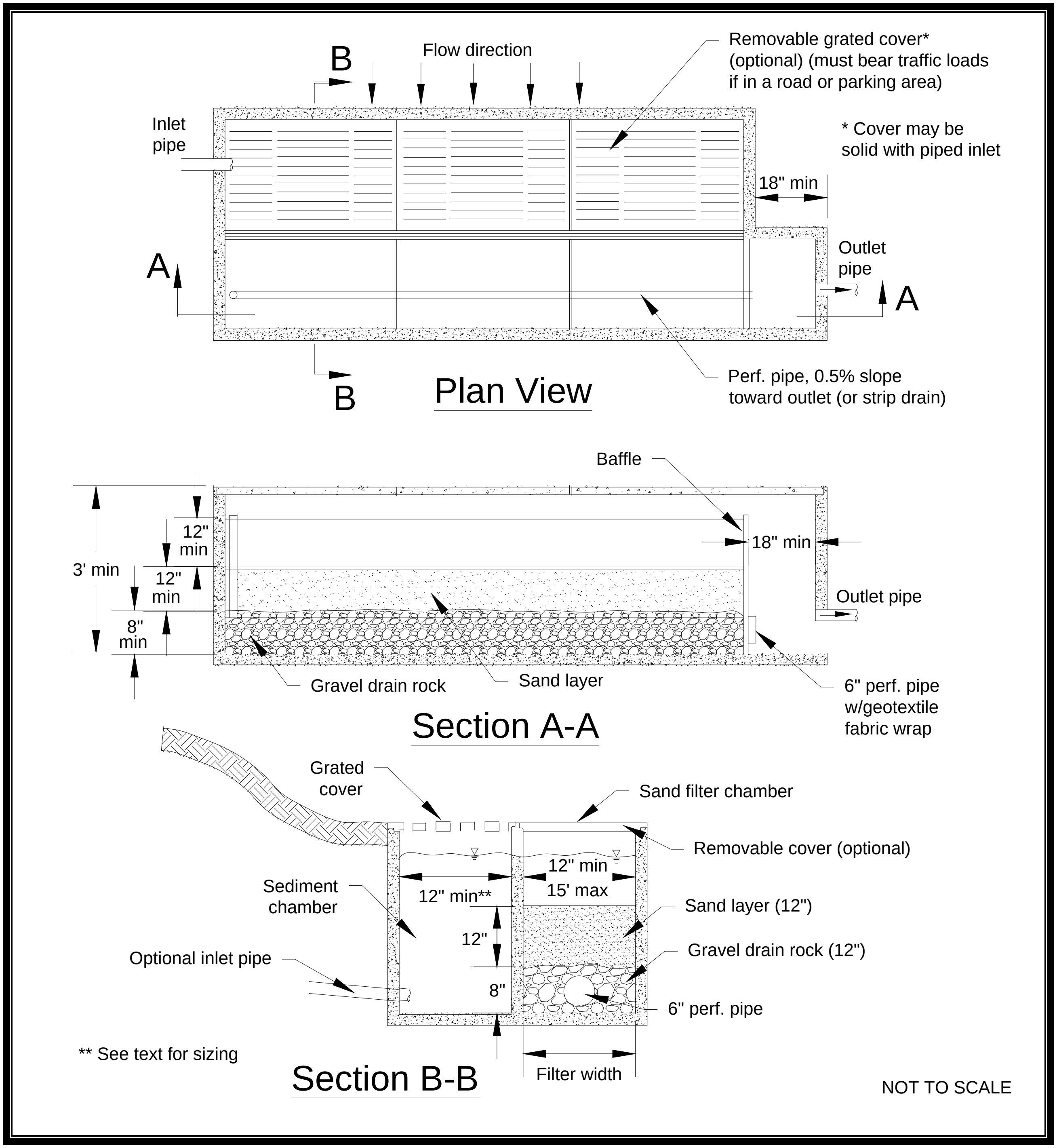


Figure 7.8 Linear Sand Filter

7.1.3.6.1 Geometry

7.1.3.6.1.a Sediment Chamber

The sediment chamber width shall be as follows:

Sand filter width, inches	12-24	24-48	48-72	72+
Sediment chamber width, inches	12	18	24	w/3

Stormwater may enter the sediment cell by sheet flow or a piped inlet.

7.1.3.6.1.b Sand Filter Chamber

The width of the sand filter chamber must be between 1 foot and 15 feet.

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.

7.1.3.6.2 Materials

Linear sand filters must conform to the materials criteria specified for wet vaults.

The drainpipe must be a minimum of 6 inches in diameter and be wrapped in geotextile.

7.1.3.7 Structural Design Considerations

Linear sand filters must conform to the structural suitability materials criteria specified for wet vaults.

7.1.3.8 Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

7.1.3.9 Construction and Maintenance

Linear sand filters must be vented as for sand filter vaults.

7.1.4 MF.04 Media Filter Drain

The media filter drain (MFD) is a linear flow-through stormwater runoff treatment device The MFD can be sited adjacent to roadside embankments (conventional design) and medians (dual media filter drain), borrow ditches, or other linear depressions.

The media filter drain (MFD), previously referred to as the *ecology embankment*, is a linear flow-through stormwater runoff treatment device that was developed by the Washington State Department of Transportation (WSDOT). The MFD can be sited along roadway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. WSDOT has developed and tested other configurations of MFD's. See the most recent version of the *Highway Runoff Manual* for more information.

MFD's have 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. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surface base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in Figure 7.9, Figure 7.10, and Figure 7.11. Note: The drawings are only templates and should be modified to fit each application per the sizing information below.

The MFD has a general use level designation (GULD) from the Department of Ecology for basic, phosphorus, and enhanced treatment. The MFD removes suspended solids, phosphorus, and metals from stormwater runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

7.1.4.1 Applicability

The MFD can be used where available right-of-way is limited, sheet flow is feasible (i.e., no curbs), lateral gradients are generally less than 25 percent (4H:1V), and longitudinal gradients are less than 5 percent.

7.1.4.1.1 Media Filter Drains

Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains are roadside embankments or other long, linear grades.

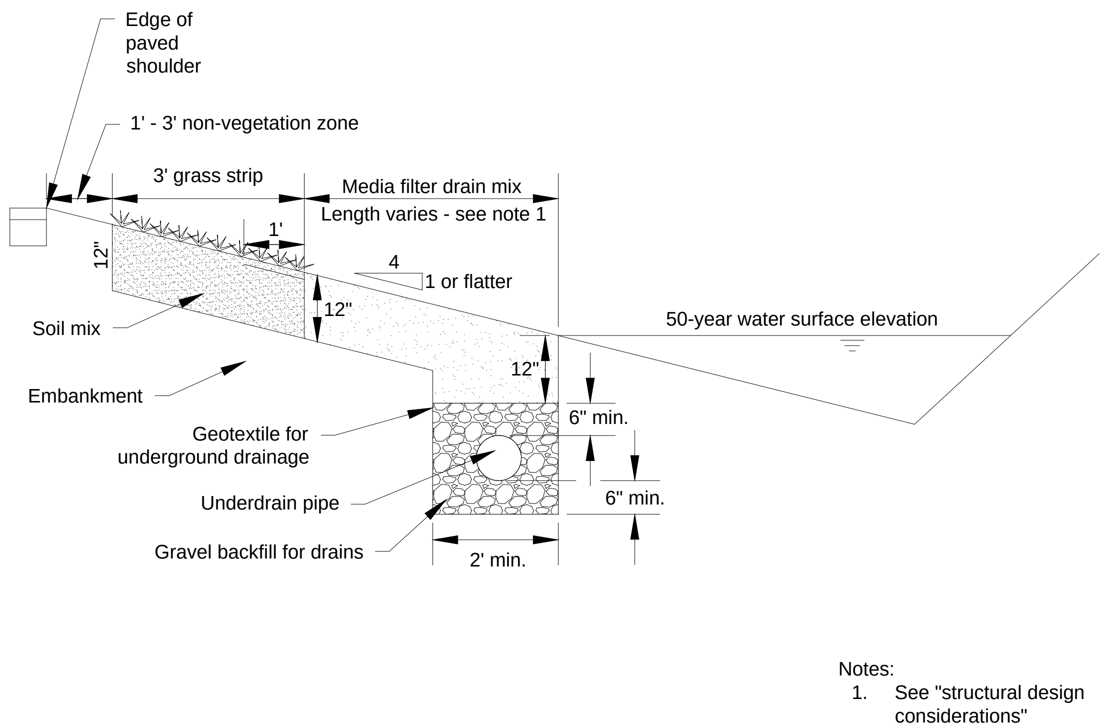


Figure 7.9 Media Filter Drain: Side Slope Application with Underdrain

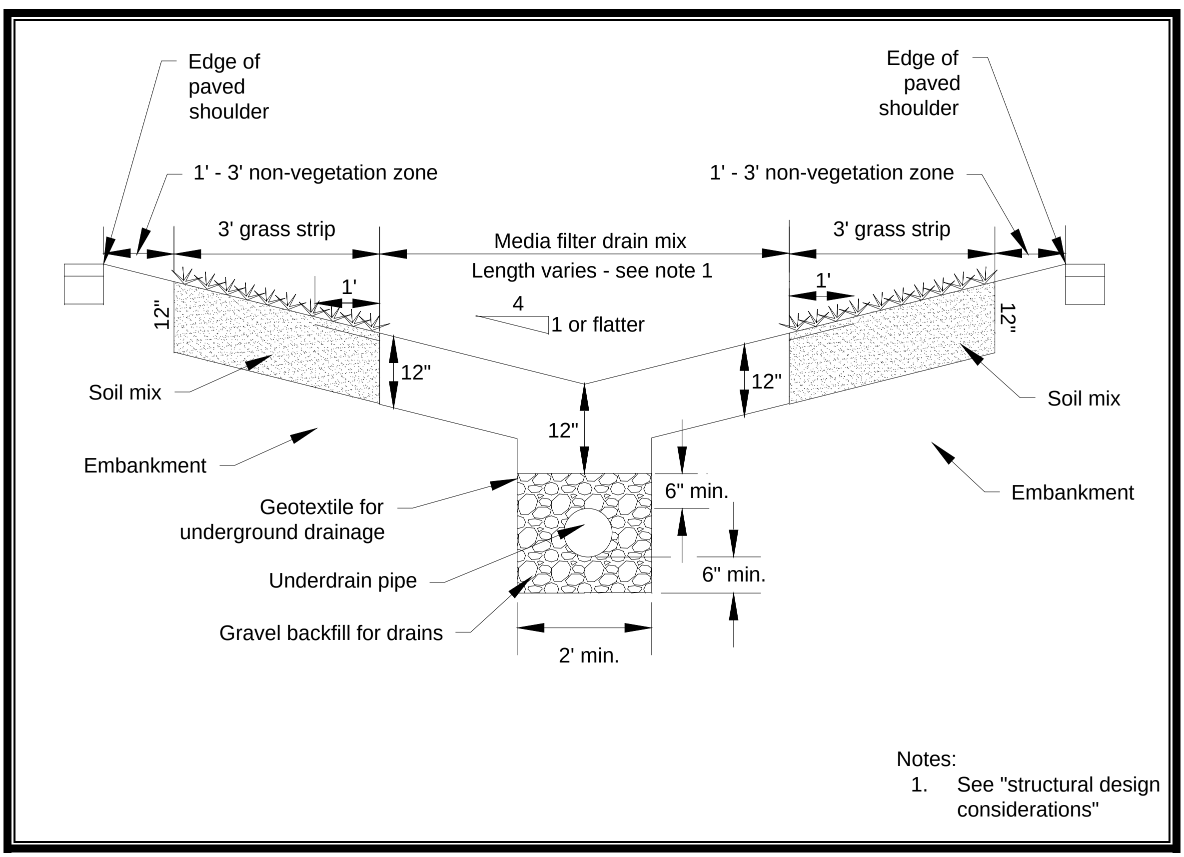


Figure 7.10 Dual Media Filter Drain: Median Application with Underdrain

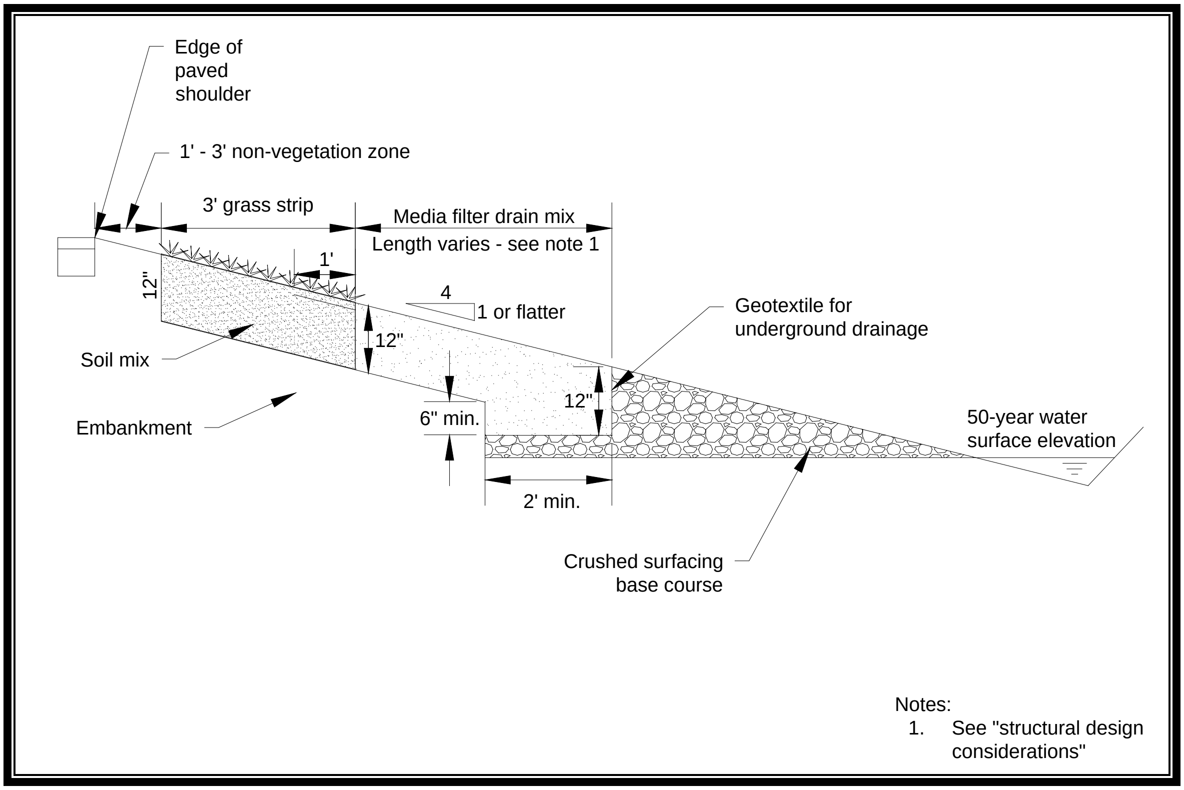


Figure 7.11 Media Filter Drain: Side Slope Application without Underdrain

7.1.4.1.2 Dual Media Filter Drains

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 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.

7.1.4.2 Limitations

7.1.4.2.1 Flow Path

The longest flow path from the contributing area delivering sheet flow to the media filter drain shall not exceed 75 feet for impervious surfaces and 150 feet for pervious surfaces.

7.1.4.2.2 Channelized Flow

Media filter drains shall not be used where continuous off-site inflow may result in channelized flows or ditch flows running down the middle of the dual media filter drain.

7.1.4.2.3 Steep Slopes

Avoid construction on longitudinal slopes steeper than 5 percent.

Avoid construction on 3H:1V lateral slopes, and preferably use flatter than 4H:1V slopes. As slopes approach 3H:1V, without design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils. 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.

In areas where slope stability may be problematic, consult a geotechnical engineer.

7.1.4.2.4 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 fill slopes adjacent to a wetland buffer. In those situations where the 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.

7.1.4.2.5 Shallow Groundwater

Mean high water table levels in the project area need to be determined to ensure that the MFD mix bed and the underdrain will not become saturated by shallow groundwater.

There must be at least 1 foot of depth between the seasonal high groundwater table and the bottom of the facility.

7.1.4.3 Submittals and Approval

As part of the submittals required by Volume I include the following:

Design information and calculations for the MFD including sizing criteria, assumptions for hydrologic modeling of the MFD and other data necessary to evaluate the suitability of the MFD in the proposed application.

The Maintenance Plan shall include maintenance procedures for the MFD, frequency of maintenance and other information necessary for the ongoing maintenance of the MFD.

The Drawings and Specifications for the project shall show the location of the MFD in the site plan, cross-sections and details of the MFD with all necessary information to construct it according to the plans, and specifications for all components of the MFD including seeding mix design, MFD bed design and testing requirements, and soil/material placement and compaction requirements.

The Soils Management Plan required by BMP LID.02 shall include the area of the MFD and proposed soil amendments.

7.1.4.4 Pretreatment

No pretreatment is required. Sheet flow runoff from the roadway surface can be routed directly to the MFD.

7.1.4.5 Hydrologic and Hydraulic Design Considerations

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the MFD mix. Therefore, the infiltration capacity of the MFD mix and of the drainage below the MFD mix bed needs to match or exceed the hydraulic loading rate.

7.1.4.5.1 Infiltration Rate

The MFD mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour, which accounts for siltation. With an additional safety factor, the rate used to size the length of the media filter drain should be 14 inches per hour.

7.1.4.5.2 Design Flow Rate

For western Washington, $Q_{Roadway}$ is the flow rate at or below which 91 percent of the runoff volume will be treated, based on a 15-minute time step, and can be determined using the water quality analysis feature in WWHM.

7.1.4.5.3 Sizing MFD Mix Bed

For runoff treatment, sizing the MFD mix bed is based on the requirement that the runoff treatment flow rate from the contributing roadway area $Q_{Roadway}$ cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$:

$$Q_{Roadway} \leq Q_{Infiltration}$$

$Q_{Roadway}$ is described under *Design Flow Rate*. $Q_{infiltration}$ may be calculated as follows.

$Q_{infiltration}$, the long-term infiltration capacity of the media filter drain is based on the following equation:

$$\frac{LTIR_{EM} * L_{EE} * W_{EE}}{C * SF} = Q_{Infiltration}$$

where: $LTIR_{EM}$ = Long-term infiltration rate of the MFD mix (use 10 inches per hour for design) (in/hr)
L_{EE} = Length of media filter drain (parallel to contributing pavement) (ft)
W_{EE} = Width of the MFD mix bed (ft)
C = Conversion factor of 43,200 ((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:

$$W_{EE} \geq \frac{Q_{Roadway} * C * SF}{LTIR_{EM} * L_{EE}}$$

Project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain does not exceed 1.0 foot. Therefore, ***Table 7-5*** was developed by WSDOT to simplify the design steps and should be used to establish an appropriate width.

Table 7-5 Design Widths for Media Filter Drains

Pavement Width that Contributes Runoff to the Media Filter Drain	Minimum Media Filter Drain Width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 7.8).

7.1.4.6 Design Criteria

Media filter drains have 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.

7.1.4.6.1 Inflow

Runoff is always 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 percent. Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure that flows remain as sheet flow.

7.1.4.6.2 No-Vegetation Zone

Stormwater runoff is conveyed to the MFD via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion, and to provide some pollutant trapping. The no-vegetation zone is a shallow gravel trench located directly adjacent to the impervious surface to be treated. The no-vegetation zone is a crucial element in a properly functioning media filter drain or other BMPs that use sheet flow to convey runoff from the impervious surface to the BMP. The no-vegetation zone functions as: a level spreader to promote sheet flow, a deposition area for coarse sediments, and an infiltration area to reduce runoff volumes.

7.1.4.6.3 Grass Strip

Adjacent to the no-vegetation zone, a grass strip, which may be amended with compost, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system.

7.1.4.6.4 Media Filter Drain Mix Bed

The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the MFD mix. Geotextile lines the underside of the MFD mix bed.

7.1.4.6.5 Conveyance System Below Media Filter Drain Mix

Treated water drains from the MFD mix bed into the conveyance system below the MFD mix. The conveyance system must be porous enough to allow treated flows to freely drain away from the MFD mix.

This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC).

7.1.4.6.5.a Underdrain Trench

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility or stormwater outfall.

The underdrain trench shall be a minimum of 2 feet wide for either the conventional or dual media filter drain. The gravel underdrain trench may be eliminated (see Figure 7.11) 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 MFD mix shall drain freely, draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

7.1.4.6.5.b Underdrain Pipe

The trench's perforated underdrain pipe is a protective measure to ensure free flow through the MFD mix. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the MFD mix and underdrain trench.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the MFD mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into subsoil from the underdrain trench. The need for underdrain pipe should be evaluated in all cases.

7.1.4.6.6 Geometry

The no-vegetation zone should be between 1 foot and 3 feet wide. Depth will be a function of how the adjacent paved section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal.

The width of the vegetated filter strip is dependent on the availability of space within the sloped area where the media filter drain is to be constructed. The baseline design criterion for the grass strip within the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if the additional space is available.

The MFD mix shall be a minimum of 12 inches deep, including the section on top of the underdrain trench. The MFD mix bed shall have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

In general, the length of a media filter drain or dual media filter drain is the same as that of the contributing pavement. Any length is acceptable as long as the surface area of the MFD mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

In profile, the surface of the media filter drain should preferably have a lateral slope less than 4H:1V (<25 percent). 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 Thurston County and 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 MFD mix bed. Consultation with a geotechnical engineer is required.

7.1.4.6.7 Materials

WSDOT Standard Specifications should be consulted for the following:

Gravel Backfill for Drains, 9-03.12(4)

Underdrain Pipe, 7-01.3(2)

Construction Geotextile for Underground Drainage, 9-33.1.

7.1.4.6.7.a MFD Mix

The MFD mix is a mixture of crushed rock (screened to 3/8" to #10 sieve), dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium. 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.

The MFD mix used in the construction of media filter drains consists of the amendments listed in ***Table 7-6***. Mixing and transportation must be done in a manner that ensures the materials are thoroughly mixed prior to pouring into the ground, and that separation does not occur during transportation or pouring.

Table 7-6 Media Filter Drain Mix

Amendment	Quantity
Mineral aggregate: Crushed screenings 3/8-inch to #10 sieve Crushed screenings 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: Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min.	3 cubic yards

Amendment	Quantity
Crushed screenings 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 Static stripping test — Pass The fracture requirement shall be at least one fractured face and will apply to material retained on the U.S. No. 10 if that sieve retains more than 4% of the total sample. The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials. Crushed screenings 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.	
Perlite: Horticultural grade, free of any toxic materials 0-30% passing US No. 18 Sieve 0-10% passing U.S. No. 30 Sieve	1 cubic yard per 3 cubic yards of mineral aggregate.
Dolomite: CAMg(CO3)2 (calcium magnesium carbonate) Agricultural grade, free of any toxic materials 100% passing US No. 8 Sieve 0% passing U.S. 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.

7.1.4.6.7.b Crushed Surfacing Base Course (CSBC)

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 shall conform to Section 9-03.9(3) of the WSDOT *Standard Specifications*. The designer should consult with a professional to ensure that the CSBC will not impede the flow of water out of the media filter drain mix. If needed, a different gradation may be specified to ensure the free flow of water out of the media filter drain mix.

7.1.4.6.7.c Soil Mix for Grass Strip

The designer should consult a landscape architect for soil mix recommendations. 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 MFD.

7.1.4.7

7.1.4.8 Site Design Elements

7.1.4.8.1 Landscaping (Planting Considerations)

Landscaping is the same as for biofiltration swales (see BMP BF.01) unless otherwise specified and approved by Thurston County.

7.1.4.8.2 Signing

Non-reflective guideposts shall be installed to delineate the MFD. The guideposts shall indicate that the area is a stormwater treatment facility and not to disturb without contacting Thurston County. This practice allows road maintenance personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the MFD is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.

7.1.4.9 Construction and Maintenance

Maintenance will consist of routine roadside management. While herbicides should not be applied directly over the MFD, it may be necessary to periodically control noxious weeds with herbicides in areas around the MFD as part of a roadside management program. The use of pesticides may be prohibited if the MFD is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor and Thurston County Environmental Health. Areas of the MFD that show signs of physical damage will be replaced based on the original design which should be included in the Maintenance Plan.

Chapter 8 - Oil and Water Separation BMPs

Oil and water separators treat stormwater runoff by removing oil floating on top of the water. There are two general types of separators: American Petroleum Institute (API) separators and coalescing plate (CP) separators. Both types use gravity to remove floating and dispersed oil. API separators (or “baffle” separators) are composed of three chambers, separated by baffles. Separator efficiency depends on detention time in the center, or detention chamber, and on droplet size. CP separators use a series of parallel plates to improve separation efficiency by providing more surface area, thus reducing space needed for the separator.

Oil and water separators must be located off-line from the primary conveyance and detention system, bypassing flows greater than the water quality design flow. Linear sand filters may also be used for oil removal. Oil control devices and facilities shall always be placed upstream of other treatment facilities and as close to the source of oil generation as possible.

> **Note**: Thurston County will not accept ownership of some types of oil control facilities without prior acceptance.

8.1 Oil and Water Separation BMPs

Three oil and water separation BMPs are described in this section:

OW.01 API (Baffle type) Separator Bay

OW.02 Coalescing Plate (CP) Separator Bay

OW.03 Oil Containment Booms.

8.1.1 OW.01 API (Baffle Type) Separator Bay

This type of separator uses internal baffles to separate the oil from the water. (API stands for American Petroleum Institute.)

8.1.1.1 Applicability

API separators are designed for use on sites larger than 2 acres.

8.1.1.2 Limitations

Ecology's 2005 *Stormwater Management Manual for Western Washington* (Ecology 2005) presents a design modification for using API separators in drainage areas smaller than 2 acres (e.g., fueling stations and commercial parking lots). However, Ecology also requires each developer to complete a detailed performance verification during at least one wet season when using their modified design. Given this requirement, Thurston County has elected not to allow the use of API separators on sites smaller than 2 acres. The following approach only applies to contributing drainage areas larger than 2 acres.

8.1.1.3 Submittals and Approval

As part of submittal required by Volume I include the following:

- Hydrologic modeling indicating design storm flows and volumes
- Design calculations demonstrating compliance with design criteria
- Manufacturer data for vault and appurtenances.

8.1.1.4 Pretreatment

No pretreatment required.

8.1.1.5 Hydrologic and Hydraulic Design Considerations

8.1.1.5.1 Design Storm

The separator shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (See Volume III). If hydrologic calculations are performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio in Figure 5.1a or 5.1b to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures.

The separator shall be located off-line, receiving only the water quality design storm flows. If it is necessary to locate the separator online, try to minimize the size of the area needing oil control, and use the online water quality design flow rate multiplied by the ratio indicated in Figure 5.1b (if hydrologic calculations are being performed using a continuous hydrologic model).

Size the separator bay for the Water Quality design flow rate.

8.1.1.5.2 Sizing

The API design criteria is based on the horizontal velocity of the bulk fluid (V_h), the oil rise rate (V_t), the residence time (t_m), width, depth, and length considerations.

Size APIs using the following procedure:

Step 1. Determine the oil rise rate, V_t, in feet per minute, using Stokes' Law (Water Pollution Control Federation, 1985) or empirical determination.

- Stokes Law equation for rise rate, V_t (ft/min):

$$V_t = 1.97g(\sigma_w-\sigma_o)D^2 /18\eta_w)$$

Where: 1.97 = conversion factor (centimeters per second/ft per minute)

g = gravitational constant (981 centimeters per second squared)

D = diameter of the oil particle (centimeters).

- Use:

oil particle size diameter, D = 60 microns (0.006 centimeters)

σ_w = water density = 0.999 grams per cubic centimeter (gm/cc) at 32°F

σ_o: Select conservatively high oil density,

For example, if diesel oil @ σ_o=0.85 gm/cc and motor oil @ σ_o = 0.90 gm/cc can be present then use σ_o=0.90 gm/cc

η_w = dynamic viscosity of water = 0.017921 poise (gm/cm-sec), at water temperature of 32°F, (see API publication 421, February, 1990)

Step 2. Determine Q:

- Q = the 15-minute Water Quality design flow rate in ft^3/min multiplied by the ratio indicated in Figure 5.1b for the site location (k). Note that WWHM gives the water quality design flow rate in ft^3/sec. Multiply this flow rate by 60 to obtain the flow rate in ft^3/min.

Step 3. Calculate horizontal velocity of the bulk fluid, Vh (in ft/min), and depth (d), ft.

$$V_h = 15V_t$$

- $d = (Q/2V_h)^{1/2}$, with
- Separator water depth, $3 \leq d \leq 8$ feet (to minimize turbulence). If the calculated depth is less than 3 feet, an API separator is not appropriate for the site. If the calculated depth exceeds 8 feet, consider using two separators (American Petroleum Institute, 1990; U.S. Army Corps of Engineers, 1994).

Step 4. Calculate the minimum residence time (tm), in minutes, of the separator at depth d:

$$t_m = d/V_t$$

- Calculate the minimum length of the separator section, l(s), using:

F = 1.65

Depth/width (d/w) of 0.5 (American Petroleum Institute, 1990)

$l(s) = FQt_m/wd = F(V_h/V_t)d$

Step 5. For other dimensions, including the length of the forebay, the length of the afterbay, and the overall length, L; refer to Figure 8.1.

Step 6. Calculate V = l(s)wd = FQtm, and Ah = wl(s)

- V = minimum hydraulic design volume, in cubic feet.
  A_h = minimum horizontal area of the separator, in square feet.

8.1.1.6 Design Criteria

Figure 8.1 provides a plan and section view of the API Separator.

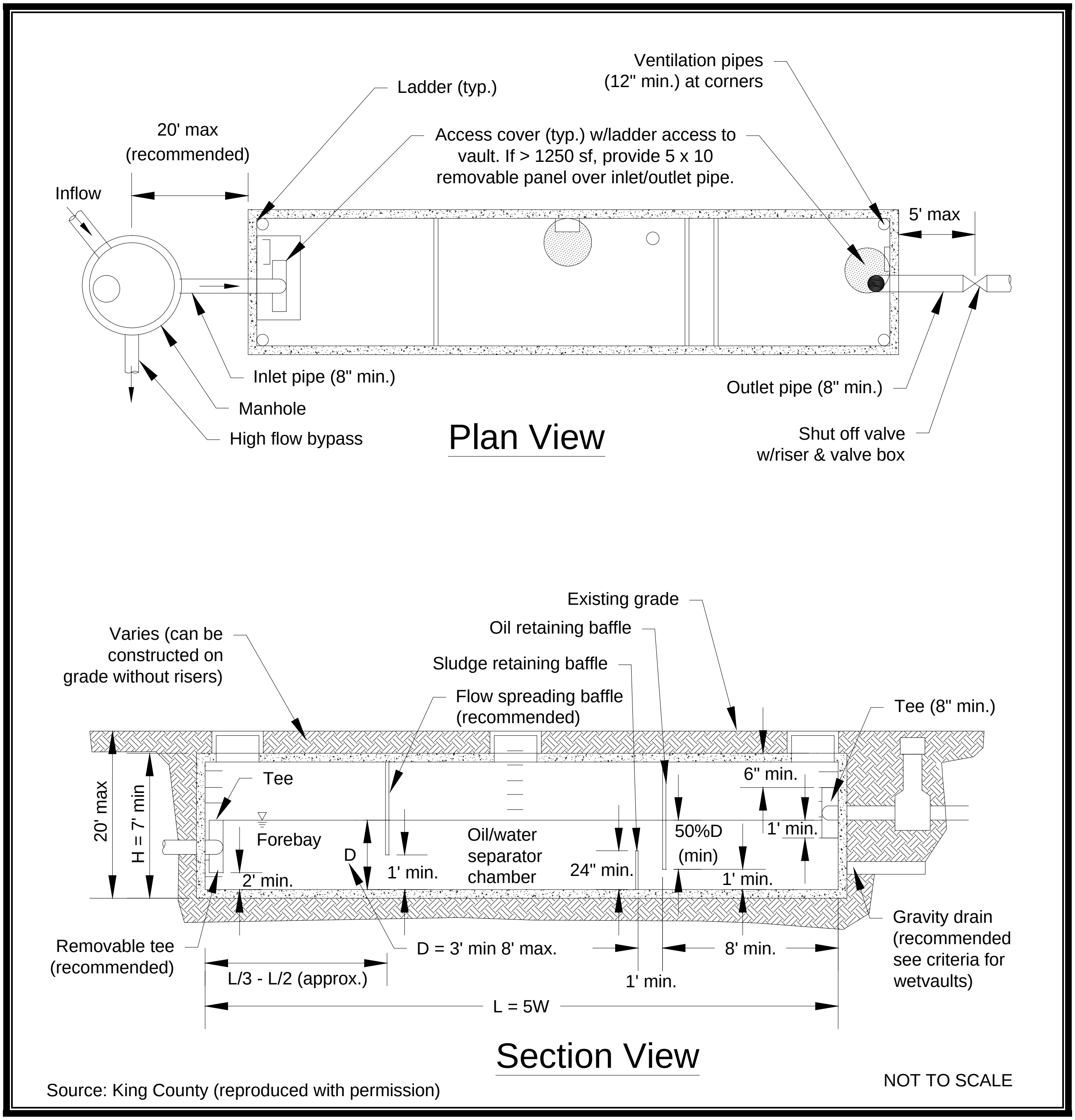


Figure 8.1 API (Baffle Type) Separator

8.1.1.6.1 Geometry

8.1.1.6.1.a Criteria for Separator Bays

To collect floatables and settleable solids, design the surface area of the forebay at ≥ 20 ft^2 per 10,000 ft^2 of area draining to the separator. The length of the forebay shall be one-third to one-half of the length of the entire separator.

Include a submerged inlet pipe with a turn-down elbow in the first bay at least 2 feet from the bottom. The outlet pipe shall be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.

Include a shutoff valve at the separator outlet pipe.

8.1.1.6.1.b Criteria for Baffles

Oil retaining baffles (top baffles) shall be located at least at one-fourth of the total separator length from the outlet, and shall extend down at least 50 percent of the water depth and at least 1 foot from the separator bottom.

Baffle height to water depth ratios shall be 0.85 for top baffles and 0.15 for bottom baffles.

8.1.1.6.2 Materials

Include roughing screens for the forebay or upstream of the separator to remove debris. Screen openings should be about three-fourths inch.

Use only impervious conveyances for oil contaminated stormwater.

8.1.1.7 Structural Design Considerations

Conform to the structural and materials criteria specified for wet vaults.

8.1.1.8 Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

8.1.1.9 Construction and Maintenance

Thurston County may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

> Inspect oil/water separators monthly during the wet season of October 1-April 30 (WEF & ASCE, 1998; Woodward-Clyde Consultants) 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 Consultants), 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 Surface Water Management, 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 Surface Water Management, 1998).

8.1.2 OW.02 Coalescing Plate (CP) Separator Bay

This type of device uses a series of stacked plates to coalesce the oil into larger droplets to enhance removal from the stormwater (see Figure 8.2).

8.1.2.1 Applicability and Limitations

Applicable for all sites requiring oil control.

8.1.2.2 Submittals and Approval

As part of submittal required by Volume I include the following:

Hydrologic modeling indicating design storm flows and volumes

Design calculations demonstrating compliance with design criteria

Manufacturer data for vault and appurtenances.

8.1.2.3 Pretreatment

Add pretreatment for total suspended solids that could clog the coalescing plate separator or otherwise impair the long-term effectiveness of the separator.

8.1.2.4 Hydrologic and Hydraulic Design Considerations

Design 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 less than 500 (laminar flow).

Locate the separator 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 5.1a of this volume. If it is necessary to locate the separator online, try to minimize the size of the area needing oil control, and use the online water quality design flow rate multiplied by the ratio indicated in Figure 5.1b.

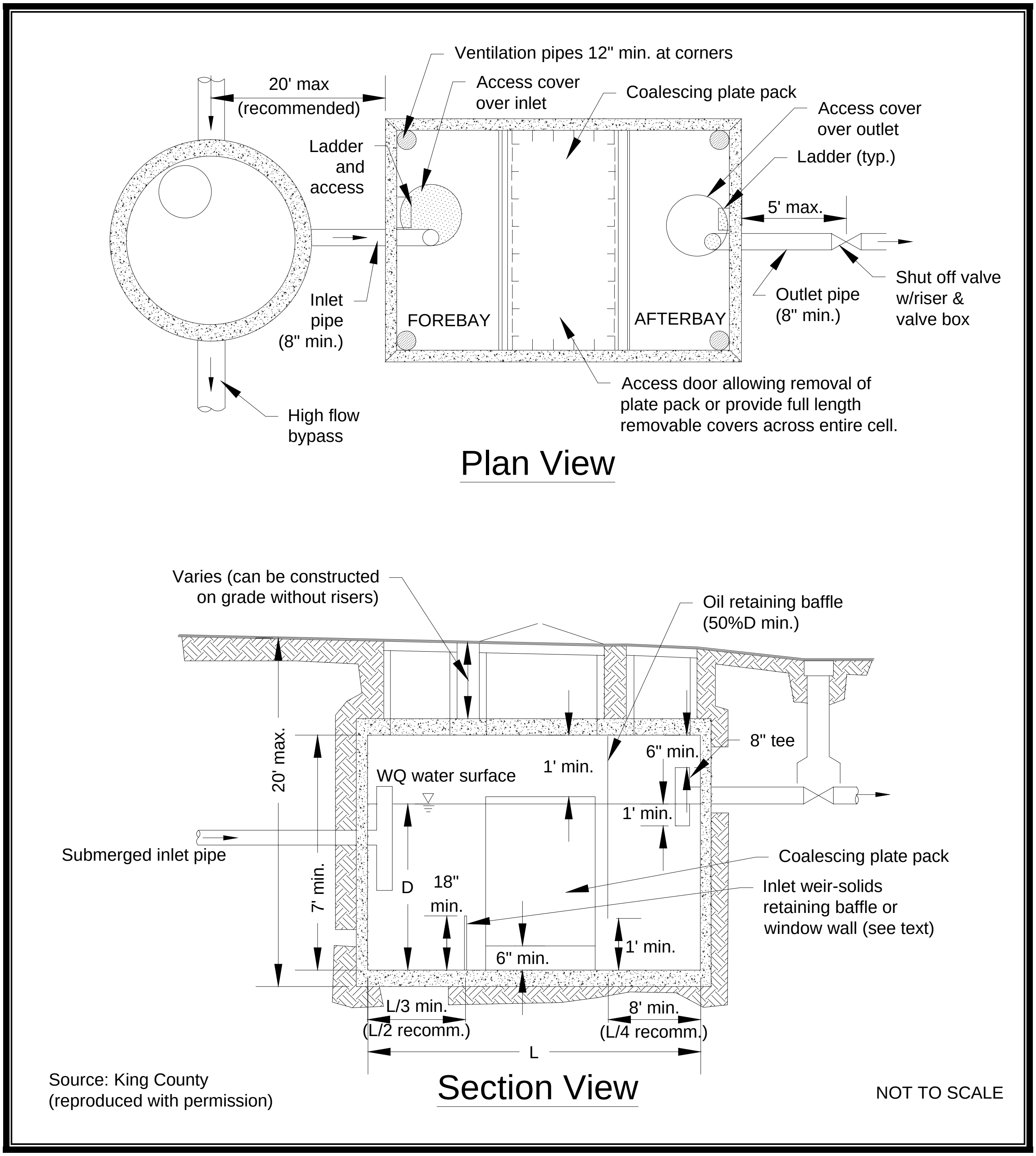


Figure 8.2 Coalescing Plate Separator

8.1.2.4.1 Sizing

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$$Ap = Q/Vt = Q/[(0.00386)*((Sw-So)/(\mu w))]$$

$$Ap = Aa(\text{cosine } b)$$

Where:

Q = k (the ratio appropriate for the project location) indicated by Figure 5.1b x the 15- minute off-line water quality design flow rate, ft3/min

Vt = Rise rate of oil droplet = 0.033 ft/min (based on oil droplet of 60 microns), or empirical determination, or Stokes Law based.

Ap = projected surface area of the plate in ft2; 0.00386 is unit conversion constant

Sw = specific gravity of water at the design temperature

So = specific gravity of oil at the design temperature

Aa = actual plate area in ft2 (one side only)

b = angle of plates with the horizontal in degrees (usually varies from 45-60 degrees).

μw = absolute viscosity of water (poise)

The above equation is based on an oil droplet diameter of 60 microns.

8.1.2.5 Design Criteria

8.1.2.5.1 Geometry

Plate spacing shall be a minimum of three-fourths of an inch (perpendicular distance between plates) (WEF and ASCE, 1998; U.S. Army Corps of Engineers, 1994; US Air Force, 1991; Jaisinghani, R., 1979).

Select a plate angle between 45° to 60° from the horizontal.

Locate plate pack at least 6 inches from the bottom of the separator for sediment storage.

Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.

Include forebay for floatables and 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 inches.

Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

8.1.3 OW.03 Oil Containment Booms

The *oil containment boom* is a weather-resistant, hydrophobic, absorbent-filled boom for removing hydrocarbon sheens from water.

8.1.3.1 Applicability

Oil containment booms can be used to remove oil from the following stormwater facilities to meet performance goals at high use intersections in the public right-of-way where oil control is required:

BMP WP.01 – Stormwater Treatment Wetland

BMP WP.02 – Wet Pond

BMP WP.03 – Wet Vault

BMP WP.04 – Combined Detention/Wet Pool Facility

BMP WP.05 – Pre-Settling Basin.

Oil containment boom technology is a low-cost, effective, and easily maintained option for surface ponds. Offers the following advantages over other treatment options:

Fully functional at flow rates exceeding treatment flow criteria

Easy and complete removal and disposal of absorbed oil

Higher reliability because sediment clogging is avoided

Effectiveness easily assessed due to aboveground installation

Reduced exposure of maintenance workers to traffic and confined-space hazards.

8.1.3.2 Limitations

Oil containment booms may not be used in stormwater BMPs that manage runoff from private development.

The oil containment boom is used in a surface pond or treatment vault. If a surface stormwater pond or vault is not included as part of the project this BMP will not be available to meet oil control requirements.

8.1.3.3 Submittals and Approval

A description of the oil containment boom proposed by the applicant shall be included in the drainage report to include manufacturer data and specifications and manufacturer's recommendations.

8.1.3.4 Pretreatment

No pretreatment is required.

8.1.3.5 Hydrologic and Hydraulic Design Considerations

No hydrologic or hydraulic design considerations are involved in using an oil containment boom.

8.1.3.6 Design Criteria

8.1.3.6.1 Geometry

The boom must be cylindrical, with a minimum diameter of 2 inches. It should be installed near the outlet end of the facility so that the oil has a maximum amount of time to rise to the water surface. Maximizing boom distance from inlet currents also maximizes contact time between the boom and the oil. The boom must span the entire width of ponds when they are filled to capacity. The boom must be placed so that it is in direct contact with the water across the entire water surface. In treatment ponds, the boom must be installed diagonally across the water surface to maximize contact area and contact time between hydrocarbons and the boom. When used in a vault, the boom must completely encircle the outlet structure (see Figure 8.3).

8.1.3.6.2 Materials

The absorbent material must consist of high-molecular-weight polymers capable of absorbing (1) C5-C18 hydrocarbons associated with fuels, and (2) longer chain hydrocarbons with frequently attached cyclic hydrocarbon structures associated with lubricating oils.

The absorbent material must exhibit the following characteristics:

- Absorb and solidify a minimum of three times its weight in liquid hydrocarbons
- Have sufficient buoyancy at the exhausted condition to continue to trap oil
- Irreversibly absorb and permanently hold the hydrocarbons so that oil leachate is not released from the sorbent. U.S. EPA guidelines for solidified hazardous waste without chemical bonds being formed or broke must also be met.

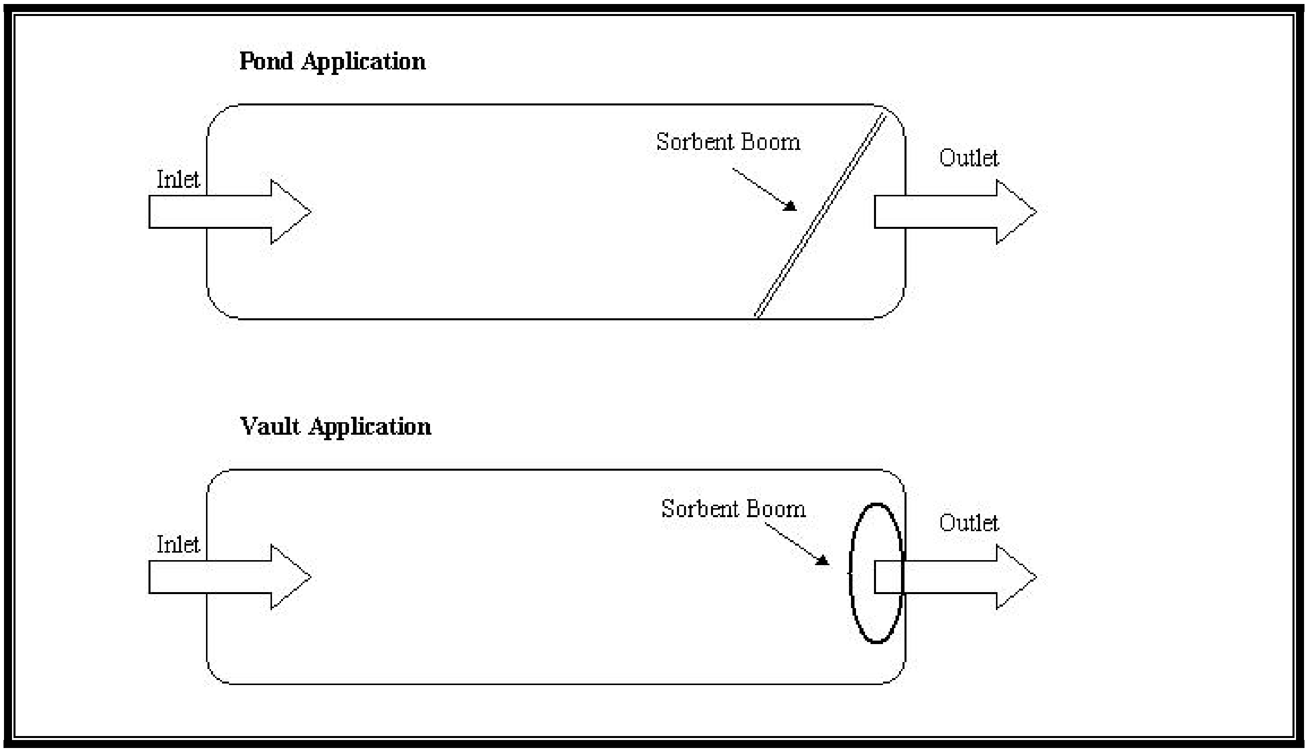


Figure 8.3 Oil Containment Boom

Contain a minimum of 99 percent active ingredient and no leachable toxicant to fish and other aquatic life. The supplier must provide appropriate information demonstrating that toxicity will not be a problem.

The absorbent boom cover fabric must meet the following criteria:

Be fabricated of photo-resistant mesh that meets the ultraviolet (UV) stability requirement for permanent erosion control blankets in Section 9-14.5 of the *Standard Specifications*

Be sized to allow for the expansion of the absorbent material to hold the specified absorption volume per foot.

Additional requirements for materials related to booms include the following:

Booms must include a weather-resistant tag to enable labeling with installation and inspection dates for tracking long-term effectiveness and maintenance activities.

Boom ends must be configured so that they can be secured to immobile structures or metal stakes with weather-resistant rope.

Chapter 9 - Chapter 9 - Emerging Technologies

This Chapter addresses emerging (new) technologies that have not been evaluated in sufficient detail to be acceptable for general usage in new development or redevelopment situations.

9.1 Background

It has become clear that the treatment BMPs described in Ecology's 1992 Stormwater Manual, in some situations, are either not applicable or do not provide reliable and cost-effective removal of pollutants. For these reasons a need to develop new stormwater treatment technologies has emerged in this State as well as nationwide.

Emerging technologies are new technologies that have not been evaluated using approved protocols, but for which preliminary data indicate that they may provide a desirable level of stormwater pollutant removal. Some emerging technologies have already been installed in Washington as parts of treatment trains or as stand-alone systems for specific applications. In some cases, emerging technologies are necessary to remove metals, hydrocarbons, and nutrients. Emerging technologies can also be used for retrofits and where land availability is unavailable.

All emerging technology BMPs shall be maintained in accordance with the manufacturer's recommendations and schedules. Owners shall provide the Thurston County Water Resources Unit with maintenance logs annually at the end of each calendar year.

9.2 Ecology Role in Evaluating Emerging Technologies

Ecology currently facilitates a process to evaluate emerging permanent and construction site stormwater treatment technologies and to convey judgments made by local jurisdictions and others on their acceptance. Based on recommendations from Ecology's Volume V Stormwater Technical Advisory Committee (TAC), Ecology is implementing the following process:

- Maintaining a web site for publishing information on emerging technologies and the protocols (TAPE and C-TAPE) used in their evaluation, which is housed at:

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

- Organizing and convening Technical Review Committees (TRC) which evaluate emerging technologies, and

- Based on performance and other pertinent data from manufacturers, and recommendations of the review committees, Ecology assesses emerging technology development levels, and posts relevant decisions and supporting documentation at its stormwater website.

9.3 Emerging Technology Use in Retrofit Situations

To achieve the goals of the Clean Water Act and the Endangered Species Act, local governments may find it necessary to retrofit existing stormwater discharges. In retrofit situations, the use of any BMPs that make substantial progress toward these goals is a step forward and is encouraged by Ecology. To the extent practicable, the performance of these BMPs should be evaluated, using approved protocols.

9.4 Acceptable Evaluation Protocols (TAPE and C-TAPE)

To properly evaluate new technologies, performance data must be obtained using an accepted protocol. Ecology has published recommended protocols at its website for use by local governments, suppliers of new technologies, and consultants.

9.5 Acceptance and Use of Emerging Technologies for New Developments and Re-developments

New developments and re-developments may propose to use emerging technologies. These technologies must be:

- Approved and listed on Ecology’s website,
- Proposed for use in accordance with Ecology’s approval conditions,
- Appropriate to the development site, and
- Approved by the Administrator or designee.

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Appendix V-A – Structures

Control structures are catch basins or manholes with a restrictor device that controls outflow from a facility to meet the desired performance. Riser-type restrictor devices ("tees" or "FROP-Ts") also provide some incidental oil and water separation, temporarily detaining oil or other floatable pollutants entering runoff due to accidental spill or illegal dumping.

Bypass and diversion structures are used to isolate flows when only part of the contributing flows are being directed to water quality.

Control Structures

Control structures are used when there is a need to control outflow flow rates from a BMP facility.

Applicability

The structures included in this appendix apply to the following BMPs:

BMP D.01 Detention Ponds

BMP D.02 Detention Tanks

BMP D.04 Detention Vaults

BMP WP.02 Wet Ponds.

Bypass and diversion structures apply to any BMPs that are designed to be "off-line", where only part of the contributing stormwater flow is routed to the treatment BMP.

Hydrologic and Hydraulic Design Considerations

Control structure restrictor devices usually consist of two or more orifices and/or a weir section sized to meet performance requirements. Several publicly available and proprietary stormwater modeling programs are capable of designing control structures.

A-1. **Methods of Analysis**

This section presents 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.

Rectangular notched weirs are typically most efficient and will result in the optimal detention system design using WWHM.

Orifices
Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = C\,A\sqrt{2gh} \qquad \text{(equation 4)}$$

where: Q = flow (cfs)
C = coefficient of discharge (0.62 for plate orifice)
A = area of orifice (ft^2)
h = hydraulic head (ft)
g = acceleration of gravity (32.2 ft/sec^2)

Figure A.0.1 illustrates this simplified application of the orifice equation.

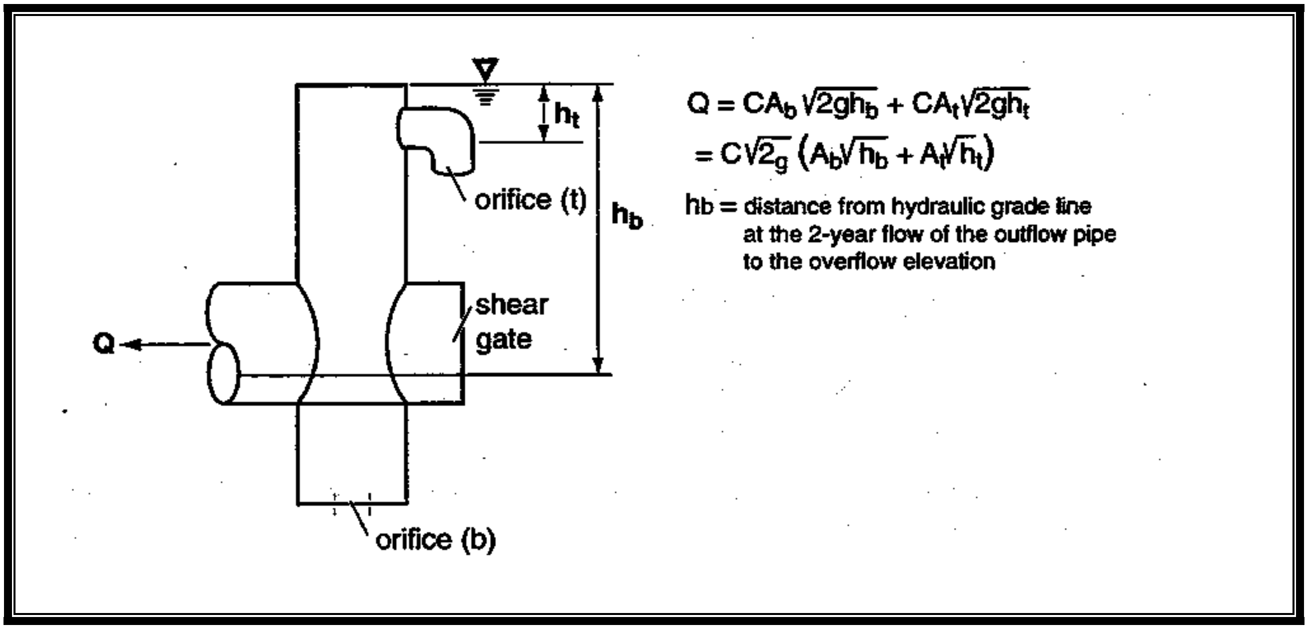


Figure A.0.1 Simple Orifice

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(equation 5)}$$

where d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

Rectangular Sharp-Crested Weir

The rectangular, sharp-crested weir design shown in Figure A-2 may be analyzed using standard weir equations for the fully contracted condition.

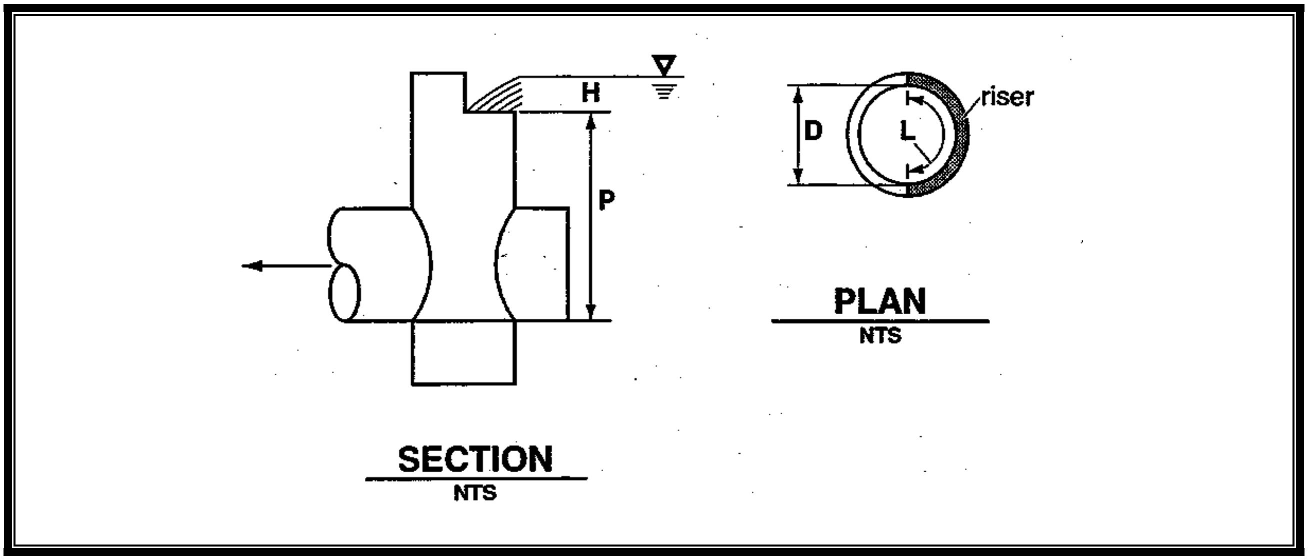


Figure A.0.2 Rectangular, Sharp-Crested Weir

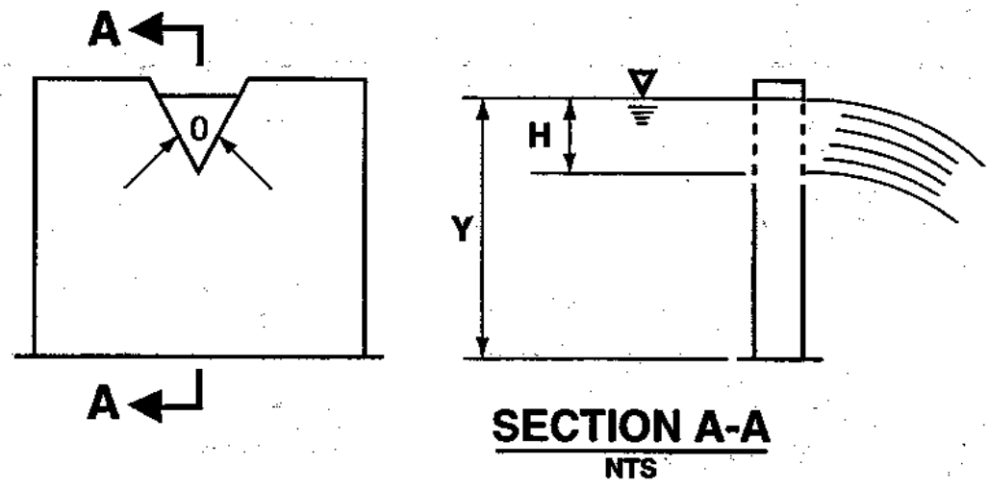
$$Q = C\,(L - 0.2H)H^{3/2} \qquad \text{(equation 6)}$$

where Q = flow (cfs)
C = 3.27 + 0.40 H/P (ft)
H, P are as shown above
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.

V-Notch Sharp - Crested Weir

V-notch weirs as shown in Figure A-3 may be analyzed using standard equations for the fully contracted condition.



$$Q = C_d(\mathrm{Tan}\ \Theta/2)H^{5/2}, \text{ in cfs}$$

Where values of C_d may be taken from the following chart:

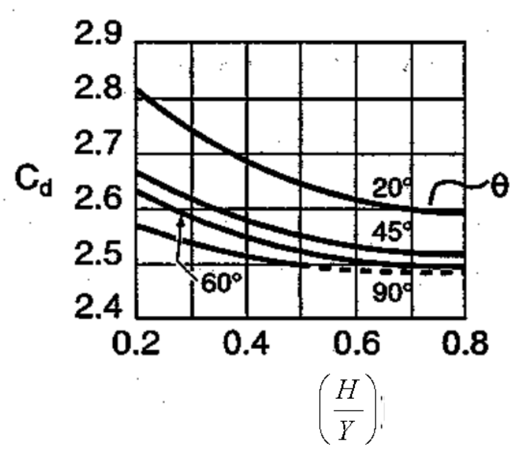


Figure A.0.3 V-Notch, Sharp-Crested Weir

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 A-4). The weir may be symmetrical or non-symmetrical.

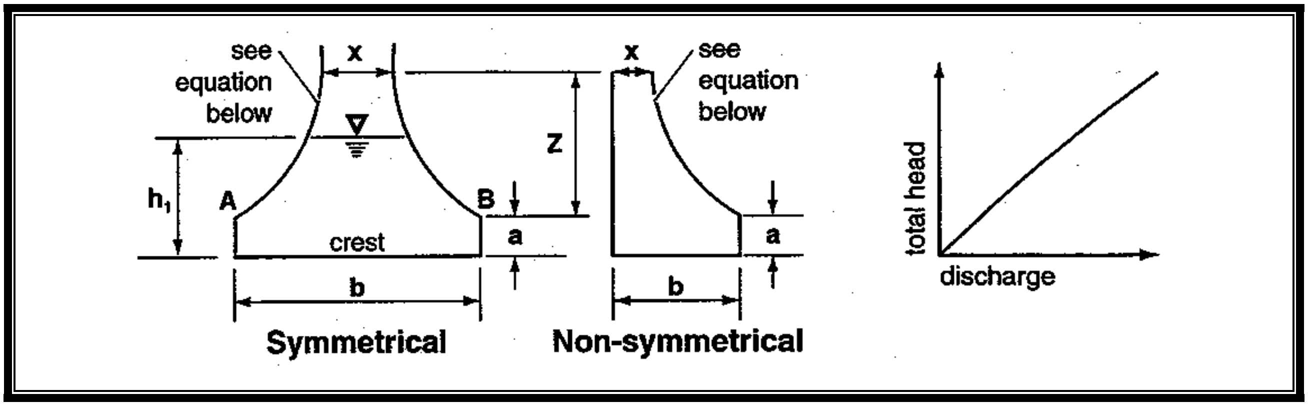


Figure A.0.4 Sutro Weir

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi} Tan^{-1}\sqrt{\frac{Z}{a}} \qquad \text{(equation 7)}$$

where a, b, x and Z are as shown in Figure A-4. The head-discharge relationship is:

$$Q = C_d \, b \sqrt{2ga}\left(h_1 - \frac{a}{3}\right) \qquad \text{(equation 8)}$$

Values of *Cd* for both symmetrical and non-symmetrical sutro weirs are summarized in ***Table A.0-1***.

Note: When b > 1.50 or a > 0.30, use Cd=0.6.

Table A.0-1 Values for Cd for Sutro Weirs

Cd Values, Symmetrical b (ft)					
a (ft)	0.50	0.75	1.0	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608
Cd Values, Non-Symmetrical b (ft)					
a (ft)	0.50	0.75	1.0	1.25	1.50

0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

A-2. **Broad-Crested Weir**

The equation for flow through a broad-crested weir that is used as a spillway section would be:

$$Q_{100} = C\,(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}\,(\operatorname{Tan}\theta)\,H^{5/2}\right] \qquad \text{(equation 1)}$$

Where:

Q_{100}	=	Peak flow for the 100-year runoff event (cfs)
C	=	Discharge coefficient (0.6)
g	=	Acceleration due to 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 100-year, 1-hour flow, indicated by an approved continuous runoff model, multiplied by a factor of 1.6, or the peak 10-minute flow computed from the 100-year, 24-hour storm and a Type 1A distribution.

Assuming C = 0.6 and Tan θ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21[LH^{3/2} + 2.4\,H^{5/2}] \qquad \text{(equation 2)}$$

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):

$$L = [Q_{100}/(3.21H^{3/2})] - 2.4\,H \quad \text{or} \quad 6 \text{ feet minimum} \qquad \text{(equation 3)}$$

Riser Overflow

The nomograph in Figure A-5 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).

Standard control structure details are shown in Figures A-6 through A-8.

A-3. **Multiple Orifice Restrictor**

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

Minimum orifice diameter is 0.5 inches. In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth shall 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.

Orifices may be constructed on a tee section as shown in Figure A-6 or on a baffle as shown in Figure A-7.

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 A-8).

Consideration must be given to 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.

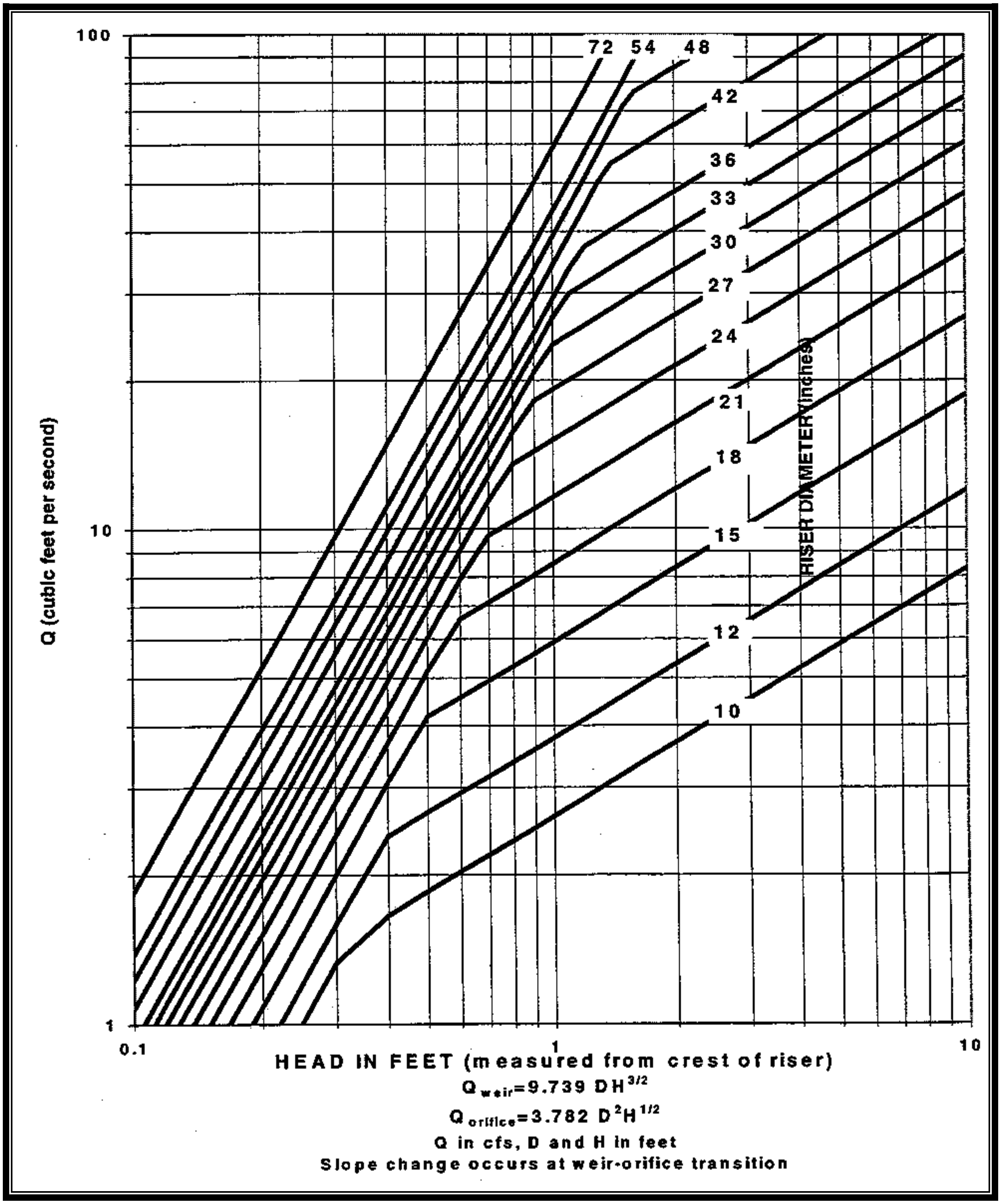
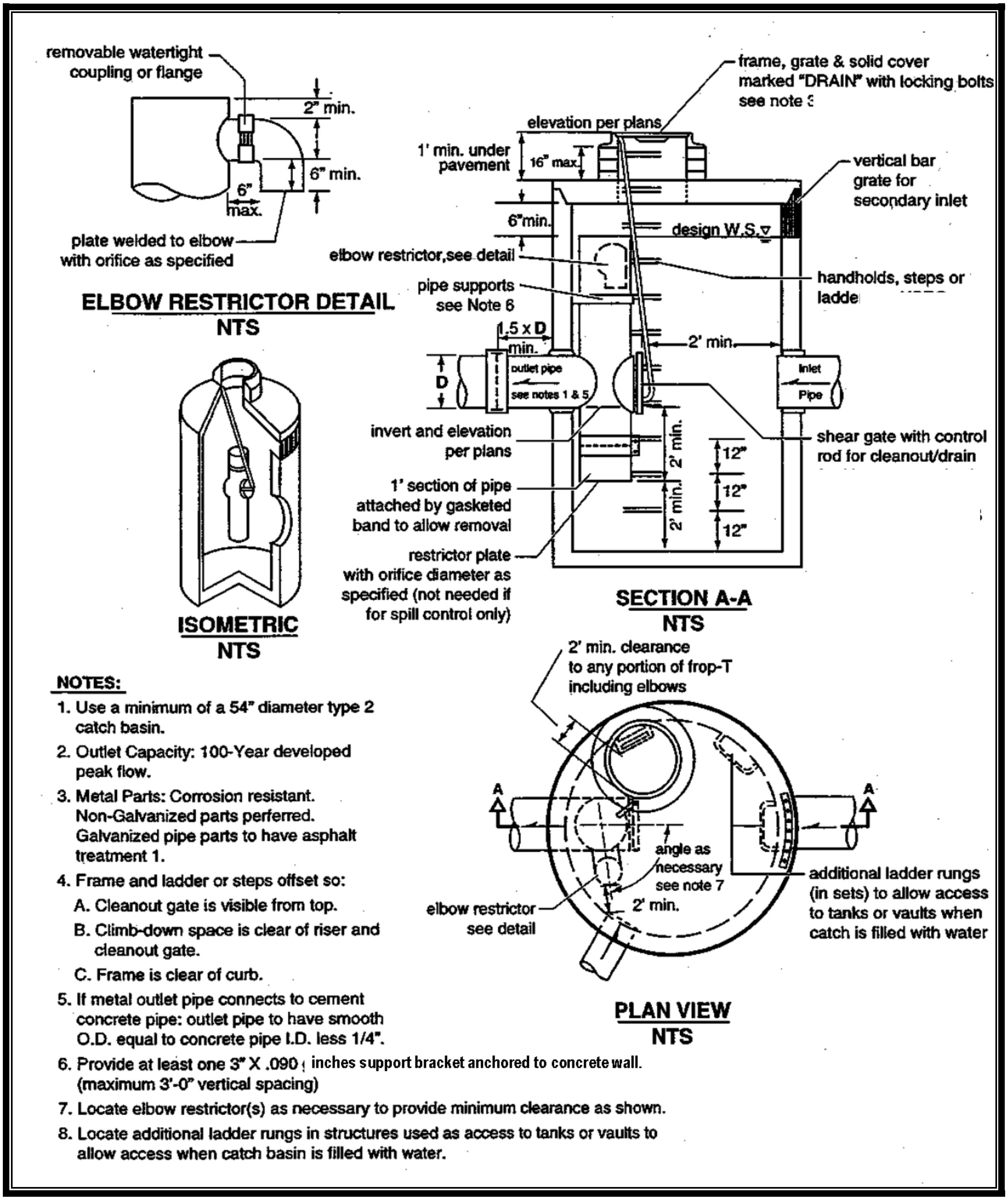


Figure A.0.5 Riser Inflow Curves



NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts perferred. 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 1/4".
6. Provide at least one 3" X .090 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.

Figure A.0.6 Flow Restrictor (TEE)

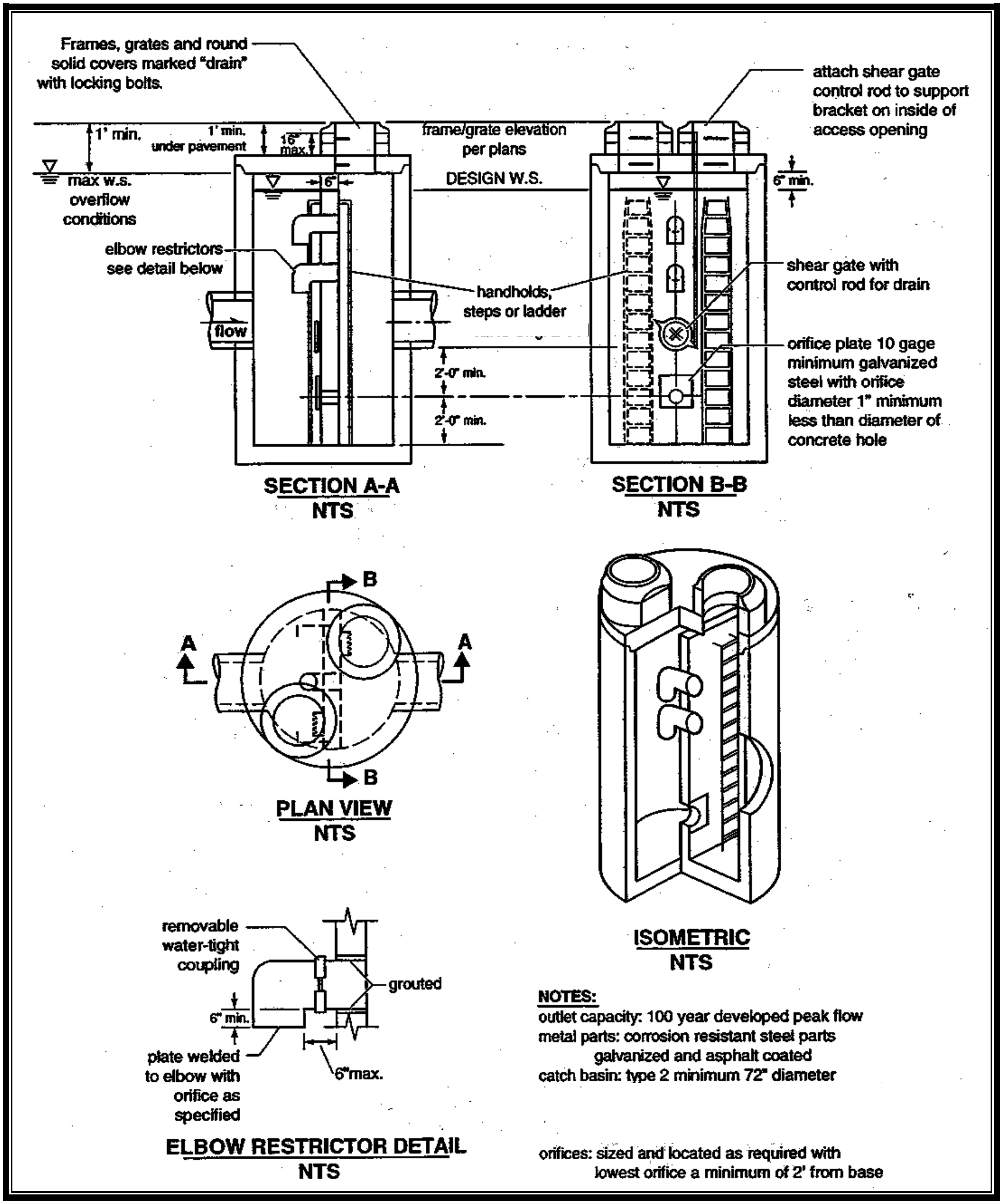
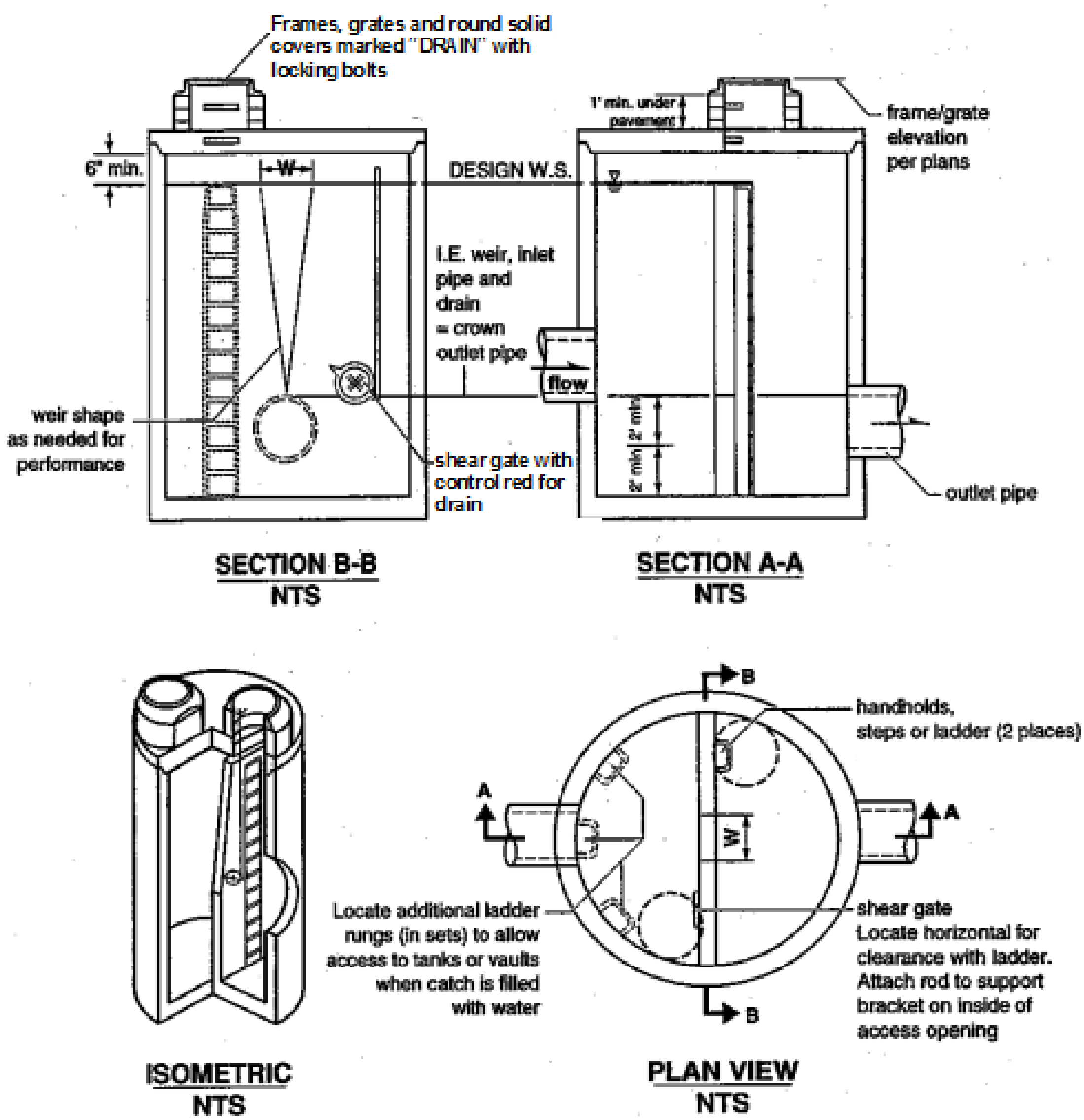


Figure A.0.7 Flow Restrictor (Baffle)



NOTES:
Outlet Capacity: 100-year developed peak flow.
Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
Catch Basin: type 2 Min. 72" diameter

Baffle Wall: to be designed with concrete reinforcing as required.
Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

Figure A.0.8 Flow Restrictor (Weir)

A-4. **Riser and Weir Restrictor**

Properly designed weirs may be used as flow restrictors (see Figure A-8). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention facility.

The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 100-year peak flow assuming all orifices are plugged. Figure A-5 can be used to calculate the head in feet above a riser of given diameter and flow.

A-5. **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 it:

Name and file number of project

Name and company of (1) developer, (2) engineer, and (3) contractor

Date constructed

Date of manual used for design

Outflow performance criteria

Release mechanism size, type, and invert elevation

List of stage, discharge, and volume at 1-foot increments

Elevation of overflow

Recommended frequency of maintenance.

Bypass and Diversion Structures

Bypass and diversion structures are used to isolate flows when only part of the contributing flows are being directed to water quality.

Applicability

Bypass and diversion structures apply to any BMPs that are designed to be “offline”, where only part of the contributing stormwater flow is routed to the treatment BMP.

The structures included in this appendix are especially suited to the following BMPs:

BMP BF.01 Basic Biofiltration Swale

BMP MF.01 Sand Filter Basin

BMP MF.02 Sand Filter Vault.

Hydrologic and Hydraulic Design Considerations

Offline sand filters placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by an approved continuous runoff model, to the treatment BMP. The sand filter must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

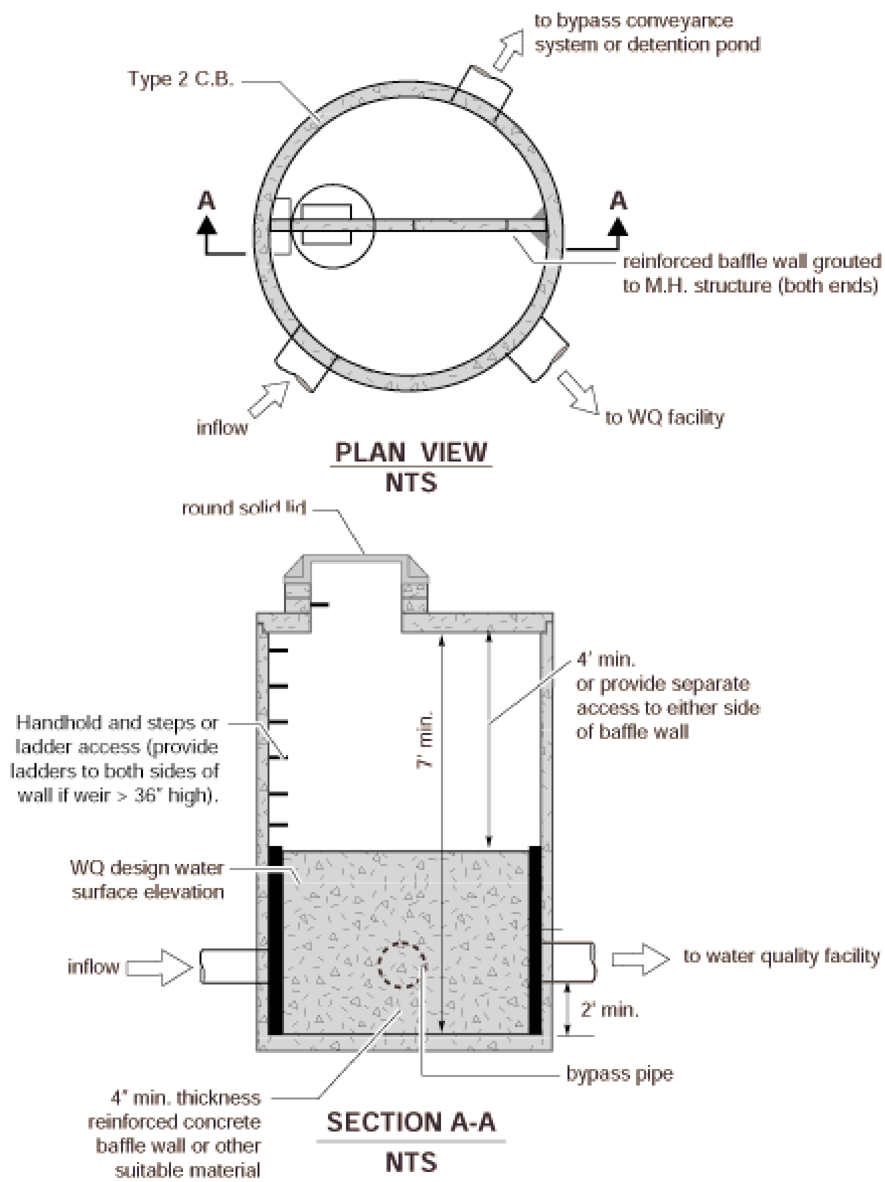
> **Note**: WWHM allows any bypasses and the runoff filtered through the sand to be directed to the downstream detention facility.

Offline sand filters placed ***downstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 2-year recurrence interval flow from the detention pond (as predicted by an approved continuous runoff model) to the treatment facility. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

Design Criteria

Figures A-9 through A-11 provide examples of flow splitters and diversion structures.

Where flow restrictor manholes are to be used, they are to be designed in a manner similar to that shown in Appendix A, Figures A-3 and A-4. Manholes used to house flow restrictor assemblies shall have a minimum diameter of 54 inches. Assemblies shall be equipped with a chain-operated lift gate that can be opened in emergency situations. Flow restrictor devices may have multiple orifices as described in Chapter 4, or may use thin-plate slotted weirs in place of orifices.



Note: The water quality discharge pipe may require an orifice plate be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimun headwater/diameter ratio of 2.0 on the outlet pipe.

Figure A.9 Flow Splitter Option A

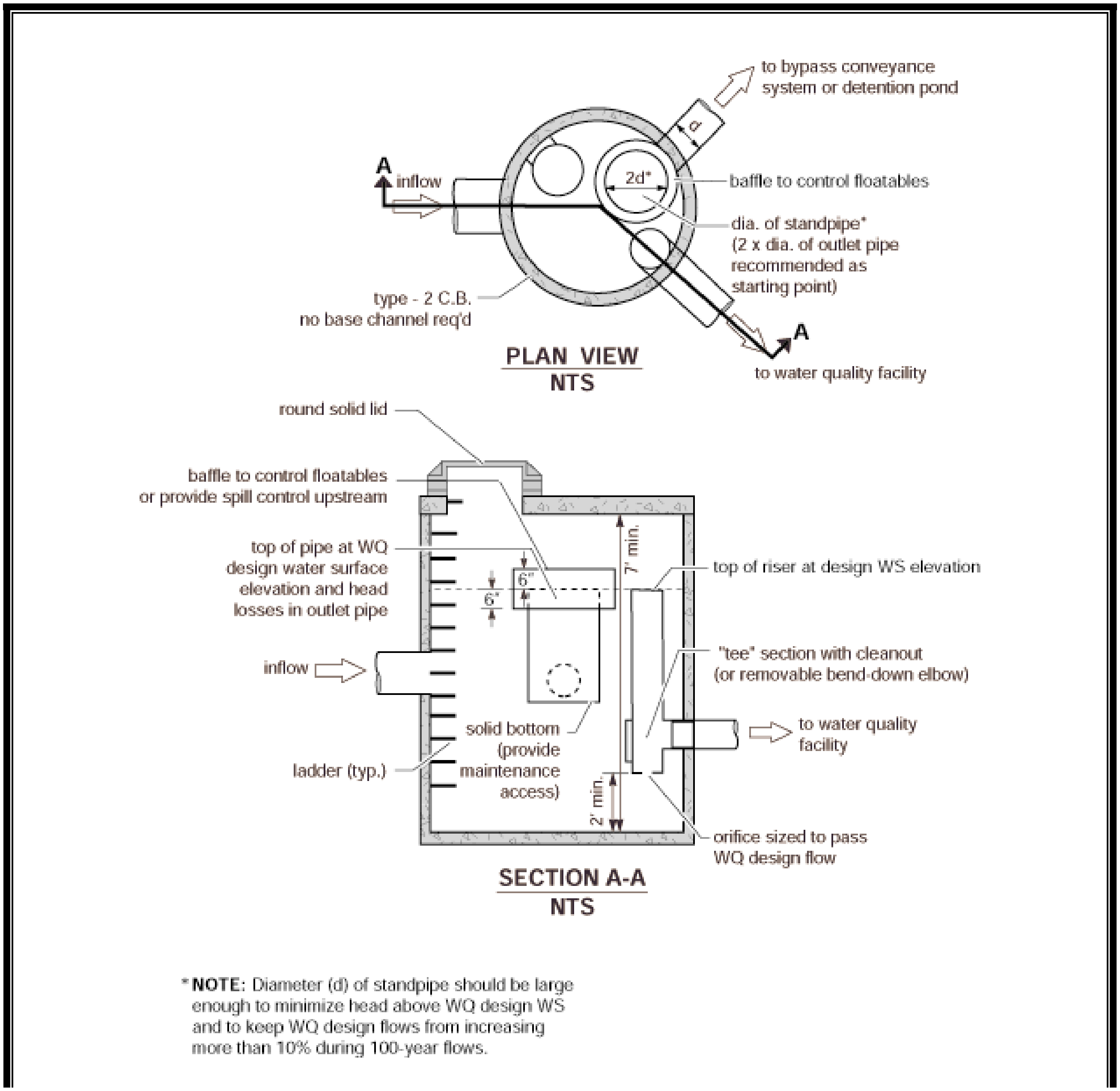
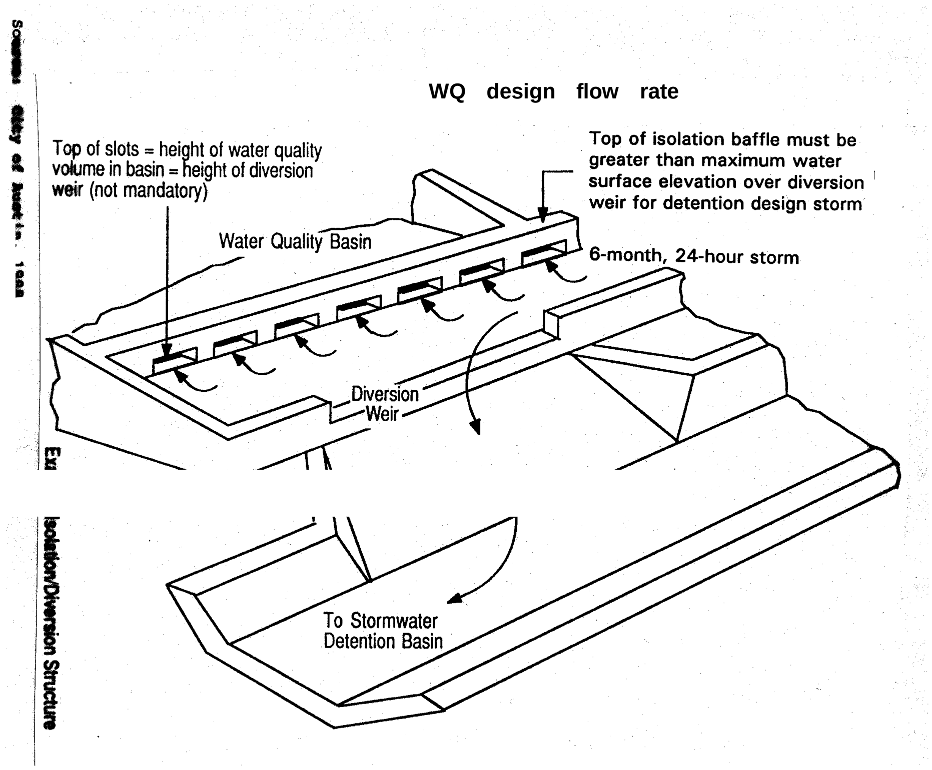


Figure A.10 Flow Splitter Option B



Source: City of Austin

Figure A.11 Example Isolation/Diversion Structure

Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inflow portion of several water quality facilities (e.g., sand filter, biofiltration swale, or filter strip). There are five flow spreader options described in this section:

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, and when spreading is required by facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a filter strip.

Options D and E are only for flows that are already unconcentrated and enter a filter strip or continuous inflow biofiltration swale. Other flow spreader options are possible with acceptance of the Administrator or designee.

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.

For higher inflows (greater than 5 cfs for the 100-year storm), a Type 1 catch basin shall be positioned in the spreader and the inflow pipe should enter the catch basin with flows exiting through the top grate. The top of the grate shall be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.

A-6. **Option A – Anchored Plate (Figure A-12)**

An anchored plate flow spreader shall be preceded by a sump with a minimum depth of 8 inches and minimum width of 24 inches. If not otherwise stabilized, the sump area shall be lined to reduce erosion and provide energy dissipation.

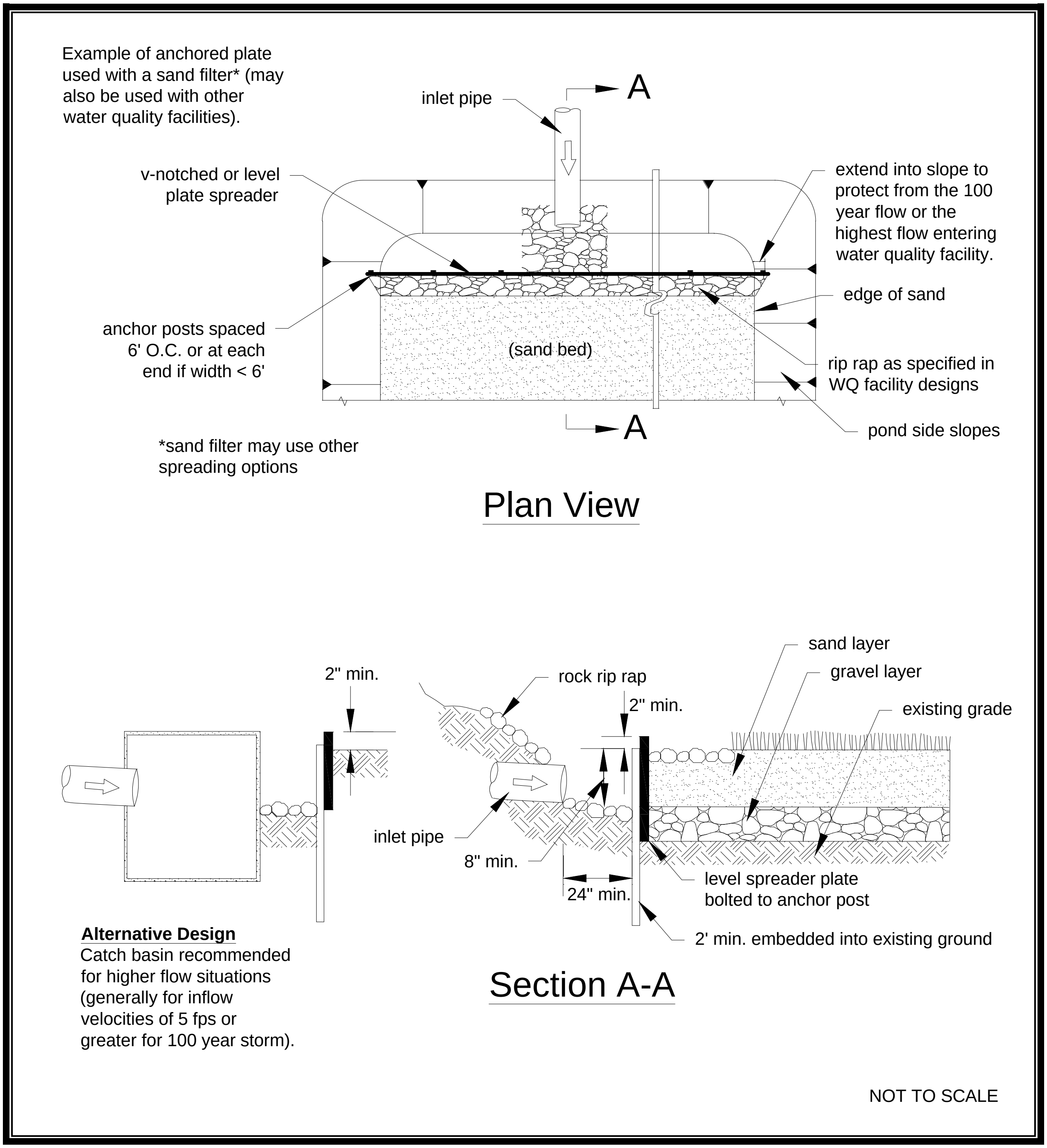


Figure A.12 Flow Spreader Option A: Anchored Plate

The top surface of the flow spreader plate shall be level, projecting at least 2 inches above the ground surface of the water quality facility, or V-notched with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs may also be used.

A flow spreader plate shall extend horizontally beyond the bottom width of the facility to prevent water from eroding the side slope. The horizontal extent shall be such that the bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the runoff treatment facility.

Flow spreader plates shall 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 shall be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

A-7. **Option B – Concrete Sump Box (Figure A-13)**

The wall of the downstream side of a rectangular concrete sump box shall extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.

The downstream wall of a sump box shall have “wing walls” at both ends. Side walls and returns shall 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 shall be reinforced with wire mesh for cast-in-place sumps.

Sump boxes shall be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

A-8. **Option C – Notched Curb Spreader (Figure A-14)**

Notched curb spreader sections shall be made of extruded concrete laid side-by-side and level. Typically five “teeth” per 4 foot section provide good spacing. The space between adjacent “teeth” forms a v-notch.

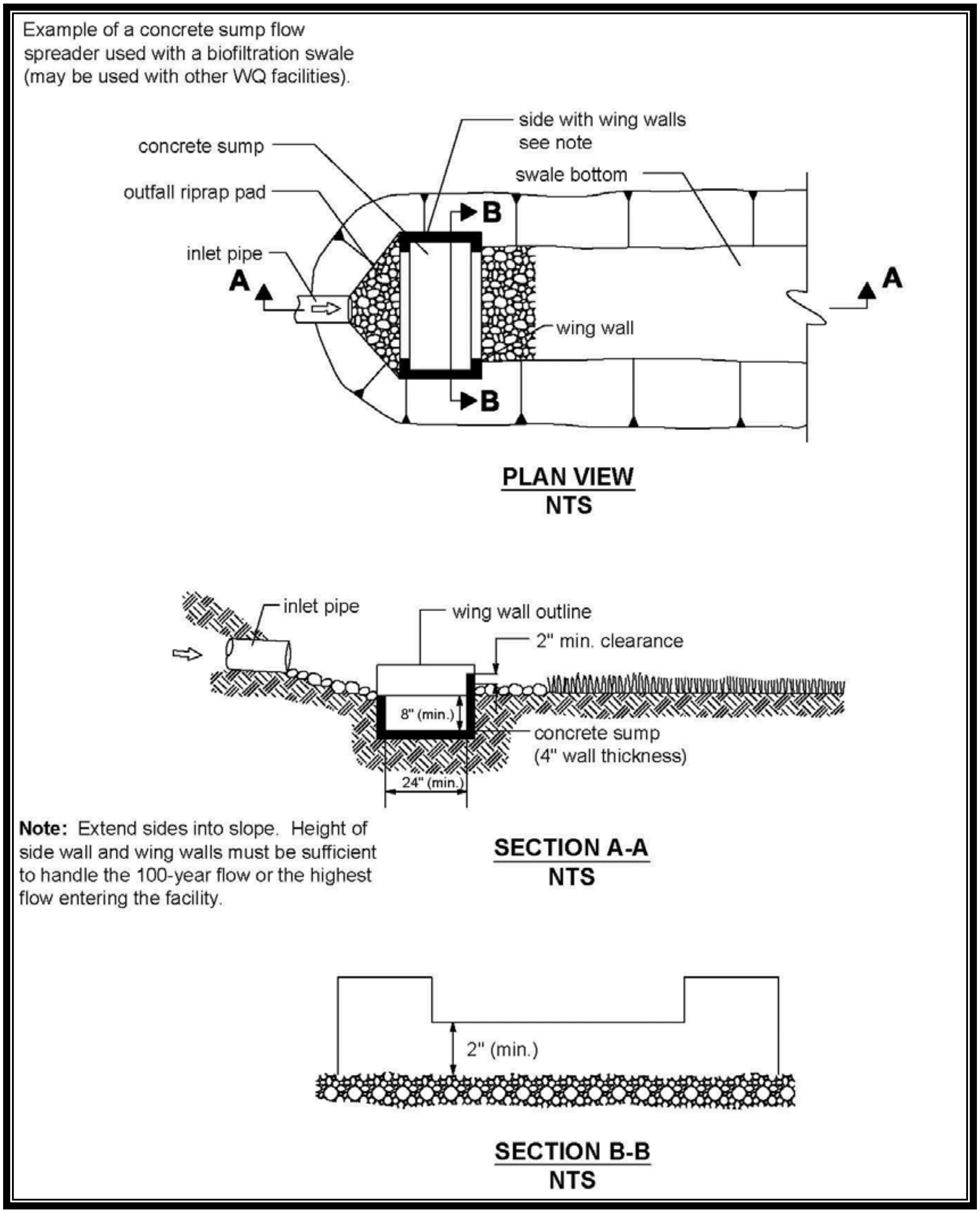


Figure A.13 Flow Spreader Option B: Concrete Sump Box

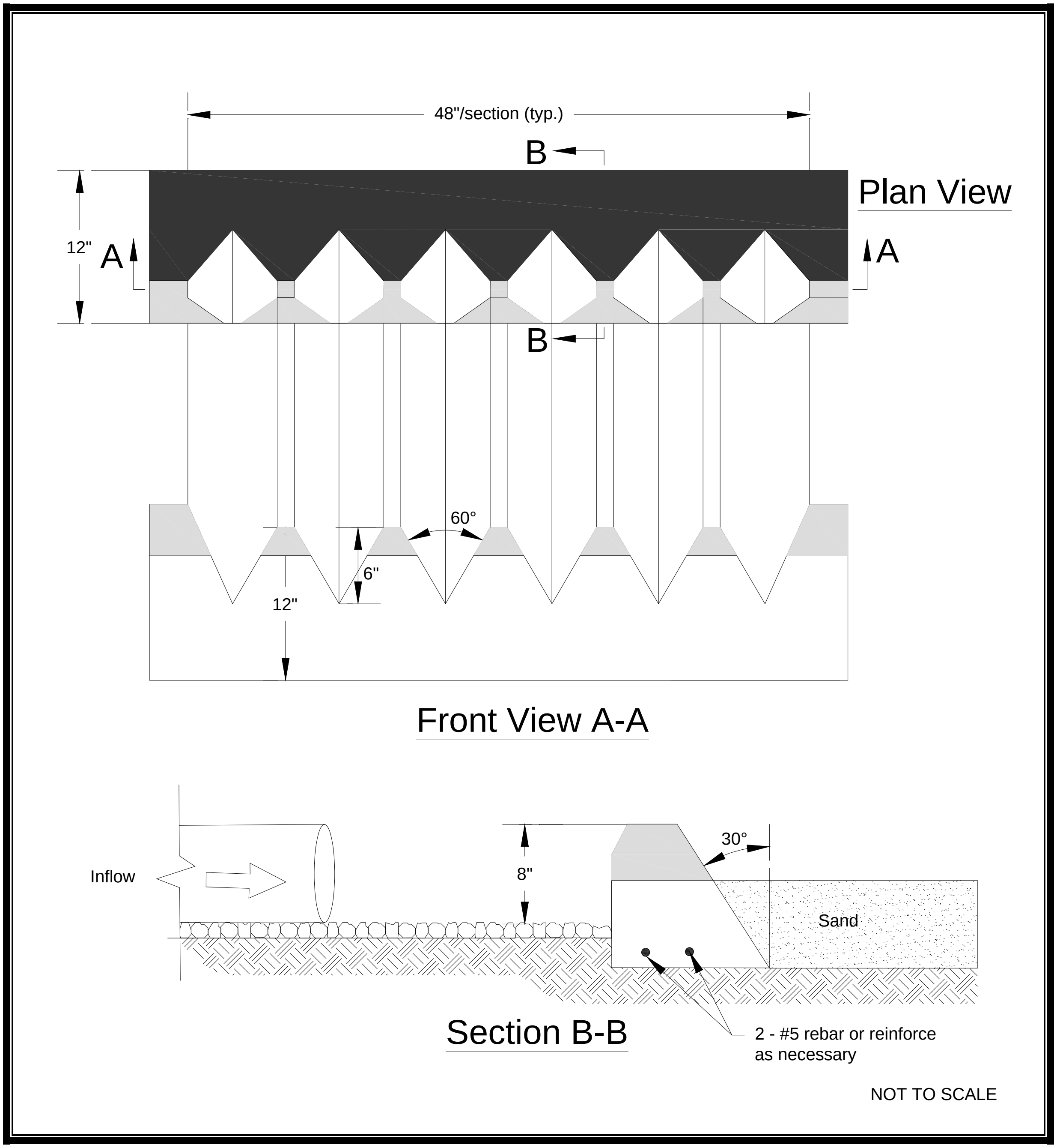


Figure A.14 Flow Spreader Option C: Notched Curb Spreader

A-9. **Option D –Through-Curb Ports (Figure A-15)**

Unconcentrated flows from paved areas entering filter strips or continuous inflow biofiltration swales can use curb ports or interrupted curbs (Option E) to allow flows to enter the strip or swale. 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 facility.

Openings in the curb shall be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening shall be a minimum of 11 inches. Approximately 15 percent or more of the curb section length shall be in open ports, and no port shall discharge more than about 10 percent of the flow.

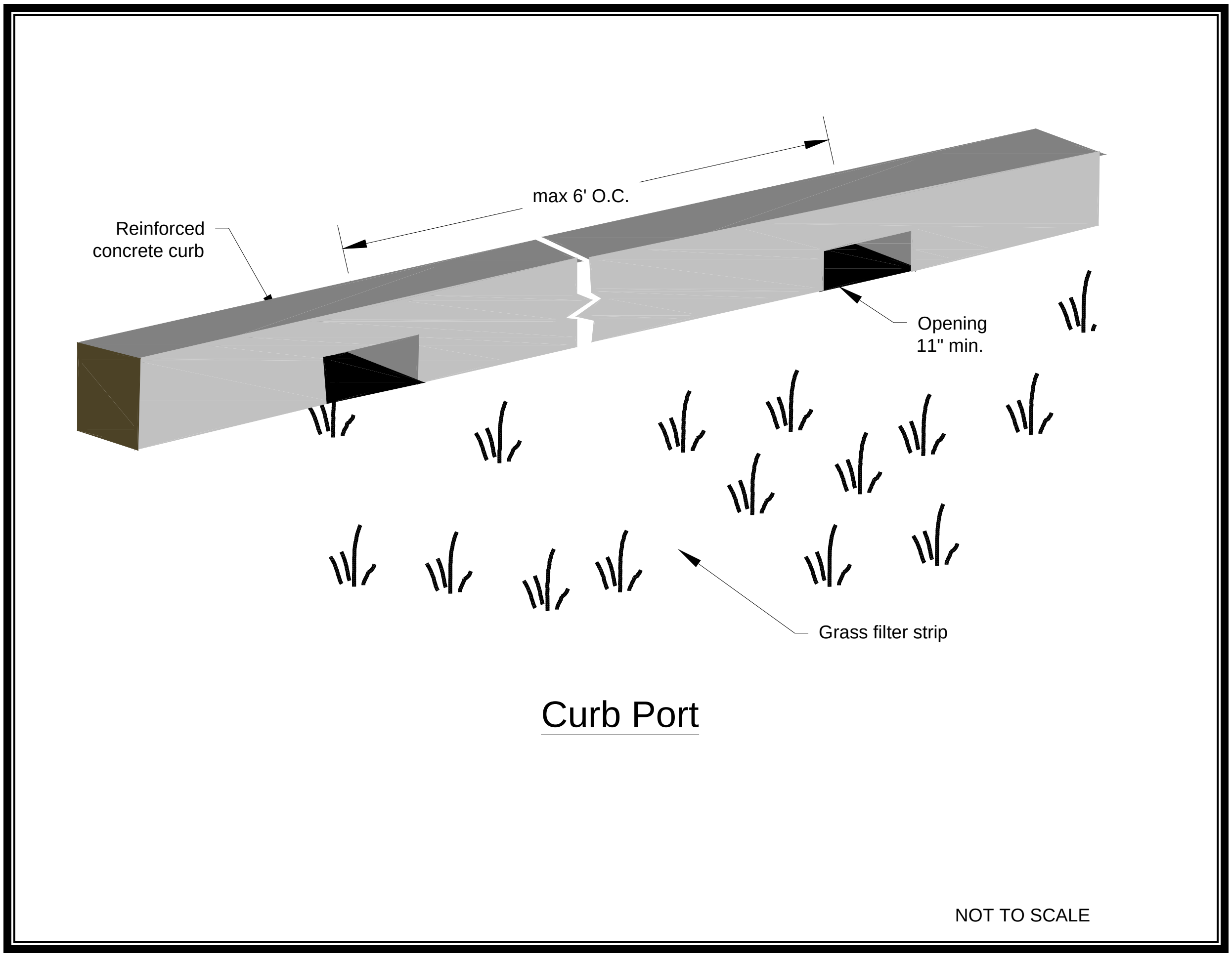


Figure A.15 Flow Spreader Option D: Through-Curb Port

A-10. **Option E – Interrupted Curb (No Figure)**

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, gaps shall be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening shall be a minimum of 11 inches. As a general rule, no opening shall discharge more than 10 percent of the overall flow entering the facility.

Appendix V-B – Facility Liners and Geotextiles

Liners are intended to reduce the likelihood that pollutants in stormwater will reach groundwater when runoff treatment facilities are constructed.

Treatment liners amend the soil with materials that treat stormwater before it reaches more freely draining soils. They have slow rates of infiltration, generally less than 2.4 inches per hour (1.7 x10-3 cm/s), but not as slow as low permeability liners. Treatment liners may be 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} centimeters squared). These types of liners are 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.

Applicability

Liners are used when there is a need to protect underlying soils from pollutants or retain permanent water for wet BMPs. Geotextiles are used in many BMPs and are not listed here.

This appendix applies to the following BMPs:

BMP LID.04 Downspout Infiltration Systems

BMP BF.01 Basic Biofiltration Swale

BMP WP.05 Presettling Basins

BMP WP.01 Stormwater Treatment Wetlands

BMP WP.02 Wet Ponds

BMP WP.04 Combined Detention and Wet Pool Facilities

MF.01 Sand Filter Basin

MF.03 Linear Sand Filter.

Liners Design Criteria

Table B-1 shows the type of liner required for use with various runoff treatment facilities. Other liner configurations may be used with prior acceptance from the County.

Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in Table B-1. Areas above the treatment volumes that are 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.

Table B.1 Lining Types Required for Runoff Treatment Facilities

Water Quality Facility	Area to be Lined	Type of Liner Required
Presettling basin	Bottom and sides	Treatment liner or Low permeability liner (If the basin will intercept the seasonal high groundwater table, a treatment liner may be recommended.)
Wet pond	First cell: bottom and sides to water quality design water surface -- Second cell: bottom and sides to water quality design water surface	Treatment liner or Low permeability liner -- Treatment liner
Combined detention/water quality facility	First cell: bottom and sides to water quality design water surface -- Second cell: bottom and sides to water quality design water surface	Treatment liner or Low permeability liner -- Treatment liner
Stormwater wetland	Bottom and sides, both cells	Low permeability liner
Sand filtration basin	Basin sides only	Treatment liner
Sand filter vault	Not applicable	No liner needed
Linear sand filter	Not applicable if in vault Bottom and sides of presettling cell if not in vault	No liner needed Treatment liner or Low permeability
Media filter (in vault)	Not applicable	No liner needed
Wet vault	Not applicable	No liner needed

B-1. Treatment Liners

This section presents the design criteria for treatment liners.

A two-foot thick layer of soil with a minimum organic content of 5% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams can be used as a treatment layer beneath a water quality or detention facility.

To demonstrate that in-place soils meet the above criteria, one sample per 1,000 square feet of facility area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer (usually two to six feet below the expected facility invert).

Typically, side wall seepage is not a concern if the seepage flows through the same stratum as the bottom of the treatment BMP. However, if the treatment soil is an engineered soil or has very low permeability, the potential to bypass the treatment soil through the side walls may be significant. In those cases, the treatment BMP side walls may 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.

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 Thurston County for acceptance.

Animal manures used in treatment soil layers must be sterilized because of potential for bacterial contamination of the groundwater.

If a treatment liner will be below the seasonal high water level, the pollutant removal performance of the liner must be evaluated by a geotechnical or groundwater specialist and found to be as protective as if the liner were above the level of the groundwater.

B-2. Low Permeability Liners

This section presents the design criteria for each of the following four low permeability liner options: compacted till liners, clay liners, geomembrane liners, and concrete liners.

For low permeability liners, the following criteria apply:

Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. In these instances, use of a low permeability liner shall be evaluated and recommended by a geotechnical engineer.

Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or compost-amended native soil (2 inches compost tilled into 6 inches of native till soil) must be placed over the liner in the area to be planted. Twelve inches of cover is preferred.

Compacted Till Liners
Liner thickness shall be 18 inches after compaction.

Soil shall be compacted to 95 percent minimum dry density, modified proctor method (ASTM D-1557).

A different depth and density sufficient to retard the infiltration rate to 2.4×10^{-5} inches per minute (1×10^{-6} centimeters squared) may also be used instead of the thickness and density criteria above.

Soil should be placed in 6-inch lifts.

Soils may be used that meet the gradation in Table B-2

below: ***Table B.2 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 percent 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} centimeters squared) may also be used instead of the above criteria.

Plasticity index shall not be less than 15 percent (ASTM D-423, D-424).

Liquid limit of clay shall not be less than 30 percent (ASTM D-2216).

Clay particles passing shall not be less than 30 percent (ASTM D-422).

The slope of clay liners must be restricted to 3H:1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the facility 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 shall 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 must be operated over the membrane.

The geomembrane fabric shall be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane determined to have a high survivability per the WSDOT standard specifications, specifically Section 9-33 Construction Geotextile (2006 or the latest version as amended). Equivalent methods for protection of the geomembrane liner will be considered. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing, and abrasion.

Geomembranes shall be bedded according to the manufacturer's recommendations.

Liners must be covered with 12 inches of top dressing forming the bottom and sides of the water quality facility, except for linear sand filters. Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic “safety fencing” or another highly visible, continuous marker is embedded 6 inches above the membrane.

If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.

Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

Concrete Liners

Concrete liners may also be used for sedimentation chambers and for sedimentation and filtration basins less than 1,000 square feet in area. Concrete shall be 5-inch thick Class 3000 or better and shall be reinforced by steel wire mesh. The steel wire mesh shall be six (6) gage wire or larger and 6 inch by 6 inch mesh or smaller. An “Ordinary Surface Finish” is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 ton per square foot or less, the concrete shall have a minimum 6 inch compacted aggregate base consisting of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75 to 1 inch. Where visible, the concrete shall be inspected annually and all cracks shall be sealed.

Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, specifications must be developed by a professional engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.

Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.

If grass is to be grown over a concrete liner, slopes must be no steeper than 5H: 1V to prevent the top dressing material from slipping. 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.

B-3. Geotextiles

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 Tables B3 and B4 in the Geotextile Specifications.

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 below in Table B5 shall be

used to specify survivability properties for the liner protection application. Table B4, Class C shall 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 Tables B3 and B4 in the Geotextile Specifications.

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 shall 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 shall be on the order of 200 lbs grab (ASTM D4632) or more.

Table B.3 Geotextile Properties for Underground Drainage

Geotextile Property Requirements[1]			
		Low Survivability	**Moderate Survivability**
Geotextile Property	**Test Method**	**Woven/Nonewoven**	**Woven/Nonwoven**
Grab Tensile Strength, min. in machine and x-machine diretion.	ASTM D4632	180 lbs/115 lbs min.	250 lbs/160 lbs min.
Grab Failure Strain, in machine and x-machine direction.	ASTM D4632	<50% / >50%	<50%/>50%
Seam Breaking Strength (if seams are present)	ASTM D4632	160 lbs/100 lbs min.	220 lbs/140 lbs min.
Puncture Resistance	ASTM D6241	370 lb/220 lbs min.	495 lbs/310 lbs min.
Tear Strength, min. in machine and x-machine direction.	ASTM D4533	67 lbs/40 lbs min.	80 lbs/50 lbs min.
Ultraviolet (UV) Radiation stability	ASTM D4355	50% strength retained min., after 500 hrs. in weatherometer	50% strength retained min., after 500 hrs. in weatherometer

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 B.4 Geotextile for Underground Drainage Filtration Properties

Geotextile Property Requirements [1]				
Geotextile Property	**Test Method**	**Class A**	**Class B**	**Class C**
AOS[2]	ASTM D4751	0.43 mm max (#40 sieve)	0.25 mm max (#60 sieve)	0.18 mm max. (#80 sieve)
Water Permittivity	ASTM D4491	0.5 sec-1 min	0.4 sec -1 min.	0.3 sec -1 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 B.5 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 D43632 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 weatherometer

[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).

Reference for Tables B-3 and B-4: Section 9-33.2 "Geotextile Properties," 2016 Standard Specifications for Road, Bridge, and Municipal Construction

Appendix V-C – Maintenance Guidelines

This appendix provides facility-specific maintenance standards. The standards are intended to provide conditions for determining, through inspection, if maintenance actions are required. Failure to meet these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, the inspection and maintenance schedules must be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Instructions for Use of Maintenance Checklists

The following pages contain maintenance tables for most of the BMPs included in Volume V. Where private developers, rather than Thurston County staff, are responsible for facility maintenance, they should plan to complete a checklist for all system components on the following schedule:

(M) Monthly from October through April.

Annually, once in late summer (preferably September)

(S) Storm-based, after any major storm (use 1 inch in 24 hours as a guideline).

The tables contained in this appendix are for reference only. The tables to be used as checklists can be downloaded from http://www.co.thurston.wa.us/stormwater/manual/manual-home.html Maintenance personnel may use the checklists and check off items inspected and problems noted during each inspection. Actions taken and corrective action recommended should also be noted.

#1 – Maintenance Checklist for Detention Ponds:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Any trash and debris which exceed five cubic feet per 1,000 square feet. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
General	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List. (Apply requirements of adopted integrated pest management policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might normally be. Noxious and nuisance vegetation removed according to applicable regulations. *(Coordinate with Thurston County.) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.*
General	Contaminants and Pollution	Any evidence of contaminants such as oil, gasoline, concrete slurries, or paint.	No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800-424-8802.)*
General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. *(Coordinate with Thurston County; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*
General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is returned to design function. (*Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator.)*
General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. *Apply insecticides in compliance with adopted integrated pest management policies.*
General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation do not hinder inspection or maintenance activities.
General	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements).	Hazard trees removed.
General	Performance	Check crest gauge against design expectations (see Maintenance and Source Control Manual).	Reading recorded. County notified if not meeting design performance.
Crest Gauge	Crest Gauge Missing/ Broken	Crest gauge is not functioning properly, has been vandalized, or is missing.	Repair/replace.

#1 – Maintenance Checklist for Detention Ponds:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Side Slopes of Pond	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Side Slopes of Pond	Erosion	Any erosion observed on a compacted berm embankment.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted berms, a professional engineer should be consulted to resolve source of erosion.*
Storage Area	Sediment	Accumulated sediment that exceeds 10 percent of the designed pond depth unless otherwise specified or affects facility inlets or outlets.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion. *(If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*
Storage Area	Liner (If Applicable)	Liner is visible and has more than three one-fourth inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation.	Dike is built back to the design elevation. *If settlement is significant, a professional engineer should be consulted to determine the cause of the settlement.*
Pond Berms Over 4 ft in height (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees on berms 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 professional engineer should be consulted for proper berm/spillway restoration.*
Pond Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	Piping eliminated. Erosion potential eliminated. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*
Emergency Overflow/ Spillway	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees on emergency spillway 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 professional engineer should be consulted for proper berm/spillway restoration.*

#1 – Maintenance Checklist for Detention Ponds:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of outflow path of spillway.	Rocks and pad depth restored to design standards. (Riprap on inside slopes need not be replaced.)
Emergency Overflow/ Spillway	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*

If you are unsure whether a problem exists, contact a professional engineer.

#2 – Maintenance Checklist for Infiltration Basins and Trenches:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Any trash and debris which exceed five cubic feet per 1,000 square feet. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
General	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List. (Apply requirements of adopted integrated pest management policies for the use	No danger of poisonous vegetation where maintenance personnel or the public might normally be. *(Coordinate with Tacoma-Pierce County Health Department) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.*
General	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. *(Coordinate removal/cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800-424-8802.)*
General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. *(Coordinate with Thurston County; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*
General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility returned to design function. *(Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator)*
General	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. *Apply insecticides in compliance with adopted integrated pest management policies.*
General	Performance	Check crest gauge against design expectations (see Maintenance and Source Control Manual).	Crest gauge results reflect design performance expectations. Reading recorded. County notified if not meeting design performance.
Crest Gauge	Crest Gauge Missing/ Broken	Crest gauge is not functioning properly, has been vandalized, or is missing.	Crest gauge present and functioning. Repair/replace crest gauge if missing or broken.
Storage Area	Water Not Infiltrating	Water ponding in infiltration basin 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. (A percolation test pit or test of facility indicates facility is only working at 90 percent of its designed capabilities. If 2 inches or more sediment is present, remove).	Facility infiltrates as designed. Sediment is removed and/or facility is cleaned so that infiltration system works according to design.

#2 – Maintenance Checklist for Infiltration Basins and Trenches:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than one-half full.	Filter bag less than one-half 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.	Water flows through filter. Replace gravel in rock filter if needed.
Trenches	Observation Well (Use Surface of Trench if Well is Not Present)	Water ponds at surface during storm events. Less than 90 percent of design infiltration rate.	Remove and replace/clean rock and geomembrane.
Ponds	Vegetation	Exceeds 18 inches.	Grass or groundcover mowed to a height no greater than 6 inches.
Ponds	Vegetation	Bare spots.	No bare spots. Revegetate and stabilize immediately.
Side Slopes of Pond	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted slope, a professional engineer should be consulted to resolve source of erosion.*
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works.	Dike is built back to the design elevation. *If settlement is significant, a professional engineer should be consulted to determine the cause of the settlement.*
Pond Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	No water flow through pond berm. Piping eliminated. Erosion potential eliminated. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*
General	Hazard Trees	If dead, diseased, or dying trees are identified.	Hazard trees removed. (*Use a certified Arborist to determine health of tree or removal requirements).*
General	Tree Growth and Dense Vegetation	Tree growth and dense vegetation which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements).	Trees and vegetation do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).

#2 – Maintenance Checklist for Infiltration Basins and Trenches:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Pond Berms (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees on berms 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 professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.	Trees on emergency spillways 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 professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway.	Rocks and pad depth restored to design standards. (Riprap on inside slopes need not be replaced.)
Emergency Overflow/ Spillway	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion*.
Presettling Ponds and Vaults	Facility or sump filled with Sediment and/or Debris	6 inches or designed sediment trap depth of sediment.	No sediment present in presettling pond or vault. Sediment is removed.
Drain Rock	Water Ponding	If water enters the facility from the surface, inspect to see if water is ponding at the surface during storm events. If buried drain rock, observe drawdown through observation port or cleanout.	No water ponding on surface during storm events. *Clear piping through facility when ponding occurs. Replace rock material/sand reservoirs as necessary. Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill.*

If you are unsure whether a problem exists, contact a professional engineer.

#3 – Maintenance Checklist for Closed Detention Systems (Tanks/Vaults):

Drainage System Feature	Defect or Problem	Condition 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. Remove blockage or replace air vent if damaged.
Storage Area	Debris and Sediment	Accumulated sediment depth exceeds 10 percent of the diameter of the storage area for one-half length of storage vault or any point depth exceeds 15 percent of diameter.	All sediment and debris removed from storage area.
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.
Storage Area	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10 percent of its design shape. (Review required by engineer to determine structural stability.)	Tank/pipe repaired or replaced to design.
Storage Area	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications and is structurally sound.
Storage Area	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than one-fourth inch wide at the joint of the inlet/outlet pipe. No water or soil entering vault through joints or walls.
Crest Gauge	Crest Gauge Missing/Broken	Crest gauge is not functioning properly, has been vandalized, or is missing.	Crest gauge present and functioning. *Repair/replace crest gauge if missing or broken.*
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole access cover/ lid is in place and secure.
Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
Manhole	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.

If you are unsure whether a problem exists, contact a professional engineer.

Tanks and vaults are a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#4 – Maintenance Checklist for Control Structure/Flow Restrictor:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25 percent of sump depth or 1 foot below orifice plate.	No trash and debris blocking or potentially blocking control structure orifice.
General	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
General	Structural Damage	Structure is not in upright position (allow up to 10 percent from plumb).	Structure in correct position.
General	Structural Damage	Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
General	Structural Damage	Any holes–other than designed holes–in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
Cleanout Gate	Damaged or Missing	Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
Cleanout Gate	Damaged or Missing	Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
Cleanout Gate	Damaged or Missing	Gate is rusted over 50 percent of its surface area.	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.
Orifice Plate	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	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole access cover/ lid is in place and secure.
Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
Manhole	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.

If you are unsure whether a problem exists, contact a professional engineer.

Control structures are usually considered a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#5 – Maintenance Checklist for Catch Basins:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	"Dump no pollutants" (or similar) stencil or stamp not visible	Stencil or stamp should be visible and easily read.	Warning signs (e.g., "Dump No Waste-Drains to Stream" or "Only rain down the drain"/ "Puget Sound starts here") painted or embossed on or adjacent to all storm drain inlets.
General	Trash and Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inlet capacity by more than 10 percent.	No trash or debris located immediately in front of catch basin or on grate opening.
General	Trash and Debris	Trash or debris (in the basin) that exceeds 1/3 of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
General	Trash and Debris	Trash or debris in any inlet or outlet pipe blocking more than one-third of its height.	Inlet and outlet pipes free of trash or debris.
General	Trash and Debris	Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
General	Sediment	Sediment (in the basin) that exceeds 1/3 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.
General	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than one-fourth inch.	No holes and cracks in the top slab allowing material to run into the basin.
General	Structure Damage to Frame and/or Top Slab	Frame not sitting flush on top slab, i.e., separation of more than three-fourth inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
General	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
General	Fractures or Cracks in Basin Walls/ Bottom	Grout fillet has separated or cracked wider than one-half-inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
General	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
General	Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.	No vegetation blocking opening to basin.

#5 – Maintenance Checklist for Catch Basins:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth present.
General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. *(Coordinate removal/cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800- 424-8802.)*
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is in place and secured.
Catch Basin Cover	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half-inch of thread.	Mechanism opens with proper tools.
Catch Basin Cover	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
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.
Grates	Grate Opening Unsafe	Grate with opening wider than seven-eighths of an inch.	Grate opening meets design standards.
Grates	Trash and Debris	Trash and debris that is blocking more than 20 percent of grate surface inletting capacity.	Grate free of trash and debris.
Grates	Damaged or Missing	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

If you are unsure whether a problem exists, contact a professional engineer.

#6 – Maintenance Checklist for Debris Barriers (e.g., Trash Racks):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20 percent of the openings in the barrier.	Barrier cleared to receive design flow capacity.
General	Damaged/Missing Bars	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than three-fourth inch.
General	Damaged/Missing Bars	Bars are missing or entire barrier missing.	Bars in place according to design.
General	Damaged/Missing Bars	Bars are loose and rust is causing 50 percent deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
General	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe.	Barrier firmly attached to pipe.

If you are unsure whether a problem exists, contact a professional engineer.

#7 – Maintenance Checklist for Energy Dissipaters:

Drainage System Feature	Defect or Problem	Condition 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.
Rock Pad	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 percent of the design depth.	Pipe cleaned/flushed so that it matches design.
Dispersion Trench	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Water discharges from feature by sheet flow. Trench redesigned or rebuilt to standards.
Dispersion Trench	Perforations Plugged	Over one-half of perforations in pipe are plugged with debris and sediment.	Perforations freely discharge flow. Perforated pipe cleaned or replaced.
Dispersion Trench	Water Flows Out Top of "Distributor" Catch Basin	Water flows out of distributor catch basin during any storm less than the design storm or is causing or appears likely to cause damage.	No flow discharges from distributor catch basin. Facility rebuilt or redesigned to standards.
Dispersion Trench	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 one-half of original size or any concentrated worn spot exceeding 1 square foot which would make structure unsound.	Structure in no danger of failing. Structure replaced to design standards if needed.
Manhole/ Chamber	Trash and Debris	Trash or debris (in the basin) that exceeds 1/3 of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
Manhole/ Chamber	Trash and Debris	Trash or debris in any inlet or outlet pipe blocking more than one-third of its height.	Inlet and outlet pipes free of trash or debris.
Manhole/ Chamber	Trash and Debris	Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
Manhole/ Chamber	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin.

#7 – Maintenance Checklist for Energy Dissipaters:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Manhole/ Chamber	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than one-fourth inch.	No holes and cracks in top slab allowing material to run into the basin.
Manhole/ Chamber	Structure Damage to Frame and/or Top Slab	Frame not sitting flush on top slab, i.e., separation of more than three-fourth inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
Manhole/ Chamber	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
Manhole/ Chamber	Fractures or Cracks in Basin Walls/ Bottom	Grout fillet has separated or cracked wider than one-half-inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
Manhole/ Chamber	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
Manhole/ Chamber	Contamination and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants.	No contaminants or pollutants present. *(Coordinate removal/cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800- 424-8802.)*
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed.
Catch Basin Cover	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than one-half-inch of thread.	Mechanism opens with proper tools.
Catch Basin Cover	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.

If you are unsure whether a problem exists, contact a professional engineer.

#8 – Maintenance Checklist for Basic and Compost-Amended Biofiltration Swales:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches or inhibits vegetation growth in 10 percent or more of swale.	No sediment deposits in treatment area of the biofiltration swale. Remove sediment deposits on grass treatment area of the 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.
General	Standing Water	When water stands in the swale between storms and does not drain freely.	Swale drains freely and no standing water in swale between storms. *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.*
General	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Spreader leveled and cleaned and flow spread evenly over entire swale width.
General	Constant Base Flow	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.	Base flow removed from swale by a low-flow pea-gravel drain the length of the swale, or by-passed around the swale.
General	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Swale has no bare spots and grass is thick and healthy. *If grass growth is poor, determine and address the cause. 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.*
General	Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Vegetation mowed or nuisance vegetation removed so that flow not impeded. *Grass mowed to a height of 3 to 4 inches. No grass clippings left in swale.*
General	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	Over-hanging limbs trimmed back and brushy vegetation on adjacent slopes removed.
General	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Inlet and outlet areas clear of sediment and debris. Material clogging or blocking the inlet/outlet area removed.
General	Trash and Debris Accumulation	Trash and debris accumulated in the bioswale.	Leaves, litter, and oily materials removed as needed. Curb cuts and level spreaders cleaned as needed.

#8 – Maintenance Checklist for Basic and Compost-Amended Biofiltration Swales:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	No eroded or scoured areas in biofiltration swale. Cause of erosion or scour addressed. *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.*

If you are unsure whether a problem exists, contact a professional engineer.

#9 – Maintenance Checklist for Wet and Continuous Inflow Biofiltration Swales:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Sediment Accumulation	Sediment depth exceeds 2 inches in 10 percent of the swale treatment area.	No sediment deposits in treatment area.
General	Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Water depth of four inches throughout swale for most of wet season. Build up or repair outlet berm so that water is retained in the wet swale.
General	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Wetland vegetation fully covers bottom of swale. Cause of lack of vigor of vegetation addressed. Replant as needed. *No cattails or nuisance vegetation present. For excessive cattail growth, cut cattail shoots back and compost offsite. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.*
General	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Inlet and outlet areas clear of sediment and debris.
General	Trash and Debris Accumulation	Any trash and debris which exceed one cubic foot per 1,000 square feet. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.	No trash and debris present. Any trash and debris removed from wet swale.
General	Erosion/Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	No eroded or scoured areas in biofiltration swale. *Cause of erosion or scour addressed, Design flows checked to assure swale is large enough to handle flows. Excess flows are bypassed or swale enlarged. Eroded areas replanted with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.*

If you are unsure whether a problem exists, contact a professional engineer.

#10 – Maintenance Checklist for Filter Strips (Basic and CAVFS):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	No sediment deposits in treatment areas. Slope re-leveled to be even and pass flows evenly through strip.
General	Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Grass is healthy and nuisance vegetation controlled such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
General	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	No trash or debris present. Any trash and debris removed from filter.
General	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	No eroded or scoured areas, cause of erosion or scour addressed. *For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel (basic filter strip) or a 50/50 mixture of crushed gravel and compost (CAVFS). 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.*
General	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Flows are spread evenly over entire filter width. Spreader is level and clean.

If you are unsure whether a problem exists, contact a professional engineer.

#11 – Maintenance Checklist for Wet Ponds:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Water level	First cell is empty, does not hold water.	Water retained in first cell for most of the year. *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 one cubic foot per 1,000 square feet of pond area.	No trash or debris on site. Any 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. (*If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*
	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.

If you are unsure whether a problem exists, contact a professional engineer.

#12 – Maintenance Checklist for Wet Vaults:

Drainage System Feature	Problem	Conditions to Check For	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	No trash or debris present. Any trash and debris removed from vault.
General	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment in vault. *(If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*
General	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
General	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
General	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified percentage of the vault surface area must provide ventilation to the vault interior (see design specifications).
Vault Structure	Damage – Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Vault Structure	Damage – Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.
Vault Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
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.

If you are unsure whether a problem exists, contact a professional engineer.

A vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#13 – Maintenance Checklist for Sand Filters (aboveground/open):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Above ground (open sand filter)	Sediment and Silt Accumulation On Top Layer	Sediment and silt depth exceeds one-half inch over 10 percent of surface area of sand filter.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section. Silt scraped off during dry periods using steel rakes or other devices. Surface layer of the media striated.
Above ground (open sand filter)	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	No trash or debris present. Any trash and debris removed from sand filter bed.
Above ground (open sand filter)	Sediment/ Debris in Cleanouts	When the cleanouts become full or partially plugged with sediment and/or debris.	No sediment or debris present. Any sediment and debris removed from cleanouts and/or drainpipes.
Above ground (open sand filter)	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, flow through the overflow pipes occurs frequently, or hydraulic conductivity is less than 1 inch per hour.	Sand filter infiltrates as designed. Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging and influent suspended solids loads (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material). *Other options include removal of thatch, aerating the filter surface, tilling the filter surface, replacing the top 4 inches of filter media, and inspecting geotextiles for clogging.*
Above ground (open sand filter)	Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities. (Consider 4-8 hour drawdown tests).	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
Above ground (open sand filter)	Short Circuiting	Drawdown greater than 12 inches per hour. When flows become concentrated over one section of the sand filter rather than dispersed. (Consider 4-8 hour drawdown tests).	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area. No leaks in the cleanouts or underdrains.
Above ground (open sand filter)	Erosion Damage to Slopes	Erosion over 2 inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes stabilized using proper erosion control measures.
Above ground (open sand filter)	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
Above ground (open sand filter)	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter. Rills and gullies on the surface of the filter can indicate improper function of the inlet flow spreader.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
Above ground (open sand filter)	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20 percent or any other failure to the piping.	Pipe repaired or replaced.

If you are unsure whether a problem exists, contact a professional engineer.

#14 – Maintenance Checklist for Sand Filters (below ground/enclosed):

Drainage System Feature	Problem	Conditions to Check For	Results Expected When Maintenance is Performed
Below Ground Vault	Sediment and Silt Accumulation on Top Layer	Sediment and silt depth exceeds one-half inch.	No sediment deposits on grass layer of sand filter that would impede permeability of the filter section. Silt scraped off during dry periods using steel rakes or other devices. Surface layer of the media striated.
Below Ground Vault	Sediment Accumulation in Presettling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment deposits in first chamber of vault.
Below Ground Vault	Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	No trash or debris present. Any trash and debris removed from vault and inlet/outlet piping.
Below Ground Vault	Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	No sediment or debris present. Any sediment and debris removed from cleanouts and/or drainpipes.
Below Ground Vault	Clogged Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently, and/or hydraulic conductivity is less than 1 inch per hour.	Sand filter infiltrates as designed. Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging and influent suspended solids loads (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material). *Other options include removal of thatch, aerating the filter surface, tilling the filter surface, replacing the top 4 inches of filter media, and inspecting geotextiles for clogging.*
Below Ground Vault	Short Circuiting	Drawdown greater than 12 inches per hour. When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area. (Consider 4-8 hour drawdown tests.)	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion. No leaks in the cleanouts or underdrains.
Below Ground Vault	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
Below Ground Vault	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
Below Ground Vault	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified percentage of the vault surface area must provide ventilation to the vault interior (see design specifications).
Below Ground Vault	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.

#14 – Maintenance Checklist for Sand Filters (below ground/enclosed):

Drainage System Feature	Problem	Conditions to Check For	Results Expected When Maintenance is Performed
Below Ground Vault	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Below Ground Vault	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.
Below Ground Vault	Baffles/Internal Walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Below Ground Vault	Access Ladder	Damaged ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

If you are unsure whether a problem exists, contact a professional engineer.

A below ground enclosed sand filter is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#15 – Maintenance Checklist for Manufactured Media Filters.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Media filter vault	Sediment Accumulation on Top of Filter Cartridges	Sediment accumulation exceeds 0.25 inches on top of cartridges.	No sediment deposits on top of cartridges. Sediment on cartridges likely indicates that cartridges are plugged and require maintenance.
Media filter vault	Sediment Accumulation in Vault	Sediment accumulation in vault exceeds 6 inches. Look for other indicators of clogged cartridges or overflow.	No sediment accumulation in vault. *Sediment in vault should be removed. Cartridges should be checked and replaced or serviced as needed.*
Media filter vault	Trash and Floatable Debris Accumulation	Trash and floatable debris accumulation in vault.	No trash or other floatable debris in filter vault.
Media filter vault	Filter Cartridges Submerged	Filter vault does not drain within 24 hours following storm. Look for evidence of submergence due to backwater or excessive hydrocarbon loading.	Filter media checked and replaced if needed. *If cartridges are plugged with oil additional treatment or source control BMP may be needed.*
Forebay	Sediment Accumulation	Sediment accumulation exceeds 6 inches or one-third of the available sump.	Sediment accumulation less than 6 inches.
Forebay	Trash and Floatable Debris Accumulation	Trash and/or floatable debris accumulation.	No trash or other floatable debris accumulation in forebay. Trash and/or floatable debris should be removed during inspections. *Significant oil accumulation may indicate the need for additional treatment or source control*.
Drain Pipes/ Cleanouts	Sediment in Drain Pipes/Cleanouts	Accumulated sediment that exceeds 20 percent of the diameter.	No sediment or debris in drainpipes or cleanouts. Sediment and debris removed.
Below ground vault	Access cover Damaged/ Not working	One maintenance person cannot remove lid after applying 80 pounds of lift, corrosion of deformation of cover.	Cover repaired to proper working specifications or replaced.
Below ground vault	Damaged Pipes	Any part of the pipes are crushed or damaged due to corrosion and/or settlement.	Pipe repaired or replaced.
Below ground vault	Vault Structure Has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab.	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault repaired or replaced so that vaults meets design specifications and is structurally sound.
Below ground vault	Vault Structure has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab.	Cracks wider than 0.5 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 0.25 inch at the joint of inlet/outlet pipe.
Below ground vault	Baffles	Baffles corroding, cracking, warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to design specifications.

#15 – Maintenance Checklist for Manufactured Media Filters.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Below ground vault	Ladder Rungs Unsafe	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.	Ladder meets design standards and allows maintenance persons safe access.
Below Ground Cartridge Type	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
Below Ground Cartridge Type	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

Also check Department of Ecology website and manufacturer guidelines for updates to O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer.

A vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#16 – Maintenance Checklist for Baffle Oil/Water Separators (American Petroleum Institute [API] Type):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Effluent Water Quality	Inspection of Discharge Water for Obvious Signs of Poor Water Quality	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or effluent, or other contaminants of any type in any chamber.	No contaminants present other than a surface oil film. Effluent discharge from vault should be clear without thick visible sheen.
Structure	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.
General	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.
General	Oil Accumulation	Oil accumulations that exceed 1 inch, at the surface of the water or 6 inches of sludge in the sump.	No visible oil depth on water. *Extract oil/sludge from vault by vactoring. Disposal in accordance with state and local rules and regulations.*
Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
Structure	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
Structure	Vault Structure Damage Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Maintenance person judges that structure is unsound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Structure	Vault Structure Damage Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.
Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

If you are unsure whether a problem exists, contact a professional engineer.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#17 – Maintenance Checklist for Coalescing Plate Oil/Water Separators:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Effluent Water Quality	Inspection of Discharge Water for Obvious Signs of Poor Water Quality	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or effluent, or other contaminants of any type in any chamber.	No contaminants present other than surface oil film. Effluent discharge from vault should be clear with no thick visible sheen.
Structure	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.
General	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
General	Oil Accumulation	Oil accumulation that exceeds 1 inch at the water surface.	No visible oil depth on water and coalescing plates clear of oil. *Oil is extracted from vault using vactoring methods. Dispose of in accordance with state and local rules and regulations. Coalescing plates are cleaned by thoroughly rinsing and flushing. Direct wash-down effluent to the sanitary sewer system where permitted. Should be no visible oil depth on water.*
Structure	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.
Structure	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

If you are unsure whether a problem exists, contact a professional engineer.

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#18 – Maintenance Checklist for Treatment Wetlands:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris	Any trash and debris accumulations which exceed five cubic feet per 1,000 square feet. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.	Trash and debris cleared from site.
General	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List. (Apply requirements of adopted integrated vegetation management (IVM) policies for the use of herbicides.)	No danger of poisonous vegetation where maintenance personnel or the public might have contact. (*Coordinate with Thurston County Noxious Weed Coordinator.) Complete eradication of noxious weeds may not be possible, however compliance with state or local eradication policies are required.*
General	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. *If chronic low levels of oil persist, plant emergent wetland plants such as Juncus effusus (soft rush) which can assist filtering small concentrations of oil.*
General	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material or damaged.	No clogging or blockage in the inlet and outlet piping.
General	Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents removed and dam or berm repaired. *(Coordinate with Thurston County; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*
General	Beaver Dams	Beaver dam results in an adverse change in the functioning of the facility.	Facility is fully functioning. *Evaluate using beaver deceiver and leveler devices. If beaver removal is necessary, contact WDFW Region 6 to coordinate with a Nuisance Wildlife Control Operator.*
General	Tree Growth and Hazard Trees	Tree growth that impedes maintenance access.	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., firewood or construction).
General	Tree Growth and Hazard Trees	If dead, diseased, or dying trees are identified, use a certified Arborist to determine the health of tree and whether removal is required.	Hazard trees removed.
General	Liner	Liner is visible and has more than three one-fourth inch holes in it.	Liner is repaired or replaced. Liner is fully covered.
Forebay	Sediment Accumulation	Sediment accumulation in forebay exceeds the design depth of the sediment zone plus 6 inches.	Accumulated sediment is removed from forebay bottom to the design depth of the sediment zone.

#18 – Maintenance Checklist for Treatment Wetlands:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Side Slopes of Wetland	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes stabilized using appropriate erosion control measure(s) such as rock reinforcement, planting of grass, or additional compaction.
Side Slopes of Wetland	Erosion	Any erosion observed on a compacted berm embankment.	*If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*
Wetland Cell	Wetland Vegetation	20 percent or more of the constructed wetland area has dead or dying vegetation, as measured by stem counts relative to the design plant coverage.	Plants in wetland cell surviving and not interfering with wetland function. Dead or dying vegetation is replaced by like species, unless recommended otherwise by the Wetlands Consultant and approved by the county. (*Watering, physical support, mulching, and weed removal may be required on a regular basis especially during the first 3 years.)*
Wetland Cell	Wetland Vegetation	Percent vegetated cover of constructed wetland bottom area, excluding exotic and invasive species, is less than 50 percent after 2 years.	Exotic/invasive species removed. Additional plantings may be required.
Wetland Cell	Wetland Vegetation	Decaying vegetation produces foul odors.	Decaying vegetation is removed, preferably in late summer.
Wetland Cell	Wetland Vegetation	Wetland vegetation is blocking flow paths causing flow back-up and flooding.	Areas of blocking vegetation are cut back sufficient to allow design flows and prevent flooding.
Wetland Cell	Wetland Vegetation	Water quality monitoring indicates that wetland vegetation is contributing phosphorus and metals to downstream waters rather than sequestering them.	Water quality monitoring indicates improved water quality. To maximize removal of wetland pollutants, wetland vegetation must be periodically harvested, particularly with respect to phosphorus and metals removal. Harvesting should occur by mid-summer before plants begin to transfer phosphorus from the aboveground foliage to subsurface roots, or begin to lose metals that desorb during plant die off. Every 3 to 5 years the entire plant mass including roots should be harvested because the below ground biomass constitutes a significant reservoir (as much as half) of the nutrients and metals that are removed from stormwater by plants.
Wetland Cell	Sediment Accumulation	Sediment accumulation inhibits growth of wetland plants or reduces wetland volume (greater than 1 feet of sediment accumulation).	Wetland dredged to remove sediment accumulation.

#18 – Maintenance Checklist for Treatment Wetlands:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Wetland Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works.	Dike restored to the design elevation. *A professional engineer should be consulted to determine the source of the settlement.*
Wetland Berms (Dikes)	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	Piping eliminated. Erosion potential eliminated. *(Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repairs.)*
Wetland Berms Over 4 ft in height (Dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees on berms 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 professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Obstruction	Tree growth or other blockage on emergency spillways may cause failure of the berm due to uncontrolled overtopping.	Obstruction on emergency spillway removed. *A professional engineer should be consulted for proper berm/spillway restoration.*
Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in an area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway.	Rocks and pad depth are restored to design standards. (Riprap on inside slopes need not be replaced.)
Emergency Overflow/ Spillway	Erosion	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. *If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*

If you are unsure whether a problem exists, contact a professional engineer.

#19 – Maintenance Checklist for Fencing/Shrubbery Screen/Other Landscaping:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Missing or Broken Parts/Dead Shrubbery	Any defect in the fence or screen that permits easy entry to a facility.	Fence is mended or shrubs replaced to form a solid barrier to entry.
General	Erosion	Erosion has resulted in an opening under a fence that allows entry by people or pets.	Soil under fence replaced so that no opening exceeds 4 inches in height.
General	Unruly Vegetation	Shrubbery is growing out of control or is infested with weeds. See also Thurston County Noxious weeds list.	Shrubbery is trimmed and weeded to provide appealing aesthetics. Do not use chemicals to control weeds.
Fences	Damaged Parts	Posts out of plumb more than 6 inches.	Posts plumb to within 1.5 inches of plumb.
Fences	Damaged Parts	Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
Fences	Damaged Parts	Any part of fence (including posts, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
Fences	Damaged Parts	Missing or loose tension wire.	Tension wire in place and holding fabric.
Fences	Damaged Parts	Missing or loose barbed wire that is sagging more than 2.5 inches between posts.	Barbed wire in place with less than three-fourth inch sag between posts.
Fences	Damaged Parts	Extension arm missing, broken, or bent out of shape more than 1.5 inches.	Extension arm in place with no bends larger than three-fourth inch.
Fences	Deteriorated Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
Fences	Openings in Fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	No openings in fabric.

#20 – Maintenance Checklist for Grounds (Landscaping):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Weeds (nonpoisonous)	Weeds growing in more than 20 percent of the landscaped area (trees and shrubs only). See also Thurston County Noxious weeds list.	Weeds present in less than five percent of the landscaped area.
General	Insect Hazard	Any presence of poison ivy or other poisonous vegetation or insect nests.	No poisonous vegetation or insect nests present in landscaped area.
General	Trash or Litter	See Detention Ponds (Checklist #1).	See Detention Ponds (Checklist #1).
General	Erosion of Ground Surface	Noticeable rills are seen in landscaped areas.	Causes of erosion are identified and steps taken to slow down/spread out the water. Eroded areas are filled, contoured, and seeded.
Trees and shrubs	Damage	Limbs or parts of trees or shrubs that are split or broken which affect more than 25 percent of the total foliage of the tree or shrub.	Trim trees/shrubs to restore shape. Replace trees/shrubs with severe damage.
Trees and shrubs	Damage	Trees or shrubs that have been blown down or knocked over.	Tree replanted, inspected for injury to stem or roots. Replace if severely damaged.
Trees and shrubs	Damage	Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Stakes and rubber-coated ties placed around young trees/shrubs for support.

#21 – Maintenance Checklist for Gates:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Damaged or Missing Components	Gate is broken, jammed, or missing.	Pond has a functioning gate to allow entry of people and maintenance equipment such as mowers and backhoe. If a lock is used, make sure the county field staff have a key.
General	Damaged or Missing Components	Broken or missing hinges such that gate cannot be easily opened and closed by one maintenance person.	Hinges intact and lubed. Gate is working freely.
General	Damaged or Missing Components	Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
General	Damaged or Missing Components	Missing stretcher bands, and ties.	Stretcher bar, bands, and ties in place.

#22 – Maintenance Checklist for Conveyance Systems (Pipes and Ditches):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Pipes	Sediment & Debris	Accumulated sediment that exceeds 20 percent of the diameter of the pipe.	Pipe cleaned of all sediment and debris.
Pipes	Vegetation	Vegetation that reduces free movement of water though pipes.	Vegetation does not impeded free movement of water through pipes. *Prohibit use of sand and sealant application and protect from construction runoff.*
Pipes	Damaged (Rusted, Bent or Crushed)	Protective coating is damaged: rust is causing more than 50 percent deterioration to any part of pipe.	Pipe repaired or replaced.
Pipes	Damaged (Rusted, Bent or Crushed)	Any dent that significantly impedes flow (i.e. decreases the cross section area of pipe by more than 20 percent).	Pipe repaired or replaced.
Pipes	Damaged (Rusted, Bent or Crushed)	Pipe has major cracks or tears allowing groundwater leakage.	Pipe repaired or replaced.
Open Ditches	Trash & Debris	Dumping of yard wastes such as grass clippings and branches. Unsightly accumulation of non-degradable materials such as glass, plastic, metal, foam, and coated paper.	No trash or debris present. Trash and debris removed and disposed of as prescribed by the County.
Open Ditches	Sediment Buildup	Accumulated sediment that exceeds 20 percent of the design depth.	Ditch cleaned of all sediment and debris so that it matches design.
Open Ditches	Vegetation	Vegetation (e.g. weedy shrubs or saplings) that reduces free movements of water through ditches.	Water flows freely though ditches. Grassy vegetation should be left alone.
Open Ditches	Erosion Damage to Slopes	Erosion damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	No erosion damage present. Slopes stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Open Ditches	Erosion Damage to Slopes	Any erosion observed on a compacted berm embankment.	*If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*
Open Ditches	Rock Lining Out of Place or Missing (If Applicable)	Native soil is exposed beneath the rock lining.	Rocks replaced to design standards.

If you are unsure whether a problem exists, contact a professional engineer.

#23 – Maintenance Checklist for Media Filter Drain.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
No Vegetation Zone adjacent to pavement	Erosion, Scour, or Vehicular Damage	No vegetation zone uneven or clogged so that flows are not uniformly distributed.	Area leveled and cleaned so that flows are spread evenly.
No Vegetation Zone adjacent to pavement	Sediment Accumulation on Edge of Pavement	Flows no longer sheet flowing off of roadway. Sediment accumulation on pavement edge exceeds top of pavement elevation.	No sediment accumulation on pavement edge that impedes sheet flow. Sediment deposits removed such that flows can sheet flow off of roadway.
Vegetated Filter	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Sediment deposits removed, slope is re-leveled so that flows pass evenly through Ecology Embankment.
Vegetated Filter	Excessive Vegetation or Undesirable Species	When the grass becomes excessively tall; when nuisance weeds and other vegetation starts to take over or shades out desirable vegetation growth characteristics. See also Thurston County Noxious weeds list.	Grass mowed and nuisance vegetation controlled such that flow not impeded. *Grass should be mowed to a height that encourages dense even herbaceous growth.*
Vegetated Filter	Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows or vehicular damage.	No eroded or scoured areas. *For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with suitable topsoil. 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.*
Media Bed	Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows or vehicular damage.	No eroded or scoured areas. *For ruts or areas less than 12 inches wide, repair the damaged area by filling with suitable media. If bare areas are large, generally greater than 12 inches wide, the media bed should be re-graded.*
Media Bed	Sediment Accumulation on Media Bed	Sediment depth inhibits free infiltration of water.	Sediment accumulation does not impeded infiltration. Sediment deposits removed and slope is re-leveled so that flows pass freely through Media Bed.
Underdrains	Sediment	Depth of sediment within perforated pipe exceeds one-half inch.	Depth of sediment within perforated pipe does not exceed one-half inch. Flush underdrains through access ports and collect flushed sediment.
General	Trash and Debris Accumulation	Any trash and debris accumulations which exceed one cubic foot per 1,000 square feet. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.	No trash or debris present. Remove trash and debris from media filter.

#23 – Maintenance Checklist for Media Filter Drain.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Flows are Bypassing Ecology Embankment	Evidence of significant flows downslope (rills, sediment, vegetation damage, etc.) of media filter drain.	Facility functions as designed. Sediment deposits removed and slope is re-leveled so that flows pass evenly through media filter drain. If media filter drain is completely clogged, it may require a more extensive repair or replacement.
General	Media Filter Drain Mix Replacement	Water is seen on surface of the media filter drain mix from storms that are less than the 91st percentile 24-hour rain event (approx 1.25" in 24 hours). Maintenance also needed on a 10-year cycle and during a preservation project.	No water ponded on surface after design storm. *Excavate and replace all of the media filter drain mix contained within the media filter drain.*

See also the latest version of the WSDOT Highway Runoff Manual for additional maintenance information.

If you are unsure whether a problem exists, contact a professional engineer.

#24 – Maintenance Checklist for Vortechs Stormwater Treatment System

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Sediment Accumulation	Sediment depth is within 6 inches of dry weather water surface elevation.	Accumulated sediment should be removed.
General	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
General	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.
Structure	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
Structure	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Structure	Vault Structure Damage – Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.

Designers must also review the most current manufacturer guidelines for any updates or additions to the following O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer.

A vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

#25 – Maintenance Checklist for Stormceptor System.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Settling chamber	Excessive Sediment Accumulation	Capacities vary depending on model number[1].	Sediments removed.
Settling chamber	Trash and Floatable Debris Accumulation	Excessive trash and floatable debris accumulation.	Minimal trash or other floatable debris.
Settling chamber	Excessive Oil Accumulation	Oil exceeds 6 inches in depth or evidence of a spill.	Oil cleaned out.
Manhole Cover	Cover Damaged/ Not Working	One maintenance person cannot remove lid after applying 80 pounds of lift, corrosion of deformation of cover.	Cover repaired to proper working specifications or replaced.
Disk Insert	Disk Insert Inlet/ Outlet Obstructed	Inlet or outlet piping obstructed.	Disk insert inlet/outlet free from obstructions.
Structure	Structure has Cracks in wall, Bottom, and Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault repaired or replaced so that vaults meets design specifications and is structurally sound.
Structure	Structure has Cracks at the Joint of any Inlet/ Outlet Pipe	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of inlet/outlet pipe.

Designers must also review the most current manufacturer guidelines for any updates or additions to the following O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer or the manufacturer’s representative.

1model number and sediment depth capacities:

Sediment Depths Indicating Required Servicing	
Model	Sediment Depth
STC 450i	8"
STC 900	8"
STC 1200	10"
STC 1800	15"
STC 2400	12"
STC 3600	17"
STC 4800	15"
STC 6000	18"
STC 7200	15"
STC 11000	15"
STC 13000	18"
STC 16000	15"

#26 – Maintenance Checklist for Filterra.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Inlet	Excessive Sediment or Trash Accumulation	Accumulated sediments or trash impair free flow of water into Filterra system.	Inlet free of obstructions and allows free distributed flow of water into Filterra system. Sediments and/or trash removed.
Mulch Cover	Trash and Floatable Debris Accumulation	Excessive trash and/or debris accumulation.	Minimal trash or other debris on mulch cover. Trash and debris removed and mulch cover raked level.
Mulch Cover	Ponding of Water on Mulch Cover	Ponding in unit could be indicative of clogging due to excessive fine sediment accumulation or spill of petroleum oils.	Stormwater drains freely and evenly through mulch cover. *Recommend contact manufacturer and replace mulch or soil if necessary.*
Vegetation	Plants not Growing or in Poor Condition	Soil/ mulch too wet, evidence of spill. Incorrect plant selection. Pest infestation. Vandalism to plants.	Plants healthy and pest free. *Contact manufacturer for advice.*
Vegetation	Excessive Plant Growth	Excessive plant growth inhibits facility function or becomes a hazard for pedestrian and vehicular circulation and safety.	Plants trimmed/pruned in accordance with manufacturer's recommendations to maintain appropriate plant density and aesthetics. Appropriate plants are present.
Structure	Structure has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the structure is not structurally sound.	Structure sealed and structurally sound.
Structure	Structure has Cracks at the Joint of any Inlet/ Outlet Pipe	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Structure repaired so that no cracks exist wider than one-fourth inch at the joint of inlet/outlet pipe.

Designers must also review the most current manufacturer guidelines for any updates or additions to the following O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer or the manufacturer's representative.

#27 – Maintenance Checklist for CDS Media Filtration System (MFS) ®.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Media filter vault	Sediment Accumulation on Top of Filter Cartridges	Sediment accumulation exceeds one-half inch on top of cartridges.	Minimal sediment deposits on top of cartridges. Excess sediment on cartridges likely indicates that cartridges are plugged and require maintenance.
Media filter vault	Sediment Accumulation in Vault	Sediment accumulation in vault exceeds 6 inches.	Sediment in vault removed.
Media filter vault	Trash and Floatable Debris Accumulation	Excessive trash and floatable debris accumulation in vault.	Minimal trash or other floatable debris in filter vault.
Media filter cartridges	Filter Cartridges Full	Filter cartridge media appears dark. Check should be performed on a dry day. Requires entry to vault[1].	Filter media checked and replaced if needed. If cartridges are plugged with oil, additional treatment or source control BMP may be needed.
Media filter cartridges	Filter Cartridges Full	Area around cartridges has standing water and cartridges are submerged 24 hours after a storm.	Filter media checked and replaced if needed. If cartridges are plugged with oil, additional treatment or source control BMP may be needed.
Media filter cartridges	Filter Cartridges Full	Water flowing over the head control box during light storm events and more than 1 inch of floatables has accumulated in the cartridge vent pipe.	Filter media checked and replaced if needed. If cartridges are plugged with oil, additional treatment or source control BMP may be needed.
Access Cover	Access Cover Damaged/ Not Working	One maintenance person cannot remove lid after applying 80 pounds of lift, corrosion of deformation of cover.	Cover repaired to proper working specifications or replaced.
Collector manifold	Damaged Piping	Any part of the pipes are crushed or damaged due to corrosion and/or settlement.	Pipe repaired or replaced.
Vault	Vault Structure has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault repaired or replaced so that vault meets design specifications and is structurally sound.
Vault	Structure has Cracks at the Joint of any Inlet/ Outlet Pipe	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist at the joint of inlet/outlet pipe.
Baffles	Baffles	Baffles corroding, cracking, warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to design specifications.
Access Ladder	Ladder Rungs Unsafe	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.	Ladder meets design standards and allows maintenance persons safe access.

Designers must also review the most current manufacturer guidelines for any updates or additions to the following O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer.

[1]Comments:

1. CDS MFS system vault is a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

2. Default maintenance is annual.

3. Configuration options include precast or cast in place concrete vaults or precast manhole structures.

#28 – Maintenance Checklist for Aqua Shield Aqua-Swirl.

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Sediment Storage area	Excessive Sediment Accumulation	Sediment accumulation within 36 inches of water surface.	Sediment removed.
Aqua Swirl Chamber	Trash and Floatable Debris Accumulation	Excessive trash and floatable debris accumulation swirl chamber.	Minimal trash or other floatable debris.
Manhole Cover	Cover Damaged/ Not Working	One maintenance person cannot remove lid after applying 80 pounds of lift, corrosion of deformation of cover.	Cover repaired to proper working specifications or replaced.
Structure	Vault Structure has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab	Cracks wider than one-half inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault repaired or replaced so that vault meets design specifications and is structurally sound.
Structure	Vault Structure has Cracks at the Joint of any Inlet/ Outlet Pipe	Cracks wider than one-half inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of inlet/outlet pipe.
Baffles	Baffles	Baffles corroding, cracking, warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to design specifications.

Designers must also review the most current manufacturer guidelines for any updates or additions to the following O&M requirements.

If you are unsure whether a problem exists, contact a professional engineer or the manufacturer's representative.

#29 – Maintenance Checklist for Bioretention (Cells, Swales, and Planter Boxes):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash	Trash and debris present.	No trash and debris present.
Concrete Sidewalls	Cracks or Failure in Concrete Planter Reservoir	Cracks wider than 0.5 inch or maintenance/inspection personnel determine that the planter is not structurally sound.	Concrete repaired or replaced.
Rockery Sidewalls	Instable Rockery	Rock walls are insecure.	Rockery sidewalls are stable (may require consultation with professional engineer, particularly for walls 4 feet or greater in height).
Earthen Side Slopes and Berms	Failure in Earthen Reservoir (Embankments, Dikes, Berms, and Side Slopes)	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and along side slopes.	Source of erosion eliminated and damaged area stabilized (regrade, rock, vegetation, erosion control blanket). For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures are in place until permanent repairs can be made.
Earthen Side Slopes and Berms	Failure in Earthen Reservoir (Embankments, Dikes, Berms, and Side Slopes)	Erosion of sides causes slope to become a hazard.	The hazard is eliminated and slopes are stabilized.
Earthen Side Slopes and Berms	Failure in Earthen Reservoir Embankments, Dikes, Berms, and Side Slopes)	Settlement greater than 3 inches (relative to undisturbed sections of berm).	The design height is restored with additional mulch.
Earthen Side Slopes and Berms	Failure in Earthen Reservoir (Embankments, Dikes, Berms, and Side Slopes)	Downstream face of berm or embankment wet, seeps or leaks evident.	Holes are plugged and berm is compacted. May require consultation with professional engineer, particularly for larger berms.
Earthen Side Slopes and Berms	Failure in Earthen Reservoir (Embankments, Dikes, Berms, and Side Slopes)	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm.	Rodents (see “Pests: Insects/Rodents”) removed or destroyed and berm repaired/ compacted.
Ponding Area	Sediment or Debris Accumulation	Accumulation of sediment or debris to extent that infiltration rate is reduced (see “Ponded water”) or surface storage capacity significantly impacted.	Sediment cleaned out to restore facility shape and depth. Damaged vegetation is replaced and mulched. Source of sediment identified and controlled (if feasible).
Ponding Area	Leaf Accumulation	Accumulated leaves in facility.	No leaves clogging outlet structure or impeding water flow.
Ponding Area	Basin Inlet via Surface Flow	Soil is exposed or signs of erosion are visible.	Erosion sources repaired and controlled.
Curb Cut Inlet	Sediment or Debris Accumulation	Sediment, vegetation, or debris partially or fully blocking inlet structure.	Curb cut is clear of debris. Source of the blockage is identified and action is taken to prevent future blockages.

#29 – Maintenance Checklist for Bioretention (Cells, Swales, and Planter Boxes):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Splash Block Inlet	Water Not Properly Directed to Facility	Water is not being directed properly to the facility and away from the inlet structure.	Blocks are reconfigured to direct water to facility and away from structure.
Splash Block Inlet	Erosion	Water disrupts soil media.	Splash block is reconfigure/repaired.
Inlet/outlet pipe	Damaged Pipe	Pipe is damaged.	Pipe is repaired/replaced. No cracks more than 0.25 inched wide at the joint of inlet/outlet pipes exist.
Inlet/outlet pipe	Clogged Pipe	Pipe is clogged.	Pipe is clear of roots or debris. Source of the blockage is identified and action is taken to prevent future blockages.
Inlets/outlet and access pathways	Blocked Access	Maintain access for inspections.	Vegetation is cleared within 1 foot of inlets and outlets. Access pathways are maintained.
Ponding Area	Erosion	Water disrupts soil media.	No eroded or scoured areas in bioretention area. Cause of erosion or scour addressed. A cover of rock or cobbles or other erosion protection measure maintained (e.g., matting) to protect the ground where concentrated water enters or exits the facility (e.g., a pipe, curb cut or swale).
Trash Rack	Trash or Debris Accumulation	Trash or debris present on trash rack.	No trash or debris on trash rack. Clean and dispose trash.
Trash Rack	Damaged Trash Rack	Bar screen damaged or missing.	Barrier repaired or replaced to design standards.
Check Dams and Weirs	Sediment or Debris Accumulation	Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, weir, or orifice.	Blockage is cleared. Identify the source of the blockage and take actions to prevent future blockages.
Check Dams and Weirs	Erosion	Erosion and/or undercutting is present.	No eroded or undercut areas in bioretention area. Cause of erosion or undercutting addressed. Check dam or weir is repaired.
Check Dams and Weirs	Unlevel Top of Weir	Grade board or top of weir damaged or not level.	Weir restored to level position.
Flow Spreader	Sediment Accumulation	Sediment blocks 35 percent or more of ports/notches or, sediment fills 35 percent or more of sediment trap.	Sediment removed and disposed of.
Flow Spreader	Damaged or Unlevel Grade Board/Baffle	Grade board/baffle damaged or not level.	Board/baffle removed and reinstalled to level position.
Overflow/ emergency spillway	Sediment or Debris Accumulation	Overflow spillway is partially or fully plugged with sediment or debris.	No sediment or debris in overflow.
Overflow/ emergency spillway	Erosion	Native soil is exposed or other signs of erosion damage are present.	Erosion repaired and surface of spillway stabilized.

#29 – Maintenance Checklist for Bioretention (Cells, Swales, and Planter Boxes):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Overflow/ emergency spillway	Missing Spillway Armament	Spillway armament is missing.	Armament replaced.
Underdrain	Blocked Underdrain	Plant roots, sediment or debris reducing capacity of underdrain. Prolonged surface ponding (see "Bioretention Soil").	Underdrains and orifice are free of sediment and debris.
Bioretention soil	Ponded Water	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.	Cause of ponded water is identified and addressed: 1. Leaf or debris buildup is removed 2. Underdrain is clear 3. Other water inputs (e.g., groundwater, illicit connections) investigated 4. Contributing area verified If steps #1-4 do not solve the problem, imported bioretention soil is replaced and replanted.
Bioretention soil	Protection of Soil	Maintenance requiring entrance into the facility footprint.	Maintenance is performed without compacting bioretention soil media.
Vegetation	Bottom Swale and Upland Slope Vegetation	Less than 75 percent of swale bottom is covered with healthy/ surviving vegetation.	Plants are healthy and pest free. Cause of poor vegetation growth addressed. Bioretention area is replanted as necessary to obtain 75 percent survival rate or greater. Plant selection is appropriate for site growing conditions.
Trees and shrubs	Causing Problems for Operation of Facility	Large trees and shrubs interfere with operation of the basin or access for maintenance.	Trees and shrubs do not hinder facility performance or maintenance activities. Prune or remove large trees and shrubs.
Trees and shrubs	Dead Trees and Shrubs	Standing dead vegetation is present.	Trees and shrubs do not hinder facility performance or maintenance activities. Dead vegetation is removed and cause of dead vegetation is addressed. Specific plants with high mortality rate are replaced with more appropriate species.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	Safety Issues	Vegetation causes some visibility (line of sight) or driver safety issues.	Appropriate height for sight clearance is maintained. Regular pruning maintains visual sight lines for safety or clearance along a walk or drive. Tree or shrub is removed or transplanted if presenting a continual safety hazard.
Emergent Vegetation	Conveyance Blocked	Vegetation compromises conveyance.	Sedges and rushes are clear of dead foliage.
Mulch	Lack of Mulch	Bare spots (without much cover) are present or mulch covers less than 2 inches.	Facility has a maximum 3-inch layer of an appropriate type of mulch and mulch is kept away from woody stems.
Vegetation	Accumulation of Clippings	Grass or other vegetation clippings accumulate to 2 inches or greater in depth.	Clippings removed.

#29 – Maintenance Checklist for Bioretention (Cells, Swales, and Planter Boxes):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Noxious Weeds	Presence of Noxious Weeds	Listed noxious vegetation is present. See Thurston County noxious weed list.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where County personnel or the public might normally be. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.
Vegetation	Weeds	Weeds are present (unless on edge and providing erosion control).	Weed material removed and disposed of. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.
Excessive Vegetation	Adjacent Facilities Compromised	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.	Vegetation does not impede function of adjacent facilities or pose as safety hazard. Groundcovers and shrubs trimmed at facility edge. Excessive leaf litter is removed.
Excessive Vegetation	Causes Facility to Not Function Properly	Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety.	Pruning and/or thinning vegetation maintains proper plant density and aesthetics. Plants that are weak, broken, or not true to form are removed or replaced in-kind. Appropriate plants are present.
Irrigation (if any)	NA	Irrigation system present.	Manufacturer's instructions for O&M are met.
Plant watering	Plant Establishment	Plant establishment period (1-3 years).	Plants are watered as necessary during periods of no rain to ensure plant establishment.
Summer Watering (after establishment)	Drought Period	Longer term period (3+ years).	Plants are watered as necessary during drought conditions and trees are watered up to five years after planting.
Spill Prevention and Response	Spill Prevention	Storage or use of potential contaminants in the vicinity of facility.	Spill prevention measures are implemented whenever handling or storing potential contaminants.
Spill Prevention and Response	Spill Response	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.	Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800-424-8802.)*
Safety	Safety (Slopes)	Erosion of sides causes slope to exceed 1:3 or otherwise becomes a hazard.	Actions taken to eliminate the hazard.
Safety	Safety (Hydraulic Structures)	Hydraulic structures (pipes, culverts, vaults, etc.) become a hazard to children playing in and around the facility.	Actions taken to eliminate the hazard (such as covering and securing any openings).

#29 – Maintenance Checklist for Bioretention (Cells, Swales, and Planter Boxes):

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Aesthetics	Aesthetics	Damage/vandalism/debris accumulation.	Facility restored to original aesthetic conditions.
Aesthetics	Edging	Grass is starting to encroach on swale.	Edging repaired.
Pest Control	Pests: Insects/Rodents	Pest of concern is present and impacting facility function.	Pests removed or destroyed and facility returned to original functionality. Do not use pesticides or *Bacillus thuringiensis israelensis (Bti).*
Pest Control	Mosquitoes	Standing water remains in the basin for more than three days following storms.	All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present.

If you are unsure whether a problem exists, contact a professional engineer.

#30 – Maintenance Checklist for Cisterns:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Roof	Debris Accumulation in Cistern	Debris has accumulated.	No debris in cistern.
Gutter	Debris Accumulation in Gutter	Debris has accumulated.	No debris in cistern or gutters.
Screens at the top of downspout and cistern inlet	Debris Accumulation in Cistern	Screen has deteriorated.	Screen is in place and functions as designed.
Screens at the top of downspout and cistern inlet	Debris Accumulation in Cistern	None. Preventative maintenance.	No debris in cistern or accumulated on screen.
Low flow orifice	Cistern Overflows Are Too Frequent	Debris or other obstruction of orifice.	Low flow orifice is clean.
Overflow pipe	Overflow Pipe	Pipe is damaged.	Overflow pipe is watertight and does not leak. Repair/replace.
Overflow pipe	Overflow Pipe	Pipe is clogged.	Debris removed. Overflow pipe can convey overflow to point of discharge.
Cistern	Accumulated Debris And/or Sediment	More than 6 inches of accumulation in bottom of cistern.	Accumulated debris and/or sediment removed.
Training and Documentation	NA	Training / written guidance is required for proper O&M.	Property owners and tenants are provided with proper training and a copy of the Maintenance and Source Control Manual.
Access and Safety	NA	Access to cistern required for maintenance or cleaning.	Any opening that could allow the entry of people is marked: “DANGER—CONFINED SPACE”.
Pest Control	Mosquito Infestation	Standing water remains for more than three days following storms.	All inlets, overflows, and other openings are protected with mosquito screens. No mosquito infestation present.

If you are unsure whether a problem exists, contact a professional engineer.

#31 – Maintenance Checklist for Vegetated Roof:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Soil / Growth Medium	Water is Not Infiltrating Properly	Water does not permeate growth media (runs off soil surface).	Facility infiltrates as designed. Aerate or replace media until stormwater infiltrates freely through growth media.
Soil / Growth Medium	Water is Not Infiltrating Properly	Growth medium thickness is less than design thickness (due to erosion and plant uptake).	Facility infiltrates as designed. Supplement growth medium to design thickness.
Soil / Growth Medium	Water is Not Infiltrating Properly	Fallen leaves or debris are present.	No leaves or debris present.
Soil / Growth Medium	Erosion/Scouring	Areas of potential erosion are visible.	Steps taken to repair or prevent erosion. Fill, hand tamp, or lightly compact, and stabilize with additional soil substrate/growth medium and additional plants.
Erosion Control Measures	Erosion/Scouring	Mat or other erosion control is damaged or depleted during plant establishment period.	Erosion control measures repaired/replaced until 90 percent vegetation coverage attained. Avoid application of mulch on extensive vegetated roofs.
System Structural Components	Deteriorating Flashing, Gravel Stops, Utilities, or Other Structures on Roof	Flashing, utilities or other structures on roof are deteriorating (can serve as source of metal pollution in vegetated roof runoff).	Structural components inspected for deterioration or failure. Repair/replace as necessary.
Roof Drain	Sediment, Vegetation, or Debris Accumulation	Sediment, vegetation, or debris blocks 20 percent or more of inlet structure.	Blockages cleared. Problems that led to blockage identified and corrected.
Roof Drain	Damaged Inlet Pipe	Inlet pipe is in poor condition.	Repaired/replaced.
Roof Drain	Clogged Inlet Pipe	Pipe is clogged.	Roots or debris removed.
Vegetation	Plant Coverage	Healthy vegetative coverage falls below 90 percent (unless design specifications stipulate less than 90 percent coverage).	Bare areas planted with vegetation If necessary, install erosion control measures until percent coverage goal is attained.
Vegetation (sedums)	NA	Extensive roof with low density sedum population.	Sedums are mulch mowed, creating cuttings from existing plants to encourage colonization.

#31 – Maintenance Checklist for Vegetated Roof:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Vegetation	Presence of Noxious Weeds	Listed noxious vegetation is present. See Thurston County noxious weed list.	No danger of poisonous vegetation where maintenance personnel or the public might normally be. Noxious and nuisance vegetation removed according to applicable regulations. 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. *(Coordinate with Thurston County.) Complete eradication of noxious weeds may not be possible. Compliance with state or local eradication policies required.*
Vegetation	Presence of Weeds	Weeds are present.	Weed material removed and disposed of, with roots manually removed with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.
Vegetation (extensive vegetated roof)	Under Fertilization	Poor plant establishment and possible nutrient deficiency in growth medium.	Organic debris allowed to replenish and maintain long-term nutrient balance and growth medium structure. Conduct annual soil test 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Minimum amount slow-release fertilizer necessary to achieve successful plant establishment is applied. Apply fertilizer only after acquiring required approval from facility owner and operator. Note that extensive vegetated roofs are designed to require zero to minimal fertilization after establishment (excess fertilization can contribute to nutrient export).

#31 – Maintenance Checklist for Vegetated Roof:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Vegetation (intensive vegetated roof)	Under Fertilization	Fertilization may be necessary during establishment period or for plant health and survivability after establishment.	Annual soil test conducted 2-3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. Apply fertilizer only after acquiring required approval from facility owner and operator. Intensive vegetated roofs may require more fertilization than extensive vegetated roofs.
Vegetation (trees and shrubs on an intensive vegetated roof)	NA	Pruning as needed.	All pruning of mature trees performed by or under the direct guidance of an ISA certified arborist.
Irrigation system (if any)	NA	Irrigation system is not working or routine maintenance is needed.	Manufacturer's instructions for O&M have been followed.
Vegetation (extensive vegetated roof)	NA	Summer watering – Plant establishment period (1-2 years).	Watered weekly during periods of no rain to ensure plant establishment (30 to 50 gallons per 100 square feet).
Vegetation (extensive vegetated roof)	NA	Summer watering – Longer term period (2+ years).	Watered during drought conditions or more often if necessary to maintain plant cover (30 to 50 gallons per 100 square feet).
Vegetation (intensive vegetated roof)	NA	Plant establishment period (1-2 years).	Watered deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system not present.
Vegetation (intensive vegetated roof)	NA	Longer term period (2+ years).	Watered during drought conditions or more often if necessary to maintain plant cover.
Spill Prevention and Response	NA	Storage or use of potential contaminants in the vicinity of facility.	Spill prevention measures exercised whenever handling or storing potential contaminants.
Spill Prevention and Response	Release of Pollutants.	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.	Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800- 424-8802.)*
Training and Documentation	NA	Training / written guidance is required for proper O&M.	Property owners and tenants provided with proper training and a copy of the Maintenance and Source Control Manual.

#31 – Maintenance Checklist for Vegetated Roof:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Safety	NA	Insufficient egress /ingress routes and fall protection.	Egress and ingress routes maintained to design standards and fire codes. Ensure appropriate fall protection.
Aesthetics	Poor Aesthetics	Damage/vandalism/debris accumulation.	Facility restored to original aesthetic conditions.
Pest Control	Mosquitoes	Standing water remains for more than three days following storms.	Standing water removed. Cause of the standing water identified, and appropriate actions taken to address the problem (e.g., aerate or replace medium, unplug drainage).

If you are unsure whether a problem exists, contact a professional engineer.

#32 – Maintenance Checklist for Permeable Pavement:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Facility – General Requirements	Unstable Adjacent Area	Runoff from adjacent pervious areas deposits soil, mulch, or sediment on paving.	No deposited soil or other materials on permeable pavement or other adjacent surfacing. All exposed soils that may erode to pavement surface mulched and/or planted.
Facility – General Requirements	Wearing Course Covered by Adjacent Vegetation	Vegetation growing beyond facility edge onto sidewalks, paths, and street edge.	Vegetation does not impede function of adjacent facilities or pose as safety hazard. Groundcovers and shrubs trimmed to avoid overreaching the sidewalks, paths and street edge.
Porous asphalt or pervious cement concrete	NA	None. Maintenance to prevent clogging with fine sediment.	Conventional street sweepers equipped with vacuums, water, and brushes or pressure washer used to restore permeability. Vacuum or pressure wash the pavement two to three times annually.
Porous asphalt or pervious cement concrete	NA	None. Maintenance to prevent clogging with fine sediment.	Use of sand and sealant application prohibited. Protect from construction runoff.
Porous asphalt or pervious cement concrete	Cracks	Major cracks or trip hazards.	Potholes or small cracks filled with patching mixes. Large cracks and settlement addressed by cutting and replacing the pavement section.
Porous asphalt or pervious cement concrete	NA	Utility cuts.	Any damage or change due to utility cuts replaced in kind.
All Pavement Types	Leaf and Debris Accumulation	Fallen leaves or debris.	Removed/disposed.
Interlocking concrete paver blocks	Missing or Damaged Paver Block	Interlocking paver block missing or damaged.	Individual damaged paver blocks removed and replaced or repaired per manufacturer’s recommendations.
Interlocking concrete paver blocks	Settlement	Settlement of surface. When deviation from original grade impedes function.	Original grade re-established. May require resetting.
All pavement types	All Pavement Types	Sediment or debris accumulation between paver blocks, on surface of pavement, or in grid voids.	Sediment at surface does not inhibit infiltration. Remove/dispose of sediment.
Interlocking concrete paver blocks	Void material is missing or low	Loss of aggregate material between paver blocks.	Refill per manufacturer’s recommendations.
Open-celled paving grid with gravel	Loss of Aggregate Material in Paving Grid	Loss of aggregate material in grid.	Aggregate gravel level maintained at the same level as the plastic rings or no more than 0.25 inch above the top of rings. Refill per manufacturer’s recommendations.

#32 – Maintenance Checklist for Permeable Pavement:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Open-celled paving grid with grass	Lack of Grass Coverage	Loss of soil and/or grass material in grid.	Refill and/or replant per manufacturer's recommendations. Growing medium restored, facility aerated and reseeded or planted, and vegetated area amended as needed.
Inlet/outlet pipe	Pipe is Damaged	Pipe is damaged.	Pipe is repaired/replaced.
Inlet/outlet pipe	Pipe is Clogged	Pipe is clogged.	Roots or debris is removed.
Inlet/outlet pipe	Erosion	Native soil exposed or other signs of erosion damage present.	No eroded or scoured areas Cause of erosion or scour is addressed.
Underdrain pipe	Blocked Underdrain	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period).	Underdrains and orifice free of sediment and debris. 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.
Spill Prevention and Response	NA	Storage or use of potential contaminants in the vicinity of facility.	Spill prevention measures exercised whenever handling or storing potential contaminants.
Spill Prevention and Response	Release of Pollutants	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.	Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with Thurston County Water Resources 360-754-4681 and/or Dept. of Ecology Spill Response 800- 424-8802.)*

If you are unsure whether a problem exists, contact a professional engineer.

#33 – Maintenance Checklist for Downspout, Sheet Flow, and Concentrated Dispersion Systems:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Splash block	Water Directed Toward Building	Water is being directed towards building structure.	Water directed away from building structure.
Splash block	Water Causing Erosion	Water disrupts soil media.	Blocks are reconfigured/ repaired and media is restored.
Transition zone	Erosion	Adjacent soil erosion; uneven surface creating concentrated flow discharge; or less than 2 foot of width.	No eroded or scoured areas. Cause of erosion or scour is addressed.
Dispersion trench	Concentrated Flow	Visual evidence of water discharging at concentrated points along trench (normal condition is a “sheet flow” from edge of trench; intent is to prevent erosion damage).	No debris on trench surface. Notched grade board or other distributor type is aligned to prevent erosion. Trench is rebuilt to standards, if necessary.
Surface of trench	Accumulated Debris	Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow from facility.	Trash or debris is removed/disposed in accordance with local solid waste requirements.
Surface of trench	Vegetation Impeding Flow	Vegetation/moss present on drain rock surface impedes sheet flow from facility.	Freely draining drain rock surface.
Pipe(s) to trench	Accumulated Debris in Drains	Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.	No trash or debris in roof drains, gutters, driveway drains, or area drains.
Pipe(s) to trench	Accumulated Debris in Inlet Pipe	Pipe from sump to trench or drywell has accumulated sediment or is plugged.	No sediment or debris in inlet/outlet pipe screen or inlet/outlet pipe.
Pipe(s) to trench	Damaged Pipes	Cracked, collapsed, broken, or misaligned drain pipes.	No cracks more than 0.25-inch wide at the joint of the inlet/outlet pipe.
Sump	Accumulated Sediment	Sediment in the sump.	Sump contains no sediment.
Access lid	Hard to Open	Cannot be easily opened.	Access lid is repaired or replaced.
Access lid	Buried	Buried.	Access lid functions as designed (refer to record drawings for design intent).
Access lid	Missing Cover	Cover missing.	Cover is replaced.
Rock pad	Inadequate Rock Cover	Only one layer of rock exists above native soil in area 6 square feet or larger, or any exposure of native soil.	Rock pad is repaired/replaced to meet design standards.
Rock pad	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad is repaired/replaced to meet design standards.
Dispersal Area	Erosion	Erosion (gullies/ rills) greater than 2 inches deep in dispersal area.	No eroded or scoured areas. Cause of erosion or scour is addressed.
Dispersal Area	Accumulated Sediment	Accumulated sediment or debris to extent that blocks or channelizes flow path.	No excess sediment or debris in dispersal area. Sediment source is addressed (if feasible).

#33 – Maintenance Checklist for Downspout, Sheet Flow, and Concentrated Dispersion Systems:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Ponded water	Ponded Water	Standing surface water in dispersion area remains for more than 3 days after the end of a storm event.	System freely drains and there is no standing water in dispersion area between storms. The cause of the standing water (e.g., grade depressions, compacted soil) is addressed.
Vegetation	Plant Survival	Dispersal area vegetation in establishment period (1-2 years, or additional 3rd year) during extreme dry weather).	Vegetation is healthy and watered weekly during periods of no rain to ensure plant establishment.
Vegetation	Lack of Vegetation Allowing Erosion	Poor vegetation cover such that erosion is occurring.	Vegetation is healthy and watered. No eroded or scoured areas are present. Cause of erosion or scour is addressed. Plant species are appropriate for the soil and moisture conditions.
Vegetation	Vegetation Blocking Flow	Vegetation inhibits dispersed flow along flow path.	Vegetation is trimmed, weeded, or replanted to restore dispersed flow path.
Vegetation	Presence of Noxious Weeds	Any noxious or nuisance vegetation which may constitute a hazard to county personnel or the public.	Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where county personnel or the public might normally be.
Pest Control	Mosquito Infestation	Standing water remains for more than three days following storms.	All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present.
Rodents	Presence of Rodents	Rodent holes or mounds disturb dispersion flow paths.	Rodents removed or destroyed, holes are filled, and flow path is revegetated.

If you are unsure whether a problem exists, contact a professional engineer.

#34 – Maintenance Checklist for Rain Gardens:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Facility – General Requirements	Mosquitoes	Standing water remains for more than three days following storms.	All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present. Rain garden drains freely and there is no standing water between storms. Cause of the standing water is addressed (see "Ponded water").
Footprint area	Trash	Trash and debris present.	No trash or debris present.
Footprint area	Debris Accumulation	Accumulated leaves in facility.	No leaves clogging outlet structure or impeding water flow.
Earthen side slopes and berms	Erosion	Persistent soil erosion on slopes.	No eroded or scoured areas. Cause of erosion or scour is addressed.
Rockery sidewalls	Unstable Rockery	Rockery side walls are insecure.	Rockery sidewalls are stable (may require consultation with engineer, particularly for walls 4 feet or greater in height).
Rain garden bottom area	Sediment Accumulation	Visible sediment deposition in the rain garden that reduces drawdown time of water in the rain garden.	No sediment accumulation in rain garden, Source of sediment addressed.
Mulch	Lack of Mulch	Bare spots (without mulch cover) are present or mulch depth less than 2 inches.	Facility has a minimum 2- to 3-inch layer of an appropriate type of mulch and is kept away from woody stems.
Splash block inlet	Water Not Properly Directed to Rain Garden	Water is not being directed properly to the rain garden and away from the inlet structure. Water splashes adjacent buildings.	Blocks are reconfigured to direct water to rain garden and away from structure.
Pipe inlet/outlet	Erosion	Rock or cobble is removed or missing and concentrated flows are contacting soil.	No eroded or scoured areas. Cause of erosion or scour is addressed. Cover of rock or cobbles protects the ground where concentrated water flows into the rain garden from a pipe or swale.
Pipe inlet/outlet	Accumulated Debris	Accumulated leaves, sediment, debris or vegetation at curb cuts, inlet or outlet pipe.	Blockage is cleared.
Pipe inlet/outlet	Damaged Pipe	Pipe is damaged	Pipe is repaired/replaced.
Pipe inlet/outlet	Clogged Pipe	Pipe is clogged.	Pipe is clear of roots and debris.
Access	Blocked Access	Maintain access for inspections.	Vegetation is cleared or transplanted within 1 foot of inlets and outlets.
Ponded water	Ponded Water	Excessive ponding water: Ponded water remains in the rain garden more than 48 hours after the end of a storm.	Rain garden drains freely and there is no standing water in the rain garden between storms. Leaf litter/debris/sediment is removed.
Overflow	Blocked Overflow	Capacity reduced by sediment or debris.	No sediment or debris in overflow.
Vegetation	Blocking Site Distances and Sidewalks	Vegetation inhibits sight distances and sidewalks.	Sidewalks and sight distances along roadways and sidewalks are kept clear.

#34 – Maintenance Checklist for Rain Gardens:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Vegetation	Vegetation Blocking Pipes	Vegetation is crowding inlets and outlets.	Inlets and outlets in the rain garden are clear of vegetation.
Vegetation	Unhealthy Vegetation	Yellowing: possible Nitrogen (N) deficiency Poor growth: possible Phosphorous (P) deficiency. Poor flowering, spotting or curled leaves, or weak roots or stems: possible Potassium (K) deficiency.	Plants are healthy and appropriate for site conditions.
Vegetation	Weeds	Presence of weeds.	Weeds are removed (manual methods preferred) and mulch is applied.
Summer watering (years 1-3)	Plant Establishment	Tree, shrubs and groundcovers in first three years of establishment period.	Plants are watered during plant establishment period (years 1-3).
Summer watering (after establishment)	Drought Conditions	Vegetation requires supplemental water.	Plants are watered during drought conditions or more often if necessary during post-establishment period (after 3 years).

If you are unsure whether a problem exists, contact a professional engineer.

#35 – Maintenance Checklist for Trees:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Tree	Excess or unhealthy growth	Health of tree at risk, or tree in conflict with other infrastructure.	Tree pruned according to industry standards to promote tree health and longevity.
Tree	NA	Young tree (i.e., within first three years).	Tree provided with supplemental irrigation and fertilization (as needed) during first three growing seasons.
Tree	NA	Evidence of pest activity affecting tree health.	Pest management activities implemented to reduce or eliminate pest activity, and to restore tree health.
Tree	Dead or Declining	Dead, damaged or declining.	Tree is replaced per planting plan or acceptable substitute.
Tree	Dead or Declining	Dead, damaged or declining.	Tree is replaced per planting plan or acceptable substitute.

#36 – Maintenance Checklist for Downspout Full Infiltration Systems:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Rock trench/well	Inflow disruption	Accumulated trash, debris, or sediment on drain rock surface impeding sheet flow into facility.	Sheet flow re-established. Material removed and disposed of in accordance with applicable solid waste requirements.
Rock trench/well	Inflow disruption	Vegetation/moss present on drain rock surface impeding sheet flow into facility.	Material removed and sheet flow re-established.
Rock trench/well	Inflow disruption	Water ponding at surface, or standing water in subgrade observation port.	Inflow to facility is consistent and no ponding is observed. Inlet piping is clear and/or rock or sand reservoirs have been replaced.
Inlet/outlet pipe conveyance	Conveyance blockage	Accumulation of trash, debris, or sediment in roof drains, gutters, driveways drains, area drains, etc.	Conveyance systems are clear of debris and free-flowing.
Inlet/outlet pipe conveyance	Conveyance blockage	Pipes to or from sump, trench, or drywell have accumulated sediment or is plugged.	Pipe systems are clear of debris and free-flowing.
Inlet/outlet pipe conveyance	Conveyance damage	Pipes to or from sump, trench, or drywell is cracked, broken, or misaligned.	Pipe systems are undamaged and free-flowing.
Roof downspout	Splash pad malfunction	Splash pad missing or damaged.	Splash pad installed and functioning correctly
Storage sump	Sediment in sump	Excess sediment accumulate in sump.	Material removed and disposed of in accordance with applicable solid waste requirements.
Storage sump	Access lid problems	Access lid cannot be opened or is missing.	Access lid is functioning as designed. Refer to record drawings to confirm type, function, and required components.

#37 – Maintenance Checklist for Dead-End Sump Vaults:

Drainage System Feature	Defect or Problem	Condition When Maintenance Is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet (includes floatables and non-floatables).	No trash or debris present. Any trash and debris removed from dead-end sump vault.
General	Sediment/ Liquid Accumulation in Vault	Sediment/liquid accumulation in vault exceeds the half the depth of the vault.	No sediment/liquid in dead-end sump vault. *(If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*
General	Damaged Pipe	Inlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
General	Access Cover Damaged/Not Working	Cover cannot be opened or removed, by one person. 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	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
Vault Structure	Damage – Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Cracks wider than one-half-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than one-fourth inch at the joint of the inlet/outlet pipe.

If you are unsure whether a problem exists, contact a professional engineer.

A vault is a confined space. Visual inspections should be performed aboveground.
If entry is required, it should be performed by qualified personnel.

Appendix V-D – Access Roads and Ramps

Access roads provide access from streets and roads to inspect or maintain BMPs. They are a critical part of BMP development but also create disturbances complicating facility design and construction. Use this appendix to ensure that safe, proper access is created.

Access ramps allow vactor trucks and other maintenance vehicles to drive into a detention pond or other open facility to remove sediment, inspect underdrain piping and outlets and perform other activities that require access to the bottom of the facility.

On large, deep ponds, truck access to the pond bottom via an access ramp is necessary for loading 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 wet pond or combined pond (trackhoes can negotiate interior pond side slopes).

Access Roads

Applicability

Access roads shall provide access to the control structure(s). Where the access road is to provide maintenance to a pond or basin, the access road shall provide access alongside the pond as necessary for vehicular maintenance access to each pond cell.

This appendix applies to the following BMPs:

BMP IN.04 Infiltration Basins

BMP D.01 Detention Ponds

BMP D.02 Detention Tanks

BMP D.04 Detention Vaults

BMP WP.02 Wet Ponds

BMP WP.05 Presettling Basins.

Design Criteria

The design guidelines for access road are given below.

D-1. **Geometry**

Maximum grade shall be 15 percent.

Outside turning radius will be a minimum of 40 feet.

Access roads shall be a minimum of 15 feet in width.

D-2. **Materials**

A paved apron must be provided where access roads connect to paved public roadways.

Access roads may be constructed with an asphalt or gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

D-3. **Fencing**

Vehicle access shall be limited by a double-posted gate if a pond is fenced or by bollards if the pond is not fenced. A minimum of one locking access road gate shall be provided that meets WSDOT Standard Plan L-3. Gates may be 14, 16, 18, or 20 feet in width. Bollards shall consist of two fixed bollards, on the outside of the access road and two removable bollards equally spaced between the fixed bollards (or all four removable if placed in the traveled way). Any fenced pipe stem access to a facility shall be fenced with a WSDOT Type 4 chain link fence with a 14 to 20 foot wide gate set at the same height, or bollards.

Fence gates shall be located only on straight sections of road.

Site Design Elements

Maintenance access road(s) will be provided 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 three feet from a property line.

Pond access roads shall be located in the same tracts when the ponds themselves are in tracts. When ponds are located in open space, the pond access roads may be located in open space also, provided that they are constructed so as to be aesthetically compatible with the open space use.

When the length of a pond access road to control structure or pond exceeds 75 feet, a vehicle turn-around must be provided, designed to accommodate vehicles having a maximum length of 31 feet and having an inside wheel path radius of 40 feet. Access roads to control structures shall have a maximum slope of 12 percent.

Access Ramps

An access ramp is needed for removal of sediment with a trackhoe and truck.

Applicability

An access ramp shall be constructed extending to the bottom of the pond.

Design Criteria

D-4. **Geometry**

The access ramp shall have a minimum width of 15 feet.

The maximum grade for the access ramp is 15 percent if paved to access road standard, or 12 percent if constructed of alternate ramp surface (see below).

The ramp must extend to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp) and it may end at an elevation 4 feet above the pond bottom, if the pond bottom is less than 1,500 square feet (measured without the ramp).

D-5. **Materials**

An alternate ramp surface can be constructed with a maximum slope of 12 percent by laying a geotextile fabric over the native soil, placing quarry spalls (2”-4”) 6 inches thick, then providing a 2-inch thick crushed rock surface.

Structural Design Considerations

The internal berm of a wet pond or combined detention and wet pond may be used for access if it is no more than 4 feet above the first wet pool cell, if the first wet pool cell is less than 1,500 square feet (measured without the ramp), and if it is designed to support a loaded truck, considering the berm is normally submerged and saturated.

Access ramps must meet the requirements for design and construction of access roads specified above.

Appendix V-E – Site Design Elements

This appendix provides guidelines for various BMPs, including fencing requirements, proper signage use, right of way information, setback requirements, landscaping and planting requirements, and guidelines for naturalistic plantings. All of these factors will help provide an overall safe, effective and aesthetically pleasing BMP.

Fencing

Applicability

A fence is required around all public stormwater facility tracts. On private facilities fences need only be constructed for those slopes steeper than 3H:1V, at the emergency overflow water surface elevation, or higher. A fence is also needed where the impoundment is a wall greater than 30 inches in height. Other regulations such as the International 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.

This section applies to the following BMPs:

BMP D.01 Detention Ponds

BMP IN.01 Infiltration Basins

BMP WP.02 Wet Ponds

BMP WP.04 Combined Detention/Wet Pool Facilities.

Design Criteria

Fencing of public drainage ponds shall consist of a minimum 6 foot high WSDOT Type 1 chain link fence, per State Standard Plan L-2. A minimum of one locking access road gate shall be provided that meets WSDOT Standard Plan L-3. Gates may be 14, 16, 18, or 20 feet in width. Fence material shall be No. 9 gauge galvanized steel fabric with bonded vinyl coating. Vinyl coating shall be green or black. All posts, cross bars, fasteners, and gates shall be painted or coated the same color as the vinyl clad fence.

Any fencing shall be placed 1 foot inside the tract or easement boundary if the pond is located in an easement, or a minimum of 5 feet from the top slope catch point.

Any pipe stem access to a basin shall be fenced with a WSDOT Type 4 chain link fence with a 14-foot gate.

Pedestrian access gates (if needed) shall be 4 feet in width and meet WSDOT Standard Plan L-3.

Vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating can be used as fence material. For steel fabric fences, the following aesthetic features may be considered:

- 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.

- Fence posts and rails that conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.

Wood fences may be used in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners.

Wood fences shall 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.

Signage

Applicability

Detention ponds, infiltration ponds, wet ponds, and combined ponds shall have a sign with educational information and emergency contact information (Figure E-1). Applicant shall submit sign design and proposed location for Administrator acceptance.

Figure E.1 Informational Sign for Wet Pond in Olympia, Washington

This section applies to the following BMPs:

BMP LID.08 Bioretention Cells

BMP LID.09 Permeable Pavement

BMP LID.11 Full Dispersion

BMP D.01 Detention Ponds

BMP IN.01 Infiltration Basins

BMP WP.02 Wet ponds

BMP WP.04 Combined Detention/Wet pool Facilities.

Design Criteria

Signs shall be placed for maximum visibility from adjacent streets, sidewalks, and paths.

An example of sign specifications for a permanent surface water control pond is provided as follows:

E-1. 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: 1½ inch; Text: 1 inch; Outer border: 1/8 inch border distance from edge: 1/4 inch; all text 1¾ inch from border.
Posts:	Pressure treated, beveled tops, 1½ inch higher than sign.
Installation:	Secure to chain link fence if available. Otherwise install on two 4"x4" 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).

A sample informational sign is presented in Figure E-1. For Homeowners Associations, the contact can be a residence address or P.O. Box.

Setbacks and Easements

Applicability

This section provides information on setbacks and easements for conveyance systems and stormwater BMPs from Volumes III and V.

Design Criteria

E-2. Natural Systems

The easements below apply to the following natural features:

- Stream channels
- Lake shores
- Wetlands
- Potholes
- Estuaries
- Gullies
- Ravines.

All natural systems shall be located within easements. Easements shall contain the natural features and shall allow Thurston County access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

E-3. Conveyance Systems

The setbacks below apply to the following facilities (design criteria are provided in Volume III):

- Channels
- Pipes
- Outfalls.

All man-made drainage facilities and conveyances shall be located within easements. Easements shall contain the facilities and shall allow Thurston County access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

Easements for Access
A minimum 20-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of lattice block pavement, crushed rock, or other acceptable surface to allow year-round equipment access to the facility. The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100-ft along the length of the easement. Contact Thurston County Water Resources for additional information on easement marker requirements.

Easements for Conveyance Systems
See Volume III for required easement widths and other requirements for conveyance systems.

E-4. Infiltration Facilities

The setbacks below apply to the following BMPs:

- LID.04 – Downspout Infiltration Systems
- LID.08 – Bioretention Facilities
- IN.01 – Infiltration Basins
- IN.02 – Infiltration Trenches
- IN.03 – Bio-Infiltration Swales
- IN.04 – Infiltration Vaults.

If the depth of the infiltration facility being considered is greater than the largest surface dimension, it is considered an injection well and is subject to the requirements of the Underground Injection Control Program, Chapter 173-218 WAC. See also Volume V, Section 3.1.3.

All infiltration facilities shall maintain minimum setback distances as follows unless different setbacks are noted in the specific BMP design guidelines. All setbacks shall be horizontal unless otherwise specified or modified with written approval of the Thurston County Environmental Health Division for wells and septic systems:

Horizontal Clearances
10 feet – from open water maximum surface elevation or edge of infiltration facility to property lines and onsite structures

50 feet – from top of slopes steeper than 15 percent and greater than 10 feet high. The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of infiltration facilities may result from this report. The geotechnical analysis and report shall address the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

10 feet – from open water maximum surface elevation or edge of infiltration facility to building sewer

50 feet – from septic tank, holding tank, containment vessel, pump chamber, and distribution box. May be reduced to 30 feet for infiltration facilities serving a single family residence.

100 feet – from edge of septic drainfield and drainfield reserve area. Infiltration facility shall be located downgradient unless site topography clearly prohibits subsurface flow from intersecting drainfield. May be reduced to 30 feet for infiltration facilities serving a single family residence.

100 feet – from drinking water wells and springs used for drinking water supplies. May be reduced to 30-feet for downspout infiltration facilities serving a single family residence. In wellhead areas, for the siting of "high risk" activities as defined through implementation of the Northern Thurston County Groundwater Management Plan, recommendation HM-14, pp. 5-88, 5-97, and 5-98, the Administrator may require the proponent to supply hydrogeologic analysis and to calculate acceptable separation distances between the activity and the well. Higher setbacks may be required if the well serves a public water system and/or Washington State Department of Health requirements apply for locations within the 1, 5, or 10 year time of travel.

300 feet – from landslide hazard area (as defined by Thurston County Code Title 17.15.600 – Geologic Hazard Areas or Title 24) unless the slope stability impacts of such systems have been analyzed and mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

100 feet – from building foundation or basement, where infiltration facilities are located upgradient from building. The Project Engineer shall perform calculations to ensure that the line of saturation, measured from the design storm elevation in the facility, at a gradient acceptable to the Administrator or designee, falls a minimum of 1 foot below the lowest floor elevation. Setbacks shall be increased as necessary to allow for saturation effects. May be reduced to 50 feet for infiltration facilities serving a single family residence.

20 feet – from building foundation or basement, where infiltration facilities are located downgradient from building. The Project Engineer shall perform calculations to ensure that the line of saturation, measured from the design storm elevation in the facility, at a gradient acceptable to the Administrator or designee, falls a minimum of 1 foot below the lowest floor elevation. Setbacks shall be increased as necessary to allow for saturation effects. May be reduced to 10 feet for infiltration facilities serving a single family residence.

Vertical Clearances
1 foot – vertical clearance from the maximum water surface surface elevation of any open water pond/facility to built structures within 25 feet.

E-5. Ponds

The setbacks below apply to the following BMPs:

- D.01 – Detention Pond
- WP.01 – Stormwater Treatment Wetland
- WP.02 – Wet Pond
- WP.04 – Combined Detention/Wet Pool Facilities

- WP.05 – Presettling Basin.

All ponds shall maintain minimum setback distances as follows:

1 foot – positive vertical clearance from maximum water surface to structures within 25 feet

10 feet – from maximum water surface to property lines and onsite structures

10 feet – from maximum water surface to building sewer

10 feet – from maximum water level location to nearest tract property boundary lines

30 feet – from maximum water surface to septic tank or distribution box

30 feet – from maximum water surface to septic drainfields and drainfield reserve areas for single family onsite sewage disposal systems

100 feet – from maximum water surface to septic drainfields and drainfield reserve areas for community onsite sewage disposal systems

50 feet – from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

100 feet – from well to stormwater control and water quality facility, maximum water surface.

In addition, all underground stormwater facilities without infiltration (BMP D.02, D.03, WP.03, MF.02, MF.03, MF.05) shall be setback from any structure or property line a distance equal to the depth of the ground disturbed in setting the structure. These facilities shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Volume III.

Planting and Landscaping Requirements

Applicability

All disturbed or exposed soil must be planted and/or landscaped. Landscaping is encouraged for most stormwater tract areas (see below for areas not to be landscaped). Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, “naturalistic” stormwater facilities may be placed in open space tracts. Bioretention facilities also have specific planting requirements.

This appendix applies to the following BMPs:

- BMP IN.02 Bioretention Facilities or Rain Gardens

- BMP D.01 Detention Ponds
- BMP BF.01 Basic Bioinfiltration Swale

Other facilities may be subject to these requirements if they include landscaping.

Design Criteria

Exposed earth on pond interiors side slopes shall be sodded or seeded with an appropriate seed mixture. Exposed earth on the pond bottom should also be sodded or seeded. All remaining areas of the tract should be planted with grass or be landscaped and mulched with a 4-inch cover of hog fuel or shredded wood mulch. Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch must be free of garbage and weeds and shall not contain excessive resin, tannin, or other material detrimental to plant growth.

General Landscaping Guidelines

The following guidelines shall be followed if landscaping is proposed for facilities.

E-6. Setbacks from Structures and Pipes

No trees or shrubs may be planted within 25 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, shall be avoided within 50 feet of pipes or manmade structures.

E-7. Berms

Planting shall be restricted on berms that impound water either permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.

Trees or shrubs may not be planted on portions of water- impounding berms taller than 4 feet high. Only grasses may be planted on berms taller than 4 feet.

Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

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. 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 wet pond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.*

All landscape material, including grass, shall be planted in good topsoil. Poor underlying soils may be made suitable for planting if amended with 4 inches of well-aged compost tilled into the subgrade. General information and links on soil amendment and can be found at the Soils for Salmon web site: <www.soilsforsalmon.org>.

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.

E-8. Trees and Shrubs

For a naturalistic effect as well as ease of maintenance, trees or shrubs should be planted in clumps to form *"landscape islands"* rather than evenly spaced.

The landscaped islands should be a minimum of 6 feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the 6-foot setback should be counted from the outer drip line of the trees (estimated at maturity).

This setback allows a 6-foot wide mower to pass around and between clumps.

Evergreen trees and trees which produce relatively little leaf-fall (such as Oregon ash, mimosa, or locust) are preferred in areas draining to the pond.

Deciduous trees must be set back so that branches do not extend over the pond (to prevent leaf-drop into the water).

Naturalistic Planting

Two generic kinds of naturalistic planting are outlined below, but other options are also possible. Native vegetation is preferred in naturalistic plantings.

E-9. Open Woodland

In addition to the general landscaping guidelines above, the following are recommended.

Landscaped islands (when mature) shall cover a minimum of 30 percent or more of the tract, exclusive of the pond area.

Shade-tolerant shrubs and groundcover plants should be planted under tree clumps. The goal is to provide a dense understory that need not be weeded or mowed.

Landscaped islands should be placed at several elevations rather than "ring" the pond, and the size of clumps should vary from small to large to create variety.

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 onsite 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.

Landscape islands (when mature) shall cover 10 percent or more of the site, exclusive of the pond area.

Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.

Landscape islands should be placed at several elevations rather than "ring" the pond.

The remaining site area shall be planted with an appropriate grass seed mix, which may include meadow or wildflower species. Native or dwarf grass mixes are preferred. Table E-2 below gives an example of dwarf grass mix developed for central Puget Sound. Grass seed should be applied at 2.5 to 3 pounds per 1,000 square feet.

Note: *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.*

Seed Mixes. The seed mixes listed in Tables E-2 through E-4were developed for central Puget Sound.

Seed Mixes for Specific Bioinfiltration Swales

The seed mixes listed below were developed for central Puget Sound.

Plant Recommendations for Bioretention Facilities

Bioretention facilities generally feature three planting zones, reflecting the different soil moisture and frequency of inundation. Tables E-5 through E-7 provide planting recommendations for the different planting zones. Tables E-5 through E-7 include both native and non-native plant species commonly available in the Puget Sound region and suitable for bioretention facilities. Refer to the bioretention facility design guidelines (BMP LID.08 in Chapter 2) for additional planting requirements. Consultation with a landscape architect is recommended for site-specific planting recommendations.

Table E.1 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 perennial rye can be reduced proportionately to the amount of wildflower seed used.

Table E.2 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
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight.
* based on Briargreen, Inc.

Table E.3 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 lanceolata*
yellow-root	*Xanthorhiza simplissima*
--	*Genista*
white lawn clover	*Trifolium repens*
white sweet clover*	*Melilotus alba*
--	*Rubus calycinoides*
strawberry*	*Fragaria chiloensis*
broadleaf lupine*	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
tufted fescue	*Festuca amethystine*
buffalo grass	*Buchloe dactyloides*
red fescue*	*Festuca rubra*
tall fescue grass*	*Festuca arundinacea*
blue oatgrass	*Helictotrichon sempervirens*

Table E.4 Plant Species Appropriate for Area of Periodic or Frequent Standing or Flowing Water (Zone 1)

Species	Common Name	Exposure	Mature Size/Spread	Comments
Trees				
*Alnus rubra**	Red alder	Sun/partial shade	30-120 feet/ 25 ft. spread	Prefers moist, rich soils, highly adaptable, drought tolerant; nitrogen fixer; rapid growing, relatively short-lived (60-90 years)
*Fraxinus latifolia**	Oregon ash	Sun/partial shade	30 ft. spread	Moist, saturated or ponded soils; flood tolerant; small green-white flowers
*Malus fusca**	Pacific crabapple	Sun/partial shade	To 40 feet/35 ft. spread	Tolerant of prolonged soil saturation; produces fruit (do not plant near public walkways)
*Salix lucida**	Pacific willow	Sun	40-60 feet/ 30 ft. spread	Wet soils; tolerates seasonal flooding should not be planted in areas near pavement or underground structures
Shrubs				
*Cornus sericea**	Red-osier dogwood, Red-twig dogwood	Sun/partial shade	To 15 feet	Prefers wet to moist organically rich soils, but is adaptable; tolerates seasonal flooding; small white flowers; berrylike fruits
Cornus sericea 'Kelseyi'	Dwarf dogwood	Sun	To 1.5 feet	Prefers wet to moist organically rich soils, but is adaptable; small white flowers; berrylike fruit; low growing, compact form; good ground cover.
Cornus sericea	'Flaviramea' Yellow dogwood	Sun/partial shade	6-8 feet	Prefers wet to moist organically rich soils, but is adaptable; easily transplanted and grown; small, white flowers; yellow stems and reddish, purple fall color
Cornus sericea 'Isanti'	Isanti dogwood	Sun/partial shade	4-5 feet	Prefers wet to moist organically rich soils, but is adaptable; deciduous shrub; tiny white flowers; red stems; purple fall color
*Lonicera involucrata**	Black twinberry	Partial shade/ Shade	2-8 feet	Moist soils; prefers loamy soils; tolerant of shallow flooding; yellow, tubular flowers attract hummingbirds
*Myrica californica**	Pacific wax myrtle	Sun/partial shade	To 30 feet	Evergreen shrub preferring moist soils; inconspicuous spring flowers; drought tolerant; if drought tolerance is not an issue try the smaller Washington native, *Myrica gale**

Species	Common Name	Exposure	Mature Size/Spread	Comments
*Physocarpus capitatus**	Pacific ninebark	Sun/partial shade	6-13 feet	Moist or dry soils; drought tolerant; snowball shaped; white flowers; seeds persist into winter
Shrubs (continued)				
*Rosa pisocarpa**	Clustered wild rose	Sun/partial shade	6-8 feet	Moist soils, tolerates seasonal flooding but also tolerant of dry conditions; pink clustered flowers; fruits persist
Salix purpunea 'Nana'	Dwarf Arctic willow	Sun/partial shade	3-5 feet	Grows well in poor soils; moderately drought tolerant; small yellow flowers in the fall
*Spiraea douglasii**	Douglas spirea, Steeplebush	Sun/partial shade	4-7 feet	Moist or dry, to seasonally inundated soils; spikes of small, pink flower clusters
Emergents				
*Carex obnupta**	Slough sedge	Sun/partial shade	1-5 feet	Moist to seasonally saturated soils; shiny foliage; excellent soil binder; drought tolerant
*Carex stipata**	Sawbeak sedge	Partial shade	10 inches-3 feet	Wet soils; excellent soil binder
*Juncus effusus**	Common rush	Sun/partial shade	1-2 feet	Wet soils; evergreen perennial; hardy and adaptable; drought tolerant; small, non-showy flowers
*Juncus ensifolius**	Daggerleaf rush	Sun	12-18 inches	Wet soils; shallow water; excellent soil binder
*Juncus tenuis**	Slender rush	Sun	.5–2.5 feet	Moist soils; tufted perennial
*Scirpus acutus**	Hardstem bulrush	Sun	4-8 feet	Wet soils; favors prolonged inundation; excellent soil binder
*Scirpus microcarpus**	Small-fruited bulrush	Sun/shade	2-4 feet	Wet soils; tolerates prolonged inundation; good soil binder; drought tolerant

Source: Adapted from PSAT 2005.
* Denotes native plant species.

Table E.5 Plant Species Appropriate for Bioretention Facility Areas Subject to Periodic Saturation During Large Storms (Zone 2)

Species	Common Name	Exposure	Mature Size	Comments
Trees				
Acer truncatum	Pacific sunset maple	Sun	To 25 feet/ 20 ft. spread	Prefers moist, well-drained soils, but drought tolerant; very cold hardy; deciduous tree with moderate growth rate
*Amelanchier alnifolia**	Western serviceberry	Sun/partial shade	10-20 feet/ 25 ft. spread	Moist to dry, well-drained soils; drought tolerant; large white flowers; purple to black berries; deciduous
*Corylus cornuta**	Beaked hazelnut	Sun/partial shade	20–30 feet/ 15 ft. spread	Moist, well-drained soils; edible nuts; intolerant of saturated soils; catkins throughout winter add interest; deciduous
*Crataegus douglasii**	Black hawthorn	Sun/partial shade	3-30 feet/ 25 ft. spread	Moist to dry, well drained, gravelly soils; small white flowers, black berries; 1 inch spines; forms thickets; deciduous
Fraxinus oxycarpa	Raywood ash	Sun	25-50 feet/ 25 ft. spread	Drought tolerant; grows in varying soil types; deciduous; can take extreme temperatures; does not tolerate constant wind or fog; resists pests and disease better than other non-native ashes; inconspicuous flowers
*Rhamnus purshiana**	Cascara sagrada	Sun/shade	20-40 feet/ 25 ft. spread	Moist to fairly dry soils; small greenish-yellow flowers; deciduous; sensitive to air pollution; yellow fall color
*Salix scouleriana**	Scouler willow	Sun/partial shade	6-40 feet/ 15 ft. spread	Moist to dry soils; drought tolerant; deciduous tree; do not plant near paved surfaces or underground structures
*Salix sitchensis**	Sitka willow	Sun/partial shade	3-26 feet/ 25 ft. spread	Moist soils; tolerates seasonal flooding; deciduous tree; do not plant near paved surfaces or underground structures
*Thuja plicata**	Western red cedar	Partial shade/shade	200 feet+/ 60 ft. spread	Moist to swampy soils; tolerates seasonal flooding and saturated soils; long-lived; prefers shade while young
Shrubs – Deciduous				
*Acer circinatum**	Vine maple	Filtered sun/shade	To 25 feet	Dry to moist soils; tolerant of shade and clay soils; excellent soil binder; beautiful fall color

Species	Common Name	Exposure	Mature Size	Comments
Hamamelis intermedia	Diane witchhazel	Sun/partial shade	10-20 feet/ 10 ft. spread	Moist, fertile, acidic soil; showy fall color – yellow to yellow-orange; long-lasting, slightly fragrant, coppery-red flowers; not drought tolerant; may require watering in dry season
Shrubs – Deciduous (continued)				
*Oemleria cerasiformis**	Indian plum/Osoberry	Sun/partial shade	5-16 feet	Moist to dry soils; prefers shade; tolerates fluctuating water table
Philadelphus x lemoinei	'Belle Etoile' Mock-orange	Sun/partial shade	5-6 feet	Prefers moist, well-drained soils, high in organic matter, but soil and pH adaptable; easily transplanted and established; fragrant, large white flowers, tinged red at the base; other cultivars available
*Ribes lacustre**	Black swamp gooseberry	Partial shade	1.5–3 feet	Moist soils; deciduous shrub; reddish flowers in drooping clusters; dark purple berries; *R. divaricatum** (Wild gooseberry) grows to 5 feet and is also an option; attracts butterflies, but is very thorny
*Rosa nutkana**	Nootka rose	Sun/partial shade	6-10 feet	Moist to fairly dry soils; tolerates inundation and saturated soils; aggressive spreader; fruits persist; less thorny that *R. rugosa*
Rosa rugosa	Rugosa rose	Sun	To 8 feet	Drought resistant; hardy, vigorous and aggressive; highly prickly; fragrant white to purple flowers; fruits persist
*Rubus parviflorus**	Thimbleberry	Sun/partial shade	4-10 feet	Moist to dry soils; white flowers; red berries; makes thickets and spreads easily
*Rubus spectabilis**	Salmonberry	Partial sun/shade	5-10 feet	Prefers moist, wet soils; good soil binder; magenta flowers; yellow/ orange fruit; early nectar source for hummingbirds; makes thickets
*Sambucus racemosa**	Red elderberry	Partial sun/partial shade	To 20 feet	Moist to dry soils; small white flowers; bright red berries; vase shaped; pithy stems lead to "messy" form – prune for tidiness
*Symphoricarpos albus**	Snowberry	Sun/shade	2-6 feet	Wet to dry soils, clay to sand; excellent soil binder; drought and urban air tolerant; provides good erosion control; spreads well in sun; white berries; flowers attract hummingbirds
*Vaccinium parvifolium**	Red huckleberry	Partial shade/shade	4-10 feet	Slightly moist to dry soils; prefers loamy, acid soils or rotting wood; tolerant of dry, shaded conditions; red fruit; tricky to transplant

Herbaceous				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Aquilegia formosa** / Western columbine	Sun/partial shade	1-3 feet	Spring	Moist soils of varying quality; tolerant of seasonal flooding; red and yellow flowers attract hummingbirds and butterflies
*Asarum caudatum** / Wild ginger	Partial shade/shade	To 10 inches	Mid spring	Moist organic soils; heart-shaped leaves; reddish-brown flowers
*Aster chilensis** / Common California aster	Sun	1.5 – 3 feet	June - September	Moist soils; white to purple flowers
*Aster subspicatus** / Douglas aster	Sun	.5 – 2.5 feet	June - September	Moist soils; blue to purple flowers
*Camassia quamash** / Common camas	Sun/partial shade	To 2.5 feet	May - June	Moist to dry soils; lots of watering needed to establish; loose clusters of deep blue flowers
Camassia leichtlinii / Giant camas		2–4 feet	May - June	Moist to dry soils; lots of watering to establish; large clusters of white, blue or greenish-yellow flowers
*Iris douglasiana** / Pacific coast iris	Sun/partial shade	1-2 feet	Spring	Tolerates many soils; withstands summer drought and seasonal flooding; white, yellow, blue, reddish purple flowers; fast growing; velvety purple flowers; vigorous
Iris foetidissima / Gladwin iris	Sun/partial shade	1-2 feet	May	Moist to dry, well-drained soils; pale lilac flower; also called Stinking Iris
*Juncus tenuis** / Slender rush	Sun	6 inches – 2.5 feet		Moist soils; yellow flowers
Iris sibirca / Siberian Iris	Sun	1-2.5 feet	Late spring – early summer	Moist soils; deep blue, purple to white flowers
*Tellima grandiflora** / Fringecup	Partial sun/shade	1-3 feet	March - June	Perennial preferring moist soils; yellowish-green to pink flowers
*Tiarella trifoliata** / Foamflower	Partial sun/shade	To 1 foot	Early - mid summer	Moist soils; perennial with some drought tolerance after established; can form dense colonies; white flowers
*Tolmiea menziesii** / Youth-on-age/Piggy-back plant	Partial shade/shade	1-2 feet	April - August	Moist soils; brownish-purple flowers; also makes and effective groundcover
Viola species* / Violets	Partial shade/shade	6-12 inches	Late spring – early summer	Moist soils; yellow to blue flowers

Table E.6 Plant Species Appropriate for Rarely Inundated Areas of Bioretention Facility (Zone 3)

Trees				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Arbutus unedo / Strawberry tree	Sun/partial shade	8-35 feet/ 8-20 ft. spread	November - December	Tolerant of extremes; tolerant of urban/ industrial pollution; white or greenish white flowers
*Calocedrus decurrens** / Incense cedar	Sun	75-90 feet/ 12 ft. spread		Tolerant of poor soils; drought tolerant after established; fragrant evergreen with a narrow growth habit; slow growing
Chamaecyparis obtusa / Hinoki false cypress	Sun/partial shade	40-50 feet/ 15-30 ft. spread		Moist, loamy, well-drained soils; very slow growing; prefers sun, but tolerates shade; does not transplant well or do well in alkaline soils. Note there are
				many alternative varieties of false cypress of varying sizes and forms from which to choose
Cornus spp. / Dogwood	Sun/partial shade	20-30 feet/ 30 ft. spread	May	Reliable flowering trees with attractive foliage and flowers; may need watering in dry season; try *C. florida* (Eastern dogwood), or *C. nuttallii** (Pacific dogwood) or hybrid 'Eddie's White Wonder'. Also, *C. kousa* for small tree/ shrub which is resistant to anthracnose
Pinus mugo / Swiss mountain pine	Sun/partial shade	15-20 feet/ 25-30 ft. spread		Prefers well-drained soil; slow growing, broadly spreading, bushy tree; hardy evergreen
Pinus thunbergiana / Japanese black pine	Sun	To 100 feet/ 40 ft. spread		Dry to moist soils; hardy; fast growing
*Prunus emarginata** / Bitter cherry	Sun/partial shade	20-50 feet/ 20 ft. spread	May - June	Dry or moist soils; intolerant of full shade; bright red cherries are attractive to birds; roots spread extensively
Prunus virginiana / Choke cherry		15-25 feet/ 15-20 ft. spread	Late spring – Early summer	Dry or moist soils; deep rooting; attractive white fragrant flowers; good fall color
*Pseudotsuga menziesii** / Douglas-fir	Sun	100-250 feet/ 50-60 ft. spread		Does best in deep, moist soils; evergreen conifer with medium to fast rate of growth; provides a nice canopy, but potential height will restrict placement

*Quercus garryana** / Oregon white oak	Sun	To 75 feet		Dry to moist, well-drained soils; slow growing; acorns

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Holodiscus discolor** / Oceanspray	Sun/partial shade	To 15 feet	June - July	Dry to moist soils; drought tolerant; white to cream flowers; good soil binder
*Mahonia aquifolium** / Tall Oregon grape	Sun/partial shade	6-10 feet	March - April	Dry to moist soils; drought resistant; evergreen; blue-black fruit; bright yellow flowers; 'Compacta' form averages 2 feet tall; great low screening barrier
*Philadelphus lewisii** / Mock-orange	Sun/partial shade	5-10 feet	June - July	Adapts to rich moist soils or dry rocky soils; drought tolerant; fragrant flowers

▶ ZONE 3

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pinus mugo pumilio / Mugho pine	Sun	3-5 feet/ 4-6 ft. spread		Adapts to most soils; slow growing and very hardy; newer additions with trademark names such as 'Slo-Grow' or 'Lo-Mound' are also available
Potentilla fruticosa / Shrubby cinquefoil	Sun	To 4 feet	May - September	Moist to dry soils; several cultivars available with varying foliage and flower hues; try 'Tangerine' or 'Moonlight'
*Ribes sanguineum** / Red-flowering currant	Sun/partial shade	8-12 feet	March - April	Prefers dry soils; drought tolerant; white to deep-red flowers attract hummingbirds; dark-blue to black berries; thornless
*Rosa gymnocarpa** / Baldhip rose	Partial shade	To 6 feet	May - July	Dry or moist soils; drought tolerant; small pink to rose flowers

Shrubs-Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Abelia x grandiflora / Glossy abelia	Partial Sun/Partial shade	To 8 feet/ 5 foot spread	Summer	Prefers moist, well-drained soils, but drought tolerant; white or faintly pink flowers

Arbutus unedo 'Compacta' / Compact strawberry tree	Sun/partial shade	To 10 feet	Fall	Prefers well drained soils; tolerant of poor soils; good in climate extremes; white to greenish-white flowers; striking red-orange fruit
Cistus purpureus / Orchid rockrose	Sun	To 4 feet	June - July	Moist to dry well-drained soils; drought resistant; fast growing; reddish purple flowers
Cistus salvifolius / White rockrose	Sun	2-3 feet/ 6 ft spread	Late spring	Moist to dry well-drained soils preferred, but can tolerate poor soils; tolerant of windy conditions and drought; white flowers
Escallonia x exoniensis 'fradesii' / Pink Princess	Sun/partial sun	5-6 feet	Spring - Fall	Tolerant of varying soils; drought tolerant when established; pink to rose colored flowers; good hedge or border plant; attracts butterflies
Osmanthus delavayi / Delavay Osmanthus	Sun/partial shade	4-6 feet	March - May	Tolerant of a broad range of soils; attractive foliage and clusters of white fragrant flowers; slow growing
Osmanthus x burkwoodii / Devil wood	Sun/partial shade	4-6 feet	March - April	Drought tolerant once established; masses of small, white fragrant flowers
Rhododendron / 'PJM' hybrids	Sun/partial shade	To 4 feet	Mid – late April	Moist to fairly dry soils; well drained organic soil; lavender to pink flowers
Stranvaesia davidiana	Sun	6-20 feet	June	Moist soils; white flowers in clusters; showy red berries
Stranvaesia davidiana / undulata	Sun	To 5 feet	June	Moist soils; lower growing irregularly shaped shrub; great screening plant
Vaccinium ovatum* / Evergreen huckleberry	Partial shade/ shade	3-15 feet	March	Moist to slightly dry soils; small pinkish-white flowers; berries in August

▶ ZONE 3

Groundcover – Evergreen

Species / Common Name	Exposure	Mature Size	Time of Bloom	Comments
*Arctostaphylos uva-ursi** / Kinnikinnik	Sun/partial shade		April - June	Prefers sandy/rocky, well-drained soils; flowers pinkish-white; bright red berries; slow to establish; plant closely for good results
*Gaultheria shallon** / Salal	Partial shade/ shade	3-7 feet	March - June	Dry and moist soils; white or pinkish flowers; reddish-blue to dark-purple fruit

Groundcover – Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Fragaria chiloensis** / Wild/Coastal strawberry	Sun/partial shade	10 inches	Spring	Sandy well drained soils; flowers white; small hairy strawberries; evergreen; aggressive spreader
Helianthemum nummularium / Sunrose	Sun	To 2 feet/ 2 ft. spread	May - July	Prefers well-drained soils, but will tolerate various soils; low-growing, woody sub shrub; many varieties are available with flowers in salmon, pink, red, yellow and golden colors
Lavandula angustifolia / Lavender	Sun/partial shade	To 1.5 feet	June - August	Adaptable to various soils; blue, lavender, pink to white flowers, semi-evergreen aromatic perennial
*Mahonia nervosa** / Cascade Oregon grape/Dull Oregon grape	Partial shade/ shade	To 2 feet	April – June	Dry to moist soils; drought resistant; evergreen; yellow flowers; blue berries
Mahonia repens / Creeping mahonia	Sun/partial shade	3 feet	April - June	Dry to moist soils; drought resistant; yellow flowers; blue berries; native of Eastern Washington
*Penstemon davidsonii** / Davidson's penstemon	Sun	To 3 inches	June - August	Low growing evergreen perennial; prefers well-drained soils; drought tolerant; blue to purple flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Achillea millefolium** / Western yarrow	Sun	4 inches – 2.5 feet	June - September	Dry to moist, well-drained soils; white to pink/reddish flowers; many other yarrows are also available
Anaphalis margaritaceae / Pearly everlasting	Sun/partial shade	To 18 inches		Drought tolerant perennial; spreads quickly; attracts butterflies
*Bromus carinatus** / Native California brome	Sun/partial shade	3-5 feet		Dry to moist soils; tolerates seasonal saturation
Carex buchannii / Leather leaf sedge	Sun/partial shade	1-3 feet		Prefers well-drained soils; copper-colored foliage; perennial clumping grass; tolerant of a wide range of soils; inconspicuous flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Carex comans / 'Frosty curls' New Zealand hair sedge	Sun/partial shade	1-2 feet	June -August	Prefers moist soils; finely textured and light green; compact, clumping perennial grass; drought tolerant when established; inconspicuous flowers
Coreopsis spp. / Tick-Seed	Sun	1-3 feet		Dry to moist soils; drought tolerant; seeds attract birds; annual and perennial varieties; excellent cut flowers
Echinacea purpurea / Purple coneflower	Sun	4-5 feet		Prefers well drained soils; hardy perennial; may need occasional watering in dry months
*Elymus glaucus** / Blue wildrye	Sun/partial shade	1.5-5 feet		Dry to moist soils; shade tolerant; rapid developing, but short lived (1-3 years); not good lawn grass
*Dicentra formosa** / Pacific bleeding-heart	Sun/shade	6-20 inches	Early spring - early summer	Moist, rich soils; heart-shaped flowers
*Erigeron speciosus** / Showy fleabane	Sun/partial shade	To 2 feet	Summer	Moist to dry soils; dark violet or lavender blooms; fibrous roots
Festuca ovina 'Glauca' / Blue fescue	Sun/partial shade	To 10 inches	May - June	Prefers moist, well-drained soils; blue-green evergreen grass; drought tolerant; shearing will stimulate new growth
*Festuca idahoensis** / Idaho fescue	Sun/partial shade	To 1 foot		Bluish-green bunching perennial grass; drought tolerant
*Fragaria vesca** / Wood strawberry	Partial shade	To 10 inches	Late spring - early summer	Dry to moist soils; white flowers
Gaura lindheimeri / Gaura	Sun	2.5-4 feet		Perennial; fairly drought tolerant and adaptable to varying soil types; long blooming period
*Geum macrophyllum** / Large-leaved avens	Sun/partial shade	To 3 feet	Spring	Moist, well-drained soil; bright yellow flowers; other Geum cultivars available, some which may require supplemental watering
Geranium maculatum / Spotted geranium	Sun/shade	To 1.5 feet	July	Moist, well-drained soils; low perennial; pale pink, blue to purple flowers
Geranium sanguineum / Cranesbill	Sun/partial shade	To 1.5 feet	May - August	Moist soils; deep purple almost crimson flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Helichrysum italicum / Curry Plant	Sun	To 2 feet	Summer	Moist or dry soils; hardy evergreen perennial; a good companion to lavender; bright yellow flowers; fragrant
Helictotrichon sempervirens / Blue oat grass	Sun/partial shade	1-1.5 feet	June - August	Tolerant of a variety of soil types but prefers well-drained soil; clumping bright blue evergreen grass; bluish white flowers
Hemerocallis fulva / Day lilies	Sun/partial shade	1-4 feet	Summer	Tolerant of a variety of soil types; easy to grow and tolerant of neglect; hardy perennial; entire plant is edible
Heuchera americana / Coral bells (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist to dry, well-drained soils; never wet; easily transplantable perennial; red, greenish-white flowers; may need supplemental watering in dry season
Heuchera micrantha / ‘Palace purple’ (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist, well-drained soils; bronze to purple foliage in shade; small, yellowish-white flowers; perennial, evergreen; a number of other species and varieties are available. Try *H. sanguinea* for bright red flowers
*Lupinus** spp. / Lupines	Sun	3-5 feet	March - September	Moist to dry soils; various native varieties; blue to purple, violet to white flowers; both native and non-native varieties
*Lupinus bicolor** / Two-color lupine	Sun	4 inches - 1.5 feet	Spring	Dry gravelly soils; small-flowered; annual
*Lupinus latifolius** / Broadleaf lupine	Sun	To 1 foot	June - August	Dry to moist soils; perennial; bushy herb; bluish flowers
*Lupinus polyphyllus** / Large-leafed lupine	Sun	To 3 feet	Spring - summer	Dry to moist, sandy to gravelly soils; perennial
*Maianthemum dilatatum** / False lily-of-the-valley	Partial shade/ shade	3-12 inches	Spring	Prefers moist soils; small, white flowers; light-green to red berries

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pennisetum alopecuroides / Fountain grass	Sun/partial shade	1-2 feet	August - September	Moist, well-drained soils; tolerant of many soil types; clump-forming grasses. A number of varieties are available in different heights and bloom times. Try *P. caudatum* (White-flowering fountain grass) and *P. alopecuroides* cultivars 'Hameln' and 'Little Bunny' (Dwarf fountain grass)
Pennisetum orientale / Oriental fountain grass	Sun/partial shade	1-3 feet	June - October	Prefers moist, well-drained soils; somewhat drought tolerant; small clumping, blooming grass, showy pink flowers; fountain grasses will benefit from annual shearing in late winter/early spring, but not required
Penstemon fruticosus / Shrubby penstemon	Sun	8–10 inches	May	Prefers well-drained soils; evergreen perennial; drought tolerant; violet-blue flowers 1 inch long attract hummingbirds
*Polystichum munitum** / Swordfern	Partial shade/ Deep shade	2-4 feet		Prefers moist, rich soil conditions, but drought tolerant; large evergreen fern
*Potentilla gracilis** / Graceful cinquefoil	Sun	1-2 feet	July	Moist to dry soils; yellow flowers
Rudbeckia hirta / Black-eyed susan	Sun/partial shade	3-4 feet	Summer	Moist to dry soils; showy flowers, hardy and easy to grow; several other varieties are available
*Smilacina racemosa** / False Solomon's seal	Partial sun/shade	1-3 feet	April - May	Moist soils; creamy white flowers; red berries