City of Lacey 2010

Stormwater Design Manual




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City of Lacey 2010
Stormwater Design Manual

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Introduction

The City of Lacey 2010 Stormwater Design Manual (SDM) is a completely revised and updated replacement for the 1994 *Drainage Design and Erosion Control Manual for Lacey*. The 2010 SDM is based on the 2005 edition of the Washington State Department of Ecology *Stormwater Management Manual for Western Washington* (SMMWW). In creating the 2010 SDM, the City of Lacey Department of Public Works has edited and reorganized Ecology's 2005 SMMWW for ease of use and local application. The reader is referred to the SMMWW for further background information and supporting details, if desired. The SMMWW is available on Ecology's website at http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

The City of Lacey is required to regulate stormwater discharges to our municipal stormwater system and to waters of the state, in compliance with the Western Washington Phase II Municipal Stormwater Permit. Under the permit, the City must establish and apply the minimum requirements specified in the Permit and provide design guidance for stormwater quality and quantity control for new development and redevelopment projects in Lacey.

This manual establishes the minimum "Core Requirements" for development, redevelopment and road projects of all sizes within the City of Lacey, and provides guidance on how to prepare and implement stormwater site plans (drainage plans and reports). Stormwater management requirements are satisfied by the application of Best Management Practices (BMPs) identified in this manual, when they are selected and designed according to the procedures and criteria specified in this manual.

The requirements of the 2010 SDM are applicable to all types of public and private land development projects – including residential, commercial, industrial, and road projects. Stormwater management for road projects shall meet all the minimum requirements stated in this manual, although federally-funded road projects may be required (per WSDOT Local Area Guidelines) to design to WSDOT Highway Runoff Manual standards, at a minimum. In this case, the more stringent stormwater requirements of this manual or the WSDOT Highway Runoff Manual shall apply.

The City of Lacey Stormwater Manual Administrator is authorized to request information or to impose requirements beyond those specified in this manual, which may occur for various reasons such as:

- to protect public safety, health and welfare;
- to prevent flooding;
- to prevent water quality degradation;
- to protect streams and channels from erosion;
- to implement regulatory mandates such as a Total Maximum Daily Load (TMDL);
- to clarify, correct, augment or update information in this manual.

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 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.

Stormwater management techniques applied in accordance with this manual are presumed to meet the technology-based treatment requirement of State law to provide all known available and reasonable methods of treatment, prevention and control (AKART; RCW 90.52.040 and RCW 90.48.010).

The technology-based treatment requirement does not excuse any discharge from the obligation to apply additional stormwater management practices as necessary to comply with State water quality standards.

The BMPs presented in this manual are listed by the Washington State Department of Ecology and are *presumed* to protect water quality and in-stream habitat, and to meet the environmental objectives of the state regulations. Project proponents always have the option not to follow the stormwater management practices in this manual, and instead choose a different approach. However, if that choice is made, 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 the Stormwater Manual Administrator early in the process.

A primary goal of stormwater management for development sites is 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 released from the site. To reach toward this goal, the use of on-site measures known as Low Impact Development will be an increasingly integral part of the planning and design of site development in Lacey. The *Low Impact Development Technical Guidance Manual for Puget Sound* (the LID Manual), published by the Puget Sound Partnership, provides guidance on LID techniques and design procedures to use in our region. Ecology recognizes the LID Manual and references it in the 2005 *Stormwater Management Manual for Western Washington*. The LID Manual can be found at the Puget Sound Partnership website: http://www.psp.wa.gov/documents.php

For the purposes of interpreting and using this manual, he words "shall," “will,” and “must” are always mandatory; the word "should" is situation-specific and not mandatory but strongly encouraged; and "may" is situation-specific and permissive. The Lacey Stormwater Manual Administrator is authorized to determine if situation-specific requirements are applicable to any particular project.

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

This manual has been adopted by local ordinance and has force of law. Failure to comply may trigger administrative or enforcement action, and result in project delays, fines or penalties.

Organization of this Manual

This manual is organized into ten chapters, briefly described here:

Chapter 1 presents the basic drainage minimum requirements (Core Requirements) and the project types and thresholds that trigger the various requirements.

Chapter 2 covers the specific contents and requirements of drainage plans and reports that are to accompany project submittals.

Chapter 3 describes the site and vicinity analysis required to be submitted with the application for the City of Lacey to evaluate the proposal.

Chapter 4 details the erosion and sediment control requirements to be implemented during the construction phase at development project sites.

Chapter 5 presents the hydraulic and hydrologic analytical methods to be used in developing the drainage design.

Chapter 6 addresses selection and design of BMPs intended to meet flow control requirements.

Chapter 7 addresses selection and design of BMPs intended to meet water quality requirements.

Chapter 8 is devoted to source control of pollution and pollution prevention.

Chapter 9 addresses the long-term operation and maintenance requirements for flow control and water quality BMPs and related features.

Chapter 10 describes the agreements and financial guarantees between the City and project proponents/owners to assign appropriate responsibility for BMP operation and maintenance.

Appendices to the chapters contain definitions, forms, maps and other information relevant to the chapters and to the application of the Core Requirements.

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Chapter 1 – Stormwater Drainage Requirements for New Development and Redevelopment

This Chapter describes the drainage design and submittal requirements necessary to implement surface water runoff policies of the City of Lacey.

1.1 DRAINAGE REVIEW

Drainage review is the evaluation by the City of Lacey of a proposed project's compliance with the drainage requirements of this manual.

Drainage review is required for any proposed project that is subject to a City of Lacey development permit or approval, and that meets any one of the conditions/thresholds embodied in the drainage review flow charts for development projects (Figure 1.2), road redevelopment projects (Figure 1.3) or general redevelopment projects (Figure 1.4). If drainage review is required, the type of drainage review is based on project and site characteristics as embodied in these flow charts.

For purposes of applying the flowcharts, Threshold Discharge Areas (referenced in Core Requirements #6 and #7) are defined as illustrated in Figure 1.1. 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 of Threshold Discharge Areas, see Section 4-2.5 of the WSDOT *Highway Runoff Manual* (2008).

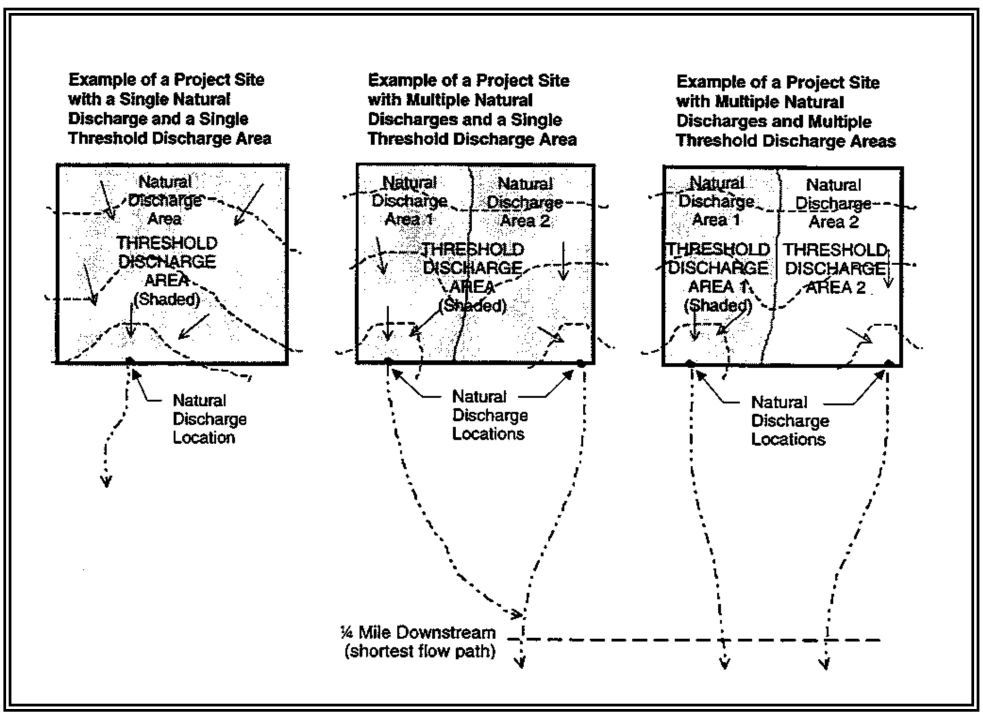

Figure 1.1 Threshold Discharge Areas

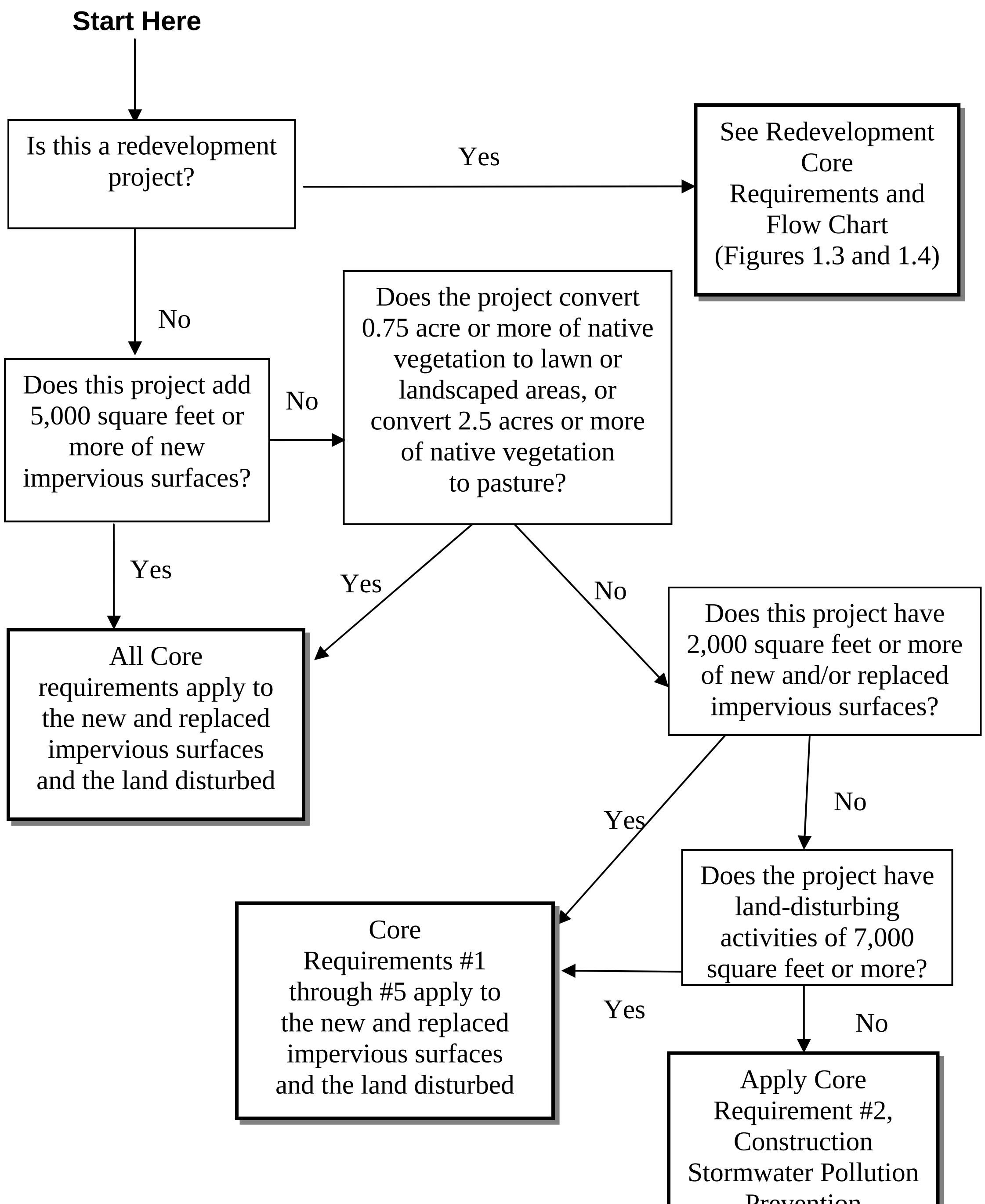

Figure 1.2 Flow Chart for Determining Requirements for New Development

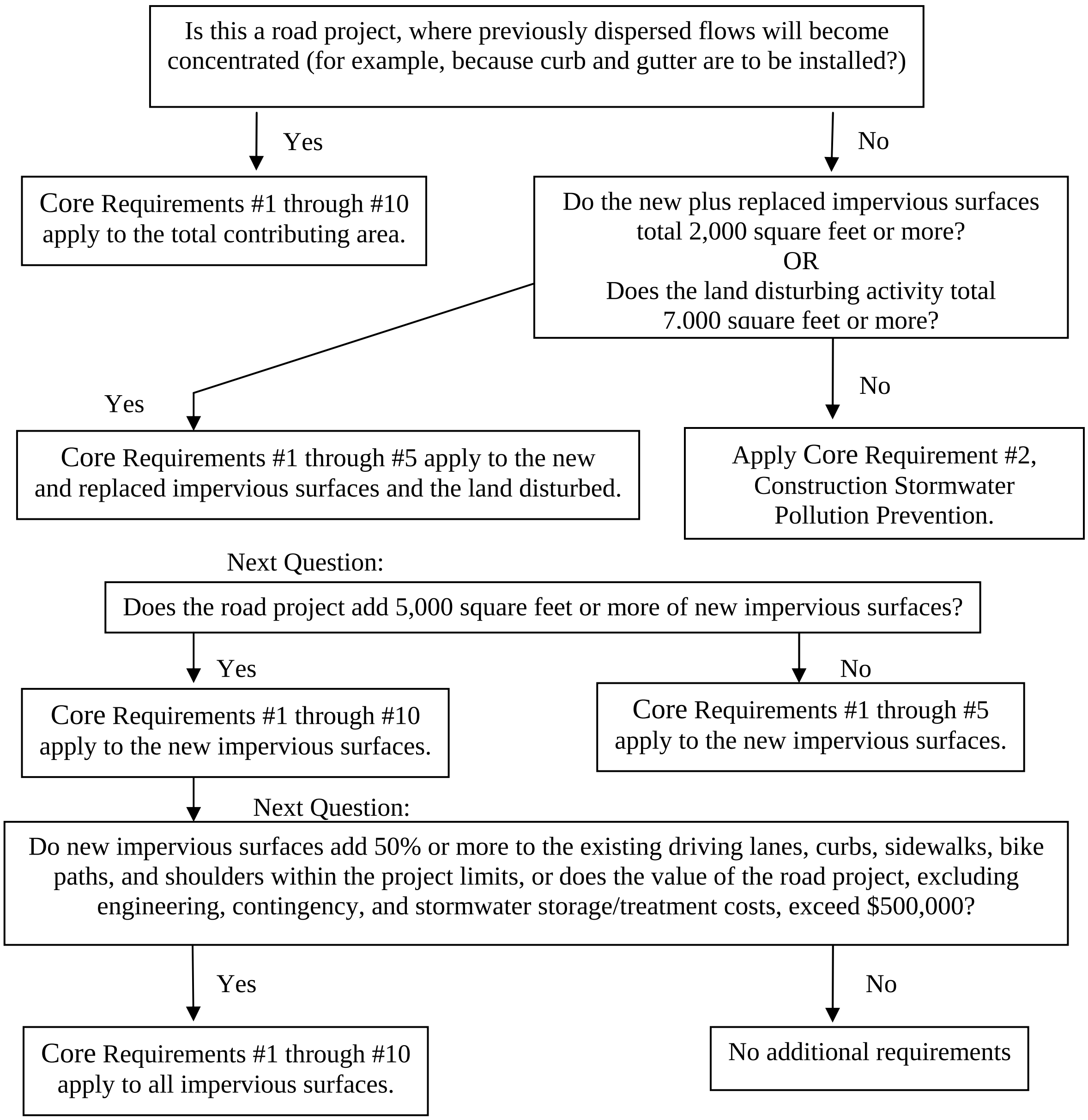

Figure 1.3 Flow Chart for Determining Requirements for Road Redevelopment

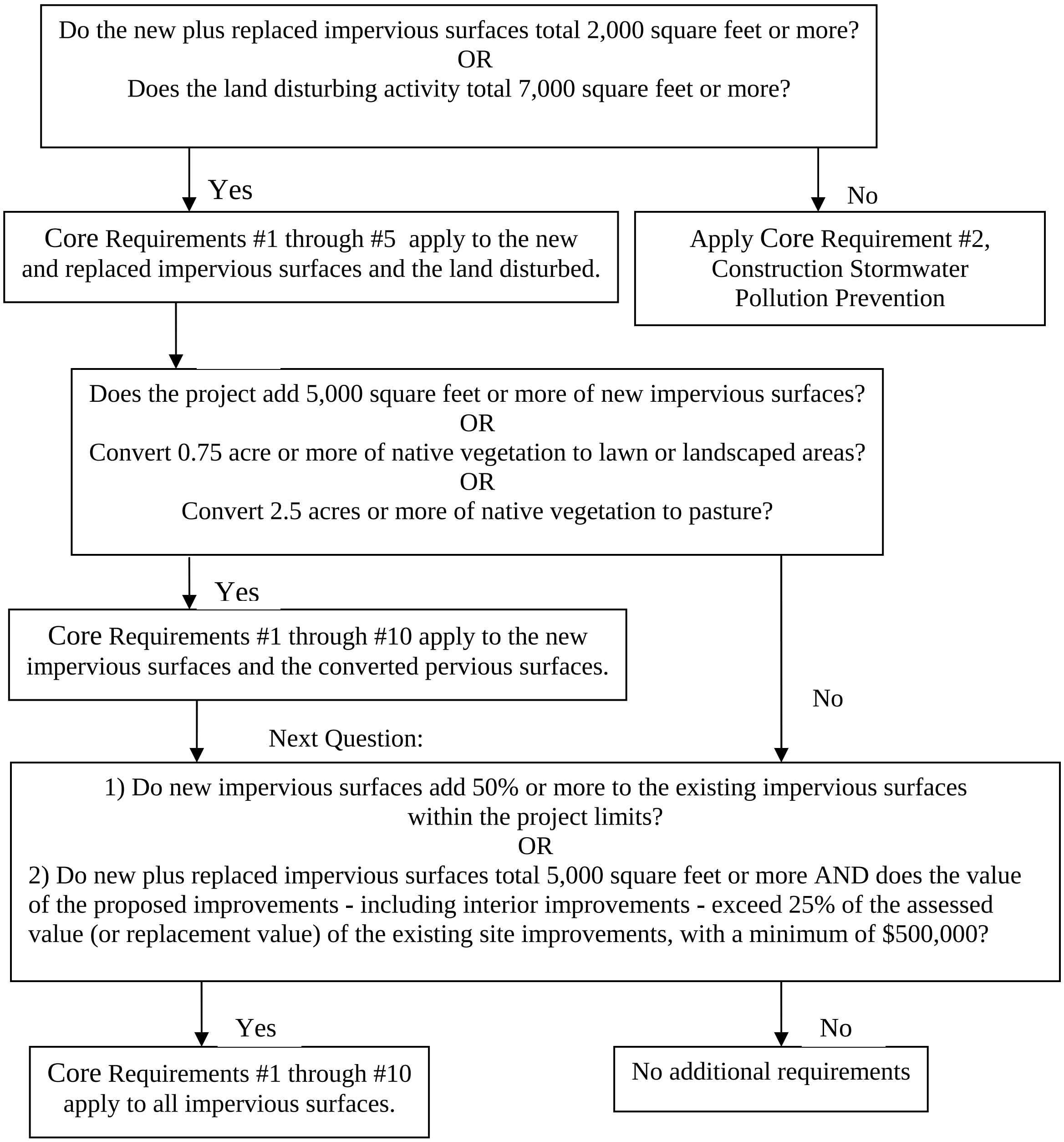

Figure 1.4 Flow Chart for Determining Requirements for Redevelopment (other than Roads)

1.1.1 DRAINAGE REVIEW TYPES AND REQUIREMENTS

Not all of the Core Requirements apply to every development or redevelopment project. The applicability varies depending on the type and size of the project. This section identifies thresholds that determine the applicability of the Core Requirements to different projects. The flow charts in Figures 1.2 through 1.4 are used to determine which requirements apply. The Core Requirements themselves are presented in Section 1.2. Development sites are to demonstrate compliance with the Core Requirements through the preparation and submittal of drainage plans and reports. The plans are described in detail in Chapter 2.

Drainage review types and requirements are summarized in Table 1.1.

Table 1.1 Project Review Core Requirements

	Small Project Drainage Review	Partial Drainage Review	Full Drainage Review
Core Requirement No. 1 **Stormwater Site Plan/Report**	X	X	X
Core Requirement No. 2 **Construction Stormwater Pollution Prevention**	X	X	X
Core Requirement No. 3 **Source Control of Pollution**	X	X	X
Core Requirement No. 4 **Preservation of Natural Drainage Systems & Outfalls**	X	X	X
Core Requirement No. 5 **On-Site Stormwater Management**	X	X	X
Core Requirement No. 6 **Runoff Water Quality Treatment**		X	X
Core Requirement No. 7 **Flow Control**		X	X
Core Requirement No. 8 **Wetlands Protection**		X	X
Core Requirement No. 9 **Operation & Maintenance**		X	X
Core Requirement No. 10 **Agreements & Financial Guarantees**		X	X

1.1.2 Exemptions

Road Maintenance

The following road maintenance practices are exempt from the Core Requirements, but should use appropriate BMPs to minimize erosion and sediment transport: pothole and square cut patching, overlaying existing asphalt or concrete pavement with asphalt or concrete without expanding the area of coverage, shoulder grading, reshaping/regrading drainage systems, crack sealing, resurfacing with in-kind material without expanding the road prism, and vegetation maintenance.

Other road maintenance activities, such as removing and replacing a paved surface to base course or lower, or repairing the roadway base without increasing the impervious surface area, are considered redevelopment and are not categorically exempt, so Core Requirements #1 through #5 apply. Any increase in the impervious surface area of a road, such as by paving the shoulders or upgrading from gravel to asphalt, is considered redevelopment and is subject to the Core Requirements that apply when the project meets or exceeds identified redevelopment thresholds.

Underground utility projects

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

Emergency projects, which, if not performed immediately, would substantially endanger life, property, or the environment, are exempt but should minimize erosion and sediment transport as much as practicable.

Any exemptions from the Core Requirements or from submittal and permitting requirements only applies to this Manual and does not relax any requirements of other applicable ordinances, regulations, or legislation except those superseded by this Manual.

1.2 CORE REQUIREMENTS

This section describes the Core Requirements for stormwater management at development and redevelopment sites. Depending on the project size, site, and location, different requirements may apply, and not all of the Core Requirements apply to every project. Refer to Section 1.1 for the applicable Core Requirements for various project types and sizes.

1.2.1 Core Requirement #1: Preparation of Stormwater Site Plans and Reports

All projects meeting the thresholds in Section 1.1 shall prepare a Stormwater Site Plan for City review. Stormwater Site Plans shall be prepared in accordance with Chapter 2 of this manual.

A Stormwater Site Plan is a comprehensive report containing all of the technical information, analysis, calculations, maps and graphics necessary for the City of Lacey to evaluate a proposed project for compliance with stormwater requirements. Stormwater Site Plans for most project submittals will generally include a Drainage Report, a Soils Report, a Maintenance Plan, a Construction Stormwater Pollution Prevention Plan, a Source Control & Pollution Prevention Plan, Drainage Plans (drawings, notes and specifications), and other supporting information such as a Wetlands Report, as applicable.

The City recommends the project applicant develop a conceptual stormwater drainage plan and discuss it with the Drainage Manual Administrator early in the project (after the Pre-Submission Meeting, but prior to application submittal) to discuss the conceptual approach proposed for a development site. This discussion also be used to identify potential problems and to outline the scope and content of the stormwater site plan.

1.2.2 Core Requirement #2: Construction Stormwater Pollution Prevention

Projects in which the new, replaced, or new plus replaced impervious surfaces total 2,000 square feet or more, or disturb 7,000 square feet or more of land, must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) as part of the Stormwater Site Plan. Each of the twelve elements must be considered and included in the SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

Projects that add or replace less than 2,000 square feet of impervious surface or disturb less than 7,000 square feet of land are not required to prepare a SWPPP, but must consider all of the twelve Elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site. This includes many single-family building sites.

Construction sites are subject to inspections by the City of Lacey as follows:

(1) prior to clearing and construction, on all sites that are determined by the City to have a high potential for sediment transport;

(2) during construction, on all sites, to verify proper installation and maintenance of required erosion and sediment controls; and

(3) upon completion of construction and prior to final approval, on all sites, to ensure proper installation of permanent stormwater controls.

For projects required to obtain coverage under Ecology's NPDES Stormwater Construction Permit for project sites greater than 1 acre, the applicant shall provide to the City of Lacey a copy of the Notice of Intent and the SWPPP prepared for the NPDES Construction Permit.

All new development and redevelopment shall comply with Construction Stormwater Pollution Prevention Plan Elements #1 through #12 below. Details related to construction stormwater BMPs are provided in Chapter 4.

1.2.2.1 The Twelve Elements of Construction Stormwater Pollution Prevention Plans

Element 1: **Mark Clearing Limits**

Prior to beginning land disturbing activities, including clearing and grading all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts. Refer to the applicable Land Use Approval (Site Plan Review, Plat, etc.) for tree retention and grading permit requirements. Consultation with the City of Lacey Tree Protection Professional and/or Public Works inspectors may be required prior to beginning land disturbing activities. Contact the City of Lacey Community Development Department for further information.

Plastic, metal, or stake wire fence may be used to mark the clearing limits, per the City of Lacey Tree Protection Professional.

The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum extent practicable. If it is not practicable to retain the duff layer in place, it should be stockpiled on-site, covered to prevent erosion, and replaced immediately upon completion of the ground disturbing activities.

Element 2: **Establish and Maintain Construction Access**

Construction vehicle access and exit shall be limited to one route, if possible.

Access points shall be stabilized with a pad of quarry spalls or crushed rock or other equivalent BMP to minimize the tracking of sediment onto public roads.

Wheel wash or tire baths shall be located onsite, if the stabilized construction entrance(s) is not effective in preventing sediment from being tracked onto public roads.

If sediment is tracked off site, public roads shall be cleaned thoroughly at the end of each day, or more frequently during wet weather. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area. Street washing is allowed only after sediment is removed in this manner.

Street wash wastewater shall be controlled by pumping back onsite, or shall otherwise be prevented from discharging into systems tributary to waters of the state.

Element 3: **Control Flow Rates**

Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site, as required by the City of Lacey.

Downstream analysis is necessary if changes in flows could impair or alter conveyance systems, streambanks, bed sediment or aquatic habitat. See Chapter 2 for offsite analysis requirements.

Where necessary to comply with Core Requirement #7, stormwater retention/detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional prior to construction of site improvements (e.g. impervious surfaces).

The City of Lacey may require pond designs that provide additional or specific 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, these facilities shall be protected from siltation during the construction phase and plans made for restoration after construction.

Element 4: **Install Sediment Controls**

Prior to leaving a construction site, or prior to discharge to an infiltration facility, stormwater runoff from disturbed areas shall pass 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. 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.

Sediment ponds, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment onsite shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.

Earthen structures such as dams, dikes and diversions shall be seeded and mulched according to the timing indicated in Element #5.

BMPs intended to trap sediment on site must be located 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. Refer to Core Requirement #4: Preservation of Natural Drainage Systems and Outfalls.

Element 5: Stabilize Soils

All exposed and unworked soils shall be stabilized by application of effective BMPs that protect the soil from the erosive forces of raindrop impact and flowing water, and wind erosion.

From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days. This condition applies to all onsite soils, whether at final grade or not. The local permitting authority may adjust these time limits if it can be shown that a development site's erosion or runoff potential justifies a different standard.

Applicable practices include, but are not limited to, temporary and permanent seeding, sodding, mulching, plastic covering, the early application of gravel base on areas to be paved, and dust control.

Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast.

Soil stabilization measures selected shall be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization measures 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.

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 requirement. Contractors shall install the bedding materials, roadbeds, structures, pipelines, and/or utilities, and re-stabilize the disturbed soils so that:

- from October 1 through April 30 no soils shall remain exposed and unworked for more than 2 days; and
- from May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.

Element 6: Protect Slopes

Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion.

Reduce slope runoff velocities by reducing the continuous length of slope with terracing and diversions, reduce slope steepness, and roughen slope surface.

Off-site stormwater (run-on) shall be diverted away from slopes and disturbed areas with interceptor dikes and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.

At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion. Temporary pipe slope drains shall handle the peak flow from a 10 year, 24 hour event assuming a Type 1A rainfall distribution. Alternatively, the 10-year and 25-year, 1-hour flow rates 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. Permanent pipe slope drains shall be sized for the 100-year, 24-hour storm event.

Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.

Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.

Check dams shall be placed at regular intervals within channels that are cut down a slope, such that slopes are protected from erosive flows.

Stabilize soils on slopes, as specified in Element #5.

Element 7: **Protect Drain Inlets**

In order to protect stormwater infrastructure and downstream water resources, all storm drain inlets made operable during construction shall be protected, as needed, so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment.

All approach roads shall be kept clean. All sediment and street wash water shall be prevented from entering storm drains without prior and adequate treatment.

Inlets shall be inspected weekly at a minimum and daily during storm events. Inlet protection devices shall be cleaned or removed and replaced when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

Element 8: **Stabilize Channels and Outlets**

All temporary on-site conveyance channels shall be designed, constructed and stabilized to prevent erosion from the expected peak 10 minute velocity of flow from a Type 1A, 10- year, 24-hour frequency storm for the developed condition. 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.

Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all conveyance systems.

Element 9: **Control Pollutants**

All pollutants, including waste materials and demolition debris, that occur onsite during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chopped and spread on-site.

Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and non-inert wastes present on the site (see Chapter 173-304 WAC for the definition of inert waste). On-site fueling tanks shall be dual-walled or provided with secondary containment, and shall be prohibited within 100 ft. of City supply wells.

Maintenance and repair of heavy equipment and vehicles involving 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 must be conducted using spill prevention measures, such as drip pans. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident. Report all spills within the City to the City Maintenance Center: 491-5644. Emergency repairs may be performed onsite using temporary plastic placed beneath and, if raining, over the vehicle.

Wheel wash, or tire bath wastewater, shall be discharged to a separate onsite treatment system or to the sanitary sewer.

Application of agricultural chemicals, including fertilizers and pesticides, shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations for application rates and procedures shall be followed.

BMPs shall be used to prevent or treat contamination of stormwater runoff by pH-modifying sources. These 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, and concrete pumping and mixer washout waters. Stormwater discharges shall not cause or contribute to a violation of the water quality standard for pH in the receiving water.

Construction sites with significant concrete work shall adjust the pH of stormwater if necessary to prevent violations of water quality standards. To use any pH adjustment chemical other than CO_2 or dry ice, construction site operators shall obtain prior approval from the DOE and present evidence of said approval to the City.

Element 10: **Control De-Watering**

Foundation, vault, and trench de-watering water which has similar characteristics to stormwater runoff at the site, shall be discharged into a controlled conveyance system, prior to discharge to a sediment trap or sediment pond. Channels must be stabilized, as specified in Element #8.

Clean, non-turbid de-watering water, such as well-point ground water, can be discharged to systems tributary to state surface waters or the municipal drain system, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of the receiving waters. These clean waters should not be routed through a stormwater sediment pond.

Highly turbid or otherwise contaminated dewatering water, such as from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, shall be handled separately from stormwater.

Other disposal options, depending on site constraints, may include: 1) infiltration, 2) transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters, 3) Ecology-approved on-site chemical treatment or other suitable treatment technologies, 4) sanitary sewer discharge with local sewer district approval, if there is no other option, or 5) use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Element 11: **Maintain BMPs**

All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with BMP specifications.

Sediment control BMPs shall be inspected weekly or after a runoff-producing storm event during the dry season and daily during the wet season.

All temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal of BMPs or vegetation shall be permanently stabilized.

Element 12: **Manage the Project**

Phasing of Construction - Development projects shall be phased where feasible in order to prevent soil erosion and, to the maximum extent practicable, the transport of sediment from the project 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 shall be permitted only if conducted pursuant to an approved site development plan that establishes permitted areas of clearing, grading, cutting, and filling. 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 City of Lacey shall be delineated on the site plans and the development site.

Lot-specific grading plans, including information specified by the City of Lacey, such as finished grades, finished floor elevations, buildable areas, and identified drainage outlets, may be required prior to preliminary plat approval subject to site-specific conditions as determined by the City of Lacey.

Seasonal Work Limitations - From October 1 through April 30, clearing, grading, and other soil disturbing activities shall be prohibited unless shown to the satisfaction of the City of Lacey that sediment-laden runoff will be prevented from leaving the site through a combination of the following:

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

Based on the information provided and/or local weather conditions, the City of Lacey may expand or restrict the seasonal limitation on site disturbance. The City of Lacey 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 shown in the plans are not observed or if erosion and sediment control measures shown in the approved plan are not installed or maintained.

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

1. Routine maintenance and necessary repair of erosion and sediment control BMPs;
2. Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the soil's vegetative cover; and
3. Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

The City of Lacey may restrict clearing and grading activities where site conditions may present a significant risk of impact to property or critical areas.

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

For construction sites one acre or larger that discharge stormwater to surface waters of the state, a Certified Erosion and Sediment Control Lead shall be identified in the Construction SWPPP and shall be on-site or on-call at all times. Certification may be obtained through an approved training program that meets the erosion and sediment control training standards established by the Department of Ecology. If a pre-construction meeting is held, this person shall attend. Refer to Chapter 4, BMP C160.

Sampling and analysis of the stormwater discharges from a construction site may be necessary on a case-by-case basis to ensure compliance with standards. Monitoring and reporting requirements may be established by the City when necessary.

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, appropriate BMPs or design changes shall be implemented as soon as possible.

Maintaining an Updated Construction SWPPP - The Construction SWPPP shall be retained onsite or within reasonable access to the site.

The SWPPP shall be modified whenever there is a significant 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, or the applicable local or 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) calendar days following the inspection.

If a Construction SWPPP is found to be inadequate (with respect to erosion and sediment control requirements), the City shall require that additional BMPs be implemented, as appropriate.

1.2.3 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 of the Department of Ecology’s 2005 *Stormwater Management Manual for Western Washington,* as described and referenced in Chapter 8.

Source Control requirements for construction sites are addressed in Chapter 4.

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

The City may use an adopted and implemented basin plan (Supplemental Requirement #1) or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) to develop more stringent source control requirements that are tailored to a specific basin.

Source control BMPs shall be identified in the stormwater site plans submitted for City review.

1.2.4 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 feasible. The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters or down gradient properties. The discharge must have an identified overflow route that is safe and certain, and leads to the ultimate outfall location (such as a receiving water or municipal drainage system). All outfalls require energy dissipation.

Offsite drainage is drainage from adjacent property that enters the proposed project site in other than a defined natural channel. Offsite flows shall not be routed through the project's conveyance, treatment, or retention/detention systems, unless those systems are sized to control those flows. Off-site contribution areas shall be mapped.

Offsite flows that are collected and routed through or around the site in a separate conveyance shall be dispersed at the downgradient property line, if feasible, or discharged at a project outfall (or outfalls) in a manner that does not violate the criteria below or cause the capacity of a conveyance system to be exceeded.

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

a) If the 100-year peak discharge is less than or equal to 0.2 cfs under existing conditions and will remain less than or equal to 0.2 cfs under developed conditions, then the concentrated runoff may be discharged onto a rock pad or to any other system that serves to disperse flows.

b) If the 100-year peak discharge is between 0.2 and 0.5 cfs under existing conditions and will remain in that range under developed conditions, then the concentrated runoff may be discharged through a dispersal trench or other dispersal system, provided the applicant can demonstrate that there will be no significant adverse impact to downhill properties or drainage systems.

c) If the 100-year peak discharge is greater than 0.5 cfs for either existing or developed conditions, or if a significant adverse impact to downgradient properties or drainage systems is likely, then a conveyance system shall be provided to convey the concentrated runoff across the downstream properties to an acceptable discharge point (i.e., an enclosed drainage system or open drainage feature where concentrated runoff can be discharged without significant adverse impact).

For (c) only, drainage easements from downstream property owners shall, if needed, be obtained prior to approval of engineering plans. If the proposed project is unable, after reasonable efforts, to obtain needed easements, the discharge approach described in (b) above may be used.

Stormwater retention, detention or treatment facilities, as required by this Manual, 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. These stormwater facilities shall not be located within the expected 10-year water elevations for all other areas.

1.2.5 Core Requirement #5: Onsite Stormwater Management

Projects shall employ Onsite Stormwater Management BMPs to convey, infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts.

Roof Downspout Control BMPs and Dispersion and Soil Quality BMPs, functionally equivalent to those in Chapter 6 are required to reduce the hydrologic disruption of developed sites.

Core Requirement #5 applies to all projects that meet the thresholds described in Section 1.1. However, all projects, including those not meeting the thresholds, should use onsite measures to the maximum extent practicable to reduce runoff and control stormwater.

All projects required to comply with Core Requirement #5 shall employ all of the following Low Impact Development BMPs as applicable (see Chapters 6 and 7):

- Restore native vegetation (BMP LID-01)
- Post-Construction Soil Quality and Depth (BMP LID-09) – All disturbed areas of the project to be landscaped shall implement this BMP to restore soil quality and depth.
- Downspout infiltration systems (BMP LID-04)
- Dispersion of roof and driveway runoff (BMPs LID-05, LID-07 and LID-08)
- In addition, Bioretention (BMP LID-10) is encouraged as an effective method to meet this core requirement.

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

1. Downspout infiltration systems including bioretention (rain gardens)
2. Downspout dispersion systems, only if infiltration is not feasible
3. Collect and convey to a public or private stormwater system if other alternatives are not feasible.

The use of Low Impact Development BMPs is more effective in reducing disruptions to the site's natural hydrologic characteristics and are preferable to more traditional BMPs such as detention ponds. In some cases, the application of onsite measures can reduce 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 (per Core Requirements #6 and #7) may not be required. An applicant may also consider using full dispersion where the impervious surface, landscape areas, and native vegetation retention as a percentage of the site meets certain thresholds (see BMP LID 03, Full Dispersion).

Chapter 6 provides guidance on selection and design of the onsite stormwater management BMPs required by Core Requirement #5.

1.2.6 <u>Core Requirement #6</u>: Runoff Water Quality Treatment

Runoff treatment shall be provided at development project sites to reduce the water quality impacts of stormwater runoff from pollution-generating surfaces. This requirement applies to all non-exempt projects that meet the thresholds described in Section 1.1. Stormwater treatment facilities shall be constructed if the following criteria are met within a threshold discharge area (see Table 1.2).

The following require construction of stormwater treatment facilities (see Table 1.2):

- **Projects in which the total of effective, pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or**

Projects in which the total area of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.

Table 1.2 Treatment Requirements by Threshold Discharge Area

	< ¾ acres of PGPS	**≥ ¾ acres of PGPS**	**< 5,000 sf of PGIS**	**≥ 5,000 sf of PGIS**
Treatment Facilities		✔		✔
Onsite Stormwater BMPs	✔	✔	✔	✔

PGPS = pollution-generating pervious surfaces
PGIS = pollution-generating impervious surfaces
sf = square feet

The above thresholds apply to both a project's onsite and offsite improvements. Once the project triggers this core requirement, all new and replaced pollution-generating impervious surfaces are required to receive water quality treatment. 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 impervious surface shall provide water quality treatment. If runoff from the total new PGIS and that portion of any replaced PGIS that requires treatment cannot be separated from the existing PGIS runoff, treatment facilities must be sized to treat all of the runoff.

Treatment Facility Sizing

Water Quality Design Storm Volume: the 91st percentile, 24-hour runoff volume calculated using WWHM with Thurston County enhancements, most current version.

Water Quality Design Flow Rate:

- *Preceding Detention Facilities or when Detention Facilities are not required*:

  The flow rate at or below which 91% of the runoff volume, as estimated by WWHM with Thurston County enhancements, most current version will be treated. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80% TSS removal).

- *Downstream of Detention Facilities*:

  The full 2-year release rate, as estimated by WWHM with Thurston County enhancements, most current version, from the detention facility.

That portion of any development project in which the PGIS or PGPS thresholds are not exceeded in a threshold discharge area shall apply Onsite Stormwater Management BMPs in accordance with Core Requirement #5.

Treatment Facility Selection, Design, and Maintenance

Stormwater treatment facilities shall be:

- selected in accordance with the process identified in Chapter 7,
- designed in accordance with the design criteria in Chapter 7, and
- maintained in accordance with an approved maintenance schedule developed per the requirements of Chapter 9.

Additional Requirements

Direct discharge of untreated stormwater from pollution-generating impervious surfaces to ground water is prohibited, except for the discharge achieved by infiltration or dispersion of runoff from residential sites through use of Onsite Stormwater Management BMPs.

An adopted and implemented Basin Plan, or a Total Maximum Daily Load (TMDL - also known as a Water Clean-up Plan) may be used to develop runoff treatment requirements that are tailored to a specific basin.

Treatment facilities applied consistent with this manual are presumed to meet the requirement 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 173-201A WAC; state ground 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.

Infiltration through use of Onsite Stormwater Management BMPs can provide both treatment of stormwater, through the ability of certain soils to remove pollutants, and volume control of stormwater, by decreasing the amount of water that runs off to surface water. Infiltration through engineered treatment facilities that utilize the natural soil profile can also be very effective at treating stormwater runoff, but pretreatment must be applied and soil conditions must be appropriate to achieve effective treatment while not impacting ground water resources.

Discharge from pollution-generating surfaces into a dry well, after pretreatment for solids reduction, can be acceptable if the soil conditions provide sufficient treatment capacity. Dry wells into gravelly soils are not likely to have sufficient treatment capability. They must be preceded by at least a basic treatment BMP. See Chapter 7 for details.

Impervious surfaces that are "fully dispersed" in accordance with BMP LID-03 in Chapter 6 are not considered effective impervious surfaces.

1.2.7 Core Requirement #7: Flow Control

Applicability

Projects must provide flow control of stormwater discharges and infiltration, to reduce the impacts of stormwater runoff from impervious surfaces and land cover conversions. This requirement applies to projects that discharge stormwater directly, or indirectly through a municipal conveyance system, into a fresh water, except for discharges into a wetland (see Core Requirement #8 for flow control requirements applicable to discharges to wetlands). If the discharge is to a stream that flows to a wetland, or to a wetland that has an outflow to a stream, both this flow control requirement and Core Requirement #8 apply.

Any exempted areas shall meet the following requirements:

- The area 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 receiving water; and
- Any erodible elements of the manmade conveyance system for the area must be adequately stabilized to prevent erosion; and
- The conveyance system pipe and ditch sizes are adequate to convey the applicable design storm, and the system outfall is adequate to dissipate the discharge; and
- Surface water from the area must not be diverted from or increased to an existing wetland, stream, or near-shore habitat sufficient to cause a significant adverse impact.

Projects discharging directly to salt water bodies are exempt from flow control.

Puget Sound (including its inlets) is the only exempt surface water body in Lacey. An exemption from flow control requirements for a water body that is not listed in Ecology's Appendix I-E (Flow Control Exempt Surface Waters) is subject to Ecology approval on the basis of a hydrologic study demonstrating the absence of significant downstream impacts.

Thresholds

The following require construction of flow control facilities and/or land use management BMPs that will achieve the standard requirement for western Washington (see Table 1.3):

- **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 ¾ acres or more of native 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 natural or man-made conveyance system from the site, or

Projects that, through a combination of effective impervious surfaces and converted pervious surfaces, cause a 0.1 cubic feet per second or greater increase in the 100-year flow frequency from a threshold discharge area as estimated using the latest version of the Western Washington Hydrology Model.

That portion of any development project in which the above thresholds are not exceeded in a threshold discharge area shall apply Onsite Stormwater Management BMPs in accordance with Core Requirement #5.

Table 1.3 Flow Control Requirements by Threshold Discharge Area		
	Flow Control Facilities	**Onsite Stormwater Management BMPs**
< ¾ acres conversion to lawn/landscape, or < 2.5 acres to pasture		✔
≥ ¾ 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	✔	✔
≥ 0.1 cubic feet per second increase in the 100-year flood frequency	✔	✔

Standard Requirement

For stormwater discharges, developed discharge durations shall match pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow; and,

For groundwater recharge, the average annual infiltration volume of stormwater from the project site after development shall match or exceed the pre-developed average annual volume infiltrated.

Runoff and volume calculations shall be provided by the Western Washington Hydrology Model (WWHM) with Thurston County enhancements, most current version. The Thurston County version of the Western Washington Hydrology Model (WWHM3), has been modified to track and compute recharge (infiltration to groundwater from pervious areas and infiltration facilities) and whether the site meets the average annual infiltration criteria.

The pre-developed condition to be matched shall be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement (modeled as "pasture" in WWHM). This standard requirement is waived for projects that will reliably infiltrate all the runoff (up to the 100-year runoff volume) from impervious and converted pervious surfaces.

The requirement to match the average annual infiltration volume may be waived for the portion of a project site that can demonstrate that the average overall infiltration rate of the native soils at that portion of the site in the pre-developed condition have an infiltration rate of less than 0.5 inches per hour.

In calculating the average annual infiltration volume for purposes of meeting the minimum infiltration requirement, the applicant may include infiltration from dispersion areas, landscaped areas, biofiltration and bioretention facilities, drywells, and other infiltration facilities.

Western Washington Alternative Requirement

An alternative requirement may be established through application of watershed-scale hydrological modeling and supporting field observations. Possible reasons for an alternative flow control requirement include:

- **Establishment of a stream–specific threshold of significant bedload movement other than the assumed 50% of the 2-year peak flow;**

Zoning and Land Clearing Ordinance restrictions, including Low Impact Development standards, that, in combination with an alternative flow control standard, maintain or reduce the naturally occurring erosive forces on the stream channel; or

A duration control standard is not necessary for protection, maintenance, or restoration of designated beneficial uses or Clean Water Act compliance.

Infiltration is the preferred method of flow control where conditions permit. However, infiltration will only be allowed where ground water quality is not threatened by such discharges.

Application of sufficient types of Onsite Stormwater Management BMPs can result in reducing the effective impervious area and the converted pervious areas such that a flow control facility is not required. Application of "Full Dispersion", BMP LID-03, also results in eliminating the flow control facility requirement for those areas that are "fully dispersed."

1.2.8 Core Requirement #8: Wetlands Protection

Applicability

These requirements apply to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system. These requirements must be met in addition to meeting Core Requirement #6, Runoff Treatment.

Thresholds

The thresholds identified in Core Requirement #6 – Runoff Water Quality Treatment, and Core Requirement #7 – Flow Control shall also be applied for discharges to wetlands.

Standard Requirement

Discharges to wetlands shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses and functions. Any hydrologic modification of a wetland must be in accordance with Lacey Municipal Code, Title 14, Chapter 14.28 Wetlands Protection, and Guide Sheet 1B (see reference below).

Additional Requirements

The standard requirement does not excuse any discharge from the obligation to apply whatever technology is necessary to comply with state water quality standards, Chapter 173-201A WAC, or state ground water standards, Chapter 173-200 WAC. Additional treatment to meet those standards may be required.

Stormwater treatment or flow control facilities shall not be built within a wetland buffer, except as may be allowed in accordance with the Lacey Municipal Code.

An adopted and implemented Basin Plan (per Section 1.3, Supplemental Requirement #1), or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) per Section 1.4 may be used to develop requirements for wetlands that are tailored to a specific basin.

For discharges to wetlands, a hydroperiod analysis must be performed and must show that the discharge will not adversely affect the wetland hydroperiod. The hydrologic analysis shall use the existing land cover condition to determine the existing hydrologic conditions, unless directed otherwise by the City of Lacey or other regulatory agency.

The hydroperiod is the pattern of fluctuation of water depth and the frequency and duration of water levels at the wetland. This includes the duration and timing of drying in the summer. A hydrologic assessment is useful to measure or estimate elements of the hydroperiod under existing pre-development and anticipated post-development conditions. This assessment involves applying the best available science to assess potential impacts and deciding whether hydrological modeling is warranted. Wetland hydroperiod analysis is of concern when proposing to discharge stormwater into or detract stormwater from a natural wetland. The purpose of the analysis is to determine whether the stormwater will change the natural hydroperiod beyond the limits allowed. The applicant should retain the services of a wetlands professional to assist in the evaluation of the wetland impacts.

Appendix I-D of the 2005 Ecology manual, “Wetlands and Stormwater Management Guidelines” is an amended version of Chapter 14 of the publication, "Wetlands and Urbanization, Implications for the Future", the final report of the Puget Sound Wetland and Stormwater Management Research Program, 1997. This guidance should be used for discharges to natural wetlands and wetlands constructed as mitigation. The amendments were added to Guidesheets 1A, 2B, and 2C to improve clarity of intent and to make them compatible with the updated manual. 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 1B of the guidelines. Refer to Ecology’s 2005 *Stormwater Management Manual for Western Washington*, Volume I, Appendix D for additional guidance on discharges to wetlands.

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

1.2.9 Core Requirement #9: Operation and Maintenance

A project-specific operation and maintenance agreement and maintenance manual, consistent with the provisions in Chapter 9, shall be provided for all proposed stormwater facilities and BMPs. The party (or parties) responsible for operation and maintenance shall be identified. For most facilities, the owner shall sign the maintenance agreement and record it at the Thurston County Auditor's Office. The maintenance agreement shall run with the land and be transferred automatically to all subsequent owners. Copies of the agreement and manual shall be retained onsite or within reasonable access to the site. For jurisdiction-owned public facilities, maintenance agreements are not required, but a copy of the maintenance manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken and when shall be kept and be available for inspection by the local government at any time.

1.2.10 Core Requirement #10: Agreements and Financial Guarantees

Maintenance and/or operational bonding or other appropriate financial guarantees are required for all projects to ensure construction and functionality of drainage facilities in compliance with applicable standards. These guarantees are to be consistent with the most recent edition of the City of Lacey Development Guidelines and Public Works Standards.

The general requirement for drainage infrastructure (e.g., conveyances, control structures, treatment facilities) is a maintenance bond as described in the Development Guidelines (a 2-year bond for 20% of the drainage infrastructure cost). Additional "operational" bonding is required for infiltration facilities, as described below.

Infiltration facilities will require an operational/maintenance bond which shall be held until adequate demonstration is made that the facility operates as designed. Such demonstration shall be made through operational testing (described in Chapter 6, Section 6.3.4) in which the design infiltration rate is verified. The City will not accept an infiltration facility unless it is demonstrated that the operational infiltration rate is at least 90% of the design rate.

The applicant shall submit a Facility Monitoring and Evaluation Report prepared and sealed by a licensed civil engineer. The report shall document field work and assess infiltration facility performance versus design. The report shall specify actions needed to restore performance. The City of Lacey will retain the infiltration facility operational bond until facility actual and design performances are roughly equivalent.

1.3 SUPPLEMENTAL REQUIREMENTS

1.3.1 Supplemental Requirement #1: Basin/Watershed Planning

Projects may be subject to alternative equivalent or more stringent requirements for runoff water quality treatment, flow control and wetlands protection/hydrologic control (Core Requirements # 6, 7 & 8), as identified in or supported by Basin/Watershed Planning. The requirements for erosion control, source control, and operation and maintenance may also be modified based on Basin/Watershed Planning.

Basin/Watershed plans shall evaluate and include, as necessary, retrofitting urban stormwater BMPs into existing development and/or redevelopment in order to achieve watershed-wide pollutant reduction and flow control goals that are consistent with requirements of the federal Clean Water Act.

1.3.2 Supplemental Requirement #2: Off-Site Analysis and Mitigation

Development projects that discharge stormwater off-site shall submit an off-site analysis report that assesses the potential off-site water quality, erosion, slope stability, and drainage impacts associated with the project and that proposes appropriate mitigation of those impacts.

All projects shall submit a *qualitative analysis* downstream from the site to the receiving water, even if 100 percent infiltration is proposed. A *quantitative* analysis may be required for any project deemed to need additional downstream information or where the Project Engineer or the Drainage Manual Administrator determines that a quantitative analysis is necessary to evaluate the offsite impacts or the capacity of the conveyance system.

Details of the off-site analysis requirements are provided in Chapter 3.

1.4 ADDITIONAL REQUIREMENTS

Requirements of this manual can be superseded or augmented by the adoption of ordinances and rules to implement the recommendations of watershed plans or basin plans, or through the adoption of actions and requirements identified in a Total Maximum Daily Load (TMDL) that is approved by Ecology and the EPA.

The requirements of Basin Plans and TMDLs promulgated in the City of Lacey are reflected in the flow control and water quality standards applied in Chapters 6 and 7, respectively.

The City of Lacey may request additional information or impose controls that differ from (and may exceed the Core requirements of) those specified in this Manual, at the discretion of the City. In doing so, the City shall act reasonably, exercising best professional judgment based on available information. Typical reasons for requiring additional information or controls may include, but are not limited to, the following:

- Water quality degradation potential
- Streambank erosion potential caused by increased flows, leading to habitat damage
- Flooding potential that may present risk to life, safety, vital services, or property
- Total maximum daily loads or other regulatory mandates imposed by State or Federal agencies

Lacey encourages the use of Low-Impact Development practices, and may address the requirements of basin plans or TMDLs by requiring them under the appropriate circumstances.

1.5 EASEMENTS AND SETBACKS

1.5.1 Easements

All man-made drainage facilities and conveyances (except as noted herein) and access routes to the boundary or buffer line of natural channels (including swales, stream channels, wetlands, potholes, gullies, ravines, etc.) shall be located within easements. Easements shall contain the functional features and shall allow the City access to these features for purposes of inspection, maintenance, flood control, water quality monitoring and other activities permitted by law.

A minimum 15-feet-wide access easement shall be provided to drainage facilities and the boundary or buffer line of natural channels as defined above 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 approved surface with structural section adequate to support equipment access to the facilities year-round.

The 15-foot minimum easement width does not apply to Onsite BMPs as defined in Chapter 6, or to conveyances associated with those BMPs located on an individual lot. The easement of such conveyances (pipes) shall be of sufficient width to allow inspection and maintenance. The minimum width shall be based on the depth of the conveyance and on soil stability factors. Easements are not required for drywells, infiltration galleries, roof runoff swales, or other similar facilities except as directed by the City.

Default easements for conveyances not associated with individual lots shall be as listed in Table 1.4.

Table 1.4 Default Easements for Conveyances

CONVEYANCE WIDTH	EASEMENT WIDTH
Channels < 30' wide	Channel + 20' from top, one side
Channels > 30' wide	Channel + 20' from top, both sides
Pipes/Outfalls < or = 60"	20' centered on pipe
Pipes/Outfalls > 60"	30' + pipe width, centered on pipe

Narrower easements may be approved based on consideration of pipe depth and soil conditions.

Prior to final project acceptance by the City of Lacey, 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.

1.5.2 Setbacks

Contact the City of Lacey regarding applicable setback standards in zoning, development, health, critical areas, or environmentally sensitive areas ordinances. In the absence of other applicable standards, the default values listed in Table 1.5 below shall apply. If any other law, regulation, or ordinance also provides for setbacks, the more restrictive shall apply.

Setbacks depicted in the BMP description figures for roof downspout control BMPs, dispersion control BMPs, and other BMPs depicted in Chapter 6 are “typical” and for reference only.

The City of Lacey may allow smaller setbacks than those shown in Table 1.5, if offsite properties will not be adversely affected. Smaller setbacks from structures may be allowed based on an adequate geotechnical/structural evaluation. At a minimum, the line of saturation, measured from the design storm elevation in the facility, shall fall a minimum of one foot below the lowest floor elevation.

A geotechnical report may be used to establish building foundation setbacks or slope setbacks that differ from the default setbacks in Table 1.5.

Table 1.5 Default Setbacks

SITE FEATURE	ENGINEERED INFILTRATION FACILITY	DRYWELLS OR TRENCHES FOR SINGLE-FAMILY RESIDENCES
Onsite/septic system	Contact Thurston County Environmental Health	30 feet/10 feet
Water supply well	Contact Thurston County Environmental Health	30 feet/10 feet
Building foundation or basement	100 feet/20 feet	50 feet/10 feet
Slopes over 15 percent	50 feet	25 feet

- For setbacks expressed as x/y, the larger setback is for downgradient site features.

- The Administrator 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.

- Comply with other applicable setback requirements, such as may be in critical areas ordinances or Building or Plumbing Codes

1.6 ADJUSTMENTS

Adjustments to the Core Requirements may be granted prior to permit approval and construction. The City's drainage manual administrator may grant an adjustment, subject to a written finding of fact, that documents the following:

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

1.7 EXCEPTIONS/VARIANCES

Exceptions/variances to the Core Requirements may be granted prior to permit approval and construction, pursuant to provisions of the Lacey Municipal Code (LMC). Title 2, Chapter 2.30 Land Use Hearings Examiner, Title 16, Chapter 16.90 Variances, and other sections of the LMC may be applicable. The LMC is available on the City of Lacey website at:

http://www.ci.lacey.wa.us/lmc/lmc_main_page.html

1.8 RELATED PERMITS, MANUALS AND PLANS

In addition to the Core Requirements and related criteria in this stormwater manual, and other permit requirements of the City of Lacey, other stormwater-related permits, manuals and plans may apply to a project site, including the following.

1.8.1 Western Washington Phase II Municipal Stormwater Permit

The City of Lacey, along with dozens of other jurisdictions in western Washington, is subject to permitting under the U.S. Environmental Protection Agency (EPA) Phase II Stormwater Regulations (40 CFR Part 122). The Washington State Department of Ecology ("Ecology") has issued the permit, formally titled the National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Small Municipal Separate Storm Sewers in Western Washington, to regulate stormwater discharges.

The Western Washington Phase II Municipal Stormwater Permit was issued on January 17, 2007, and modified on June 17, 2009. The Permit is available on Ecology's website: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/PermitsPermit tees.html

1.8.2 Low Impact Development Technical Guidance Manual for Puget Sound

The "LID Manual" is published by the Puget Sound Partnership and provides guidance on LID techniques and design procedures in Washington State. Ecology recognizes the LID Manual and references it in the *Stormwater Management Manual for Western Washington* (2005). The LID Manual can be found at the Puget Sound Partnership website: http://www.psp.wa.gov/documents.php

1.8.3 Basin and Watershed Plans

Projects may be subject to equivalent or more stringent requirements for erosion control, source control, treatment, operations and maintenance (O&M), and alternative requirements for flow control and wetlands hydrologic control as identified in basin/watershed plans.

Basin/watershed plans shall evaluate and include, as necessary, retrofitting of urban stormwater BMPs for existing development or redevelopment to achieve watershed pollutant reduction and flow control goals consistent with requirements of the Clean Water Act. Standards developed from basin plans shall not modify any minimum requirement until the basin plan is both formally adopted and implemented by the local governments within the basin, and approved or concurred with by Ecology. Refer to Appendix I-A of Ecology's 2005 *Stormwater Management Manual for Western Washington* for examples of how basin planning can alter the minimum requirements.

As of the effective date of this manual, the following basin plans that may potentially affect project sites within Lacey have been adopted:

- Woodland and Woodard Creek Basin (within the City of Lacey, and the UGA to the north, south and east of Lacey);
- Chambers/Ward/Hewitt Creek Basin (western Lacey);
- McAllister/Eaton Creek Basin (eastern Lacey, and the UGA to the east of Lacey).

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

http://www.co.thurston.wa.us/stormwater/Basin%20Plans/Basin Plans home.htm

1.8.4 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 2005 *Stormwater Management Manual for Western Washington*:

Construction Stormwater Permit (NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated with Construction Activity): For construction sites with one or more acres of disturbed area with the potential to discharge stormwater to surface waters.

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

Section 401 Water Quality Certifications: Certification required for projects that require a fill or dredge permit under Section 404 of the Clean Water Act.

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.

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.

Underground injection control program: An Ecology program (WAC 173-218) which may require registration or restrictions for certain infiltration systems (see Ecology website for more information).

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Appendix 1A
Guidance for Altering Core Requirements through Basin Planning

Basin Planning Applied to Source Control (Core Requirement #3)

Basin plans can identify potential sources of pollution and develop strategies to eliminate or control these sources to protect beneficial uses. A basin plan can include the following source control strategies:

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

Basin Planning Applied to Runoff Treatment (Core Requirement #6)

Basin plans can develop different runoff treatment requirements and performance standards to reduce pollutant concentrations or loads based on an evaluation of the beneficial uses to be protected within or downstream of a watershed. Consideration must be given to the antidegradation provisions of the Clean Water Act and implementing state water quality standards. The evaluation should include an analysis of existing and future conditions. Basin specific requirements and performance standards can be developed based on an evaluation of pollutant loads and modeling of receiving water conditions.

The Basic Treatment Level is viewed as a minimum technology-based requirement that must be applied regardless of the quality of the receiving waters. Additional levels of control beyond the Basic Treatment Level of Core Requirement #6 may be justified in order to control the impacts of future development.

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

Basin Planning Applied to Flow Control **(Core Requirement #7)**

Basin planning is well-suited to control stream channel erosion for both existing and future conditions. Flow control standards developed from a basin plan may include a combination of on-site, regional, and stream protection and rehabilitation measures. On-site standards are usually the primary mechanism to protect streams from the impacts of increased high flows in future conditions. Regional flow control facilities are used primarily to correct existing stream erosion problems. Basin plans can evaluate retrofitting opportunities, such as modified outlets for existing stormwater detention facilities.

Stream protection and rehabilitation measures may be applied where stream channel erosion problems exist that will not be corrected by on-site or regional facilities. However, caution is urged in the application of such measures. If the causes of the stream channel erosion problems still exist, repairs to the physical expression of those problems may be short-lived. In some instances, it may be prudent to apply in-stream measures to reduce impacts until the basin hydrology is improved.

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

Basin Planning Applied to Wetlands and other Sensitive Areas

(Core Requirement #8)

Basin planning can be used to develop alternative protection standards for wetlands and other sensitive areas, such as landslide hazard areas, wellhead protection areas, and ground water quality management areas. These standards can include source control, runoff treatment, flow control, stage levels, and frequency and duration of inundations.

Chapter 2 - Drainage Plans and Reports

This chapter details the requirements for stormwater drainage-related engineering plans and reports, to be submitted as part of a permit application for Site Plan Review to the City of Lacey Department of Public Works. The submittals described in this chapter are required for compliance with Core Requirement #1, Preparation of Stormwater Site Plans and Reports, and preparation of a Construction Stormwater Pollution Prevention Plan (SWPPP) per Core Requirement #2.

This chapter primarily describes how to submit drainage plans and reports for proposed development projects for review by the City of Lacey. The basic drainage requirements these submittals must address are contained in Chapter 1, with design methods, details, and criteria included in other chapters. A Checklist for Development Project Drainage Submittal is included in Appendix 2B, to assist in preparing a complete submittal for drainage review.

The intent of these requirements is to present a framework so the design plans and technical support data required to develop the plans follow consistent formats. These conventions are necessary to facilitate efficient review and evaluation of engineering designs for compliance with Lacey ordinances and regulations. Complete and properly prepared engineering plans, reports and supporting information will facilitate the approval process, the construction process, and the long-term operation and maintenance of the proposed stormwater system.

State law requires that engineering work (such as stormwater facility design) shall be performed by or under the direct supervision of a professional engineer licensed to practice in Washington state. Construction Stormwater Pollution Prevention Plans (SWPPPs) that involve engineering principles must also be prepared by or under the direction of a licensed engineer.

Chapter Organization

The information in this chapter is organized as follows:

- Section 2.1 Drainage Review Types and Submittals

  Describes the type of permit or project, the type of drainage review required, and the plans that must be submitted for drainage review.
- Section 2.2 Drainage Submittals for Initial Permit Application

  Describes in detail the submittal requirements related to drainage and stormwater management for initial permit applications.
- Section 2.3 Stormwater Site Plans for Drainage Review

  Describes the contents and specifications for drainage plans and reports.
- Section 2.4 Preparation of Stormwater Site Plans

  Describes the general procedure for drainage design and plan preparation.

- Section 2.5 Plans Required After Drainage Review
  Addresses plan changes after permit issuance, and final submittals.
- Section 2.6 Plans Required After Stormwater Site Plan Approval
  Describes the requirements for plan changes and corrections.

2.1 Drainage Review Types and Submittals

This section provides an overview of the types of plans required for drainage review at various permit stages. The type of permit or project, and the type of drainage review required determines the complexity of the plans that must be submitted for drainage review. Information on other permit requirements and materials, including applications, fees, right-of-way use requirements and other code requirements can be obtained from the Lacey Public Works Department.

Table 2.1 summarizes the submittal requirements for the various types of developments permitted by Lacey at the permit application stage and at the design review stage.

The requirements for the various submittals listed in Table 2.1 are described in subsequent sections of this chapter.

Table 2.1 Drainage Submittals

Type of Permit or Project	Type of Drainage Review	Submittals for Permit Application	Submittals for Drainage Review
Subdivisions, Binding Site Plans	Partial or Full	Plat Map, Preliminary Plans, Level 1 Down-stream Analysis	Engineering Plans, Drainage Report
Commercial or Industrial	Partial or Full	Engineering Plans	Engineering Plans, Drainage Report
Short Plats, Single-Family Residential	Partial	Site Plan	Small Project Drainage Plan
	Partial or Full	Site Plan	Engineering Plans, Drainage Report
Other	Partial or Full	Project-specific	Engineering Plans, Drainage Report

Full Drainage Review is required for all projects that result in greater than 5,000 sf of new impervious surface, or converts greater than 0.75 acre of native vegetation to lawn, or converts more than 2.5 acres from native vegetation to pasture. Under Full Drainage Review, all Core Requirements must be met, and the Drainage Report must address (include) all sections.

Partial Drainage Review is required for projects that do not meet the thresholds for Full Drainage Review. Based on the project type and size, as defined below, a subset of the Core Requirements must be met, and the scope of the Drainage Report is reduced accordingly, as shown in Table 2.2.

Type 1 - Small Project: A single-family residence or duplex project.

Type 2 - Critical Area Project: Projects that contain or are adjacent to a flood, erosion or steep slope hazard area, or land-disturbing activities greater than 7,000 sf

Type 3 - Drainage Modification: Projects that construct or modify a drainage pipe with diameter 12 inches and greater (or ditch with equivalent flow capacity), or receives runoff from such a pipe/ditch.

Table 2.2 Drainage Review Types and Requirements

Type of Drainage Review	*Applicable Core Requirements (CR)*	*Minimum Applicable Drainage Report Sections*
Full Drainage Review	All (CR 1-10)	All (Sections 1-10, plus all appendices)
Partial Drainage Review Type 1 Small Project	CR 2	Sections 1, 2, 3, 8 plus applicable appendices
Partial Drainage Review Type 2 Critical Area Project	CR 1-5 apply to new and replaced impervious surface and disturbed land; other adopted relevant requirements	Sections 1, 2, 3, 8 plus applicable appendices
Partial Drainage Review Type 3 Drainage Modification	CR 1-5, 9	Sections 1, 2, 3, 6, 8, 9 plus applicable appendices

Note: For Drainage Report Sections, see Section 2.3.2

The City of Lacey may require application of additional Core Requirements or other requirements, and/or Drainage Report sections, on a project-by-project basis according to the circumstances of each project.

2.1.1 Pre-Submittal Conference

Most projects will require a pre-submission meeting, after which the appropriate permit applications will be issued. Drainage review requirements will be addressed at this meeting. For further information on the application process, refer to the City of Lacey *Development Guidelines and Public Works Standards.*

2.1.2 Plans Required for Permit Submittal

Most projects require some level of drainage analysis and plans to be submitted with the initial development permit application. Table 2.1 lists the types of plans required for each category of development. The permit submittals may require engineering or not depending on the type of project. "Preliminary plans" and "plat maps" for subdivisions and binding site plans and "engineering plans" for commercial/industrial development are engineered plans. "Site plans" for short plats and single-family residential projects are not required to be engineered plans.

2.1.3 Plans Required for Drainage Review

Certain small projects under Partial Drainage Review may submit non-engineered plans using pre-engineered plans and details. Most Partial Drainage Review and all Full Drainage Review projects must submit fully engineered plans and reports.

Projects requiring Partial or Full Drainage Review must submit Engineering Plans and an engineered Drainage Report addressing all of the applicable Core Requirements.

2.1.4 Design Plan Certification

All preliminary plans, engineering plans and drainage reports must be stamped and signed by a civil engineer licensed in the State of Washington.

All land boundary surveys and legal descriptions used for preliminary and engineering plans must be stamped and signed by a land surveyor licensed in the State of Washington. Topographic survey data and mapping prepared for a proposed project may be performed by the civil engineer who stamps the engineering plans.

2.2 Drainage Submittals for Initial Permit Application

This section describes in detail the submittal requirements for initial permit applications. Note that this section addresses only the required submittals related to drainage and stormwater management. Other required submittals are detailed in the applicable permit application.

2.2.1 Subdivisions and Binding Site Plans

Applications for proposed subdivisions and binding site plan projects must include engineered preliminary plans, which shall include the following elements:

1. An initial site analysis, including general soils information and an initial assessment of the feasibility of using L.I.D. methods on the site (see Chapter 3, Site & Vicinity Analysis, Section 3.1).

2. A conceptual drainage plan prepared, stamped and signed by a civil engineer licensed in the State of Washington, showing the location and type of the following features:
   - Existing and proposed flow control facilities
   - Existing and proposed water quality facilities
   - Existing and proposed conveyance system

3. A site plan including the following:
   - Field topographic base map
   - Name and address of land surveyor; land surveyor's seal and signature
   - Notation for field or aerial survey
   - Datum and benchmark/location and basis of elevation
   - Contour intervals 2 feet at slope $< 15\%$; 5 feet at slope $\geq 15\%$
   - Location of all on-site and adjacent critical areas

4. A Level 1 (qualitative) Downstream Analysis, as described in Chapter 3, Section 3.2. A higher level of downstream analysis may be required prior to preliminary approval or as a condition of engineering plan submittal. The Downstream Analysis must be prepared, stamped and signed by a civil engineer licensed in the State of Washington.

All plans submitted to the City of Lacey shall meet the criteria for maps and plan sheets specified in the latest version of the Development Guidelines and Public Works Standards.

2.2.2 Commercial and Industrial Site Development

Engineering plans, as described in Section 2.3.1, for commercial/industrial permits must be submitted as part of the initial permit application. Most such projects will go through Full Drainage Review. Projects that may qualify for Partial Drainage Review should request that designation at the pre-application meeting.

2.2.3 Short Subdivisions and Single-Family Residences

Applications for short plats require a plot plan, which is a simplified preliminary plan. Plot plans shall include the following information:

1. A conceptual drainage plan showing the location and type of the following features:
    a. Existing and proposed flow control facilities
    b. Existing and proposed water quality facilities
    c. Existing and proposed conveyance system
2. A site plan including the following:
    a. General site topography
    b. Existing and proposed structures
    c. Existing on-site and adjacent water features

2.3 Stormwater Site Plans for Drainage Review

This section presents the contents and specifications for plans and reports to be submitted for drainage review. These requirements apply to projects subject to Partial or Full Drainage Review. Drainage review submittals shall consist of a Stormwater Site Plan with engineered Drainage Plan Drawings, Drainage Report, Construction SWPPP and Stormwater Facilities Maintenance Plan.

The Stormwater Site Plan is the comprehensive document containing all of the technical information and analysis necessary for the City of Lacey to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. It comprises the entire drainage-related submittal to the City, and addresses the two main phases of stormwater control at a site: during construction (the temporary erosion and sediment control plan), and after construction (the permanent stormwater control plan).

The contents of the Stormwater Site Plan will vary with the type and size of the project and individual site characteristics. The scope of the Stormwater Site Plan also varies depending on the applicability of the Core Requirements (see Chapter 1), but will generally contain the following main components:

- **Drainage Plan Drawings**

  Engineered drainage plan maps, profiles and details for facilities construction; Full-size plan sheets shall be included in the civil plan set, with reduced-size sheets in the drainage report. See description below in Section 2.3.1.

- **Drainage Report**

  Design information, calculations, plans, details, specifications and supplemental data in a bound report. See description below in Section 2.3.2.

- **Construction Stormwater Pollution Prevention Plan (SWPPP)**

  Addressing the 12 elements listed in Core Requirement #2; bound separately, with final copies for use at the construction site. See below and Chapter 4.

- **Stormwater Facilities Maintenance Plan**

  For long-term operation, maintenance and functionality of drainage systems; bound separately, with final copies for finished-site owner to use at the site. Refer to Chapter 9 for description of contents.

The intent of Sections 2.3 and 2.4 is to provide a framework for uniformity in plan preparation and presentation. Such uniformity will increase the efficiency of the review and approval process. Properly drafted engineering plans and clear, complete supporting documents will also facilitate the construction of facilities, and their long-term maintenance and functionality.

State law requires that engineering work be performed by or under the direction of a professional engineer licensed to practice in Washington State. Plans involving construction of facilities for treatment and/or flow control (such as detention ponds or infiltration basins), structural source control BMPs, or drainage conveyance systems generally involve engineering principles and shall be prepared by or under the direction of a licensed engineer. Construction Stormwater Pollution Prevention Plans (SWPPPs) that involve engineering calculations and an engineered design must also be prepared by or under the direction of a licensed engineer.

2.3.1 Drainage Plan Specifications

Full and Partial Drainage Review require engineered stormwater drainage plans containing the following two main elements:

1. Site Improvement Plans - for permanent stormwater control
2. Temporary Erosion & Sediment Control (TESC) Plans - for the construction phase

Full-size plan sheets shall be submitted for review along with the remainder of the civil plan set, and reduced-size (11” x 17”) fold-outs of the drainage and TESC plan sheets shall be included in the drainage report.

2.3.1.1 Site Improvement Plans

Site Improvement Plan drawings supporting the Stormwater Site Plan shall be sufficiently clear and concise for engineering review and to construct the project in proper sequence, using specified methods and materials, with sufficient dimensions to fulfill the intent of drainage laws, ordinances and this manual. All plans shall meet the criteria for plan sheets specified in the latest version of the Development Guidelines and Public Works Standards. Plans will include sheets adequate to display the following:

- Vicinity Map
    - Project boundaries
    - Sub-basin boundaries
    - Off-site areas tributary to the project
    - Existing ground contours
    - Major drainage features (e.g., streams, channels, wetlands, ponds)
    - Receiving waters and flow path(s) to receiving water.

- Site Map
    - Property boundaries
    - Existing and proposed features and structures on-site and within 100 feet of project boundaries
    - Easements
    - Roads and right-of-way
    - Existing and proposed utilities: sewer, water, power, communications, etc.
    - Common open space
    - Public dedications
    - Existing topography for the project site and at least 50 feet beyond site boundaries
    - Ground surface elevations around points of stormwater discharge extending at least 50 feet downstream of all discharge points; spot elevations as necessary to delineate boundaries and depth of existing hydrologic features (floodplains, wetlands, channels, swales, streams, depressions, springs, seeps, storm drain systems, ditches, pipes)
    - Flow direction arrows for surface flow and for conveyance systems
    - Location and size of other natural features (existing vegetation, trees, etc.)
    - Finished grades

2.3.1.2 Temporary Erosion and Sediment Control Plans

The Stormwater Pollution Prevention Plan (SWPPP) for the construction phase of the project includes Temporary Erosion and Sediment Control (TESC) Plan drawings and the SWPPP report narrative. The SWPPP provides descriptions and information for the twelve elements listed for Core Requirement #2, and all the supporting information and additional direction necessary for implementing TESC measures. The SWPPP shall be prepared as a stand-alone document, with a summary in Section 4 of the Drainage Report.

Using the Site Improvement Plan as a base, the TESC Plan shall at a minimum illustrate the following information:

- Base map required information;
- Existing and proposed roads, driveways, parking areas, buildings, drainage facilities, and utility corridors not associated with roadways;
- Critical areas and their buffers
- Proposed final topography.

The SWPPP shall be generally designed for proposed topography, but shall address all phases of construction. Separate SWPPPs for different project phases may be required. The SWPPP shall be revised as necessary, or as directed by the City of Lacey, to address changing site conditions.

The TESC Plan drawings shall be consistent with the SWPPP narrative and shall include:

1. Clearing limits.
2. Areas with high susceptibility to erosion.
3. Critical area limits, buffers and compliance measures.
4. Details sufficient to illustrate the design.
5. ESC measures for on- and off-site utility construction.
6. The construction sequence specified.
7. Standard ESC plan notes (see Appendix 4B).
8. An inspection and maintenance program, with designation of a Certified ESC supervisor and 24-hour contact number(s) (per BMP C160, page 4-53).

The TESC Plan shall contain the following information related to specific erosion and sediment control measures, as applicable:

Cover Measures

1. Type(s) and location(s) of temporary cover measures;
2. Conditions that control use of different types of covers (e.g. season, soil, slope)
3. Type(s) and location(s) of permanent cover measures;
4. Approximate quantity of each cover measure;
5. Sufficient detail for installation;
6. Mulch types, seed mixes, fertilizers, and soil amendments specifications and application rates;

7. Surface roughening areas, methods and equipment;
8. PAM locations and application methods.

Perimeter Protection

1. Location(s) and type;
2. Typical details;
3. Fabric type for silt fence;
4. Documentation that compost meets Grade A standards (WAC 173-350-220)

Traffic Area Stabilization

1. Location of construction entrances;
2. Typical details for construction entrances;
3. Location of construction roads and parking areas;
4. Measure to create and maintain stabilized construction roads and parking areas;
5. Location and typical details of wheel wash/tire bath;
6. List of dust control products and location of application areas.

Sediment Retention

1. Trap/pond location(s);
2. Pond berm dimensions and slopes;
3. Storage required and stage-storage table;
4. Section view(s) through pond and outlet structure;
5. Documentation of DOE approval of chemical or electro-coagulation treatment;
6. Details for disposal of chemically-treated waters;
7. Documentation of local sewer district approval for discharge to sanitary sewer;
8. Details of control structure, dewatering mechanism, inlet/outlet protection;
9. Cell divider details;
10. Indicate depth gage for sediment measurement;
11. Catch basins to be protected, catch basin protection details.

Surface Water Control

1. Locate all pipes, ditches, interceptor ditches, dikes, berms, swales, level spreaders, flow splitters, check dams, etc.;
2. Details sufficient for installation and maintenance;
3. Locations of and outlets from dewatering systems, including backup if necessary;
4. Temporary conveyance inverts.

Wet Season Requirements

1. List all wet season requirements; state clearly on plans.

2.3.2 Drainage Report Specifications

The Drainage Report portion of the Stormwater Site Plan is a comprehensive document containing all the technical information, analysis and supporting data needed to develop the Site Improvement Plan. The report must contain all calculations, conceptual design analysis, supplemental studies and reports (e.g., soils reports, wetland delineations, etc.) used to develop the drainage plans.

The Drainage Report shall contain the following components, sections and appendices:

Title Page
Project Engineer's Certification
Table Of Contents

Section 1.	Overall Project Summary	
Section 2.	Conditions and Requirements	(reference: Chapter 1)
Section 3.	Site & Vicinity Analysis	(ref: Chapter 3)
Section 4.	Construction Erosion & Sediment Control Summary	(ref: Chapter 4)
Section 5.	Conveyance System Analysis & Design	(ref: Chapter 5)
Section 6.	Flow Control Facilities Analysis & Design	(ref: Chapter 6)
Section 7.	Water Quality Facilities Analysis & Design	(ref: Chapter 7)
Section 8.	Stormwater Pollution Prevention & Source Control	(ref: Chapter 8)
Section 9.	Storm Facilities Operation & Maintenance Summary	(ref: Chapter 9)
Section 10.	Agreements and Guarantees	(ref: Chapter 10)

Appendices:

Appendix 1. Stormwater Facility Summary Forms

Appendix 2. Site Stormwater Drainage Plans & Details (11"x 17" fold-out map sheets of the Site Improvement Plans and the Temporary Erosion and Sediment Control Plans)

Appendix 3. Design Calculations (WWHM printouts, tables and data used, etc.)

Appendix 4. Supplemental Reports and Information (soils report, wetlands, etc.)

Appendix 5. Construction Stormwater Pollution Prevention Plan (SWPPP)

Appendix 6. Stormwater Facilities Maintenance Plan (including Source Control Plan and Vegetation Management Plan – see Chapter 9)

All Drainage Reports must contain these sections, though some may not apply to a given project. In that case, the section may be marked "N/A" with a brief explanation. The *Checklist for Development Project Drainage Submittal* (Appendix 2B) shall be used to verify that all required elements of the Drainage Report and plans have been addressed. Submit the completed Checklist with the Stormwater Site Plan/drainage report submittal.

Revisions to a Drainage Report shall be submitted as a complete revised report.

Drainage Report Section 1
Overall Project Summary

The project summary must provide a general description of pre-developed and proposed site conditions, site and project site area, description and size (extent) of improvements and a description of stormwater runoff before and after development.

For re-development projects, the summary must also indicate the current assessed building value and the cost of proposed improvements (excluding land value).

The project summary shall include a **site location map** showing the general site location and identifying roads or features that border the site, and all significant geographical features and critical areas in the vicinity.

Section 1 shall include one or more tables summarizing the existing and proposed impervious area, disturbed pervious area, and undisturbed area, for each sub-basin defined for the project and in total.

The summary will include descriptions of the following:

- Proposed drainage system operation (step-by-step)
- Conveyance methods
- Storage/detention features
- Water quality treatment features
- Results of LID (low impact development) feasibility analysis & LID design considerations
- Landscaping and aesthetic considerations for facilities

The project summary shall also include a summary of conveyance, flow control and water quality facility sizing calculations, preferably in a tabular format.

Drainage Report Section 2
Conditions and Requirements

This section describes the Core Requirements applicable to the project, and the basis for applying those requirements (e.g. Full Drainage Review based on project characteristics).

It also describes any additional requirements based on other conditions, such as (but not necessarily limited to) the following:

- adopted basin plans
- location of the project in a basin draining to a water quality-impaired water body or subject to a TMDL (such as the Henderson Inlet watershed)
- location of the project in an aquifer sensitive area or Wellhead Protection Area

- presence of critical areas (wetlands, Threatened and Endangered Species habitat, flood hazard areas, erosion hazard areas, steep slopes) on or near the project
- project will discharge to a known downstream conveyance/flooding problem.

Construction of developments, roads or drainage facilities may require additional permits from other agencies. These permits may contain more restrictive drainage requirements than those in this manual. This section of the report must identify any such permits and the permit requirements that affect the drainage plan. Refer to Chapter 1 of this manual for information on the Core Requirements and additional requirements that may apply.

Drainage Report Section 3
Site and Vicinity Analysis

The site and vicinity analysis section is used to report the results of the Site and Vicinity Analyses described in Chapter 3 of this manual. This section will report the following:

- Study area definition
- Resource review results (existing trees, wells, fuel tanks, septic systems, etc.)
- Field inspection results (site features and conditions)
- Suitability for L.I.D. (areas that drain well, soils and vegetation to preserve, etc.)
- Drainage system and drainage problem description
- Mitigation measures

The site analysis includes analysis of drainage, soils and environmental conditions, and summaries of the soils report and any other applicable reports & studies (e.g. wetlands). Complete reports and studies shall be included in Appendix 2 of the Drainage Report.

Details regarding the requirements for and contents of the Soils Report are provided in Chapter 3.

The following figures shall be included in the report:

- **General vicinity, site and drainage maps** that shows the following:

  a. Limits of analysis area;
  b. Offsite tributary areas and points of discharge to the project;
  c. Sub-basins and associated acreage;
  d. Existing discharge points to and from site;
  e. Routes of existing, construction phase and future flows;
  f. Receiving waters

  The vicinity map should clearly locate the property, identify all roads bordering the site, show the route of stormwater off-site to the local natural receiving water, and show significant geographic features and sensitive/critical areas (streams, wetlands, lakes, steep slopes, etc.).

The site map should display the acreage and outlines of all drainage basins; routes of existing, construction, and future flows at all discharge points; and the length of travel from the farthest upstream end of a proposed storm drainage system to any proposed flow control and treatment facility.

- **Soils map** showing the soil types in the study area

Thurston County soil survey maps may be used, but it is the design engineer's responsibility to verify the soils at the site and to otherwise document soil conditions (e.g. infiltration capacity, restrictive layers, etc.) relevant to stormwater management.

Drainage Report Section 4
Construction Erosion and Sediment Control Summary

Section 4 presents the analysis and design of the Erosion and Sediment Control (ESC) Plan. This includes both the technical basis of the ESC Plan as described in Section 2.3.1.2 above, and the basis for the Construction Stormwater Pollution Prevention Plan (SWPPP). Refer to Chapter 4 for construction ESC standards and guidance.

This section shall include:

- Sufficient information to justify the overall ESC plan and the choice of individual ESC measures
- All hydrologic and hydraulic information and calculations used to analyze and size ESC facilities
- Identification of areas with a high susceptibility to erosion and special protection measures
- Identification of any ESC recommendations from special reports for the project
- Identify the project's designated Certified Erosion and Sediment Control Lead (name, contact information, certification number).
- Construction sequence, inspection/maintenance schedule and phasing (when applicable)
- Supporting documentation for any proposed exceptions to or modifications of the standards

This section shall also:

- Identify all activities during construction that could contribute pollutants to surface or stormwater (other than sediment)
- Identify typical measures used to prevent spills and exposure of such pollutants to stormwater

Drainage Report Section 5
Conveyance System Analysis and Design

This section will document the methods and results of analyses used to evaluate and design the conveyance system per the hydraulic computation guidance in Chapter 5.

This section will contain two parts, as follows:

Part A Performance Standard

This part briefly summarizes the applicable performance standard (e.g., 25-year return period peak runoff) used for the conveyance system.

Part B Conveyance System

This part provides a brief narrative description of the conveyance system, and identifies all components of the system, including pipes, inlets, manholes, open channels, natural channels, and culverts.

The minimum information presented for the conveyance system shall include, as applicable:

- Design flow rates for each component
- Pipe/culvert/ditch dimensions, inverts, slopes and flow capacities

All calculations, equations, graphs, nomographs and references used shall be provided in Appendix 3 of the Drainage Report (Design Calculations), and summarized in this section.

Drainage Report Section 6
Flow Control Facilities Analysis and Design

This section will document the methods and results of analyses used to determine flow control requirements and to design flow control facilities, per the guidance in Chapter 6.

This section will contain three parts, as follows:

Part A Existing and Developed Hydrology

Part B Performance Standards

Part C Flow Control System

Part A Existing and Developed Hydrology

The following information shall be reported for existing and proposed conditions:

- o Analysis methodology (e.g,, WWHM3), assumptions and inputs
- o Land-covers (type, area, etc.) for total site and for each subarea
- o Soil hydrologic factors

At a minimum, the following information must be provided on a topographical map:

- o delineation and acreage of areas draining to the site
- o delineation of on-site drainage basin/subbasin areas
- o flow control facility locations
- o outfalls
- o overflow route(s)
- o natural streams and drainage features

Part B Performance Standards

This part documents the applicable flow control standard.

Part C Flow Control System

This part provides a brief narrative description of the flow control system and identifies and describes all components of the flow control system, including BMPs, control structures and flow splitters, as applicable.

The locations of all flow control system components shall be shown in site plan exhibit(s). Dimensions, elevations and stage-storage relationships of flow control facilities shall be provided. Provide section views showing inflow, outflow, design water surface levels, minimum freeboard, and elevations of high groundwater and restrictive soil layers when applicable.

All calculations (WWHM files, orifice calculations, and other calculations) used to design the flow control system shall be provided in Appendix 3 of the Drainage Report (Design Calculations), and summarized in this section.

Drainage Report Section 7
Water Quality Facilities Analysis and Design

This section will document the methods and results of analyses used to determine water quality requirements and to design water quality facilities, per the guidance in Chapter 7.

This section will contain two parts, as follows:

Part A   Treatment Standard

This part documents the applicable water quality treatment standard (e.g., basic or phosphorus-control).

Part B   Water Quality Treatment System

This part provides a brief narrative description of the proposed water quality facilities, and provides a design summary for each facility. The location of each facility shall be shown on a drainage exhibit.

The design summary for each facility shall include the following information, as applicable:

- maps and data of area and subareas draining to facility
- areas of pollutant-generating impervious and pervious surfaces draining to the facility
- design water quality flow rate or volume
- stage-storage relationship
- dimensions, inverts and elevations (on exhibit)

All calculations, equations, graphs and references used shall be provided in Appendix 3 of the Drainage Report (Design Calculations), and summarized in this section.

Drainage Report Section 8
Stormwater Pollution Prevention and Source Control

This section will document the specific Best Management Practices to apply to the project site to prevent stormwater from contacting pollutants, and to address and control potential sources of pollution, per the guidance in Chapter 8.

The goal of source control is to apply pollution prevention practices on a developed site to reduce the contamination of stormwater runoff at it source – where the rain falls and runoff begins. Pollution prevention reduces the amount of contaminants in runoff water, which in turn reduces the discharge of contaminants into the environment.

Drainage Report Section 9
Stormwater Facilities Operation and Maintenance Summary

All flow control, water quality, and other drainage-related facilities that are to be privately maintained shall be provided with a Stormwater Facilities Maintenance Plan based on the guidance in Chapter 9, and included in full in Appendix 6 of the Drainage Report (see below). Section 9 of the Drainage Report shall provide a summary of the

Maintenance Plan, including an outline of inspection and maintenance tasks for each facility, and the recommended frequency with which each task shall be performed, to maintain facility functionality and compliance with design criteria and standards.

Drainage Report Section 10
Agreements and Guarantees

Any agreements and guarantees, as determined by application of the guidance in Chapter 10 of this manual, shall be included in this section of the Drainage Report.

Bond Quantities Worksheet

If the City requires a performance bond or other financial guarantee for proper construction and operation of construction site BMPs, and/or proper construction and functioning of permanent drainage facilities, the design engineer shall provide documentation to establish the appropriate bond amount, and include it in Section 10.

DRAINAGE REPORT APPENDICES

Drainage Report Appendix 1
Stormwater Facility Summary Forms

Provide completed standard forms for all proposed stormwater facilities. Stormwater Facility Summary Forms are in Appendix 3B at the end of Chapter 3 of this manual.

Drainage Report Appendix 2
Site Stormwater Drainage Plans and Details

Provide 11” x 17” fold-out reductions of the site plan, vicinity map, drainage plans, drainage facility details, conveyance systems, construction-phase temporary erosion and sediment control plans, and other relevant maps and graphics. Maps, details and illustrations that are not part of the plan set may be presented on 8 ½” x 11” sheets provided the information is clearly presented.

Drainage Report Appendix 3
Design Calculations

Provide complete calculations for the conveyance, flow control and water quality facilities, including printouts of the WWHM computation files and any other computer printouts or manual calculations used in the stormwater design. Present the calculations in a clear and orderly manner, labeled and annotated as needed, to facilitate an efficient review and approval process.

Drainage Report Appendix 4
Supplemental Reports and Information

Depending on site and vicinity characteristics, various special reports and studies may be required to provide supplemental information.

The various types of supplemental reports and information may include:

- Soils Report
- Soil Management Plan (to meet Core Requirement #5, per BMP LID-09)
- Wetland Delineation and Description
- Floodplain delineation
- Flood protection facility conformance
- Critical areas analysis and delineation
- Geotechnical/geology
- Groundwater quality and/or hydrogeology
- Slope protection/stability
- Erosion/deposition
- Hydrology/Fluvial geomorphology
- Anadromous fisheries impacts
- Surface water quality
- Structural engineering

Such reports must be prepared and certified by professionals in the field.

Drainage Report Appendix 5
Construction Stormwater Pollution Prevention Plan

Provide the complete Construction SWPPP as described in Chapters 1 and 4 of this manual.

Drainage Report Appendix 6
Stormwater Facilities Maintenance Plan

The full Stormwater Facilities Maintenance Plan document, described in Chapter 9, shall be included in this Appendix. The Maintenance Plan includes a description of the site drainage systems, an outline of inspection and maintenance tasks for each facility, and the recommended frequency with which each task shall be performed, with the goal being to maintain facility functionality and compliance with design criteria and standards. The Maintenance Plan also includes a Source Control Plan and a Vegetation Management Plan. The final version shall also be bound separately for the site facilities owner.

2.4 Preparation of Stormwater Site Plans

This section describes the general procedure for site analysis, drainage design and preparing stormwater drainage plans and reports.

2.4.1 Stormwater Site Plans: Step-By-Step

The eight general steps involved in developing a Stormwater Site Plan are listed below.

1. Collect and Analyze Information on Existing Conditions
2. Prepare Preliminary Development Layout
3. Perform Off-site Analysis (at the local government's option)
4. Determine Applicable Core Requirements
5. Prepare a Permanent Stormwater Control Plan
6. Prepare a Construction Stormwater Pollution Prevention Plan
7. Complete the Stormwater Site Plan
8. Check Compliance with All Applicable Minimum Requirements

The level of detail needed for each step depends upon the project size as explained in the individual steps. A narrative description of each of these steps follows.

Step 1 – Collect and Analyze Information on Existing Conditions

Collect and review information on the existing site conditions, including topography, drainage patterns, soils, ground cover, presence of any critical areas, adjacent areas, existing development, existing stormwater facilities, and adjacent on- and off-site utilities. Analyze data to determine site limitations including:

- Areas with high potential for erosion and sediment deposition (based on soil properties, slope, etc.); and

- Locations of sensitive and critical areas (e.g. vegetative buffers, wetlands, steep slopes, floodplains, geologic hazard areas, streams, etc.).

Delineate these areas on the vicinity map and/or a site map that are required as part of Step 7 – Completing a Stormwater Site Plan. Prepare an Existing Conditions Summary that will be submitted as part of the Site Plan. Part of the information collected in this step should be used to help prepare the Construction Stormwater Pollution Prevention Plan.

Step 2 – Prepare Preliminary Development Layout

Based upon the analysis of existing site conditions, locate the buildings, roads, parking lots, and landscaping features for the proposed development. Consider the following points when laying out the site:

- Fit development to the terrain to minimize land disturbance;
  Confine construction activities to the least area necessary, and away from critical areas;
- Preserve areas with natural vegetation (especially forested areas) as much as possible;
- On sites with a mix of soil types, locate impervious areas over less permeable soil (e.g., till), and try to restrict development over more porous soils (e.g., outwash);
- Cluster buildings together;
- Minimize impervious areas; and
- Maintain and utilize the natural drainage patterns.

The development layout designed here will be used for determining threshold discharge areas, for calculating whether size thresholds under Core Requirements #6, #7, and #8 are exceeded (see Chapter 1), and for the drawings and maps required for the Stormwater Site Plan.

Step 3 – Perform an Offsite Analysis

An offsite analysis is required for projects that add 5,000 square feet or more of new impervious surface, or that convert ¾ acre of pervious surfaces to lawn or landscaped areas, or convert 2.5 acres of forested area to pasture.

The offsite (vicinity) analysis approach is outlined in Chapter 3. This approach relies first on a qualitative analysis. If the qualitative analysis indicates a potential problem, the City of Lacey will require a quantitative analysis and may require mitigation. For more information, see Chapter 3.

Step 4 – Determine and Read the Applicable Core Requirements

Chapter 1 establishes project size thresholds for the application of Core Requirements to new development and redevelopment projects. See the flow charts in Figures 1.2 and 1.3.

Step 5 – Prepare a Permanent Stormwater Control Plan

Select stormwater control BMPs and facilities that will serve the project site in its developed condition. A preliminary design of the BMPs and facilities is necessary to determine how they will fit within and serve the entire preliminary development layout. After a preliminary design is developed, the designer may want to reconsider the site layout to reduce the need for construction of facilities, or the size of the facilities by reducing the amount of impervious surfaces created and increasing the areas to be left undisturbed.

After the designer is satisfied with the BMP and facilities selections, the information must be presented within a Permanent Stormwater Control Plan. The Permanent Stormwater Control Plan is one of the two main components of a Stormwater Site Plan, along with the Construction Stormwater Pollution Prevention Plan (see Step 6, below).

The Drainage Report and Drainage Plans shall contain the following information related to the Permanent Stormwater Control Plan:

(a) Existing Site Hydrology

If flow control facilities are proposed to comply with Core Requirement #7, provide a listing of assumptions and site parameters used in analyzing the pre-developed site hydrology. The acreage, soil types, and land covers used to determine the pre-developed flow characteristics, along with basin maps, graphics, and exhibits for each subbasin affected by the project should be included. The pre-developed condition to be matched shall be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Provide a topographic map, of sufficient scale and contour intervals to determine basin boundaries accurately, and showing:

- Delineation and acreage of areas contributing runoff to the site;
- Flow control facility location;
- Outfall;
- Overflow route; and
- All natural streams and drainage features.

The direction of flow, acreage of areas contributing drainage, and the limits of development should be indicated. Each basin within or flowing through the site should be named and model input parameters referenced.

(b) Developed Site Hydrology

All Projects:

Totals of impervious surfaces, pollution-generating impervious surfaces, and pollution generating pervious surfaces must be tabulated for each threshold discharge area for which On-site Stormwater Management BMPs are the sole stormwater management approach. These are needed to verify that the thresholds for application of treatment facilities (Core Requirements #6 and #8) and flow control facilities (Core Requirements #7 and #8) are not exceeded.

Projects and Threshold Discharge Areas within Projects That Require Treatment and Flow Control Facilities:

Provide narrative, mathematical, and graphic presentations of model input parameters selected for the developed site condition, including acreage, soil types, and land covers, road layout, and all drainage facilities.

Developed basin areas, threshold discharge areas, and flows should be shown on a map and cross-referenced to computer printouts or calculation sheets. Developed basin flows should be listed and tabulated.

Any documents used to determine the developed site hydrology should be included. Whenever possible, maintain the same basin name as used for the pre-developed site hydrology. If the boundaries of a basin have been modified by the project, that should be clearly shown on a map and the name modified to indicate the change.

Final grade topographic maps shall be provided. Ecology recommends local governments also require finished floor elevations.

(c) Performance Standards and Goals

If treatment facilities are proposed, provide a listing of the water quality menus used (Chapter 7). If flow control facilities are proposed, provide a confirmation of the flow control standard being achieved (e.g., the Ecology flow duration standard).

(d) Flow Control System

Provide a drawing of the flow control facility and its appurtenances. This drawing must show basic measurements necessary to calculate the storage volumes available from zero to the maximum head, all orifice/restrictor sizes and head relationships, control structure/restrictor placement, and placement on the site.

Include computer printouts, calculations, equations, references, storage/volume tables, graphs as necessary to show results and methodology used to determine the storage facility volumes. Where the Western Washington Hydrology Model (WWHM) or other approved runoff model, is used, its documentation files should be included.

(e) Water Quality System

Provide a drawing of the proposed treatment facilities, and any structural source control BMPs. The drawing must show overall measurements and dimensions, placement on the site, location of inflow, bypass, and discharge systems.

Include WWHM or other approved model printouts, calculations, equations, references, and graphs as necessary to show the facilities are designed consistent with the Volume V requirements and design criteria.

(f) Conveyance System Analysis and Design

Present an analysis of any existing conveyance systems, and the analysis and design of the proposed stormwater conveyance system for the project. This information should be presented in a clear, concise manner that can be easily followed, checked, and verified. All pipes, culverts, catch basins, channels, swales, and other stormwater conveyance appurtenances must be clearly labeled and correspond directly to the engineering plans.

Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan (SWPPP)

The Construction SWPPP for projects adding or replacing 2,000 square feet of impervious surface or more, or clearing 7,000 square feet or more, must contain sufficient information to satisfy the local government Plan Approval Authority that the potential pollution problems have been adequately addressed for the proposed project.

An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise information concerning existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved.

The 12 Elements listed below (see Core Requirement #2 in Chapter 1, Section 1.2) must be considered in the development of the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the Construction SWPPP. These elements are described in detail in Section 1.2.2.1. They cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources.

The 12 Elements are:

- Mark Clearing Limits
- Establish Construction Access
- Control Flow Rates
- Install Sediment Controls
- Stabilize Soils
- Protect Slopes
- Protect Drain Inlets
- Stabilize Channels And Outlets
- Control Pollutants
- Control De-Watering
- Maintain BMPs
- Manage the Project

A complete description and BMPs applicable to each element is given in Chapter 4.

On construction sites that discharge to surface water, the primary consideration in the preparation of the Construction SWPPP is compliance with the State Water Quality Standards. The step–by-step procedure outlined in Chapter 4 is recommended for the development of Construction SWPPPs.

On construction sites that infiltrate all stormwater runoff, the primary consideration in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

Step 7 – Complete the Stormwater Site Plan

The Stormwater Site Plan encompasses the entire submittal to the City of Lacey for drainage review, as described in Section 2.3.2 above.

Step 8 – Check Compliance with All Applicable Core Requirements

A Stormwater Site Plan as designed and implemented should specifically fulfill all Core Requirements applicable to the project. The Stormwater Site Plan should be reviewed to check that these requirements are satisfied.

2.5 Plans Required After Drainage Review

This section addresses requirements for:

- Plan changes after permit issuance
- Final corrected plan submittal
- Final plat, short plat and binding site plan submittals

2.5.1 Plan Changes After Permit Issuance

Revised plans shall be submitted for approval prior to construction. The plan change submittal shall include the following:

- Plan change form or letter
- Revised Drainage Report or addendum
- Three sets of engineering plans
- Any other information needed for review

2.5.2 Final Corrected Plan Submittal

Corrected plans (professionally drafted revisions applied to the original approved plans) reflecting changes to the design made based on unforeseen field conditions or design improvements shall be submitted to the City. The ESC plan does not need to be included. The Final Corrected Plan must be stamped, signed and dated by a civil engineer licensed in the State of Washington.

2.5.3 Final Plat, Short Plat and Binding Site Plan Submittals

These submittals are required for approval and recording. Requirements and fees are available from the City of Lacey. Final submittals shall be accepted only after the approval of preliminary plans and any required engineering plans, and after the construction of any required drainage facilities.

All final map sheets and pages shall be prepared, stamped and signed by a land surveyor licensed in the State of Washington.

2.6 Plans Required After Stormwater Site Plan Approval

This section includes the specifications and contents required of those plans submitted after the City has approved the original Stormwater Site Plan.

2.6.1 Stormwater Site Plan Changes

If the designer wishes to make changes or revisions to the originally approved stormwater site plan, the proposed revisions shall be submitted to the City prior to construction. The submittals should include the following:

1. Substitute pages of the originally approved Stormwater Site Plan that include the proposed changes.
2. Revised drawings showing any structural changes.
3. Any other supporting information that explains and supports the reason for the change.

2.6.2 Final Corrected Plan Submittal

If the project included construction of conveyance systems, treatment facilities, flow control facilities, or structural source control BMPs (i.e., this does not extend to construction of On-site Stormwater Management BMPs), the applicant shall submit a final corrected plan ("as-builts") to the City when the project is completed. These should be engineering drawings that accurately represent the project as constructed. These corrected drawings must be professionally drafted revisions that are stamped, signed, and dated by a licensed civil engineer registered in the state of Washington.

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Appendix 2A
Standard Notes for Stormwater Drainage Plans

1. All workmanship and materials shall be in accordance with City/County standards and the most current copy of the State of Washington Standard Specifications for Road, Bridge and Municipal Construction (WSDOT/APWA).

2. Temporary erosion/water pollution measures shall be required in accordance with Section 1-07.15 of the Standard Specifications and the Lacey Stormwater Manual.

3. Proponent shall comply with all other permits and other requirements of the governing authority or agency.

4. A preconstruction meeting shall be held prior to the start of construction or staking of the site.

5. All storm mains and retention/detention areas shall be staked for grade and alignment by an engineering or survey firm licensed to perform such work.

6. Storm drain pipe shall be as specified in the latest version of the City of Lacey Development Guidelines and Public Works Standards.

7. Special structures, oil/water separators, and outlet controls shall be installed per plans and manufacturers recommendations.

8. Provide traffic control plan(s) as required in accordance with MUTCD.

9. Call underground locate line 1-800-424-5555 at least 48 hours prior to any excavations.

10. All surveying and staking shall be performed by an engineering or surveying firm capable of performing such work. The engineer or surveyor directing such work shall be licensed by the State of Washington.

11. The minimum staking of storm sewer systems shall be as follows:

    A. Stake location of all catch basins, manholes and other fixtures for grade and alignment.

    B. Stake location, size, and depth of retention/detention facility.

    C. Stake finished grade of all stormwater features, including but not limited to catch basin/manhole rim elevations, overflow structures, weirs, and invert elevations of all pipes in catch basins, manholes, and pipes that daylight.

12. Pipe materials used for stormwater conveyance shall be as approved by the jurisdiction. Pipe size, slope, cover, etc., shall be as specified in the City of Lacey Development Guidelines and Public Works Standards.

13. 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 and sections to match the side slope.

14. If drainage outlets (stub-outs) are to be provided for each individual lot, the stub-outs shall conform to the following:

    A. 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.

    B. Outlets on each lot shall be located with a five-foot-high, 2"x 4" stake marked "storm" or "drain." The stub-out shall visibly extend above surface level and be secured to the stake.

    C. Pipe material shall be as approved by the jurisdiction.

    D. Drainage easements are required for drainage systems designed to convey flows through individual lots.

    E. 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).

    F. All individual stub-outs shall be privately owned and maintained by the lot home owner.

15. The storm drainage system shall be constructed according to approved plans on file with the jurisdiction. Any material deviation from the approved plans will require written approval from the jurisdiction.

16. A copy of the approved stormwater plans must be on the job site whenever construction is in progress.

17. All disturbed areas shall be seeded and mulched or similarly stabilized to the satisfaction of the jurisdiction. For sites where grass has been planted through hydroseeding, the performance bond will not be released until the grass has been thoroughly established, unless otherwise approved by the jurisdiction.

18. All building downspouts on commercial sites shall be connected to the storm drainage system, unless otherwise approved by the jurisdiction.

19. All erosion control and stormwater facilities shall be regularly inspected and maintained by the contractor during the construction phase of the development project.

20. The contractor shall be responsible for providing adequate safeguards, safety devices, protective equipment, flaggers, and any other needed actions to protect the life, health, and safety of the public, and to protect property in connection with the performance of work covered by the contract. Any work within the traveled right-of-way that may interrupt normal traffic flow shall require at least one flagger for each lane of traffic affected. All sections of the current W.S.D.O.T. Standard Specifications for Traffic Control shall apply.

21. It shall be the sole responsibility of the contractor to obtain street use and other related or required permits prior to any construction activity in the jurisdiction's right-of-way. It shall also be the responsibility of the contractor to obtain all required permits prior to any construction.

22. No final cut or fill slope shall exceed two (2) horizontal to one (1) vertical without stabilization by rockery or by a structural retaining wall.

23. The project engineer shall verify the locations, widths, thicknesses, and elevations of all existing pavements and structures, including utilities and other frontage improvements, that are to interface with new work, provide all trimming, cutting, saw cutting, grading, leveling, sloping, coating, and other work, including materials as necessary to cause the interface with existing works to be proper, without conflict, acceptable to the engineer and the jurisdiction, complete in place, and ready to use.

24. Compaction of all fill areas shall be per current APWA specifications. Fill shall be provided in 6" maximum lifts and shall be compacted to 95 percent of its maximum relative density.

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Appendix 2B
Checklist for Development Project Drainage Submittal

Check all applicable items to verify inclusion in submitted Drainage Report and Plans. This checklist is intended to assist the project applicant and engineer in the preparation and submittal of a complete package of the information required in this manual. Part 1 is for the Drainage Report, Part 2 is for the Drainage Plans.

Basic Information

The following information shall be included on the title page of the Drainage Report and all Drainage Plan sheets:

Project Name ______________________________

Project Address ______________________________

Project Location – Section/Township/Range ______________________________

Date of Report/Plans ______________________________

Project Applicant ______________________________

Company Name ______________________________

Company Address ______________________________

Office Phone ____________________ Mobile Phone ____________________

Email Address ______________________________

Project Engineer ______________________________

Business Name ______________________________

Business Address ______________________________

Office Phone ____________________ Mobile Phone ____________________

Email Address ______________________________

☐ Engineer's Certification Statement is on Drainage Report and all Drainage Plan sheets, with Professional Engineer's (P.E.) stamp & signature

Phasing: Project is being developed as (check one):

- ☐ a single phase for the entire site
- ☐ multiple phases, this is for Phase No. ____ of ____

PART I: DRAINAGE REPORT

2010 SDM, Chapter 1: Stormwater Drainage Requirements

Flow Chart used to determine applicable Core Requirements:

- ☐ Figure 1.2 for New Development
- ☐ Figure 1.3 for Road Redevelopment
- ☐ Figure 1.4 for Redevelopment other than roads

Core Requirements and Supplemental Requirements applicable to this project:

☐	Core Requirement #1	Prepare Stormwater Site Plans & Reports
☐	Core Requirement #2	Construction Stormwater Pollution Prevention
☐	Core Requirement #3	Source Control of Pollution
☐	Core Requirement #4	Preserve Natural Drainage Systems & Outfalls
☐	Core Requirement #5	On-site Stormwater Management
☐	Core Requirement #6	Runoff Water Quality Treatment
☐	Core Requirement #7	Flow Control
☐	Core Requirement #8	Wetlands Protection
☐	Core Requirement #9	Operation & Maintenance
☐	Core Requirement #10	Agreements & Financial Guarantees
☐	Supplemental Req't. #1	Basin & Watershed Planning
☐	Supplemental Req't. #2	Off-site Analysis & Mitigation

☐ Additional Permits or Requirements that apply (e.g. due to a TMDL)

Description: ____

____

____

☐ Adjustments, Exceptions or Variances to Core Requirements requested

Description: ____

____

____

☐ Adjustments, Exceptions or Variances granted

Description: ____

____

____

Type of Project (Initial Permit Application):

- ☐ Subdivision
- ☐ Binding Site Plan
- ☐ Commercial Development
- ☐ Industrial Development

Type of Drainage Review: ☐ Full ☐ Partial

If Partial Review, Project Type: ☐ Small ☐ Critical Area ☐ Drainage Modification

☐ Drainage Plans, Drainage Report & Calculations, and Construction SWPPP are stamped & signed by a civil engineer licensed in Washington

☐ All land surveys & legal descriptions are stamped & signed by a land surveyor licensed in Washington

☐ Soils Report is stamped & signed by a soil scientist, geologist or geotechnical engineer licensed in Washington

☐ All other Supplemental Reports & Information (e.g. wetlands delineation, etc) prepared and certified by professionals in the specific field

Type of Project (Initial Permit Application):

- ☐ Subdivision
- ☐ Binding Site Plan
- ☐ Commercial Development
- ☐ Industrial Development

Type of Plan Set Submitted (check one type - Preliminary or Engineering Plans):

☐ Preliminary Plans, including the following elements:

1. Initial Site Analysis, including soils information and LID assessment.
2. Conceptual drainage plan, showing the location and type of:
   - ☐ Existing and proposed flow control facilities
   - ☐ Existing and proposed water quality facilities
   - ☐ Existing and proposed conveyance system
3. Site Plan, including the following:
   - ☐ Field topographic base map
   - ☐ Land Surveyor's name, address, seal and signature
   - ☐ Notation for field or aerial survey
   - ☐ Datum and benchmark/location and basis of elevation
   - ☐ Contours at appropriate intervals
   - ☐ Location of all on-site and adjacent critical areas
4. Level 1 Downstream Analysis, as described in Chapter 3.

☐ Engineered Stormwater Drainage Plans for Partial or Full Drainage Review, including the following elements:

1. Site Improvement Plans

   (a) Vicinity Map, including the following:

   - ☐ Project boundaries
   - ☐ Sub-basin boundaries
   - ☐ Off-site areas tributary to the project
   - ☐ Contours
   - ☐ Major drainage features
   - ☐ Receiving water and flow path to receiving water

   (b) Site Map, including the following:

   - ☐ Property boundaries
   - ☐ Existing and proposed structures on-site
   - ☐ Existing and proposed structures within 100 feet of project
   - ☐ Easements
   - ☐ Roads and right-of-way
   - ☐ All existing and proposed utilities: water, sewer, power, etc.
   - ☐ Common open space
   - ☐ Public dedications
   - ☐ Existing topography for the project site and at least 50 feet beyond site boundaries in all directions
   - ☐ Ground surface elevations around points of stormwater discharge extending at least 50 feet downstream of all discharge points; spot elevations as necessary to delineate boundaries and depth of existing hydrologic features (floodplains, wetlands, channels, swales, streams, storm systems, springs, seeps, etc.)
   - ☐ Flow direction arrows for surface flow and conveyance systems
   - ☐ Location and size of other natural features (rock outcroppings, existing vegetation, trees)
   - ☐ Finished grades proposed

2. Temporary Erosion & Sediment Control Plans (TESC Plans)

   The TESC Plan contains the following general information:

   - ☐ Clearing limits
   - ☐ Areas with high susceptibility to erosion
   - ☐ Critical area limits, buffers and compliance measures
   - ☐ Details sufficient to illustrate the design
   - ☐ ESC measures for on- and off-site utility construction
   - ☐ Specify the construction sequence
   - ☐ ESC standard plan notes
   - ☐ An inspection and maintenance program, with designation of a certified ESC supervisor and 24-hour contact number(s).

The TESC Plan contains the following information related to specific erosion and sediment control measures, as applicable:

(a) Cover Measures

- ☐ Type(s) and location(s) of temporary cover measures
- ☐ Conditions that control the use of different types of covers (e.g. time of year, soil, slope)
- ☐ Type(s) and location(s) of permanent cover measures
- ☐ Approximate quantity of each cover measure
- ☐ Sufficient detail for installation
- ☐ Mulch types, seed mixes, fertilizers, and soil amendments specifications and application rates
- ☐ Surface roughening areas, methods and equipment
- ☐ PAM locations and application methods

(b) Perimeter Protection

- ☐ Location(s) and type
- ☐ Typical details
- ☐ Fabric type for silt fence
- ☐ Documentation that compost meets Grade A standards

(c) Traffic Area Stabilization

- ☐ Location of construction entrance(s)
- ☐ Typical details for construction entrances
- ☐ Location of construction roads and parking areas
- ☐ Measure to create and maintain stabilized construction roads and parking areas
- ☐ Location and typical details of wheel wash/tire bath
- ☐ List of dust control products and location of application areas

(d) Sediment Retention

- ☐ Trap/pond location(s)
- ☐ Pond berm dimensions and slopes
- ☐ Storage required and stage-storage table
- ☐ Section view(s) through pond and outlet structure
- ☐ Documentation of DOE approval of chemical or electro-coagulation treatment
- ☐ Details for disposal of chemically-treated waters
- ☐ Documentation of local sewer district approval for discharge to sanitary sewer
- ☐ Details of control structure, dewatering mechanism, and inlet/outlet protection
- ☐ Cell divider details
- ☐ Indicate depth gage for sediment measurement
- ☐ Catch basins to be protected, catch basin protection details

(e) Surface Water Control

- ☐ Locate all pipes, ditches, interceptor ditches, dikes, berms, swales, level spreaders, flow splitters, check dams, etc.
- ☐ Details sufficient for installation and maintenance
- ☐ Locations of and outlets from dewatering systems, including backup if necessary
- ☐ Temporary conveyance inverts

(f) Wet Season Requirements

- ☐ List all wet season requirements; state clearly on plans.

The Drainage Report contains the following sections:

- ☐ Title Page
- ☐ Project Engineer's Certification
- ☐ Table of Contents
- ☐ Section 1: Overall Project Summary
- ☐ Section 2: Conditions and Requirements
- ☐ Section 3: Site & Vicinity Analysis
- ☐ Section 4: Construction Erosion and Sediment Control Summary
- ☐ Section 5: Conveyance System Analysis and Design
- ☐ Section 6: Flow Control Facilities Analysis and Design
- ☐ Section 7: Water Quality Facilities Analysis and Design
- ☐ Section 8: Stormwater Pollution Prevention & Source Control Plan
- ☐ Section 9: Stormwater Facilities Operation & Maintenance Summary
- ☐ Section 10: Agreements and Guarantees

Appendices

- ☐ Appendix 1: Stormwater Facility Summary Forms
- ☐ Appendix 2: Site Stormwater Plans & Details (Improvements & TESC)
- ☐ Appendix 3: Design Calculations (WWHM printouts, data tables, etc.)
- ☐ Appendix 4: Supplemental Reports and Info. (Soils Report, etc.)
- ☐ Appendix 5: Construction Stormwater Pollution Prevention Plan (SWPPP)
- ☐ Appendix 6: Stormwater Facilities Maintenance Plan

The Drainage Report sections contain the following information:

Drainage Report Section 1: Overall Project Summary

- ☐ Descriptions of pre-developed & proposed site conditions & land cover
- ☐ Parcel/site data (Parcel Number(s), Parcel Area, Project Site Area)
- ☐ Size and extent of improvements
- ☐ Description of site stormwater behavior pre- and post-development
- ☐ Site Location Map
- ☐ Summary Tables of existing and proposed impervious areas, disturbed pervious areas, and undisturbed pervious areas, for each sub-basin
- ☐ Description of overall drainage system proposed
- ☐ Description of conveyance systems
- ☐ Description of flow control and water quality treatment features
- ☐ L.I.D. feasibility analysis
- ☐ Landscaping and aesthetic considerations for stormwater facilities
- ☐ Summaries of design calculations for conveyance systems, flow control facilities and water quality facilities
- ☐ If project is a redevelopment, current assessed building value and the cost of proposed improvements (excluding land)

Drainage Report Section 2: Conditions and Requirements

- ☐ List of applicable Core Requirements and description of how each is addressed
- ☐ List of applicable basin plans, TMDLs, critical/sensitive areas, and other permits required, and description(s) of how addressed

Check all that apply to this project:

- ☐ Project subject to an adopted Basin Plan
- ☐ Project located in basin with impaired receiving water and/or subject to a TMDL
- ☐ Project located in a wellhead protection area or aquifer sensitive area
- ☐ Critical Areas (wetlands, habitat, flood hazard area, steep slopes) present on or near project site
- ☐ Downstream conveyance and/or flooding problem

Drainage Report Section 3: Site & Vicinity Analysis

- ☐ Study Area definition
- ☐ Resource Review results (existing wells, septic systems, tanks, etc.)
- ☐ Field Inspection results (existing features)
- ☐ Drainage System and drainage problem description
- ☐ Mitigation measures
- ☐ Analysis of drainage, soils and environmental conditions, including a Soils Report and other applicable information (e.g. a Wetlands Report)

The following figures shall be included with the Site & Vicinity Analysis:

- ☐ Vicinity, Site and Drainage Maps that show the following:
  - ☐ Parcels, roads and geographic features in site vicinity
  - ☐ Limits of analysis area
  - ☐ Offsite tributary areas & points of discharge to project
  - ☐ Sub-basins and associated acreage
  - ☐ Existing discharge points to and from site
  - ☐ Flow Routes (existing, construction phase, future)
  - ☐ Receiving waters
- ☐ Soils Map showing the soils in the study area

Note: See below under Chapter 3 for further details of the Site & Vicinity Analysis, including Soils Report contents.

Drainage Report Section 4: Construction Erosion & Sediment Control Summary

- ☐ Includes sufficient information to justify the overall ESC plan and the choice of individual ESC measures
- ☐ Includes all hydrologic and hydraulic information and calculations used to analyze and size ESC facilities
- ☐ Identifies areas with a high susceptibility to erosion and special protection measures
- ☐ Identifies any ESC recommendations from special reports for the project
- ☐ Includes supporting documentation for any proposed exceptions to or modifications of the standards
- ☐ Identifies all activities during construction that could contribute pollutants to surface or stormwater (other than sediment)
- ☐ Identifies typical measures used to prevent spills and exposure of such pollutants to stormwater

Note: See below under Chapter 4 for further details of the Construction Erosion & Sediment Control requirements and SWPPP contents.

Drainage Report Section 5: Conveyance Systems Analysis and Design

Part A Performance Standard

- ☐ Applicable performance standard (e.g., 25-year peak runoff) used for the conveyance system is briefly summarized.

Part B Conveyance System

☐ A brief narrative description of the conveyance system is provided

☐ All components of the system are identified, including pipes, inlets, manholes, open channels, natural channels, and culverts.

☐ Design flow rates for each component are presented

☐ Pipe/culvert/ditch dimensions, inverts, slopes, flow capacities stated

☐ All calculations, equations, graphs, nomographs and references used are provided in an appendix to this section of the report, and summarized in this section.

Note: See below under Chapter 5 for further details of Conveyance Systems analysis and documentation in the Drainage Report.

Drainage Report Section 6: Flow Control Facilities Analysis and Design

Part A Existing and Developed Hydrology

The following included for existing and proposed conditions:

☐ Analysis methodology (e.g, WWHM3), assumptions and inputs

☐ Land-covers

☐ Soil types

The following information provided on a topographical map:

☐ Delineation and acreage of areas draining to the site

☐ Delineation of on-site drainage areas

☐ Flow control facility locations

☐ Outfalls

☐ Overflow route(s)

☐ Natural streams and drainage features

Part B Performance Standards

☐ Applicable flow control standard is documented

Part C Flow Control System

☐ Brief narrative description of the flow control system provided

☐ Describes stormwater discharge locations (i.e. all site stormwater will be contained and infiltrated on-site, or discharge off-site is proposed)

☐ Identifies and describes all components of the system, including BMPs, control structures and flow splitters, as applicable

- ☐ Locations of all flow control system components are shown in site plan exhibit(s)
- ☐ Dimensions, elevations and stage-storage relationships of flow control facilities are provided
- ☐ All calculations (WWHM files, orifice calculations, detention storage, and other calculations) used to design the flow control system are provided in an appendix to this section of the report
- ☐ All calculations are summarized and tabulated in this section

Note: See below under Chapter 6 for further details of Flow Control analysis and documentation in the Drainage Report.

Drainage Report Section 7: Water Quality Facilities Analysis and Design

Part A Treatment Standard

- ☐ Applicable water quality treatment standards documented (e.g. basic or phosphorus-control).

Part B Water Quality Treatment System

- ☐ Brief narrative description of proposed water quality facilities, and design summary for each facility is provided.
- ☐ Location of each facility shown on a drainage exhibit.

Design summary for each facility includes the following, as applicable:

- ☐ Area draining to facility
- ☐ Areas of pollutant-generating impervious and pervious surfaces draining to the facility
- ☐ Design water quality flow rate or volume
- ☐ Stage-storage relationship
- ☐ Dimensions and inverts (on exhibit)
- ☐ All calculations, equations, graphs & references used are provided in an appendix to this section of report, and summarized in this section
- ☐ If not an approved method, the proposed treatment option has received approval from the City of Lacey Drainage Manual Administrator prior to plan submittal

Note: See below under Chapter 7 for further details of Water Quality analysis and documentation in the Drainage Report.

Drainage Report Section 8: Stormwater Pollution Prevention & Source Control

- ☐ BMPs for source control are listed and described

Drainage Report Section 9: Facilities Operation and Maintenance Summary

- ☐ Operation & Maintenance Manual provided, per Chapter 9 criteria

Drainage Report Section 10: Agreements and Guarantees

- ☐ Project Agreements and/or Guarantees are listed in this section

APPENDICES:

Drainage Report Appendix 1: Stormwater Facility Summary Forms

- ☐ Facility Summary Form provided for each facility
- ☐ 8 ½-inch sketch provided for each facility with the form

Drainage Report Appendix 2: Site Stormwater Drainage Plans & Details

- ☐ Site Improvement Plans provided
- ☐ Temporary Erosion & Sediment Control Plans provided

Drainage Report Appendix 3: Design Calculations

- ☐ WWHM report printouts provided
- ☐ all relevant calculations, data tables, nomographs, etc. provided

Drainage Report Appendix 4: Supplemental Reports and Info.

- ☐ Soils Report included
- ☐ other supplemental reports and information included (list/describe):

____

____

____

Drainage Report Appendix 5: Construction SWPPP

- ☐ Complete Construction Stormwater Pollution Prevention Plan provided

Drainage Report Appendix 6: Stormwater Facilities Maintenance Plan

- ☐ Complete Stormwater Facilities Maintenance Plan provided
- ☐ Maintenance Plan includes Source Control Plan
- ☐ Maintenance Plan includes Vegetation Management Plan

2010 SDM, Chapter 3: Site and Vicinity Analysis
(include in Drainage Report, Section 3)

Part A – Site Analysis

1. Preliminary Drainage Analysis
   - ☐ Identifies existing drainage features and patterns at site
   - ☐ Includes topography and land use (on-site and adjacent to site)
   - ☐ Identifies existing site features including pavement, structures, wells, septic systems and storage tanks
   - ☐ Includes drainage features such as streams, storm drains and ponds
   - ☐ Identifies off-site drainage (onto site and downstream from site)
   - ☐ Identifies locations where runoff water enters and leaves the site
   - ☐ Identifies receiving waters (on-site and/or downstream)

2. Soils Report
   - ☐ Identifies soil series/types present at the site, with approximate site coverage for each soil type
   - ☐ Identifies Hydrologic Soil Group(s) of site soils (map and text)
   - ☐ Addresses erosion potential
   - ☐ Includes elevation and description of seasonally high groundwater
   - ☐ Includes elevations and descriptions of soil layers
   - ☐ Identifies limitations to infiltration (e.g. glacial till)
   - ☐ Includes estimate of infiltration rate
   - ☐ Supports preliminary assessment of feasibility of using Low Impact Development techniques and BMPs at this site.
   - ☐ Includes discussion of how the site soil and groundwater conditions affected the selection & design of flow control & water quality systems
   - ☐ Includes map of soil test locations in relation to current site plan
   - ☐ Includes complete soil logs with elevations
   - ☐ Addresses everything in the soils checklist (Appendix 3A)

3. On-Site and Adjacent Critical Areas
   - ☐ Site Analysis identifies whether site contains or is located within surface water bodies, ravines or gullies, closed depressions, seeps or springs, wetlands or wetland buffer, flood hazard area or flood zone, steep slopes, special protection area, or subject to a TMDL

- ☐ Includes discussion of how the presence of each such area identified affected the selection & design of flow control & water quality systems

4. Feasibility of Low Impact Development
   - ☐ Roof Downspout Control BMPs are included in design
   - ☐ Dispersion and Soil Quality BMPs are included in design
   - ☐ If either of above are not included in design, site analysis describes the conditions that preclude their use
   - ☐ Other LID BMPs are included in design to the maximum extent feasible and described in the Site Analysis Report

Part B – Vicinity (Off-Site) Analysis

1. Define and Map the Study Area
   - ☐ Includes site vicinity map showing property lines and streets
   - ☐ Includes topographic map showing site boundaries, study area boundaries, downstream flowpath, receiving waters, and any potential or existing problems
   - ☐ Includes other maps and photos illustrating site/vicinity features

2. Review Available Information on the Study Area

   Check all that were reviewed and are referenced in the Vicinity Analysis:
   - ☐ Adopted basin plans
   - ☐ Drainage studies
   - ☐ Groundwater management area plans/Wellhead Protection Area Maps
   - ☐ Critical Area Maps
   - ☐ Floodway/floodplain (FEMA) studies and maps
   - ☐ Drainage complaints history from City
   - ☐ Road drainage problems
   - ☐ USDA Soil Survey for Thurston County
   - ☐ Wetlands Inventory Maps
   - ☐ Stream habitat reports, and salmon distribution reports;
   - ☐ Other available offsite analysis reports in the same subbasin

3. Field Inspect the Study Area
   - ☐ Physically inspected the existing onsite and offsite drainage systems of the study area for each discharge location for existing or potential problems and drainage features

- ☐ Investigated problems reported or observed during the resource review
- ☐ Located existing/potential constrictions or capacity deficiencies in the drainage system
- ☐ Identified existing/potential flooding problems
- ☐ Identified existing/potential overtopping, scouring, bank sloughing, or sedimentation
- ☐ Identified significant destruction of aquatic habitat (e.g. siltation, stream incision)
- ☐ Collected data on features such as land use, impervious surface, topography, soils, presence of streams, and wetlands
- ☐ Collected information on pipe sizes, channel characteristics, drainage structures
- ☐ Verified tributary drainage areas identified in Task 1
- ☐ Contacted the City of Lacey, neighboring property owners, and residents about drainage problems

4. Describe the Drainage System, and its existing and predicted problems

For each drainage system component (e.g. pipe, culvert, bridges, outfall, pond, vault) the following are addressed in the analysis:

- ☐ Location
- ☐ Physical description
- ☐ Field observations
- ☐ Identified problems

The following information is provided for each existing or potential problem:

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

☐ Downstream Analysis Provided

If provided, type: ☐ Qualitative analysis ☐ Quantitative analysis

Downstream analysis includes:

- ☐ Method utilized
- ☐ Assumptions
- ☐ Model parameters
- ☐ Data sources

☐ Calculations included for capacity of channels, culverts, gutters, etc.

☐ Nomographs and tables used are provided

☐ Headwater/Tailwater analysis for culverts provided

☐ Capacities, design flows and velocities for each link are provided

Downstream Point of Compliance: _________________________________

Pre- development flow to downstream Point of Compliance = _________ cfs

Post-development flow to downstream Point of Compliance = _________ cfs

5. Describe the Receiving Waters, and their existing and predicted problems

- ☐ Downstream flowpath described, from site to receiving waters
- ☐ Receiving waters described

For each receiving water (stream, lake, pond, wetland, groundwater) the following are addressed in the analysis:

☐ Yes ☐ N.A. Known water quality impairment

☐ Yes ☐ N.A. Requirements of applicable TMDL

☐ Yes ☐ N.A. Requirements of applicable basin plan

☐ Yes ☐ N.A. Requirements of groundwater protection rules

☐ Analysis includes discussion of potential impacts of the project on water quality issues identified in this task

6. Propose Mitigation Measures

☐ Analysis includes evaluation of proposed mitigation measures for all problems identified in Tasks 4 & 5 above

☐ Analysis includes description of how proposed stormwater controls will mitigate existing or potential new problems

2010 SDM, Chapter 4: Construction Erosion & Sediment Control
(include in Drainage Report, Section 4, and in Construction SWPPP)

Check all elements shown on the Construction Stormwater Pollution Prevention Plan (Construction SWPPP) and list BMPs (or BMP numbers) used for each:

☐ Element #1: Mark Clearing Limits
BMPs Used: ____

☐ Element #2: Establish Construction Access
BMPs Used: ____

☐ Element #3: Control Flow Rates
BMPs Used: ____

☐ Element #4: Install Sediment Controls
BMPs Used: ____

☐ Element #5: Stabilize Soils
BMPs Used: ____

☐ Element #6: Protect Slopes
BMPs Used: ____

☐ Element #7: Protect Drain Inlets
BMPs Used: ____

☐ Element #8: Stabilize Channels and Outlets
BMPs Used: ____

☐ Element #9: Control Pollutants
BMPs Used: ____

☐ Element #10: Control De-Watering
BMPs Used: ____

☐ Element #11: Maintain BMPs
BMPs Used: ____

☐ Element #12: Manage the Project
BMPs Used: ____

Note: Any Elements not used must be justified in Drainage Report.

General Principles applied to the Construction SWPPP include the following:

☐ Duff layer, native topsoil and natural vegetation are retained in an undisturbed state to the maximum extent practicable

☐ Prevent pollutant release. Select source control BMPs as a first line of defense. Prevent erosion rather than treating turbid runoff.

☐ Select BMPs depending on site characteristics (topography, drainage, soil type, ground cover, etc.) and the construction plan.

☐ Divert runoff away from exposed areas wherever possible. Keep clean water clean.

☐ Limit the extent of clearing operations and phase construction operations.

☐ Before reseeding a disturbed soil area, amend all soils with compost wherever topsoil has been removed.

☐ Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.

☐ Minimize slope length and steepness.

☐ Reduce runoff velocities to prevent channel erosion.

☐ Prevent the tracking of sediment off-site.

☐ Select appropriate BMPs for the control of pollutants other than sediment.

☐ Certified Erosion and Sediment Control Lead is identified in C-SWPPP

☐ Standard Notes for Erosion Control Plans are included in C-SWPPP

☐ Construction Sequence included in the Construction SWPPP

Pollution Prevention BMPs shown on Construction SWPPP drawings:

☐ Clearing Limits
☐ Perimeter Protection
☐ Sediment Retention
☐ Dust Control
☐ Stabilized Construction Entrance
☐ Soil Stabilization Measures
☐ Concrete Washout Area
☐ Inlet/Catch Basin Protection
☐ Others: ____

☐ Methods and procedures for trapping sediment before it reaches stormwater features or surface waters are described

☐ Prevention of soil loss due to vehicles tracking it away from the site is discussed

☐ Procedures for stabilizing exposed soil in or near environmentally sensitive areas is addressed

☐ The project engineer has addressed which facilities will be inspected and at what point in construction they will be inspected to ensure that facilities will operate as designed

☐ Pollutants other than sediments to be controlled on the work site are described

2010 SDM, Chapter 5: Hydrologic & Hydraulic Analysis (Drainage Report, Section 5)

Part A – Hydrologic Analysis

Hydrologic Model & Version used for analysis and calculations:
Water Quality BMP Sizing: ___________________________________
Flow Duration Control: ______________________________________
Conveyance Design: ____

☐ WWHM Project Files (.whm and .wh2) included in Drainage Report
☐ WWHM .wdm File included in Drainage Report
☐ WWHM Report File (.doc) included in Drainage Report

Modeling Credits applied: ____

Part B – Conveyance Design

Is a new conveyance system proposed? ☐ Yes ☐ No
Hydraulic calculations for new system in Drainage Report? ☐ Yes ☐ No

Will site discharge flow to an existing conveyance system? ☐ Yes ☐ No

Ex. system description: ____
Hydraulic calculations for ex. system in Drainage Report? ☐ Yes ☐ No

Hydraulic computation method used for analysis and calculations of:
Peak Flow Conveyance: ____
Downstream Analysis: ____

2010 SDM, Chapter 6: Flow Control (Drainage Report, Section 6)

On-site Stormwater Management BMPs proposed:

☐ BMP LID-01 Protect and/or Restore Natural Vegetation
☐ BMP LID-02 Reduce Effective Impervious Areas
☐ BMP LID-03 Full Dispersion
☐ BMP LID-04 Downspout Infiltration Systems
☐ BMP LID-05 Downspout Dispersion

- ☐ BMP LID-06 Perforated Stub-out Connections
- ☐ BMP LID-07 Concentrated Flow Dispersion
- ☐ BMP LID-08 Sheet Flow Dispersion
- ☐ BMP LID-09 Post-Construction Soil Quality and Depth
- ☐ BMP LID-10 Bioretention Facilities (e.g. “Rain Gardens”)
- ☐ BMP LID-11 Alternative (Permeable) Paving Surfaces
- ☐ BMP LID-12 Vegetated (“Green”) Roofs

Detention Facilities proposed:

- ☐ BMP D-01 Detention Ponds
- ☐ BMP D-02 Detention Tanks
- ☐ BMP D-03 Detention Vaults
- ☐ BMP D-04 Parking Lot Detention

Discharge Facilities proposed:

- ☐ Control Structure with Flow Restrictor (orifice/weir)
- ☐ Emergency Overflow Spillway Weir

Infiltration Flow Control Facilities proposed:

- ☐ BMP IN-01 Infiltration Basins
- ☐ BMP IN-02 Infiltration Trenches

Site Suitability Criteria met for Infiltration:

- ☐ Setbacks ☐ Groundwater Protection Areas ☐ High Use Areas
- ☐ Depth to Bedrock, Seasonal High Water Table or Impermeable Layer

Site Characterization Criteria met for Infiltration:

- ☐ Topography within 500 ft. of site
- ☐ Anticipated site use
- ☐ Location of Groundwater Protection Areas and time-of-travel zones
- ☐ Location of water supply wells (public and private)
- ☐ Description of site geology, soils and groundwater regime
- ☐ Adequate number and depth of test pits/borings
- ☐ Geotechnical report with soil logs, soil characterization, and recommendations

Design Infiltration Rate determination method:

- ☐ In-Situ Infiltration Measurements
- ☐ ASTM Gradation Testing

2010 SDM, Chapter 7: Water Quality Treatment (Drainage Report, Section 7)

Water Quality Menus:

Step 1:	Infiltration Treatment is feasible	☐ Yes	☐ No
	Infiltration Treatment is proposed	☐ Yes	☐ No
Step 2:	Metals Treatment is required	☐ Yes	☐ No
Step 3:	Phosphorus Control is required	☐ Yes	☐ No
Step 4:	In Groundwater Protection Area	☐ Yes	☐ No
	if Yes, type of GPA:		
	Wellhead Protection Area	☐ Yes	☐ No
	Critical Aquifer Recharge Area	☐ Yes	☐ No
	Nitrate Hot Spot	☐ Yes	☐ No
Step 5:	High Use Site – Oil Control Required	☐ Yes	☐ No
Step 6:	Pre-Treatment Required	☐ Yes	☐ No

Water Quality Treatment Options Proposed:

Pre-Treatment Options:

- ☐ BMP PT-01 Pre-settling Basin
- ☐ BMP PT-02 Pre-settling Wetvault
- ☐ BMP PT-03 Hydrodynamic Settling Devices

Infiltration & Bioinfiltration Treatment Options:

- ☐ BMP IN-01t Infiltration Basins (for treatment)
- ☐ BMP IN-02t Infiltration Trenches (for treatment)
- ☐ BMP IN-03 Bio-infiltration Swales
- ☐ BMP IN-04 Bioretention Areas

Biofiltration Options:

- ☐ BMP BF-01 Basic Biofiltration Swale
- ☐ BMP BF-02 Wet Biofiltration Swale
- ☐ BMP BF-03 Continuous Inflow Biofiltration Swale
- ☐ BMP BF-04 Basic or Compost-Amended Filter Strip
- ☐ BMP BF-05 Narrow Area Filter Strip

Wetpool Options:

- ☐ BMP WP-01 Basic or Large Wetpond
- ☐ BMP WP-02 Wetvault
- ☐ BMP WP-03 Stormwater Treatment Wetland
- ☐ BMP WP-04 Combined Wetpool + Detention Facilities

Media Filtration Treatment Options:

- ☐ BMP MF-01 Sand Filter Basin
- ☐ BMP MF-02 Sand Filter Vault
- ☐ BMP MF-03 Linear Sand Filter
- ☐ BMP MF-04 Commercial Media Filter
- ☐ BMP MF-05 Media Filter Drain

Oil Control Options:

- ☐ BMP OC-01 Catch Basin Inserts
- ☐ BMP OC-02a Oil-Water Separator, API (Baffle type)
- ☐ BMP OC-02b Oil-Water Separator, CP (Coalescing Plate)

2010 SDM, Chapter 8: Source Control (Pollution Prevention)

Operational BMPs for Source Control of pollutants are applied to site ☐ Yes ☐ No

Operational Pollution Prevention BMPs Proposed: ___________________________

____

____

Structural BMPs for Source Control of pollutants are applied to site ☐ Yes ☐ No

Structural Pollution Prevention BMPs Proposed: ____________________________

____

____

2010 SDM, Chapter 9: Operation & Maintenance

A complete O & M manual was prepared and included ☐ Yes ☐ No

O & M manual includes all stormwater facilities on site ☐ Yes ☐ No

2010 SDM, Chapter 10: Agreements & Guarantees

Check all that apply and are provided for this project:

<u>Type</u> <u>Description</u>

☐ Drainage Easements ____

Recorded: ____

☐ Utility Easements ____

Recorded: ____

☐ Access Easements ____

Recorded: ____

☐ Vegetation Protection Tract ____

☐ Residential Agreement to Maintain Stormwater Facilities and to Implement a Pollution Source Control Plan

☐ Commercial/Industrial Agreement to Maintain Stormwater Facilities and to Implement a Pollution Source Control Plan

☐ Performance Bonds ____

☐ Financial Guarantees ____

☐ Deeds ____

☐ Other ____

☐ Instruments needed to guarantee preservation of the drainage system and access for maintenance purposes are described

☐ Organization responsible for operation and maintenance of storm drainage facilities is named

Responsible party during construction:

____

Responsible party after construction:

____

* * * * *

Certification of Professional Engineer:

I hereby certify that the submitted stormwater civil drawings for (name of project) have been prepared by me or under my supervision and meet minimum standards of the City of Lacey and normal standards of engineering practice. I understand that the jurisdiction does not and will not assume liability for the sufficiency, suitability, or performance of civil drawings designed by me or under my supervision stamped by me.

Prior to submitting the drawings and report to the City of Lacey for review, I have carefully reviewed the checklist and assure that all items provided on it have been included into the documents being submitted.

Signed: ______________________________ Date: _______________

P.E. Stamp & Seal:

PART II: DRAINAGE PLANS (Stormwater Civil Drawings)

( ) Thirty scale drawing utilized for stormwater civil drawings

( ) Civil drawings are presented on 24 x 36 inch sheets

( ) 15-foot access easement from the right-of-way to the drainage facility has been provided for maintenance

( ) Minimum setback from onsite septic system observed (30 to 100 feet depending on soil type

( ) Minimum setback from water supply observed (100 feet)

( ) Minimum setback from the foundation or basement observed (dependent on the line of saturation)

( ) Minimum setback from slopes over 15 percent grade observed (50-feet)

( ) Vicinity Map is included

The following vicinity map components are included:

- ( ) Project boundaries
- ( ) Sub-basin boundaries (shown on overall storm sheet)
- ( ) Off-site area tributary to the site
- ( ) Contours
- ( ) Major drainage features
- ( ) Flow path to receiving waters

( ) Site map

The following site map components are included:

- ( ) Existing and Proposed Contours at maximum 2-foot intervals (confirmed with current survey data; general contours provided by sites like Thurston County Geo-Data will not be acceptable). Existing topography for the site extends at least 50-feet beyond
- ( ) Finished grade elevations
- ( ) Existing structures within 100-feet of the project boundaries
- ( ) Existing and proposed utilities
- ( ) Easements for utilities
- ( ) Environmentally sensitive areas and buffers

- ( ) 100-year flood plain
- ( ) Wellhead Protection Areas
- ( ) Existing and proposed wells onsite and on adjacent properties
- ( ) Existing and proposed fuel tanks
- ( ) Existing and proposed septic systems
- ( ) lot dimensions and areas
- ( ) Proposed and existing drainage facilities
- ( ) Cross section details to build facilities
- ( ) Proposed structures including roads and parking surfaces (provide square footages of these areas)

Stormwater Conveyance:

The following conveyance system information is included on the civil drawings:

Plan View - Conveyance System

- ( ) Number at each manhole/catch basin
- ( ) Flow direction with arrow on pipe/channel
- ( ) The required roof drain and dry well system note included on drawings
- ( ) Anti-dumping message is included at all catch basins

Profile View - Conveyance System (for private & public systems)

- ( ) Station, offset, and number at each manhole/catch basin
- ( ) Manhole/catch basin type and size
- ( ) Manhole/catch basin rim elevations
- ( ) Type and size of pipe
- ( ) Invert in and out (include compass direction)
- ( ) Length of pipe in lineal feet
- ( ) Grades (Ft./Ft.)
- ( ) Show catch basin crossing profiles (each crossing) on the sheet where they occur

Stormwater Treatment

- ( ) 30 millimeter wet pond liner included
- ( ) 3 to 1 length to width treatment ratio included

- ( ) Bottom of treatment swale is sod, sides are hydro-seeded
- ( ) Minimum swale width is 2 feet, maximum swale width is 10 feet
- ( ) Maximum design flow water depth is 2 inches
- ( ) Maximum design flow velocity is 1.5 feet per second
- ( ) Maximum flow line slope is 4 percent, minimum flow line slope is 1 percent
- ( ) Minimum treatment flow length is 50 feet for swales, 10 feet for filter strips
- ( ) Steepest side slopes for swales are 3:1, 5:1 is preferred
- ( ) Planting schedule is provided for constructed wetlands
- ( ) Permanent pool depth of 3 feet is maintained the constructed wetland or wet pond
- ( ) Permanent pool area of the pond equals 2.5 percent of the impervious surface draining to the pond
- ( ) Pond side slopes have interior side slopes of three horizontal to one vertical or latter

Stormwater Safety

- ( ) Trash racks are provided for all pipe entering or exiting storm facilities for pipe 18 inches or larger
- ( ) 3 foot safety benches included for all ponds 4 ½ feet or deeper. Benches shall occur every 4 ½ feet
- ( ) Ponds with interior side slopes greater than 3:1 have fencing or 10 feet of impenetrable vegetation to prevent children from entering the pond area

Stormwater Infiltration

- ( ) Infiltration trenches must have a minimum of 10 feet of separation from edge to edge
- ( ) Only the bottom area and 25 percent of the sides of infiltration trenches are counted in sizing calculations
- ( ) Filter fabric is installed only on the top and sides of the infiltration trenches
- ( ) Trenches as nearly as practical follow a contour line

Erosion Control Drawing

(place this section after the cover sheet in civil drawings)

The following erosion control information is included on the civil drawings:

( ) Locations of soil pits with soil types (not just in the report)

( ) Infiltration test locations

( ) Construction entrance detail

( ) Silt fences and traps

( ) Mulching and vegetation plan

( ) Clearing and grubbing limits

( ) Existing and finished grade

( ) Details and locations of all BMPs

( ) Location and details of temporary sediment ponds

( ) All existing and proposed catch basins with silt socks referenced for inlet protection

( ) All erosion control features are shown on the civil drawings

( ) City of Lacey erosion control details (with City approval blocks) have been included on the civil drawings

Miscellaneous Details and Notes:

( ) Storm Detail Sheet provided
(include City of Lacey details with Lacey title blocks)

( ) Storm General Notes provided

( ) Erosion Control Details provided

( ) Erosion Control Notes provided

Chapter 3 – Site and Vicinity Analysis

Projects subject to Drainage Review must collect and analyze sufficient and appropriate data to allow evaluation of the site for its proposed use, and to evaluate the potential impacts to offsite areas, including receiving waters. Site and Vicinity Analysis is used, in part, to address the following Core Requirements:

#4 Preservation of Natural Drainage Systems and Outfalls

#5 On-Site Stormwater Management

#8 Wetlands Protection

The Site and Vicinity Analysis is to be included in Section 3 of the Drainage Report submittal accompanying a permit application for Drainage Review. Any relevant site and vicinity information that can be provided at the pre-application meeting can aid in project planning and promote timely project review.

3.1 SITE ANALYSIS

The Site Analysis shall address the following elements, at a minimum:

- Site Planning for Stormwater
- Preliminary Drainage Analysis
- Soils Report
- On-site and adjacent Critical Areas
- Assess the feasibility of using Low-Impact Development (LID) techniques to manage stormwater on-site.

3.1.1 Site Planning for Stormwater

Consideration of the natural characteristics of a site during the initial stages of project planning will help facilitate the site layout and drainage design. Existing topography, soils, vegetation and drainage patterns can have a significant effect on the site drainage, and should be considered in designing the site and stormwater systems. Smart site planning and stormwater design includes adapting to the site's inherent characteristics rather than ignoring or working against them. This is the basis for Low-Impact Development (LID), where the intention is to keep stormwater dispersed and more closely mimic a site's natural hydrologic functions compared to traditional development and end-of-pipe drainage practices. LID site planning and drainage design techniques are strongly encouraged, to address the goals of infiltrating stormwater, preventing water quality degradation and protecting water resources to the maximum extent feasible.

Site planning and design are integrated with stormwater management requirements, and the way a site is designed and developed will impact the size, extent and cost of the necessary stormwater facilities. But a project's impacts on water resources and overall cost of the stormwater management system can be reduced through smart planning and design.

There are two primary site design strategies that shall be considered in developing the site layout and stormwater drainage systems:

1. Manage Stormwater On-Site. As stated in Core Requirement #5, one of this manual's main stormwater goals is to retain, disperse and infiltrate stormwater on-site as much as feasible. On a natural site, stormwater is "managed" near where it falls, mainly by soaking into the ground and by plant interception, and this approach can be applied on the developed site as well. Preserve large trees and native soils on-site to the maximum extent possible. Determine if infiltration is feasible anywhere on the site, and if so, then design the site layout to utilize well-drained soils. A main goal should be to use existing soils wisely; do whatever can be done to infiltrate stormwater as much as possible, and reduce pond storage and flows off the developed site. Keep stormwater dispersed and spread-out as much as possible, and use small-scale LID drainage systems, rather than concentrating flows in larger common facilities.

2. Minimize Effective Impervious Areas. Reduce impervious areas as much as possible, and prevent runoff flows from concentrating by disconnecting them and draining impervious surfaces overland to pervious areas. Consider using alternative paving surfaces, such as permeable pavement or interlocking pavers. Keep impervious subbasin areas small, and the corresponding drainage facilities can be kept small as well – and more readily integrated into the site and landscaping.

3.1.2 Preliminary Drainage Analysis

The Preliminary Drainage Analysis shall identify current (at the time of proposal) site features and drainage patterns, including:

- Topography (Note: for entire City of Lacey, elevation datum is NGVD29)
- Land-use
- Site features (existing structures, pavement, wells, septic systems, storage tanks)
- Drainage features (streams, storm drains, ponds, etc), and identify the following:
    - Off-site drainage
    - On-site receiving waters
    - Locations where stormwater runoff enters and leaves the site
    - Receiving water(s)

3.1.3 Soils Report

The Soils Report for the site analysis shall identify the soils present at the site based on the Soil Survey for Thurston County. Where available, additional soils information (e.g., geotechnical reports from prior proposals, basin plans) shall be consulted to identify soil and groundwater conditions in a deeper soil profile than is available from the soil survey.

The Soils Report shall address any aspects of site soils that may affect the stormwater drainage plan, including the following issues:

- Soil Type (Unit Series per NRCS/SCS Soil Survey of Thurston County)
- Hydrologic Soil Groups
- Descriptions of soil layers (color, composition, texture, moisture, induration, etc.)
- Erosion potential
- Elevations of ground surface, soil layers and current water table
- Elevation and evidence of seasonal and historic maximum high groundwater levels
- Restrictive (low permeability) soil layers (e.g., cemented hardpan, glacial till)
- Estimate of infiltration potential, including suitable locations on-site for stormwater infiltration, and recommended design infiltration rate.

The soils information shall support a preliminary assessment of the feasibility of Low Impact Development. The soils report shall discuss the relevance of site soil and groundwater conditions to the selection and design of flow control and water quality control systems. The Soils Report shall address all of the items listed in Appendix 3A, including a map of soil test locations relative to the current (latest) site plan, and soil logs for each test pit or boring. The Soils Report shall be stamped and signed by a licensed Geologist (L.G.), Engineering Geologist (L.E.G.), Hydrogeologist (L.H.G.), or Professional Engineer with geotechnical expertise (P.E.), licensed in Washington.

3.1.4 On-site and Adjacent Critical Areas

The Site Analysis shall identify whether the site contains, or is located wholly or in part within, or discharges to, any of the following:

- Wetlands or wetland buffer
- Lakes, streams or other surface waters
- Seeps or springs
- Ravines or gullies
- Closed depressions
- Flood hazard area/flood zone (include FEMA map and panel number)
- Steep slopes
- Henderson Inlet Protection Area
- Wellhead Protection Area or groundwater protection zone
- Area subject to a current Total Maximum Daily Load (TMDL) or a TMDL under development

The Site Analysis shall contain a discussion of how the presence of each such area identified affects the selection and design of flow control and water quality control systems.

3.1.5 Feasibility of Low Impact Development

The term "Low Impact Development" (LID) refers to a stormwater management and site development strategy that emphasizes conservation of on-site natural features and small-scale stormwater controls, to more closely mimic pre-development hydrologic functions.

LID minimizes the stormwater impacts of land development by adapting the project to the site, minimizing runoff and utilizing soils and vegetation to process stormwater. This is in contrast to the traditional land development approach of clearing vegetation, grading and compacting soils, creating a highly impervious site, and dealing with stormwater by collecting and conveying it to large ponds. In the traditional approach, stormwater is a problem solved with structural facilities, whereas in the LID approach, stormwater facilities are integrated landscape amenities.

LID is proving to be a broadly-favored approach to stormwater management. In 2009, the State of Washington became the first state in the nation to require new developments to implement LID where feasible in NPDES Phase I jurisdictions. This requirement will trickle-down to Phase II jurisdictions (such as Lacey), so it is the intent of this manual to strongly emphasize the use of LID techniques where feasible on development projects in the City of Lacey.

Roof Downspout Control BMPs and Dispersion and Soil Quality BMPs (as described in Chapter 6 of this manual) are required where feasible, to reduce the hydrologic disruption caused by the project. If such BMPs are not to be employed, the site analysis must document the conditions that preclude their use. To facilitate the use of such BMPs, the Drainage Manual Administrator may require special designs or allow design variations.

Other LID techniques, as described in Chapters 6 and 7, are required to the maximum extent feasible and must be considered in the site analysis report. Technical and operational criteria (relating to functionality) shall be used to assess LID feasibility.

The City of Lacey may require a low-impact development approach to site design on a case-by-case basis, in order to mitigate potential project impacts on sensitive receiving waters or other critical areas.

3.2 VICINITY ANALYSIS

Vicinity Analysis is used to identify offsite locations (such as critical areas and/or water bodies) that may be impacted by a proposed project. Information developed during Vicinity Analysis will be used to establish appropriate levels of flow control and water quality protection. Offsite water quality, erosion, slope stability, and drainage impacts that may be caused or aggravated by a proposed project shall be evaluated, and measures for preventing impacts and for not aggravating existing impacts shall be identified. "Aggravating existing impacts" means increasing the frequency of occurrence and/or severity of an impact.

The vicinity analysis shall extend downstream for the entire flow path from the project site to the receiving water or a distance sufficient to consider relevant impacts, as determined by the City. If a 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 beyond any improvements proposed as mitigation to the extent impacts to downstream properties can be determined. The analysis must extend upstream to a point beyond any backwater effects caused by the project. The entire area of potential impacts shall be considered in the vicinity analysis.

The existing and potential impacts to be evaluated and mitigated shall include:

- Conveyance system capacity problems;
- Localized flooding;
- Upland erosion impacts, including slope stability and landslide hazards;
- Stream channel erosion at the outfall location and to the downstream limit of analysis;
- Violations of surface water quality standards as identified in a Basin Plan or a TMDL (Water Clean-up Plan); or violations of groundwater standards in a wellhead protection area.

3.2.1 Six Tasks of Vicinity Analysis

The vicinity analysis for each downstream system leaving the site shall include the following six tasks:

<u>Task 1 – Define and map the study area</u>

The analysis shall include a site vicinity map showing property lines and streets; a topographic map (at a minimum, a USGS 1:24000 Quadrangle topographic map) showing site boundaries, study area boundaries, streets and prominent features, downstream flowpath, and potential/existing problems; and other maps and photos as desired to illustrate features of the site and vicinity.

Task 2 – Review available information on the study area

The project proponent shall review, at a minimum, relevant information from the following sources related to the project, and reference them in the Vicinity Analysis:

- Adopted basin plans
- Drainage studies
- Groundwater management area plans/Wellhead Protection Area Maps
- Critical Area Maps
- Floodway/floodplain (FEMA) studies and maps
- Drainage complaints history from City
- Road drainage problems (per City of Lacey and Thurston County)
- USDA SCS/NRCS Soil Survey for Thurston County
- Wetlands Inventory Maps
- Stream habitat reports, and salmon distribution reports;
- Other available offsite analysis reports in the same subbasin.

Task 3 – Field inspect the study area

The design engineer shall physically inspect the existing onsite and offsite drainage systems of the study area for each discharge location for existing or potential problems and drainage features.

- Investigate problems reported or observed during the resource review
- Locate existing/potential constrictions or capacity deficiencies in the drainage system
- Identify existing/potential flooding problems
- Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation
- Identify significant destruction of aquatic habitat (e.g., siltation, stream incision)
- Collect data on features such as land use, impervious surface, topography, soils, presence of streams, and wetlands
- Collect information on pipe sizes, channel characteristics, drainage structures
- Verify tributary drainage areas identified in Task 1
- Contact the City of Lacey, neighboring property owners, and residents about drainage problems

Task 4 – Describe the drainage system, and its existing and predicted problems

For each drainage system component (e.g., pipe, culvert, bridges, outfall, pond, vault) the following shall be addressed in the analysis:

- location,
- physical description
- field observations
- identified problems

The descriptions shall be used to determine whether adequate mitigation can be identified, or whether more detailed quantitative analysis is necessary. The following information should be provided for each existing or potential problem:

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

Task 5 – Describe the receiving waters, and their existing and predicted problems

For each receiving water (e.g., stream, lake, pond, wetland, salt water body, groundwater) the following shall be addressed in the analysis:

- Known water quality impairment (on state 303d list);
- Requirements of applicable TMDL;
- Requirements of applicable Basin Plan
- Requirements of applicable groundwater protection rules.

The analysis shall contain a discussion of the potential impacts of the project on the water quality issues identified in this task.

Task 6 – Propose Mitigation Measures

The Vicinity Analysis will evaluate proposed mitigation measures for all problems identified and described in Tasks 4 and 5. The analysis will document how flow control and water quality control measures selected and designed by procedures contained in this Manual will mitigate the potential to create new problems or aggravate existing conditions.

In many cases, design of flow control and water quality systems according to the procedures contained in this manual will be adequate demonstration of mitigation. Some downstream flooding, erosion or water quality conditions may not be mitigated by measures selected and designed by procedures contained in this Manual. Upon review of this analysis and the severity of an existing problem, the City of Lacey may require more detailed analysis and/or additional mitigation measures.

Levels of Vicinity Analysis

Level 1 – Qualitative Analysis

At the Preliminary Design/Permit Application stage, the level of analysis must be sufficient for the City to evaluate whether the project has adequately identified potential impacts and whether proposed mitigation measures are supported by the analysis. Some "rough" quantitative analysis, which can be based on non-surveyed field data, may be necessary at this stage.

Level 2 – Quantitative Analysis

At the Design Review stage, the level of analysis (quantitative rigor) shall be sufficient to satisfactorily provide all of the information requested in the Site and Vicinity Analysis and listed in the Checklist for Development Project Drainage Submittal (Appendix 2A).

Appendix 3A
Soils Report Requirements and Forms

The project proponent shall prepare a Soils Report, for inclusion in the Drainage Report, that conforms to the requirements of this Appendix. The Soils Report shall be oriented toward site stormwater management needs, and provide comprehensive information and recommendations regarding the site's geologic setting, soils characteristics and the existence and movement of surface water/shallow groundwater and stormwater.

Each soils report shall include the following components:

Soils Report Text:

The report narrative shall include descriptions and discussion of:

- The site's existing surface features;
- The proposed development & drainage plans;
- The site's geologic setting, landforms, and depositional history;
- Research conducted, field methods used and laboratory methods used;
- The findings and results of investigations and analyses;
- Recommendations related to site stormwater management, including any potential limitations or hazards, and the relevance of site soil and groundwater conditions to the selection and design of flow control and water quality control systems. Include recommended long-term infiltration rate(s) and an assessment of the suitability of the project site's soil conditions for using low-impact development (L.I.D.) techniques.

Soils Report Form 1, Site Information:

Provide one copy as the summary or cover sheet for the remainder of the report (all Form 2 sheets, soil logs and the site soil data map) for the project site.

Soils Report Form 2, Soil Log Summary:

Provide one form for each boring/pit, summarizing soil information based on soil logs. The soil report preparer should read all instructions prior to completing the forms.

Soil Logs:

Provide one soil log sheet for each boring/pit, with a graphical description of the vertical soil section. Data should extend to at least 6 feet below bottom of proposed facilities.

Site Soil Data Map:

The report shall include a site map showing locations of all soil samples/borings/pits referenced in the report, in relation to the latest proposed site layout and drainage plan.

NRCS Soils Map:

The report shall include a map showing NRCS mapped soil series on and around the site.

SOILS REPORT FORM 1:
SITE INFORMATION

STAFF USE ONLY

____
____
____

Please Read Instructions First. Please Print Clearly.

PROJECT TITLE:	Sheet of
PROJECT NUMBER:	**REPORT DATE:**
PREPARED BY:	
SITE ADDRESS OR LEGAL DESCRIPTION	
PROJECT DESCRIPTION	
SITE DESCRIPTION	
SUMMARY OF SOILS WORK PERFORMED Number of borings: Number of test pits:	
FINDINGS & RECOMMENDATIONS Soils: Soil Infiltration Rate(s): Suitability for LID: Feasibility of Flow Control Infiltration: Feasibility of Infiltration Treatment: General Stormwater Management Approach: Further Soils Work/Analysis:	
I certify that I prepared this report and conducted or supervised the related work, and that I am qualified to perform this work. I represent this work to be complete and accurate within the bounds inherent to the practice of soil science, and to be suitable for its intended use. SIGNED: ____________________ DATE: ____________________	

SOILS REPORT FORM 2:
SOIL LOG SUMMARY

STAFF USE ONLY

____
____
____

Please Read Instructions First. Please Print Clearly.

PROJECT TITLE:	Sheet of
PROJECT NUMBER:	**SOIL TEST DATE:**
PREPARED BY:	

SOIL LOG:

LOCATION:

ELEVATIONS: Surface = Bottom =

Types Of Test(s) ☐ Boring: ☐ Pit: ☐ Infiltration: ☐ Other:	**NRCS Soil Series:** Mapped: Observed:	**Hydrologic Soil Group:**
Depth To Water: Encountered: Seasonal High: Historic High: Not encountered:	**Impermeable Layer Description/Depth:**	**Misc. Notes:**

Erosion Potential: Topog./slope ____________ NRCS estimate____________
Runoff Potential:
Ponding Potential:

Site Infiltration Rate

NRCS estimate:

From soil textural analysis:

From field testing:

Recommended Long-Term Rate:

SOIL STRATA DESCRIPTION:

HOR	DPTH	COL	TEX	% CLA	% ORG	% C.FR	STRC	MOT	IND	CEM	ROO	PRC	F.S. PRC

Comments & Key Findings:

Instructions For Completing Soils Report Form 1

Form 1 is the summary and/or cover page for the remainder of the soils report, for all projects requiring a soils report.

1. Provide a legible map on 8.5” by 11” paper showing the site and major landmarks (e.g., roadways and surface waters) within about ¼ mile of site.
2. Under “Project Description” provide parcel acreage, type of proposed development, and approximate proposed impervious cover.
3. Under “Site Description” describe topography, terrain and current/natural cover.
4. Under “Summary of Soils Work Performed” indicate methods used to sample soils (pit/boring) and number of sample locations. Indicate field and/or lab tests performed (e.g. textural analysis, infiltration rate determination)
5. Show soil test boring/pit locations on a current site plan map.
6. Under “Findings & Recommendations”
    a. Compare soils encountered with NRCS soils descriptions (include NRCS soils map, from NRCS website).
    b. Provide estimate of site long-term infiltration rate.
    c. Indicate if soils are generally suitable for runoff flow control and/or water quality treatment based on infiltration criteria in Chapters 6 and 7
    d. Indicate if soils are suitable for Low Impact Development Practices
    e. Describe recommended overall approach for managing site stormwater (e.g., infiltrate, surface ponds, on-site stormwater management)
    f. Describe any recommended further soils testing or analysis.
7. Sign and date form. Affix professional seal. The Soils Report shall be certified by a licensed Geologist (L.G.), Engineering Geologist (L.E.G.), Hydrogeologist (L.H.G.), or Professional Engineer with geotechnical expertise (P.E.), licensed in Washington.

Instructions For Completing Soils Report Form 2

Form 2 is the detailed record of soil information obtained on the project site.
One copy of Form 2 is required for each soil test location (boring or pit).

1. State the Soil Log number (or other designation), and location in reference to permanent features. Provide boring or pit logs that detail soil profile/strata information. Logs shall conform to Unified Soil Classification Standards and standard practice of the geotechnical engineering profession. Indicate the elevations of the ground surface and the bottom of the boring or test pit.
2. State what type of tests were performed and briefly describe.
3. Determine soil series through comparison of log description with NRCS soil series descriptions and maps.

4. Indicate NRCS Hydrologic Soil Group (letter designation: A, B, C or D) based on soil series determination.

5. Indicate depth to groundwater, if encountered; indications of seasonal high groundwater based on presence of mottling, gleying or other evidence; and historic high groundwater level based on any available indicators. Indicate whether groundwater table is perched.

6. Indicate depth to impervious layer, if encountered.

7. Indicate susceptibility of site soils to erosion based on NRCS k-factor and relevant site physical characteristics. Potential for runoff and ponding based on NRCS data.

8. Indicate long-term infiltration rate estimated using NRCS estimates based on soil type, or based on lab and/or field analyses as described in Chapter 6.

9. Provide descriptions of the physical attributes of the soil strata. Utilize standard nomenclature and abbreviations (provide legend) to address the following factors:

   a. Horizon: soil layer with distinct characteristics, labeled A, B, etc.

   b. Depth: distance to horizon interval (top & base), from ground surface.

   c. Color: Munsell code for hue, value & chroma. For example, 10YR 4/2.

   d. Textural Class: 2-letter designation of soil classification in terms of relative proportions of sand, silt and clay. For example, SL = sandy loam

   e. % Clay: Clay percentage in soil horizon; relevant to drainage capability.

   f. % Organic Matter: by volume; relates to infiltration and pollutant-removal.

   g. % Coarse Fragments (>2mm dia): relevant to drainage and other site factors.

   h. Structure: describes the size and shape of natural soil "clods" or clumps. Use 3-letter abbreviation to indicate *grade* (Weak, Moderate, Strong), *size* (Fine, Medium, Coarse) and *form* (Granular, Blocky, Platy). For example, SMG.

   i. Mottling: where present, use 3-letter abbreviation to indicate *abundance* (Few, Common, Many), *size* (Fine, Medium, Coarse) and *contrast* (Faint, Distinct, Prominent). For example, CFD.

   j. Induration: physical compaction of a layer, such as a glacial till. Where present, describe as Very Weak, Weak, Moderate, Strong or Very Strong.

   k. Cementation: Aggregation of soil particles due to chemical processes; describe as for induration. Note the cementing agent under "Comments & Key Findings."

   l. Roots: Where present, describe using 2-letter abbreviation to indicate *abundance* (Few, Common, Many) and *size* (Fine, Medium, Coarse). Medium = 2-5mm dia.

   m. PRC refers to general range of percolation rates (in./hr.) per NRCS Soil Survey.

   n. F.S. PRC refers to the Field Saturated Percolation Rate (in./hr.), estimated using all available information. Rate shall be a single number reflecting effects of the entire soil column, and may vary from "PRC" rate range in previous column.

10. Provide any relevant comments and describe key findings about site soils & drainage.

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Appendix 3B
Facility Summary Form

Complete one (1) form for each facility on the project site, including flow control and water quality treatment facilities (BMPs) such as, but not limited to, the following: detention ponds, vaults, or tanks; infiltration ponds, trenches, swales, or vaults; bioretention facilities (rain gardens, bioretention swales/slopes); biofiltration BMPs (filter strips, biofiltration swales); oil/water separators; wet ponds; constructed wetlands; dispersion areas & flow spreaders; StormFilters^{TM} & other proprietary devices; sand filters; etc.

Attach 8 ½" x 11" sketch showing location of facility.

Applicant may prepare one copy of pages 1 to 4 for the project and then attach multiple copies of pages 5 & 6 for each separate facility.

Facility Name or Identifier (e.g., Pond A): ____

Total Number of Facilities Associated with Project: This is Number ______ of ______ total

(For which a Facility Summary Form is being prepared)

Name of Road or Street to Access Facility*:* ____

Name of Nearest Major Cross Street: ____

Hearings Examiner Case Number: ____

City Project No./Bldg. Permit No.: ____

Parcel Number(s): ____

To be completed by City Staff:

Utility Facility Number:

Project Number:

Parcel Number Status:
(Known, Public, Unknown, or Unassigned)

Basin and Subbasin:
(basin, subbasin, future)

Notes:

Part 1 - Project Name and Proponent

Project Name: ______________________________

Project Owner: ______________________________

Project Contact: ______________________________

Address: ______________________________

Phone: ______________________________

Project Proponent (if different): ______________________________

Address: ______________________________

Phone: ______________________________

Project Engineer: ______________________________

Firm: ______________________________

Phone: ______________________________

Part 2 - Project Location

¼-Section ________ **Section** __________ **Township** ___________ **Range** ____________

Names and Addresses of Adjacent Property Owners: (attach add'l sheet if required):

Part 3 - Type of Permit Application

Type of permit (e.g. Building, Plat, etc.): ______________________________

Other Permits Required:
(such as WDFW HPA, Grading, Rockery/Retaining Wall, NPDES Construction Storm, Forest Practices/Clearing etc.)

____

____

Other Agencies (Federal, State, Local, etc.) that have had or will review this Drainage Plan:

____

____

Part 4 - Proposed Project Description

What stream/lake/saltwater basin is this project in (e.g., Salmon, Green Cove, Woodland):

Project Area, acres (total area of all parcels):

Project Area Disturbed, acres (total of all areas disturbed by project):
(Include all area cleared, graded, etc. as part of this project)

Onsite Impervious Surfaces: *(excluding offsite public / private street frontage)*:

Existing Impervious Surface, acres: ____

Replaced Impervious Surface, acres: _______________________________________

Existing Impervious Converted to Landscape, acres: ________________________

New Impervious Surface, acres: ____

Total Impervious, acres (existing, new, and replaced): _______________________

Zoning: ____

Onsite:

Residential Subdivision:

Number of Lots:_______________________________________

Lot size (average), acres: ________________________________

Building Permit/Commercial Plat:

Building(s) Footprint, acres: _____________________________

Concrete Paving, acres: ________________________________

Gravel Surface, acres: _________________________________

Lattice Block or Porous Paving, acres: ____________________

New Public Roads (including gravel shoulder), acres: ________________________

New Private Roads (including gravel shoulder), acres: _______________________

Frontage Improvements (including gravel shoulder), acres: ____________________________

Existing road frontage to center of right-of-way, acres: _____________________________

Part 5 - Pre-Developed Project Site Characteristics

Stream through site, y/n: ________________

Name: ____

DNR Type: ____

Type of feature this facility discharges to (i.e., lake, stream, intermittent stream, pothole, roadside ditch, sheet flow to adjacent private property, etc.

Swales, Ravines, y/n:

Steep slopes, (steeper than 15%) y/n: ____________

Erosion hazard, y/n:
(soil types classified "highly erodible" by NRCS soil survey)

100 yr. Floodplain, y/n: _________________

Lakes or Wetlands, y/n: _________________

Seeps/Springs, y/n: _____________________

High Groundwater Table, y/n: ____________

(depth to seasonal high groundwater table less than 5-feet)

Wellhead Protection or Aquifer Sensitive Area, y/n: ________

Other:

Part 6 - Facility Description

Total Area Tributary to Facility Including Offsite (acres): _____________________

Total Onsite Area Tributary to Facility (acres): ______________________________

Design Impervious Area Tributary to Facility (acres): _______________________

Design Landscaped Area Tributary to Facility (acres): _______________________

Design Native Vegetation Area Tributary to Facility (acres): ___________________

Design Total Tributary Area to Facility (acres): ________________

Water Quality Design Volume: ______________________________

Water Quality Design Flow: ________________________________

100 Year return interval, 24-hr Design Flow: __________________

Part 7 - Release to Groundwater (if applicable)

Design Infiltration Rate ________________ in/hr

Average Annual Infiltration per WWHM __________________

Designed for 100% Infiltration (Yes/No): _______________

Designed for Infiltration Treatment (Yes/No): __________

Part 8 - Release to Surface Water (if applicable)

Discharge Structure: (check/complete all that apply)

Single orifice ______________ Elev. ______________Dia.

Multiple orifice _____________ Elev. 1 ____________Dia.

Elev. 2 ____________Dia.

Elev. 3 ____________Dia.

Weir _______________Elev. ______________Type______________

Overflow ____________Elev.________ Dia./Width:________________

Spillway ___________ Elev. _____________Max Elev.___________

Pump(s) ___________Model/Type: ___________________Rating: __________

Other____

Discharge to surface water:

Return Period:	Pre-Developed	Post-Developed
2 year:		
5 year:		
10 year:		
25 year:		
50 year:		
100 year:		

Design Max surface water elevation: __________ ft (msl)

Design Maximum pond depth: _______________ft

Pond Volume at Max design water level: ____________________ cubic feet

Overflow water elevation: __________________ ft (msl)

Sediment storage volume: _________________ft (depth below outlet)

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Chapter 4 – Construction Erosion & Sediment Control and Stormwater Pollution Prevention

This chapter contains City standards and guidance to address Core Requirement #2, Construction Stormwater Pollution Prevention. Construction projects must apply for coverage under the NPDES General Permit for Stormwater Associated with Construction Activities if

- the project results in the disturbance of one acre or more of land, including clearing, grading, and excavation activities, and
- the project discharges stormwater from the site into a surface water or discharges to a storm drain system that discharges to a surface water.

Some construction projects may require an individual NPDES permit. Compliance with the City standards does not necessarily imply compliance with the State of Washington's NPDES general or individual construction stormwater permits. It is the responsibility of the project proponent to meet applicable state permit requirements. For further background on erosion and sediment control principles, please refer to the current version of the *Stormwater Management Manual for Western Washington, Volume II*.

4.1 GENERAL EROSION AND SEDIMENT CONTROL REQUIREMENTS AND GUIDELINES

The 12 Elements listed below must be addressed in the Construction Stormwater Pollution Prevention Plan (as reflected in Chapter 1, Core Requirement #2) and included in the Drainage Report unless site conditions render the element unnecessary. If an element is considered unnecessary, the justification must be clearly provided in the Drainage Report.

These elements cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources.

The 12 Elements are:

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

A complete description of each BMP is given in Section 4.4. The Checklist for Development Project Drainage Submittal (Appendix 2A) shall be used to document that all of the elements have been addressed.

The following general principles should be applied to the development of the Construction Stormwater Pollution Prevention Plan (SWPPP):

- The duff layer, native topsoil, and natural vegetation should be retained in an undisturbed state to the maximum extent practicable.
- 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.
- Limit the extent of clearing operations and phase construction operations.
- Before reseeding a disturbed soil area, amend all soils with compost wherever topsoil has been removed. Refer to BMP LID.02 , Post-Construction Soil Quality and Depth.
- Incorporate natural drainage features, using adequate buffers and protecting areas where flow enters the drainage system.
- Minimize slope length and steepness.
- Reduce runoff velocities to prevent channel erosion.
- Prevent the tracking of sediment off-site.
- Select appropriate BMPs for the control of pollutants other than sediment.

4.2 TESC DESIGN PROCEDURE

There are three basic steps in producing the Temporary Erosion and Sediment Control (TESC) portion of the Drainage Plans:

Step 1 - Data Collection

Step 2 - Data Analysis

Step 3 - Construction SWPPP Development and Implementation

Steps 1 and 2 described below are intended for projects that are adding or replacing 2,000 square feet or more of impervious surface, or clearing 7,000 square feet or more. The small project ESC plan is available for single-family home and similar small construction projects.

Step 1 - Data Collection

Develop site and vicinity information related to the following types of information as described in Chapter 3:

- Topography
- Drainage
- Soils
- Land Use/Ground Cover
- Critical Areas
- Adjacent Areas
- Encumbrances/site constraints: wells, septic drain fields, utilities, etc.

Step 2 - Data Analysis

Use the data collected in Step 1 to evaluate potential problems and limitations of the site. Determine those areas that have critical erosion hazards. The following are some important factors to consider in data analysis:

Topography: 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.

Drainage: Natural drainage patterns that consist of overland flow, swales and depressions should be used 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 they are not properly stabilized. Ensure that increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for temporary stormwater retention and detention should be considered at this point.

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.

Soils: 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. Infiltration sites should be properly protected from clay and silt which will reduce infiltration capacities.

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

Critical Areas: Critical areas may include flood hazard areas, mine hazard areas, slide hazard areas, sole source aquifers, wetlands, streambanks, fish-bearing streams, and other water bodies. Any critical areas within or adjacent to the development should exert a strong influence on land development decisions. **Critical areas and their buffers shall be delineated on the drawings and clearly flagged and fenced in the field.** Chain link fencing may be more useful than flagging to assure that equipment operators stay out of critical areas, and may be required. No work shall take place within critical areas and their buffers, pursuant to LMC Title 14.

Adjacent Areas: 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. The types, values, and sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems, should be evaluated. Erosion and sediment controls should be selected accordingly.

Precipitation Records: Refer to Chapters 6 and 7 to determine the required rainfall records and the method of analysis for design of BMPs.

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.

Step 3 - Construction SWPPP - TESC Plan Development and Implementation

After collecting and analyzing the data to determine the site limitations, the designer can then develop a TESC Plan for the Construction SWPPP. **Each of the 12 required elements (see Chapter 1, Minimum Requirement #2) must be addressed and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.**

The Department of Ecology provides a template for preparing the Construction SWPPP at

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

The following table presents recommended BMPs for each of the required elements.

Table 4.0 Construction SWPPP Elements and BMPs	
Element	**Suggested BMPs**
Element #1: Mark Clearing Limits	BMP C101: Preserving Natural Vegetation BMP C102: Buffer Zones BMP C103: High Visibility Plastic or Metal Fence BMP C104: Stake and Wire Fence
Element #2: Establish Construction Access	BMP C105: Stabilized Construction Entrance BMP C106: Wheel Wash BMP C107: Construction Road/Parking Area Stabilization
Element #3: Control Flow Rates	BMP C240: Sediment Trap BMP C241: Temporary Sediment Pond Refer to Chapters 6 and 7 for descriptions of these BMPs.
Element #4: Install Sediment Controls	BMP C233: Silt Fence BMP C234: Vegetated Strip BMP C235: Straw 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	BMP C120: Temporary and Permanent Seeding BMP C121: Mulching BMP C122: Nets and Blankets BMP C123: Plastic Covering BMP C124: Sodding BMP C125: Topsoiling BMP C126: Polyacrylamide for Soil Erosion Protection BMP C130: Surface Roughening BMP C131: Gradient Terraces BMP C140: Dust Control BMP C180: Small Project Construction Stormwater Pollution Prevention

Table 4.0 Construction SWPPP Elements and BMPs	
Element	**Suggested BMPs**
Element #6: Protect Slopes	BMP C120: Temporary and Permanent Seeding BMP C130: Surface Roughening BMP C131: Gradient Terraces BMP C200: Interceptor Dike and Swale BMP C201: Grass-Lined Channels 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	BMP C220: Storm Drain Inlet Protection
Element #8: Stabilize Channels & Outlets	BMP C202: Channel Lining BMP C209: Outlet Protection
Element #9: Control Pollutants	BMP C151: Concrete Handling BMP C152: Sawcutting and Surfacing Pollution Prevention See Chapter 8 – Source Control BMPs
Element #10: Control De-Watering	Practices as described in Chapter 1, Core Requirement #2
Element #11: Maintain BMPs	Practices as described in Chapter 1, Core Requirement #2
Element #12: Manage the Project	Practices as described in Chapter 1, Core Requirement #2

In addition to the requirements of Table 4.0, the following requirements relate to inspections and monitoring:

A Certified Erosion and Sediment Control Lead shall be identified in the Construction SWPPP and shall be on-site or on-call at all times. Certification may be through any of the programs listed on Ecology's website under Certified Erosion and Sediment Control Lead (CESCL) - Training and Certification Programs, or any equivalent local or national certification and/or training program. CESCL Training and Certification information is on Ecology's website at

http://www.ecy.wa.gov/programs/wq/stormwater/cescl.htm

Sampling, analysis and reporting of the stormwater discharges from a construction site may be required on a case-by-case basis, in addition to any monitoring that may be required for compliance with an NPDES permit.

Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, the SWPPP shall be modified, as appropriate, in a timely manner.

The Construction SWPPP shall be retained on-site or within reasonable access to the site. The Construction SWPPP shall be modified whenever there is a significant change in the design, construction, operation, or maintenance of any BMP.

Specific requirements related to the contents and format of the Erosion and Sediment Control section of the Drainage Report are found in Chapter 2, Drainage Submittal Requirements.

4.3 STANDARDS AND SPECIFICATIONS FOR ESC BMPS

This section contains standards and specifications for temporary BMPs to be used as applicable during the construction phase of a project.

These standards and specifications are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. In those instances where appropriate BMPs are not found in this chapter, experimental management practices can be considered. Minor modifications to standard practices may also be considered. However, such practices must be approved by the City. All experimental management practices and modified standard practices are required to achieve the same or better performance than the BMPs listed in Chapter 4.

The standards for each individual BMP are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards

Note that the "Conditions of Use" always refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance.

Information on streambank stabilization is available in the *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2000.

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html also provides information on emerging erosion and sediment control BMPs.

Chapter 6 of WSDOT's Highway Runoff Manual, which may be found at http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/HighwayRunoff2004.pdf provides further potentially useful design guidance.

BMPs shall be designed and installed in accordance with the specifications contained in the descriptions in this Chapter.

BMP C101: Preserving Natural Vegetation

Purpose

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

Conditions of Use

- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- As required by Lacey Municipal Code 14.32 Tree and Vegetation Protection and Preservation, and other potential requirements or recommendations pertaining to natural vegetation and trees.

Design and Installation Specifications

Natural vegetation can be preserved in natural clusters 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:

- Tree preservation and protection on site shall meet the requirements of Lacey Municipal Code 14.32 Tree and Vegetation Protection and Preservation, and shall follow the recommendations of the City of Lacey Tree Protection Professional and approved tree protection plan.
- Tree protection fencing shall be placed around the trees that are to be saved. Tree protection fencing shall be inspected by the City of Lacey Tree Protection Professional prior to land clearing activities.
- Consider the location, species, size, age, vigor, and the work involved.
- Fence or clearly mark areas around trees that are to be saved. It is required to keep ground disturbance away from the trees at least as far out as the dripline or distance shown on approved clearing and grading plans, or per the City of Lacey Tree Protection Professional.

Plants need protection from three kinds of injuries:

- *Construction Equipment* - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.

- *Grade Changes* - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees can tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

  When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

  Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- *Excavations* **-** Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:

  Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

  Backfill the trench as soon as possible.

  Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.

- The windthrow hazard of Pacific silver fir and madrona is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions where 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 lopers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

BMP C102: Buffer Zones

Purpose

An undisturbed area or strip of natural vegetation or an established suitable planting that will 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 be used to protect natural swales and can be incorporated into the natural landscaping of an area.

Critical-areas buffer zones should not be used as sediment treatment areas. These areas shall remain completely undisturbed. The City of Lacey may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment, per Lacey Municipal Code Title 14.

Design and Installation Specifications

- Preserving natural vegetation or plantings in clusters, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas. Steel construction fencing is the most effective method in protecting sensitive areas and buffers. Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.
- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.
- Vegetative buffer zones for streams, lakes or other waterways shall be established by the local permitting authority or other state or federal permits or approvals.

Maintenance Standards

- Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.

BMP C103: High Visibility Plastic or Metal 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 or roads; and, (4) protect areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, plastic or metal fence may be used (subject to approval by the City of Lacey):

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

Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least four feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every six inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.
- 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 its visibility reduced, it shall be repaired or replaced immediately and visibility restored.

BMP C104: Stake and Wire 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 or roads; and, (4) protect any areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, stake or wire 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

- See Figure 4.1 for details.
- More substantial fencing shall be used if the fence does not prevent encroachment into those areas that are not to be disturbed.

Maintenance Standards

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

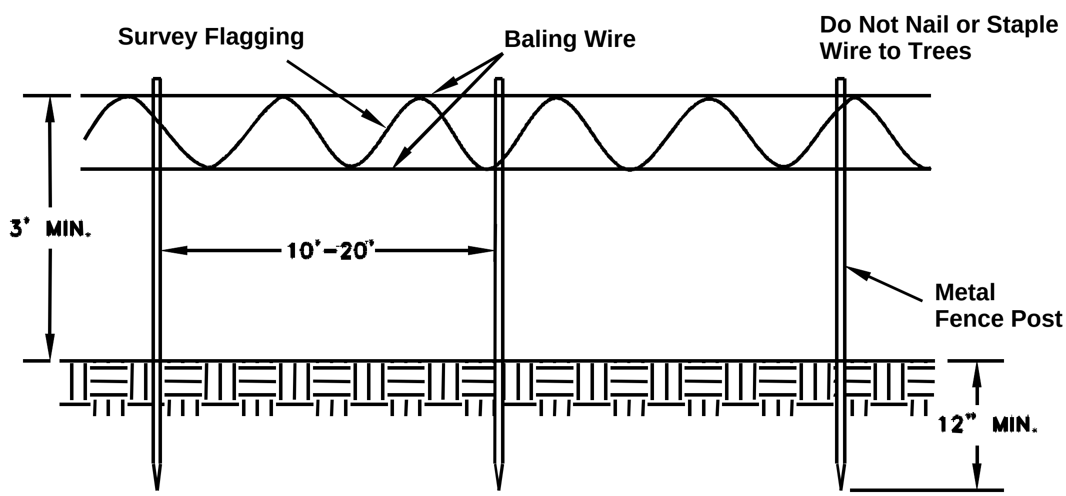


Figure 4.1 – Stake and Wire Fence

BMP C105: Stabilized Construction Entrance

Purpose

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

Conditions of Use

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

On large commercial, highway, and road projects, the designer shall include enough extra materials (such as through a force account) 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 4.2 for details.
- 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)

- 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.
- Fencing (see BMPs C103 and C104) 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.

Maintenance Standards

- Quarry spalls shall be added if the pad is no longer in accordance with the specifications.
- 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 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, the construction of a small sump shall be considered. The sediment would then be washed into the sump where it can be controlled.

- Any quarry spalls that are loosened from the pad, which end up on the roadway shall be removed immediately.
- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see BMPs C103 and C104) shall be installed to control traffic.
- Upon project completion and site stabilization, all construction accesses intended as permanent access for maintenance shall be permanently stabilized

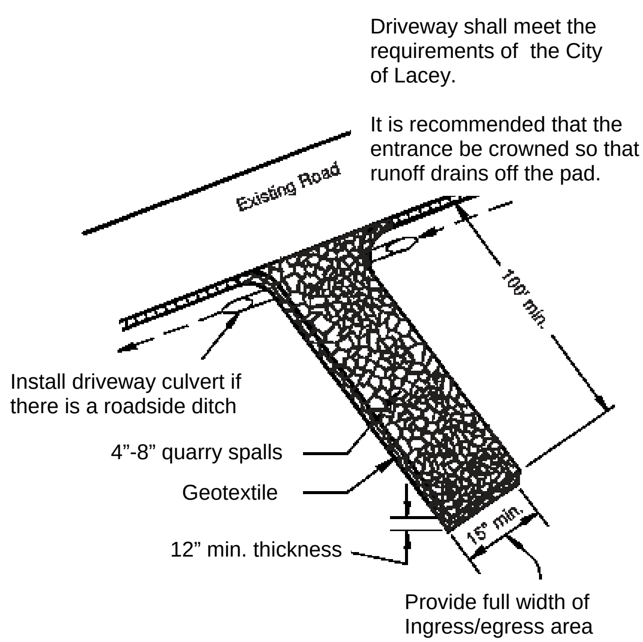


Figure 4.2 - Stabilized Construction Entrance

BMP C106: Wheel Wash

Purpose

Wheel washes 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 generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street.
- Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot x 10-foot sump can be very effective.

Design and Installation Specifications

- Suggested details are shown in Figure 4.3. The Local Permitting Authority may allow other designs. A minimum of 6 inches of asphalt treated base (ATB) over crushed base material or 8 inches over a good subgrade is recommended to pave the wheel wash.
- Use a low clearance truck to test the wheel wash before paving. Either a belly dump or lowboy will work well to test clearance.
- Keep the water level from 12 to 14 inches deep to avoid damage to truck hubs and filling the truck tongues with water.
- Midpoint spray nozzles are only needed in extremely muddy conditions.
- Wheel wash systems should be designed with a small grade change, 6 to 12 inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent re-suspension of sediment. A drainpipe with a 2- to 3-foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling. Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 - 0.5 pounds per 1,000 gallons of water increases effectiveness and reduces cleanup time. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash water.

Maintenance Standards

- The wheel wash should start out the day with fresh water.
- The wash water should be changed a minimum of once per day. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wash water will need to be changed more often.

- Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system, such as closed-loop recirculation or land application, or to sanitary sewer with local sewer district approval.

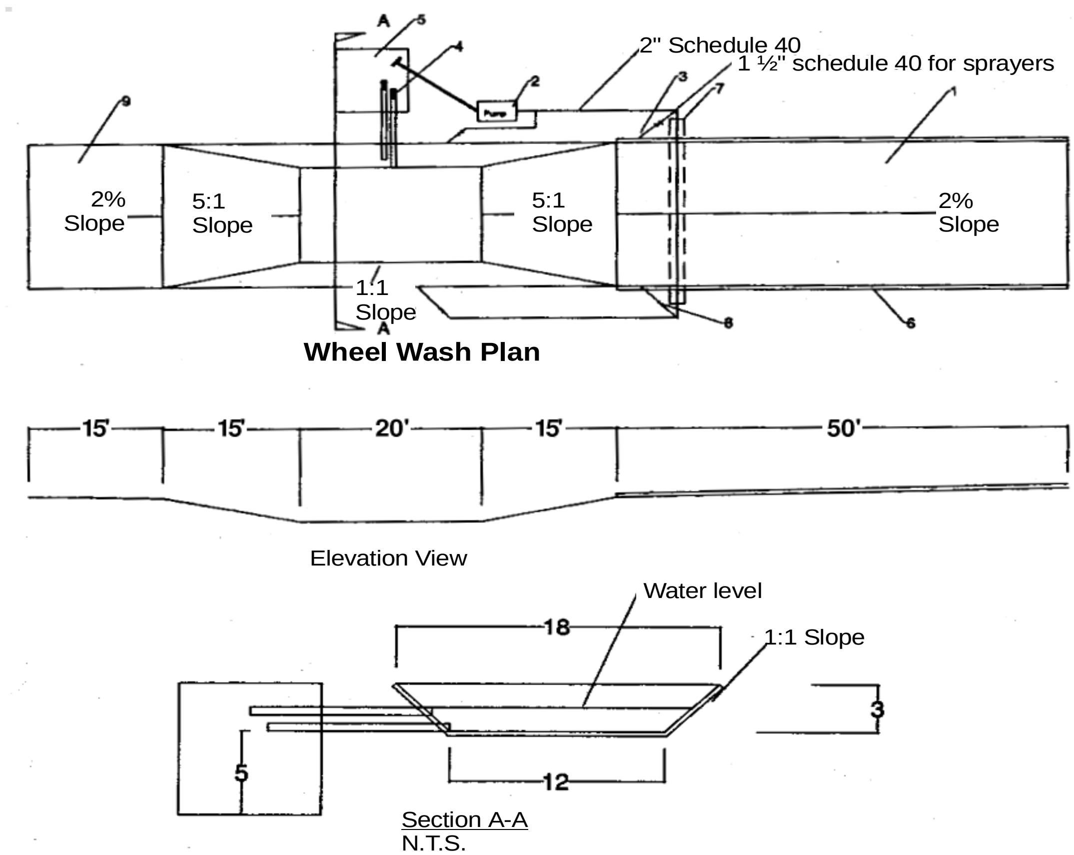


Figure 4.3 – Wheel Wash

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.

BMP C107: Construction Road/Parking Area Stabilization

Purpose

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

Conditions of Use

- Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
- Fencing (see BMPs C103 and C104) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

- On areas that will receive asphalt as part of the project, install the first lift as soon as possible.
- A 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMPs 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 generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include wetlands. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.
- Storm drain inlets shall be protected to prevent sediment-laden water from entering the storm drain system (see BMP C220).

Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Crushed rock, gravel base, hog fuel, 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.

BMP C120: Temporary and Permanent Seeding

Purpose

Seeding is intended 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 may be used throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a Bonded Fiber Matrix. The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch over hydromulch and blankets.
- Retention/detention ponds should be seeded as required.
- Mulch is required at all times because it protects seeds from heat, moisture loss, and transport due to runoff.
- 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

- The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1. Seeding that occurs between July 1 and August 30 will require irrigation until 75 percent grass cover is established. Seeding that occurs between October 1 and March 30 will require a mulch or plastic cover until 75 percent grass cover is established.
- To prevent seed from being washed away, confirm that all required surface water control measures have been installed.
- The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, 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 the subgrade should be initially ripped to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches the rototilling process should be done in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.
- 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 2-10 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.
- 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.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. Mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, and kenaf; compost; or blends of these. Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as polyacrylamide or polymers. 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.
- Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.
- On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of

mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.

In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

- When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. One way to overcome this is to increase seed quantities by up to 50 percent.
- Vegetation establishment can also be enhanced by dividing the hydromulch operation into two phases:
    1. Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift;
    2. Phase 2- Install the rest of the mulch and tackifier over the first lift.

An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800-1000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

1. Irrigation
2. Reapplication of mulch
3. 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 can be accomplished in a number of ways:

    Recent research has shown that the best method to improve till soils is to amend these soils with compost. The optimum mixture is approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils. Please note: The compost should meet specifications for Grade A quality compost in Ecology Publication 94-038.

Other soils, such as gravel or cobble outwash soils, may require different approaches. Organics and fines easily migrate through the loose structure of these soils. Therefore, the importation of at least 6 inches of quality topsoil, underlain by some type of filter fabric to prevent the migration of fines, may be more appropriate for these soils.

Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.

- Areas that will be seeded only and not landscaped may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Native topsoil should be re-installed on the disturbed soil surface before application.
- Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets. 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. Local suppliers or the local conservation district should be consulted for their 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 local authority may be used.

  Table 4.1 represents the standard mix for those areas where just a temporary vegetative cover is required.

Table 4.1
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 4.2 provides just one recommended possibility for landscaping seed. Also recommended for soil-amended areas, or where low water and low pesticide use are being emphasized, is the ProTime 705 PDX Ecology Seed Mixture, manufactured by ProTime Lawn Seed. (http://www.protimelawnseed.com/pt_705.html). It produces a green cover without supplemental irrigation and normally requires no fertilizer after establishment.

Table 4.2
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 4.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

Table 4.3
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 4.4 presents a mix recommended for bioswales and other intermittently wet areas.

Table 4.4
Bioswale Seed Mix*

	% 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

** Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

The seed mix shown in Table 4.5 is 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 4.5 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

** Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

The meadow seed mix in Table 4.6 is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. 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 4.6 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

- Any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows) shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the local authority 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.
- Seeded areas shall be supplied with adequate moisture, but not watered to the extent that it causes runoff.

BMP C121: Mulching

Purpose

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

Conditions of Use

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and during the hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 4.7. 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.

Maintenance Standards

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

Table 4.7
Mulch Standards and Guidelines

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2"-3" thick; 5 bales per 1000 sf or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. Straw should be used only if mulches with long-term benefits are unavailable locally. It should also 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 1000 sf or 1500 - 2000 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 ¾-1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch.
Composted Mulch and Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. 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.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2" minimum thickness	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch	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” thick; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	This material is 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).

BMP C122: Nets and Blankets

Purpose

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

Conditions of Use

Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.
- For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.

Design and Installation Specifications

- See Figure 4.4 and Figure 4.5 for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed per manufacturer's installation instructions.
- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.
- Installation of Blankets on Slopes:
  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. NOTE: Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.

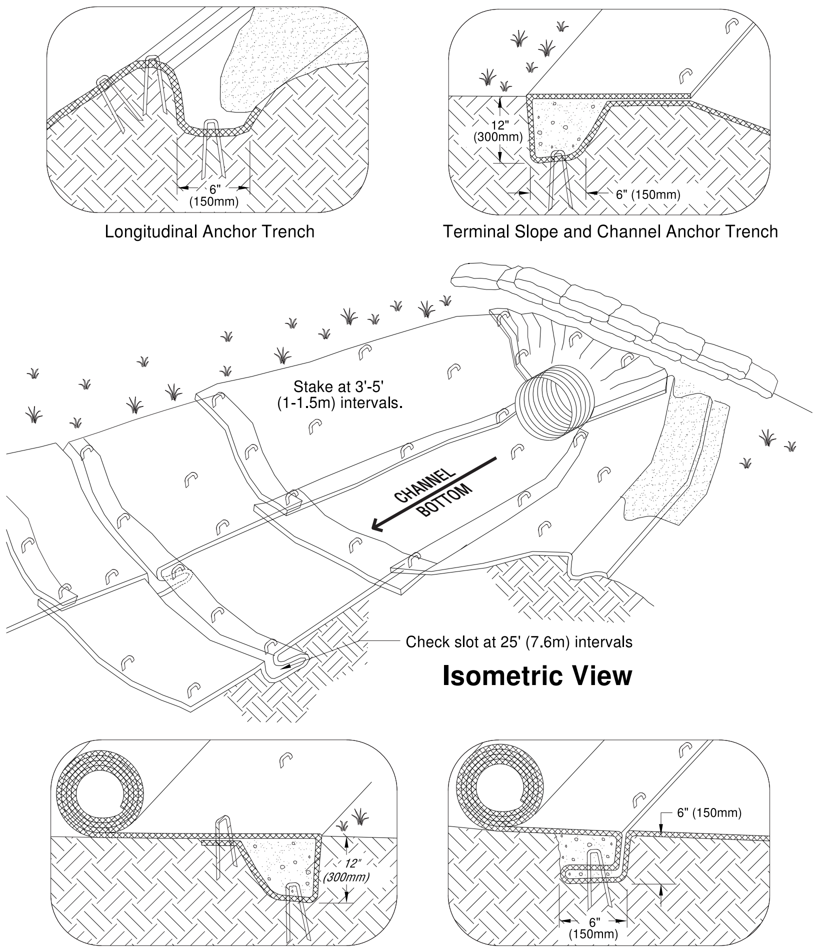
5. Roll the blanket slowly down the slope as installer walks backwards. NOTE: The blanket rests against the installer’s legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.
6. If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.

- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the 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 WSDOT, Texas Transportation Institute, and other websites. For all products, provide information and specifications for local government review and approval.
- 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 (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.
- 100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.
- Most netting used with blankets is photodegradable, meaning 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

- Good contact with the ground must be maintained, and erosion must not occur beneath the net or blanket.
- Any areas of the net or blanket that are damaged or not in close contact with the ground shall be repaired and stapled.
- If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.



Initial Channel Anchor Trench **Intermittent Check Slot**

NOTES:

1. Check slots to be constructed per manufacturer's specifications.
2. Staking or stapling layout per manufacturer's specifications.

Figure 4.4 – Channel Installation

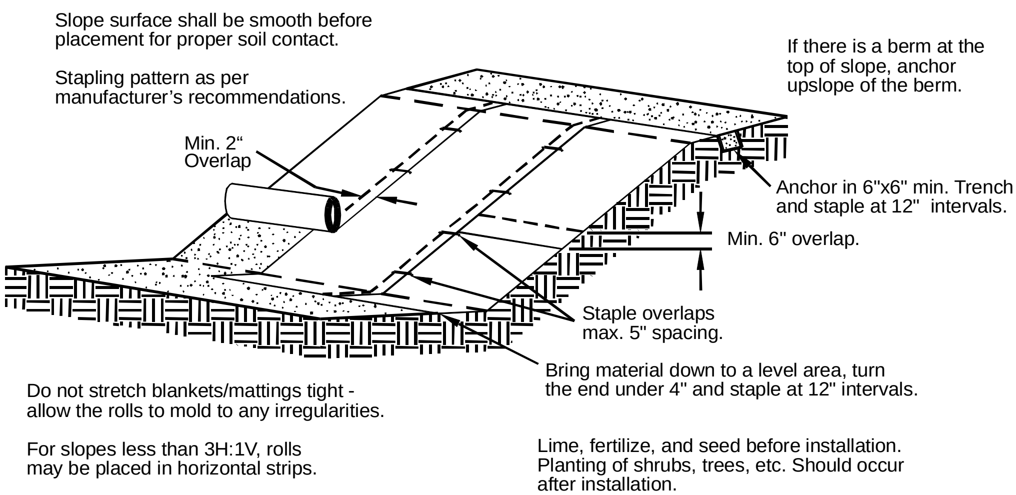


Figure 4.5 - Slope Installation

BMP C123: Plastic Covering

Purpose

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

Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than six months) applications.
- Clear plastic sheeting can be used over newly-seeded areas to create a greenhouse effect and encourage grass growth if the hydroseed was installed too late in the season to establish 75 percent grass cover, or if the wet season started earlier than normal. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.
- 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.
- Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to convey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.
- Other uses for plastic include:
    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; and,
    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. On long or wide slopes, or slopes subject to wind, all seams should be taped;
  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 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.
- If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.
- When the plastic is no longer needed, it shall be completely removed.
- Dispose of old tires appropriately.

BMP C124: Sodding

Purpose

The purpose of sodding is to establish permanent turf for immediate erosion protection and to 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. Compost used should meet Ecology publication 94-038 specifications for Grade A quality compost.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- Roll the sodded area and irrigate.
- When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

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

Purpose

To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the 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

- Native soils should be left undisturbed to the maximum extent practicable. Native soils disturbed during clearing and grading should be restored, to the maximum extent practicable, 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. Commercially available mycorrhiza products should be used when topsoil is brought in from off-site.

Design and Installation Specifications

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

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil depth shall be at least 8 inches with a minimum organic content of 10 percent dry weight and pH between 6.0 and 8.0 or matching the pH of the undisturbed soil. This can be accomplished either by returning native topsoil to the site and/or incorporating organic amendments. Organic amendments should be incorporated to a minimum 8-inch depth except where tree roots or other natural features limit the depth of incorporation. Subsoils below the 12-inch depth should be scarified at least 2 inches to avoid stratified layers, where feasible. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.

- If blended topsoil is imported, then fines should be limited to 25 percent passing through a 200 sieve.
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, recent practices have shown that incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- Locate the topsoil stockpile so 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.
- Allow sufficient time in scheduling for topsoil to be spread prior to seeding, sodding, or planting.
- Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.
- Ripping or re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.
- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.
- 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.

Stockpiling of topsoil shall occur in the following manner:

- Side slopes of the stockpile shall not exceed 2:1.
- An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles between October 1 and April 30. 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.

- Erosion control seeding or covering with clear plastic or other mulching materials of stockpiles shall be completed within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Native topsoil stockpiles shall not be covered with plastic.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.
- When native topsoil is to be stockpiled and reused the following should apply to ensure that the mycorrhizal bacterial, earthworms, and other beneficial organisms will not be destroyed:
  1. Topsoil is to be re-installed within 4 to 6 weeks;
  2. Topsoil is not to become saturated with water;
  3. Plastic cover is not allowed.

Maintenance Standards

- Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.

BMP C126: Polyacrylamide for Soil Erosion Protection

Purpose

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

Applying PAM to bare soil in advance of a rain event significantly reduces erosion and controls sediment in two ways. First, PAM increases the soil's available pore volume, thus increasing infiltration 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 not be directly applied to water or allowed to enter a water body.

In areas that drain to a sediment pond, PAM can be applied to bare soil under the following conditions:

- During rough grading operations.
- Staging areas.
- Balanced cut and fill earthwork.
- Haul roads prior to placement of crushed rock surfacing.
- Compacted soil roadbase.
- Stockpiles.
- After final grade and before paving or final seeding and planting.
- Pit sites.
- Sites having a winter shut down. In the case of winter shut down, or where soil will remain unworked for several months, PAM should be used together with mulch.

Design and Installation Specifications

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 1/2 pound PAM per 1000 gallons water per 1 acre of bare soil. Table 4.8 and Figure 4.6 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 4.8
PAM and Water Application Rates

Disturbed Area (ac)	PAM (lbs)	Water (gal)
0.50	0.25	500
1.00	0.50	1,000
1.50	0.75	1,500
2.00	1.00	2,000
2.50	1.25	2,500
3.00	1.50	3,000
3.50	1.75	3,500
4.00	2.00	4,000
4.50	2.25	4,500
5.00	2.50	5,000

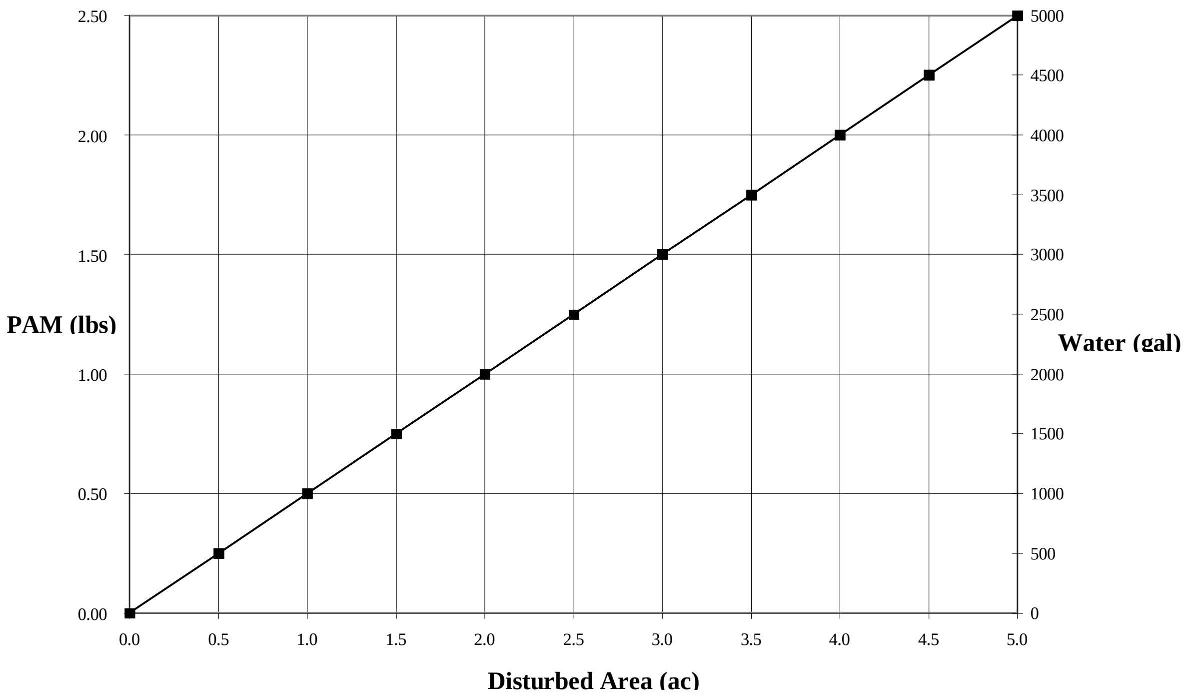


Figure 4.6 - PAM and Water Application Rates

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 (1/2 pound PAM/1000 gallons/acre).
- PAM has infinite solubility in water, but dissolves very slowly. Dissolve pre-measured dry granular PAM with a known quantity of clean water in a bucket several hours or overnight. Mechanical mixing will help dissolve the PAM. Always add PAM to water - not water to PAM.
- 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 5-10 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 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 3 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 off-site.
- 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 should be used.

  The specific PAM copolymer formulation must be anionic. **Cationic PAM shall not be used in any application because of known aquatic toxicity problems.** Only the highest drinking water grade PAM, certified for compliance with ANSI/NSF Standard 60 for drinking water treatment, will be used for soil applications. Recent media attention and high interest in PAM has resulted in some entrepreneurial exploitation of the term "polymer." All PAM are polymers, but not all polymers are PAM, and not all PAM products comply with ANSI/NSF Standard 60. PAM use shall be reviewed and approved by the local permitting authority. PAM designated for these uses should be "water soluble" or "linear" or "non-crosslinked". Cross-linked or water absorbent PAM, polymerized in highly acidic (pH<2) conditions, are used to maintain soil moisture content.

- The PAM anionic charge density may vary from 2-30 percent; a value of 18 percent is typical. Studies conducted by the United States Department of Agriculture (USDA)/ARS demonstrated that soil stabilization was optimized by using very high molecular weight (12-15 mg/mole), highly anionic (>20% hydrolysis) PAM.
- PAM tackifiers are available and being used in place of guar and alpha plantago. Typically, PAM tackifiers should be used at a rate of no more than 0.5-1 lb. per 1000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 – 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 two months. More PAM applications may be required for steep slopes, silty and clayey soils (USDA Classification Type "C" and "D" soils), long grades, and high precipitation areas. When PAM is applied first to bare soil and then covered with straw, a reapplication may not be necessary for several months.
- Loss of sediment and PAM may be a basis for penalties per RCW 90.48.080.

BMP C130: Surface Roughening

Purpose

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

Conditions of Use

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

Design and Installation Specifications

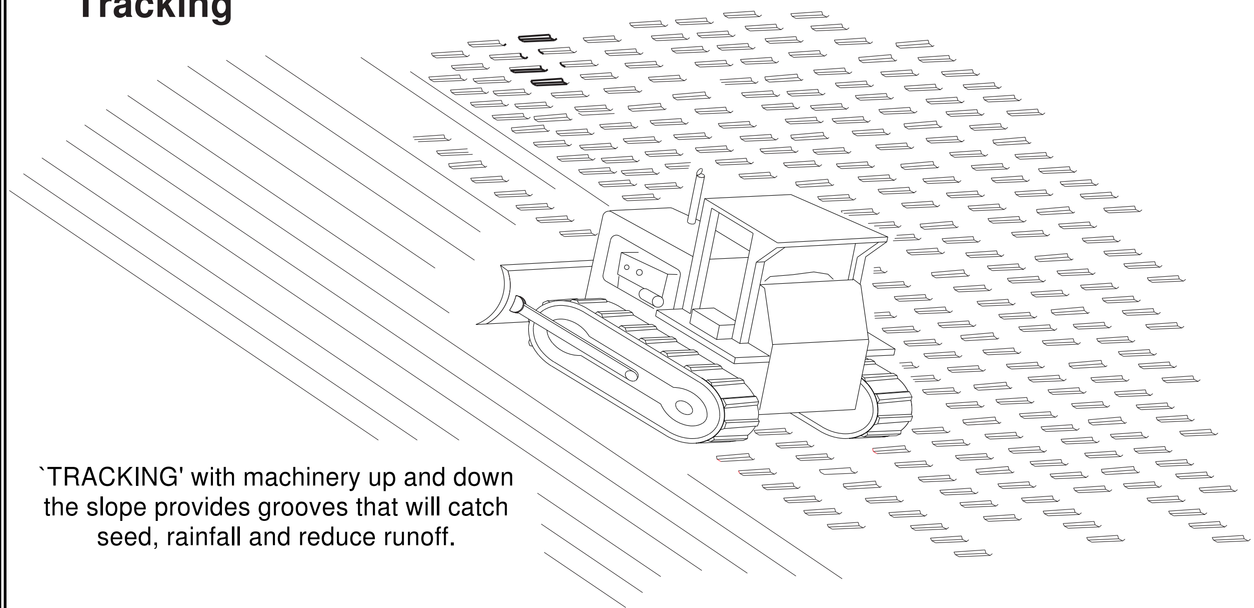
There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See Figure 4.7 for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

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

Maintenance Standards

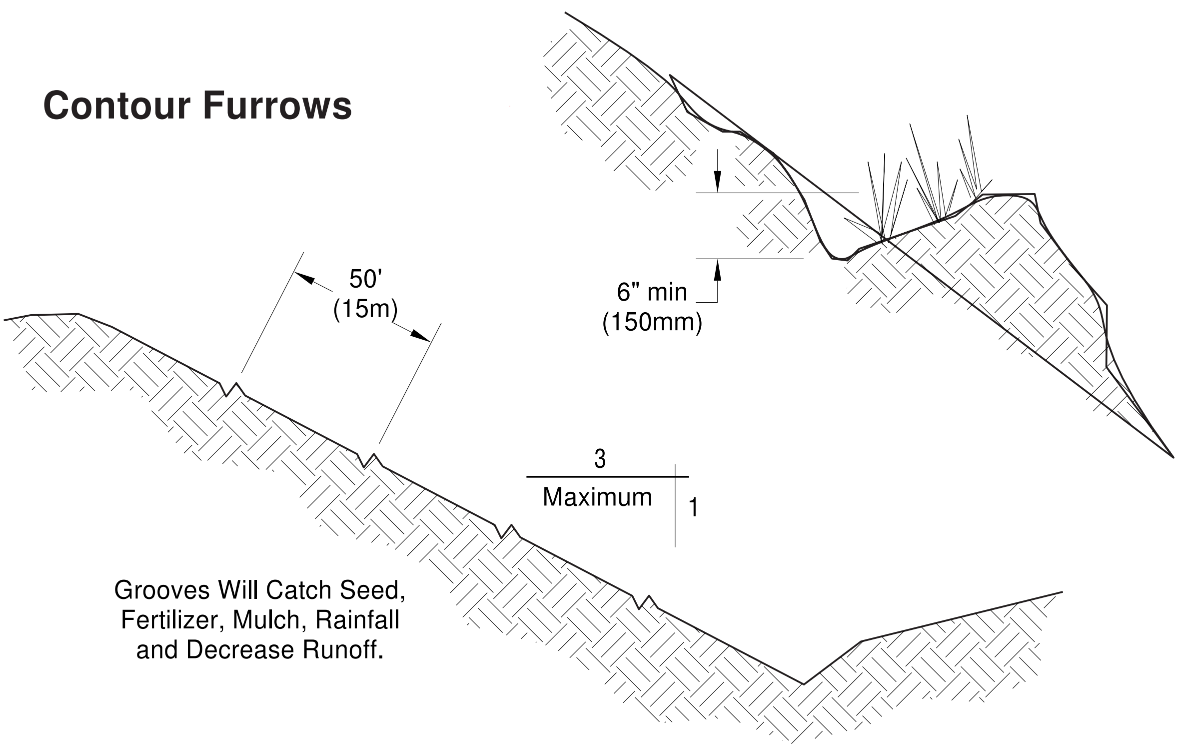
- Areas that are graded in this manner should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.

Tracking



`TRACKING' with machinery up and down the slope provides grooves that will catch seed, rainfall and reduce runoff.

Contour Furrows



Grooves Will Catch Seed, Fertilizer, Mulch, Rainfall and Decrease Runoff.

Figure 4.7 – Surface Roughening by Tracking and Contour Furrows

BMP C131: Gradient Terraces

Purpose

Gradient terraces 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 4.8 for gradient terraces.

Design and Installation Specifications

- The maximum spacing of gradient terraces should be determined by the following method:

  $$VI = (0.8)s + y$$

  Where: VI = vertical interval in feet

  s = land rise per 100 feet, expressed in feet

  y = a soil and cover variable with values from 1.0 to 4.0

  Values of "y" are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1½ tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section should meet the design dimensions.
- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.
- Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is nonerosive for the soil type with the planned treatment.
- All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.
- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet.
- The drainage area above the top should not exceed the area that would be drained by a terrace with normal spacing.
- The terrace should have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping.
- The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

Maintenance Standards

- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

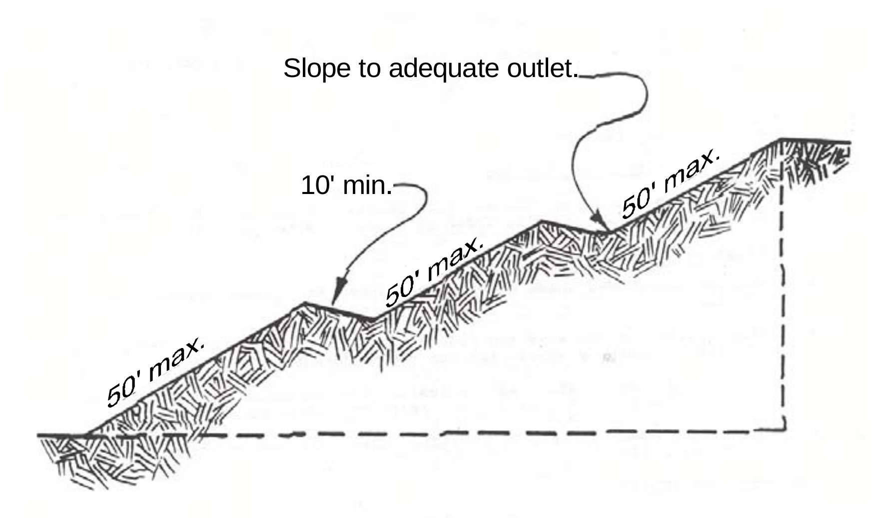


Figure 4.8 - Gradient Terraces

BMP C140: Dust Control

Purpose

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

- 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, refer to Stabilized Construction Entrance (BMP C105).
- Irrigation water can be used for dust control. Irrigation systems should be installed as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Used oil is prohibited from use as a dust suppressant. Local governments may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126) 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, especially in eastern Washington. Since the wholesale cost of PAM is about $ 4.00 per pound, this is 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 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 your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes compliance with this BMP.

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 to be used 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. In addition, contractors can save money by buying some materials in bulk and storing them at their office or yard.

Conditions of Use

- Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric and steel "T" posts.
- Materials 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:

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

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

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. This BMP is intended to minimize and eliminate concrete process water and slurry from entering waters of the state.

Conditions of Use

Any time concrete is used, these management practices shall be utilized. 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 or asphalt.
- Unused concrete remaining in the truck and pump shall be returned to the originating batch plant for recycling.
- 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 or asphalt.
- 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.
- Washdown from areas such as concrete aggregate driveways shall not drain directly to natural or constructed stormwater conveyances.
- When no formed areas are available, washwater and leftover product shall be contained in a lined container. Contained concrete shall be disposed of in a manner that does not violate groundwater or surface water quality standards.

Maintenance Standards

Containers shall be checked for holes in the liner daily during concrete pours and repaired the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

Sawcutting and surfacing operations generate slurry and process water that contain fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. This BMP is intended to minimize and eliminate process water and slurry from entering waters of the State.

Conditions of Use

Anytime sawcutting or surfacing operations take place, these management practices shall be utilized. 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

- Slurry and cuttings shall be vacuumed 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.
- Collected slurry and cuttings shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Process water that is generated during hydro-demolition, surface roughening or similar operations shall not drain to any natural or constructed drainage conveyance and shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Cleaning waste material and demolition debris shall be handled and disposed of in a manner that does not cause contamination of water. If the area is swept with a pick-up sweeper, the material must be hauled 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

Prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system or watercourses by minimizing the storage of hazardous materials onsite, storing materials in a designated area, and installing secondary containment.

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

The following steps should be taken to minimize risk:

- Temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Material Safety Data Sheets (MSDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (Oct 1 – April 30), consider storing materials in a covered area.
- Materials should be stored in secondary containments, such as earthen dike, horse trough, or even a children’s wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in “bus boy” trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, 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% of the total enclosed container volume of all containers, or 110% of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, 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.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (Oct 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).
- The spill kit should include, at a minimum:
    - 1-Water Resistant Nylon Bag
    - 3-Oil Absorbent Socks 3”x 4’
    - 2-Oil Absorbent Socks 3”x 10’
    - 12-Oil Absorbent Pads 17”x19”
    - 1-Pair Splash Resistant Goggles
    - 3-Pair Nitrile Gloves
    - 10-Disposable Bags with Ties
    - Instructions

BMP C160: Certified Erosion and Sediment Control Lead

Purpose

The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control (ESC), and water quality protection. The designated person shall be the Certified Erosion and Sediment Control Lead (CESCL) who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.

Conditions of Use

A CESCL shall be made available on projects one acre or larger that discharge stormwater to surface waters of the state.

- 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 details below).

      Ecology will maintain a list of ESC training and certification providers at: www.ecy.wa.gov/programs/wq/stormwater.

    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 three years.
- The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, on call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, 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.

- Keeping daily logs, and inspection reports. Inspection reports should include:

  - Inspection date/time.

  - Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.

  - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:

    1) Locations of BMPs inspected,

    2) Locations of BMPs that need maintenance,

    3) Locations of BMPs that failed to operate as designed or intended, and

    4) Locations of where additional or different BMPs are required.

  - Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.

  - Any water quality monitoring performed during inspection.

  - General comments and notes, including a brief description of any BMP repairs, maintenance or installations made as a result of the inspection.

- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

Minimum Requirements for ESC Training and Certification Courses

General Requirements

1. The course shall teach the construction stormwater pollution prevention guidance provided in the most recent version of:
    a. The Washington State Dept. of Ecology Stormwater Management Manual for Western Washington,
    b. Other equivalent stormwater management manuals approved by Ecology.

2. Upon completion of course, each attendee shall receive documentation of certification, including, at a minimum, a wallet-sized card that certifies completion of the course. Certification shall remain valid for three years. Recertification may be obtained by completing the 8-hour refresher course or by taking the initial 16-hour training course again.

3. The initial certification course shall be a minimum of 16 hours (with a reasonable time allowance for lunch, breaks, and travel to and from field) and include a field element and test.
    a. The field element must familiarize students with the proper installation, maintenance and inspection of common erosion and sediment control BMPs including, but not limited to, blankets, check dams, silt fence, straw mulch, plastic, and seeding.
    b. The test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.

4. The refresher course shall be a minimum of 8 hours and include a test.
    a. The refresher course shall include:
        i. Applicable updates to the Stormwater Management Manual that is used to teach the course, including new or updated BMPs; and
        ii. Applicable changes to the NPDES General Permit for Construction Activities.
    b. The refresher course test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.
    c. The refresher course may be taught using an alternative format (e.g. internet, CD ROM, etc.) if the module is approved by Ecology.

Required Course Elements

1. Erosion and Sedimentation Impacts
    a. Examples/Case studies

2. Erosion and Sedimentation Processes
    a. Definitions
    b. Types of erosion
    c. Sedimentation
        i. Basic settling concepts
        ii. Problems with clays/turbidity

3. Factors Influencing Erosion Potential
    a. Soil
    b. Vegetation
    c. Topography
    d. Climate

4. Regulatory Requirements
    a. NPDES - Construction Stormwater General Permit
    b. Local requirements and permits
    c. Other regulatory requirements

5. Stormwater Pollution Prevention Plan (SWPPP)
    a. SWPPP is a living document – should be revised as necessary
    b. 12 Elements of a SWPPP; discuss suggested BMPs (with examples)
        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

6. Monitoring/Reporting/Recordkeeping
    a. Site inspections/visual monitoring
        i. Disturbed areas
        ii. BMPs
        iii. Stormwater discharge points
    b. Water quality sampling/analysis
        i. Turbidity
        ii. pH
    c. Monitoring frequency
        i. Set by NPDES permit
        ii. Inactive sites - reduced frequency

d. Adaptive Management
   i. When monitoring indicates problem, take appropriate action (e.g. install/maintain BMPs)
   ii. Document the corrective action(s) in SWPPP
e. Reporting
   i. Inspection reports/checklists
   ii. Discharge Monitoring Reports (DMR)
   iii. Non-compliance notification

Instructor Qualifications

1. Instructors must be qualified to effectively teach the required course elements.

2. At a minimum, instructors must have:

   a. Current certification as a Certified Professional in Erosion and Sediment Control (CPESC), or
   b. Completed a training program for teaching the required course elements, or
   c. The academic credentials and instructional experience necessary for teaching the required course elements.

3. Instructors must demonstrate competent instructional skills and knowledge of the applicable subject matter.

BMP C161: Payment of Erosion Control Work

Purpose

Payment for erosion control must be addressed during project development and design. Method of payment should be identified in the SWPPP.

Conditions of Use

Erosion control work shall be a separate bid item in the contract.

Several acceptable ways to bid erosion control work are described in the most recent edition of *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction.* These include:

- Temporary Erosion and Sediment Control (TESC) Lump Sum.
- TESC-Force Account.
- Unit Prices.
- Lump Sum.

BMP C162: Scheduling

Purpose

Sequencing a construction project reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that serious erosion and sedimentation problems can be avoided.

Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of 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 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.

BMP C180: Small Project Construction Stormwater Pollution Prevention

Purpose

To prevent the discharge of sediment and other pollutants to the maximum extent practicable from small construction projects.

Conditions of Use

On small construction projects, those adding or replacing less than 2,000 square feet of impervious surface or clearing less than 7,000 square feet.

Design and Installation Specifications

- Plan and implement proper clearing and grading of the site. It is most important only to clear the areas needed, thus keeping exposed areas to a minimum. Phase clearing so that only those areas that are actively being worked are uncovered.

Note: Clearing limits should be flagged in the lot or area prior to initiating clearing.

- Soil shall be managed in a manner that does not permanently compact or deteriorate the final soil and landscape system. If disturbance and/or compaction occur the impact must be corrected at the end of the construction activity. This shall include restoration of soil depth, soil quality, permeability, and percent organic matter. Construction practices must not cause damage to or compromise the design of permanent landscape or infiltration areas.

- Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Soil piles shall be covered until the soil is either used or removed. Piles shall be situated so that sediment does not run into the street or adjoining yards.

- Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds, which are highly erodible, and prepares the lot for temporary cover, which will further reduce erosion potential.

- Remove excess soil from the site as soon as possible after backfilling. This will eliminate any sediment loss from surplus fill.

- If a lot has a soil bank higher than the curb, a trench or berm should be installed moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.

- The construction entrance shall be stabilized where traffic will be leaving the construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.

- Provide for street cleaning as needed to remove any sediment that may have been tracked out. Sediment shall be removed by shoveling or sweeping and carefully removed to a suitable disposal area where it will not be re-eroded.

- Utility trenches that run up and down slopes must be backfilled within seven days. Cross-slope trenches may remain open throughout construction to provide runoff interception and sediment trapping, provided that they do not convey turbid runoff off site.

4.4 Runoff Conveyance and Treatment BMPs

BMP C200: Interceptor Dike and Swale

Purpose

Provide 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 to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area or sediment-laden runoff from leaving the construction site.

Conditions of Use

- Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely convey the stormwater.
- Locate upslope of a construction site to prevent runoff from entering disturbed area.
- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.
- Locate downslope to collect runoff from a disturbed area and direct it to a sediment basin.

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 should be one acre or less.
- Design capacity for 10-year, 24-hour storm for temporary facilities, 25-year, 24-hour storm for permanent facilities.

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%, maximum is 1%.
Compaction	Minimum of 90 percent ASTM D698 standard proctor.

Horizontal Spacing of Interceptor Dikes:

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach

Slopes <5% Seed and mulch applied within 5 days of dike construction (*see BMP C121, Mulching*).

Slopes 5 - 40% Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap or other measures to avoid erosion.

- 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 bottom shall be level.
Depth	1-foot minimum.
Side Slope	2:1 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.

- 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 4.9 for 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.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a bonded fiber mulch (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch in lieu of hydromulch and blankets.

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.
- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, consultant the drainage conveyance requirements of the local government with jurisdiction.
- 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 special mulch protection such as fiberglass roving or straw and netting provide stability until the vegetation is fully established. See Figure 4.10.
- Check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.
- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.
- **V-shaped grass channels** generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross section is least desirable because it is difficult to stabilize the bottom where velocities may be high.
- **Trapezoidal grass channels** are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. (Note: it is difficult to construct small parabolic shaped channels.)
- Subsurface drainage, or riprap channel bottoms, may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or a high water table.
- Provide outlet protection at culvert ends and at channel intersections.
- Grassed channel side slopes generally are constructed 3:1 or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

Maintenance Standards

- During the establishment period, check grass-lined channels after every rainfall.
- After grass is established, periodically check the channel; check it after every heavy rainfall event. Immediately make repairs.
- It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.
- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

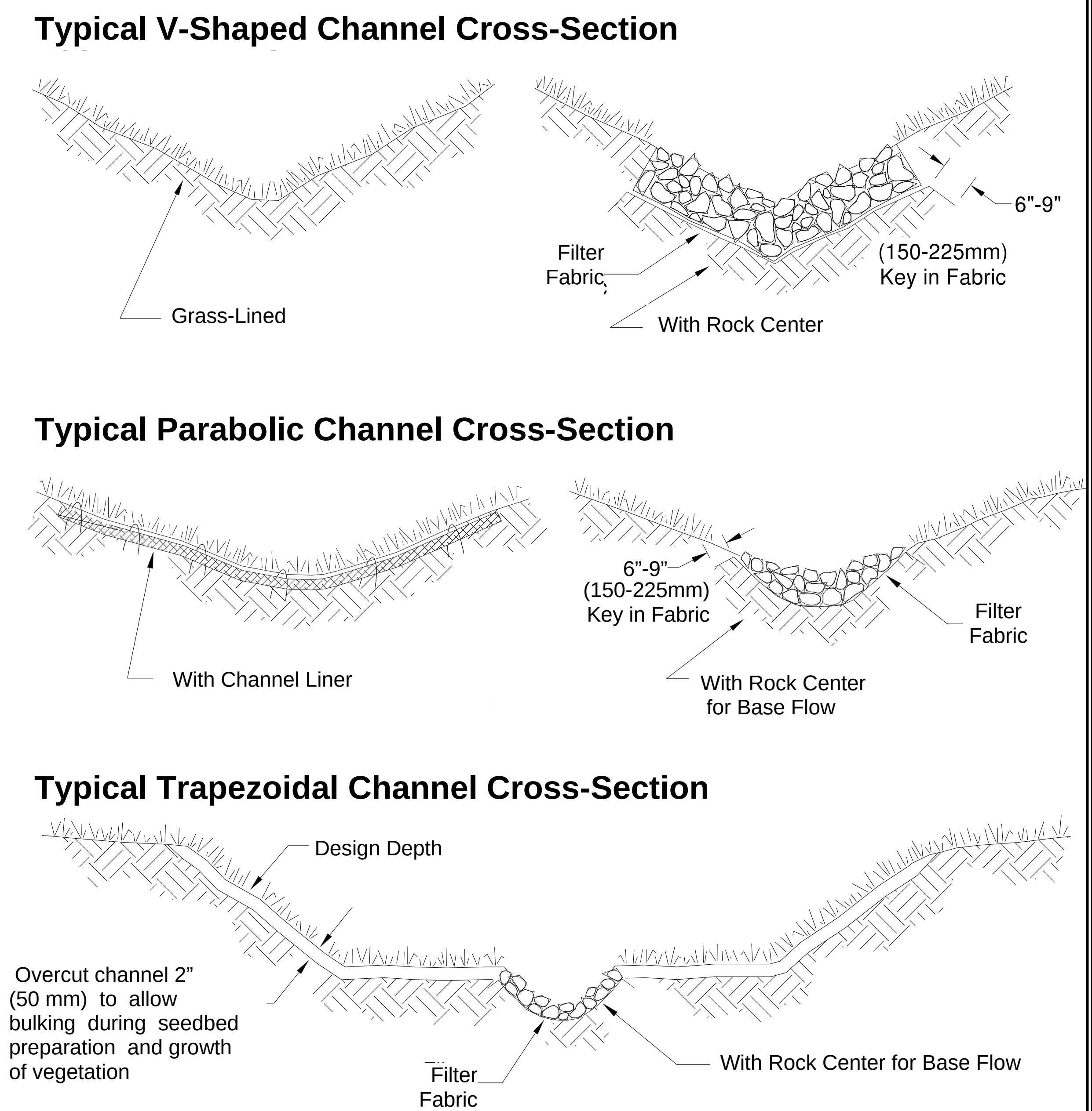
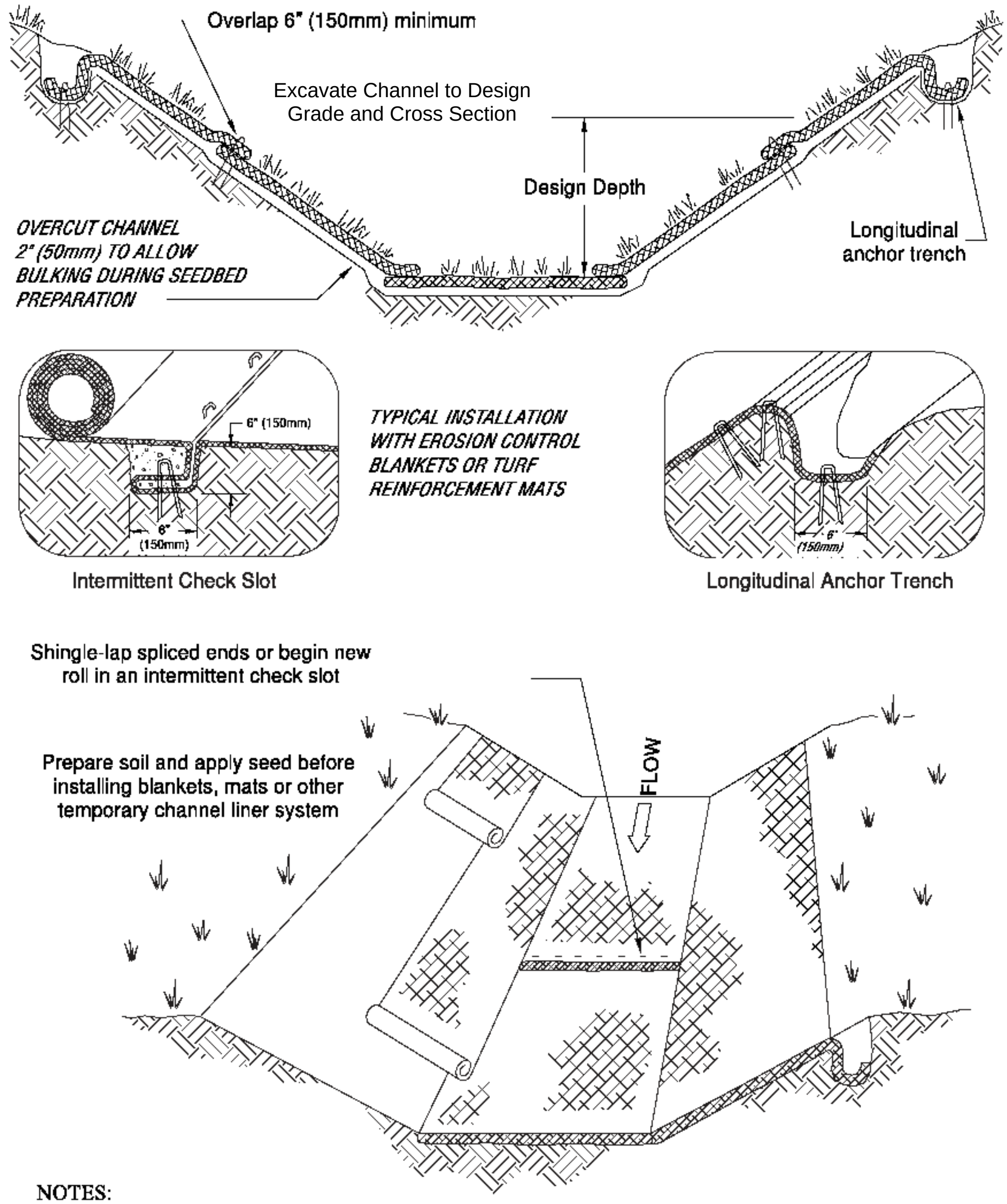


Figure 4.9 – Typical Grass-Lined Channels



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 4.10 – Temporary Channel Liners

BMP C202: Channel Lining

Purpose

To protect erodible channels by providing a channel liner using either blankets or riprap.

Conditions of Use

- 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.
- 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.

- Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.
- A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile should be keyed in at the top of the bank.
- Filter fabric shall not be used on slopes greater than 1-1/2:1 as slippage may occur. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

BMP C203: Water Bars

Purpose

A small ditch or ridge of material is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch.

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: 2:1 maximum; 3:1 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:

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 dike and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

BMP C204: Pipe Slope Drains

Purpose To use a pipe to convey stormwater anytime water needs to be diverted away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use Pipe slope drains should be used

- When a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion (Figure 4.11).
- On highway projects, at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. 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.
- Where water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

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. Permanent pipe slope drains shall be sized for the 25-year, 24-hour peak flow.
- 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.
- Piping of water through the berm at the entrance area is a common failure mode.
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. Sand bags may also be used at pipe entrances as a temporary measure.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed anytime 90 degree bends are utilized. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “t” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “t” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10-20 feet of pipe length or so, depending on the size of the pipe and quantity of water to 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 shall be set by the local government.

Maintenance Standards

- Check inlet and outlet points regularly, especially after storms.
- The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe, however, debris may become lodged in the pipe.

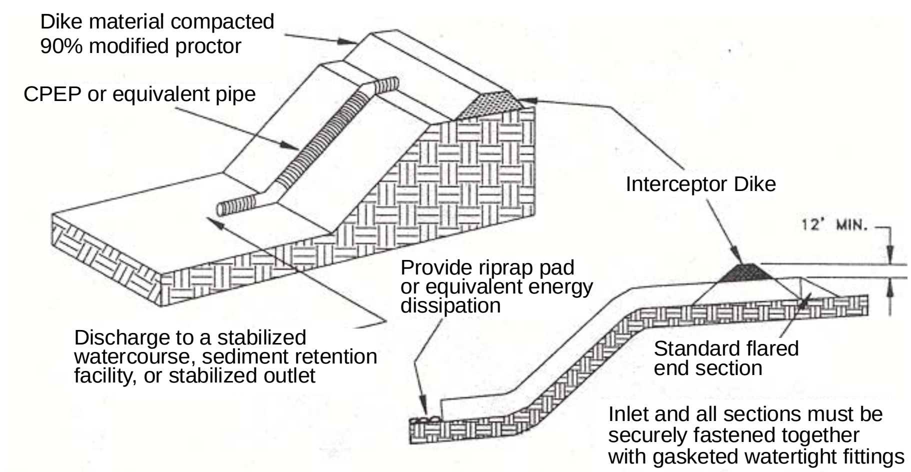


Figure 4.11 - Pipe Slope Drain

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, or to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

Use when excessive water must be removed from the soil. The soil permeability, depth to water table and impervious layers are all factors which may govern the use of subsurface drains.

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 should 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

- Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment or roots.
- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Drain placement should be planned to minimize this problem.
- Where drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.

BMP C206: Level Spreader

Purpose

To provide a temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Conditions of Use

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.
- Outlet to be constructed level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not reconcentrate after release unless intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- 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 should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.

- Level spreaders shall be setback from the property line unless there is an easement for flow.
- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sand bags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figures 4.12 and 4.13 provide a cross-section and a detail of a level spreader.

Maintenance Standards

- The spreader should be inspected 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.

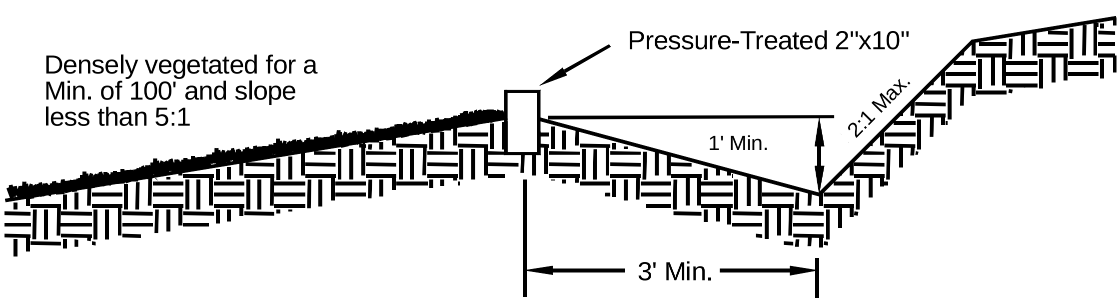


Figure 4.12 - Cross Section of Level Spreader

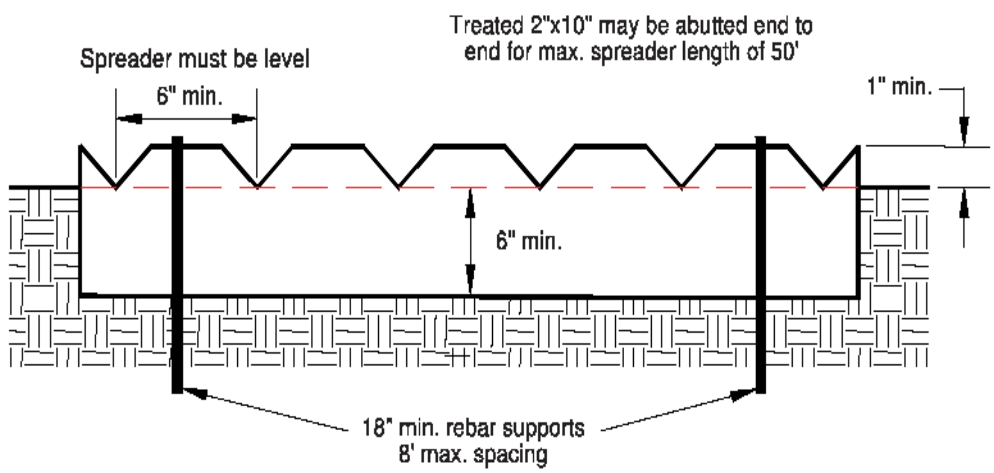


Figure 4.13 - Detail of Level Spreader

BMP C207: Check Dams

Purpose

Construction of small dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

Conditions of Use

- 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 a permitting agency.
- Check dams shall not be placed 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.
- Check dams in association with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. A deep sump should be provided immediately upstream of the check dam.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to prevent further sediment from leaving the site.
- Check dams can be constructed of either rock or pea-gravel filled bags. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Check dams should be placed perpendicular to the flow of water.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Keep 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.
- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or by mechanical means (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.
- 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 4.14 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.

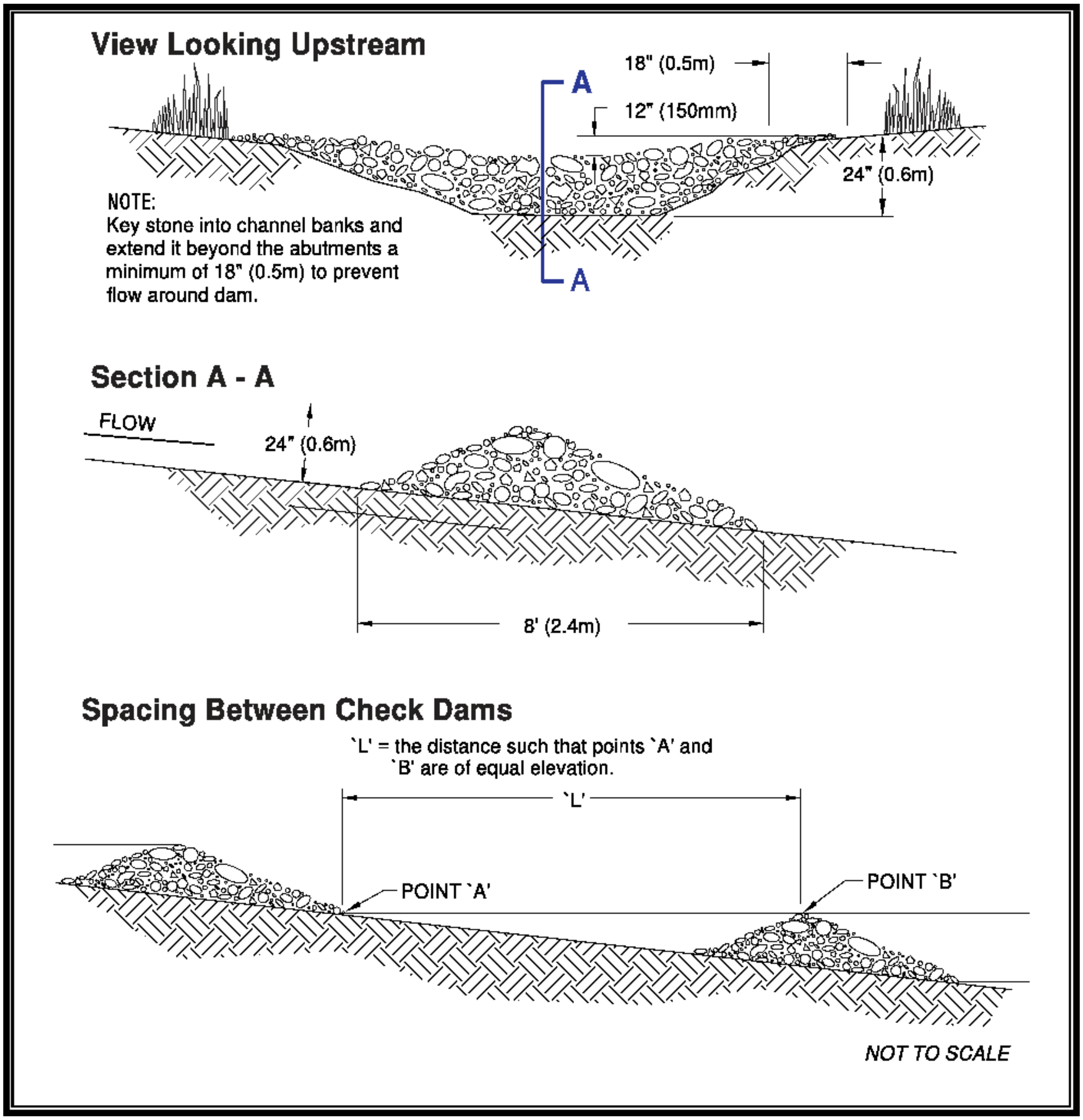


Figure 4.14 - Check Dams

BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

Purpose

Triangular silt dikes may be used as check dams, for perimeter protection, for temporary soil stockpile protection, for drop inlet protection, or as a temporary interceptor dike.

Conditions of Use

- May be used in place of straw bales for temporary check dams in ditches of any dimension.
- 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

- 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 should be No. 11 gauge wire and should be 200 mm to 300 mm in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.
- Check dams should be located and installed as soon as construction will allow.
- Check dams should be placed 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 Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of use Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

- The receiving channel at the outlet of a 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).
- 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 should 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. See Volume V 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 using Catch Basin Filters

Purpose

To prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Protection should be provided 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.

Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe controls may be needed.

Note: Wrapping or placing a filter fabric strip over or under a catch basin grate is not an acceptable BMP.

- *Catch basin Filters* - Inserts should be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. This type of inlet protection provides flow bypass without overflow and therefore is a better method for inlets located along active rights-of-way. The catch basin filter is inserted in the catch basin just below the grating. It should include:
- At least 5 cubic feet of sediment storage.
- Dewatering provisions.
- High-flow bypass that will not clog under normal use at a construction site.
- Submit manufacturer specifications for permitting agency approval.

Maintenance Standards

- Catch basin filters should be inspected frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area and stockpile and stabilize as appropriate.

BMP C233: Silt Fence

Purpose

Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Figure 4.15 for details on silt fence construction.

Conditions of Use

Silt fence may be used downslope of all disturbed areas.

- Silt fence is not intended to treat concentrated flows, nor is it 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 silt fence, rather than by a sediment pond, is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.
- Silt fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

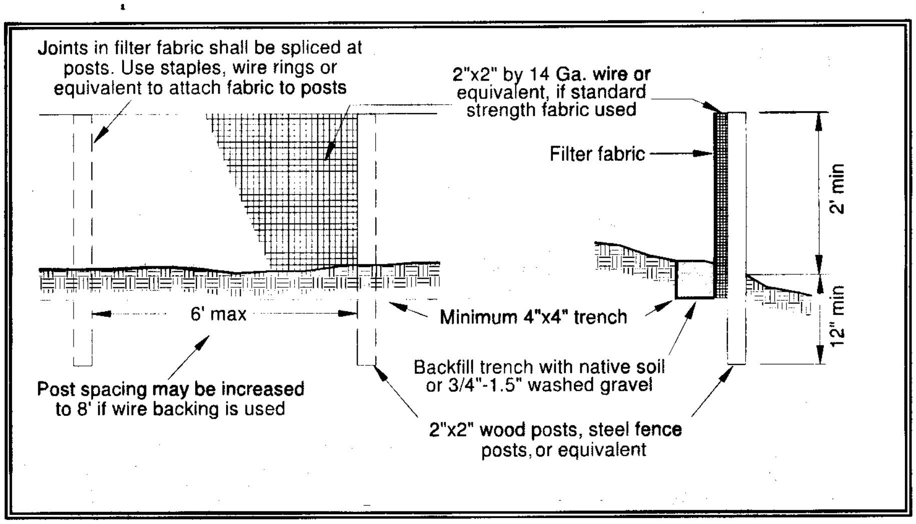


Figure 4.15 – Silt Fence

Design and Installation Specifications

Drainage area of 1 acre or less or in combination with sediment basin in a larger site.

Maximum slope steepness (normal (perpendicular) to fence line) 1:1.

- Maximum sheet or overland flow path length to the fence of 100 feet.
- No flows greater than 0.5 cfs.
- The geotextile used 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 4.9):

Table 4.9 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

- Standard strength fabrics shall be supported 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, if permitted by local regulations.
- Standard Notes for construction plans and specifications follow. Refer to Figure 4.15 for standard silt fence details.

  The contractor shall install and maintain temporary silt fences at the locations shown in the Plans. The silt fences shall be constructed in the areas of clearing, grading, or drainage prior to starting those activities. A silt fence shall not be considered temporary if the silt fence must function beyond the life of the contract. The silt fence shall prevent soil carried by runoff water from going beneath, through, around, or over the top of the silt fence, but shall allow the water to pass through the fence.

  The minimum height of the top of silt fence shall be 2 feet above the adjacent uphill ground surface.

  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.

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. 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 of the posts with the geotextile being up-slope of the mesh back-up support.

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 can not 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.

The fence posts shall be placed or driven a minimum of 18 inches. 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 3:1 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.

Silt fences shall be located on contour (same elevation at all points of the fence), 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. The local permitting authority may require the contractor to verify fence elevation.

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.

Wood, steel or equivalent posts shall be used. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges. Steel posts shall consist of either size 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. or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.

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 4.16 for slicing method details.

  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.

  Install posts 3 to 4 feet apart in critical retention areas and 6 to 7 feet apart in standard applications.

  Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

  Install posts with the nipples facing away from the silt fence fabric.

  Attach the 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, each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

  Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

  No more than 24 inches of a 36-inch fabric is allowed above ground level.

  The rope lock system must be used in all ditch check applications.

  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 trap or 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.

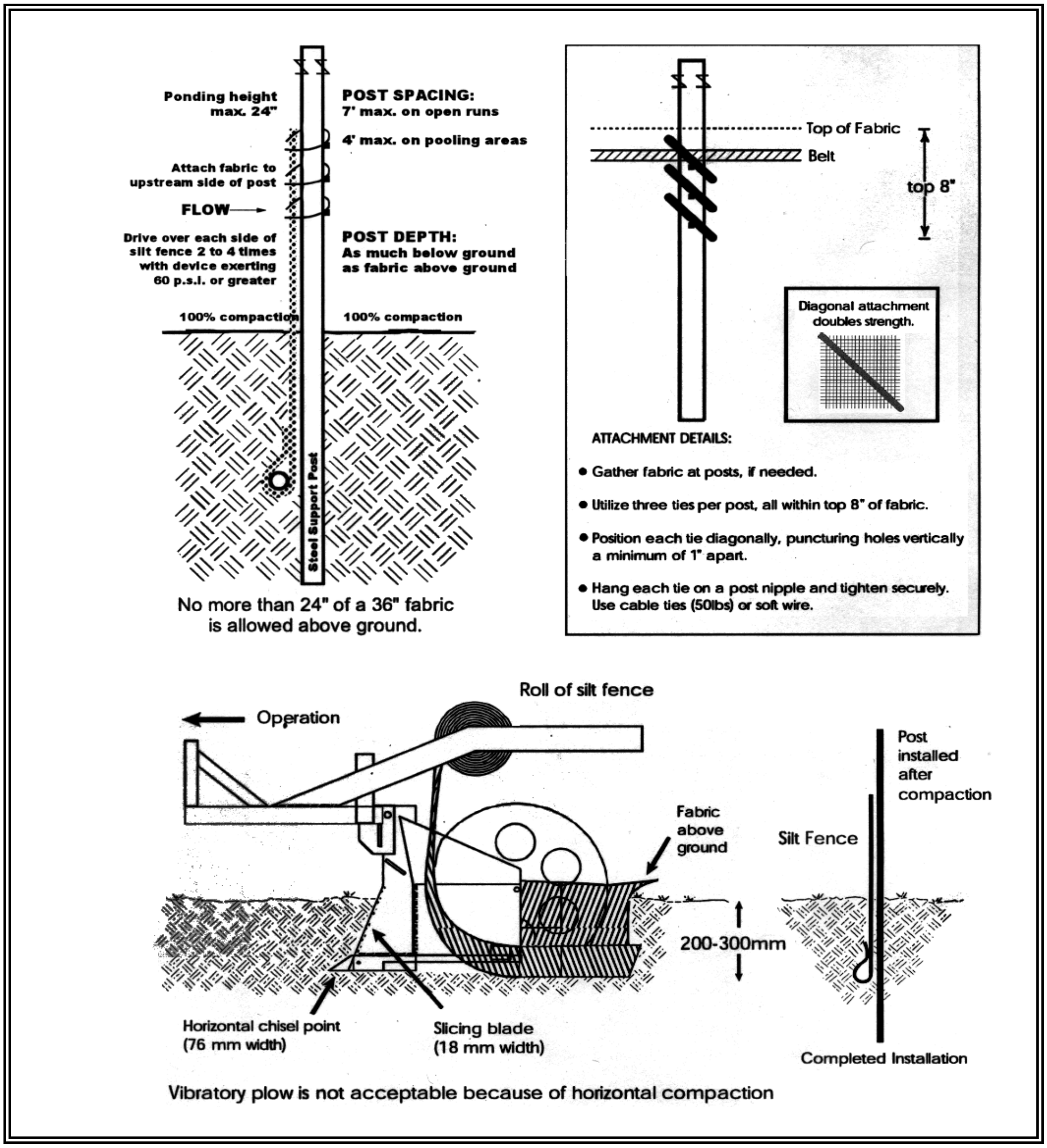


Figure 4.16 – Silt Fence Installation by Slicing Method

BMP C234: Vegetated Strip

Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

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 following criteria are met (see Table 4.10; flowpath length refers to slope length uphill of the vegetated strip):

Table 4.10
Vegetated Strips

Average Slope	Slope Percent	Flowpath Length
1.5H:1V or less	67% or less	100 feet
2H:1V or less	50% or less	115 feet
4H:1V or less	25% or less	150 feet
6H:1V or less	16.7% or less	200 feet
10H:1V or less	10% or less	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a minimum of a 25-foot wide continuous strip of dense vegetation with a permeable topsoil. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
- The slope within the strip shall not exceed 4H:1V.
- 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

Straw wattles are temporary erosion and sediment control barriers consisting of straw that is wrapped in biodegradable tubular plastic or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment. Straw wattles 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 4.17 for typical construction details.

Conditions of Use

- Disturbed areas that require immediate erosion protection.
- Exposed soils during the period of short construction delays, or over winter months.
- On slopes requiring stabilization until permanent vegetation can be established.
- Straw wattles are effective for three to six months.
- If conditions are appropriate, wattles can be staked to the ground using willow cuttings for added revegetation.
- Rilling can occur beneath wattles if not properly entrenched and water can pass between wattles if not tightly abutted together.

Design Criteria

- It is critical that wattles are installed perpendicular to the flow direction and parallel to the slope contour.
- Narrow trenches should be dug across the slope on contour to a depth of 3 to 5 inches on clay soils and soils with gradual slopes. On loose soils, steep slopes, and areas with high rainfall, the trenches should be dug to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Excavated material should be spread evenly along the uphill slope and compacted using hand tamping or other methods.
- Construct trenches at contour intervals of 3 to 30 feet apart depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Install the wattles snugly into the trenches and 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.
- At a minimum, wooden stakes should 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.

Maintenance Standards

- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

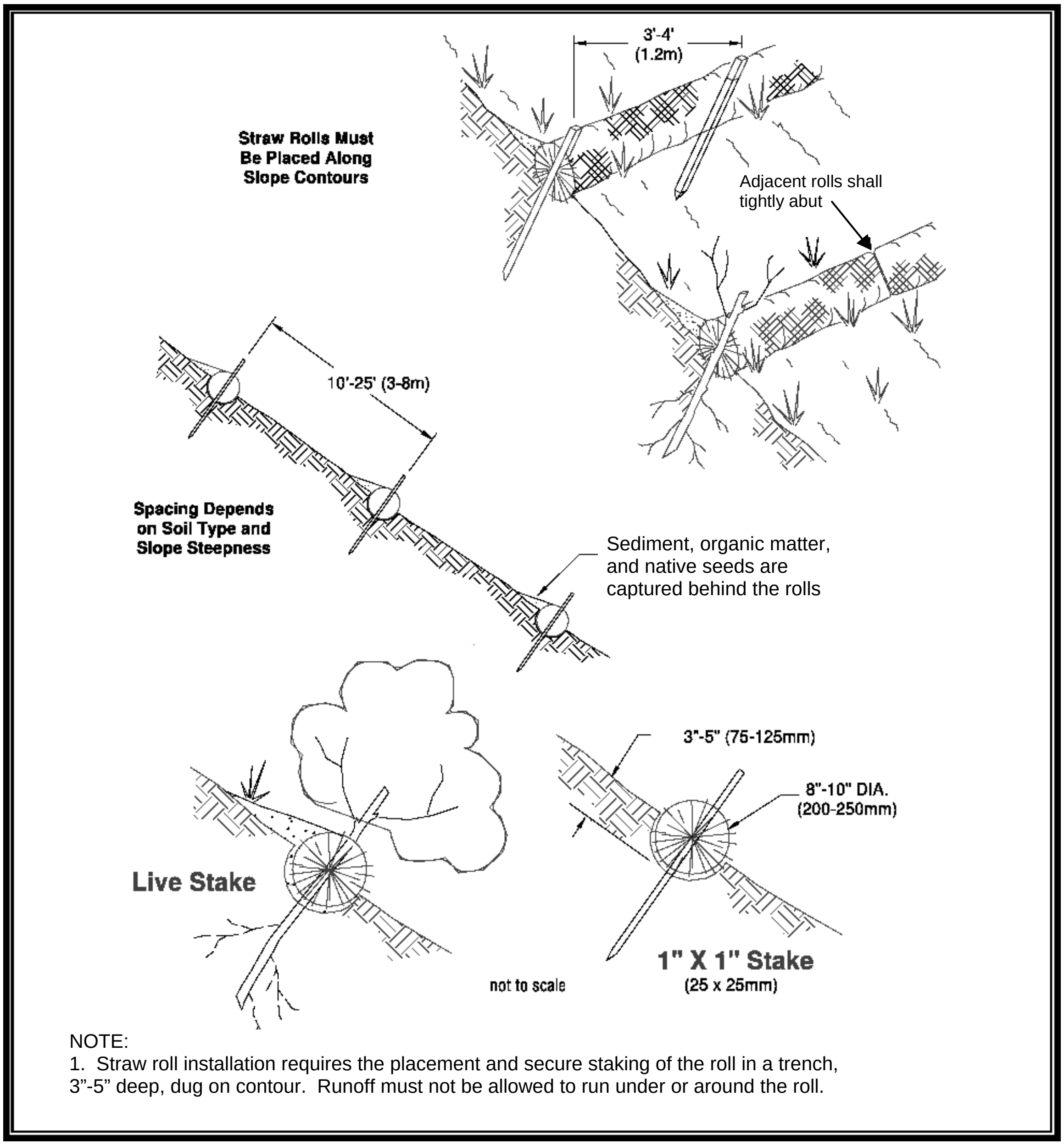


Figure 4.17 – Straw Wattles

BMP C240: Sediment Trap

Purpose A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

***Conditions of Use*:**

- 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.

- It is intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of six months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

- Sediment traps and ponds 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 onsite, 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 or pond. 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 and ponds. This includes combined facilities and infiltration facilities. 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, then 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 if approved by the City of Lacey.

Design and Installation Specifications

- See Figures 4.18 and 4.19 for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention.
- To determine the sediment trap geometry, first calculate the design surface area (*SA*) of the trap, measured at the invert of the weir. Use the following equation:

$$SA = FS(Q_2/V_S)$$

where

Q_2 = Design inflow 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 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:

$$SA = 2 \text{ x } Q_2/0.00096 \text{ or } 2080 \text{ square feet per cfs of inflow}$$

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 mark 1-foot above the bottom of the trap.
- Sediment traps may not be feasible on utility projects due to the limited work space or 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.

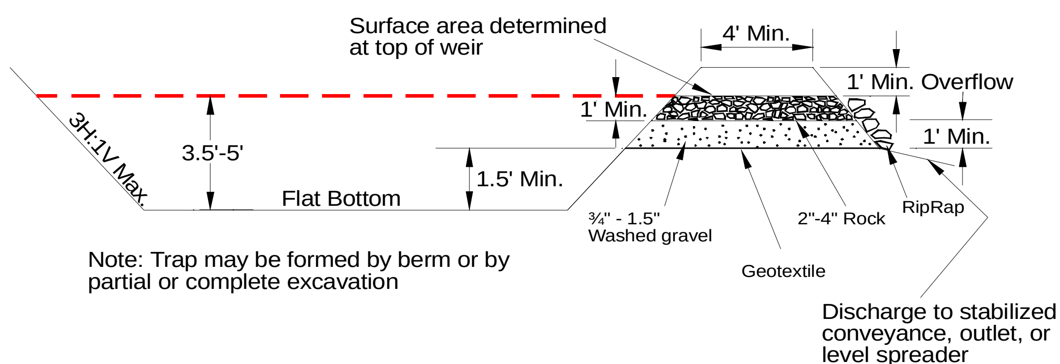


Figure 4.18 Cross-Section of Sediment Trap

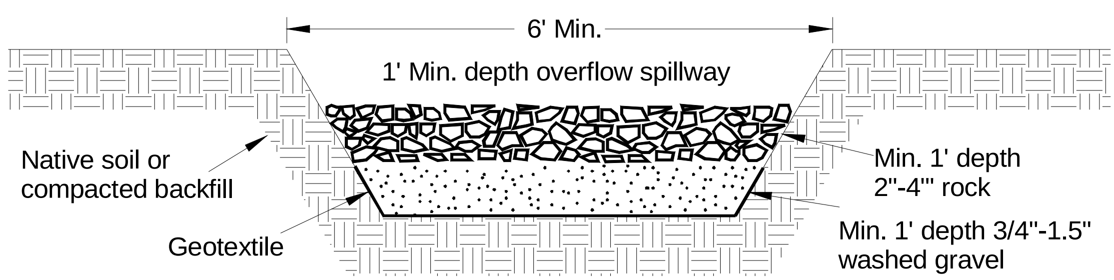


Figure 4.19 Sediment Trap Outlet

BMP C241: Temporary Sediment Pond

Purpose

Sediment ponds remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually reduce turbidity only slightly.

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 basins 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. Also, sediment traps and ponds are attractive to children and can be very dangerous. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is required, 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 ft^3) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).
- See Figure 4.20, Figure 4.21, and Figure 4.22 for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention. The surface area requirements of the sediment basin must be met. This may require enlarging the permanent basin to comply with the surface area requirements. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the basin.
- Use of infiltration facilities for sedimentation basins during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. The infiltration pretreatment facility should be fully constructed and used with the sedimentation basin to help prevent clogging.

- Determining Pond Geometry

  Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year runoff event (Q_2). The 10-year 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.

  Determine the required surface area at the top of the riser pipe with the equation:

  SA = 2 x Q_2/0.00096 or 2080 square feet per cfs of inflow

  See BMP C240 for more information on the derivation of the surface area calculation.

  The basic geometry of the pond can now be determined using the following design criteria:

- Required surface area SA (from Step 2 above) at top of riser.
- Minimum 3.5-foot depth from top of riser to bottom of pond.
- Maximum 3:1 interior side slopes and maximum 2:1 exterior slopes. The interior slopes can be increased to a maximum of 2:1 if fencing is provided at or above the maximum water surface.
- One foot of freeboard between the top of the riser and the crest of the emergency spillway.
- Flat bottom.
- Minimum 1-foot deep spillway.
- Length-to-width ratio between 3:1 and 6:1.
- Sizing of Discharge Mechanisms.

  The outlet for the basin consists of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 100-year storm. If, due to site conditions and basin geometry, a separate emergency spill-way is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year storm. However, an attempt to provide a separate emergency spillway should always be made. The runoff calculations should be based on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak rate of runoff. However, the riser outlet design will not adequately control the basin 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 basin, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations. The size of the basin, the expected life of the construction project, the anticipated downstream effects and the anticipated weather conditions during construction, should be considered to determine the need of additional discharge control. See Figure 4.23 for riser inflow curves.

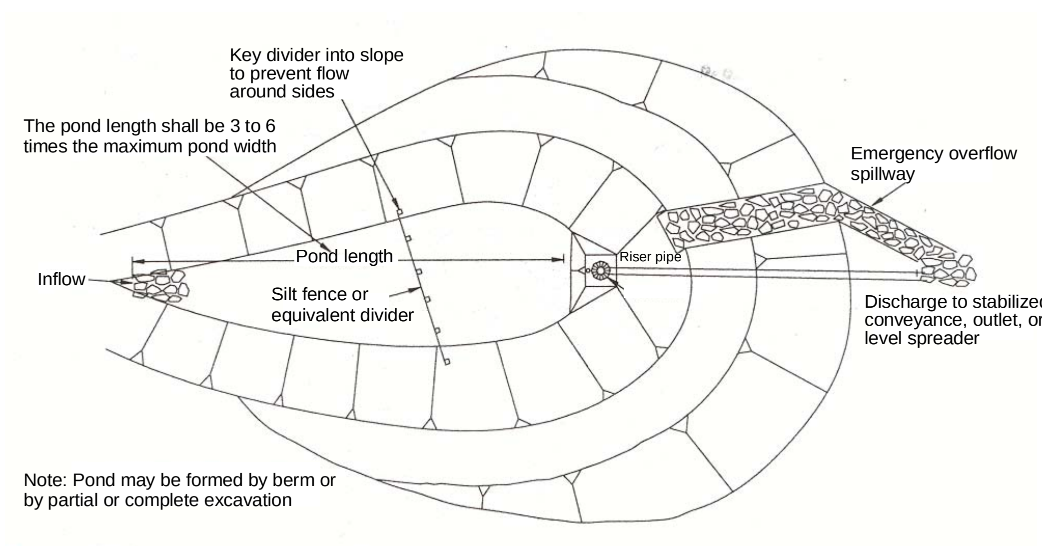


Figure 4.20 – Sediment Pond Plan View

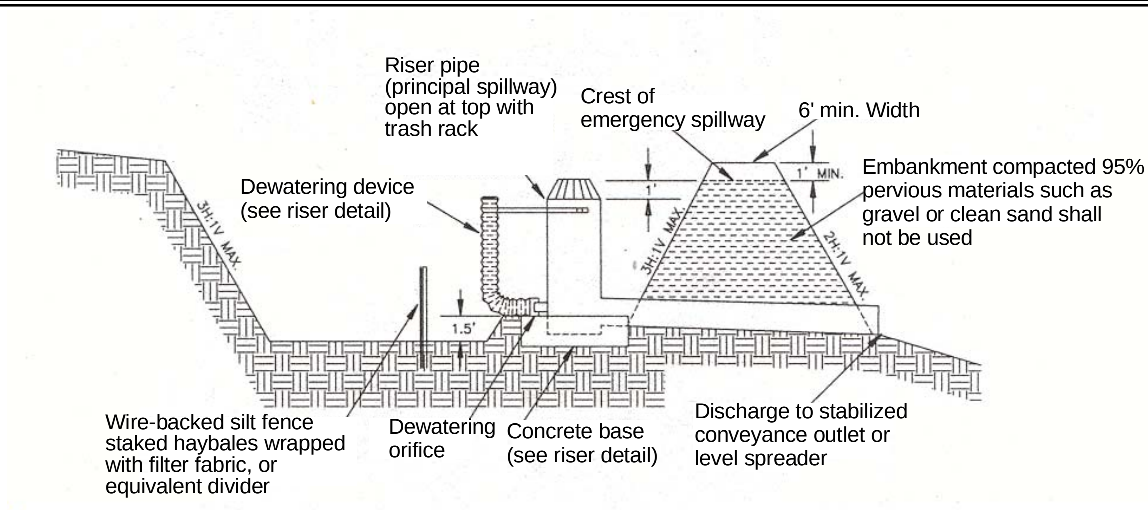


Figure 4.21 – Sediment Pond Cross Section

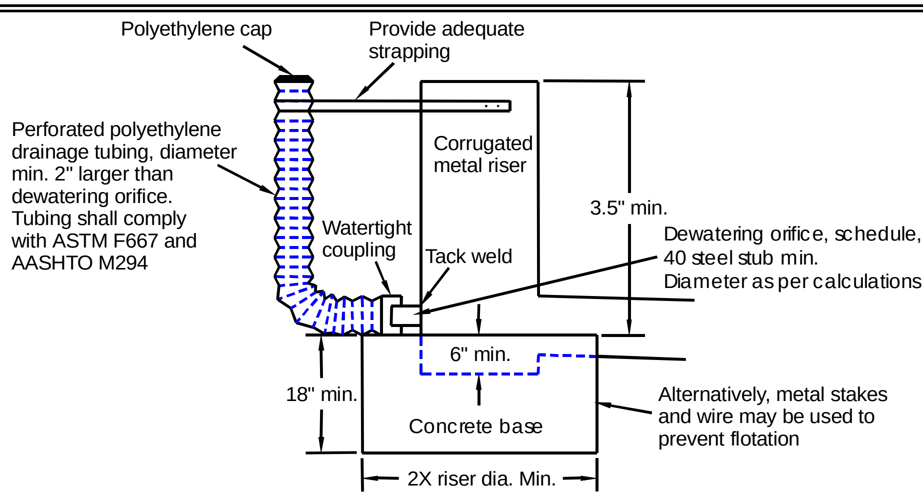


Figure 4.22 – Sediment Pond Riser Detail

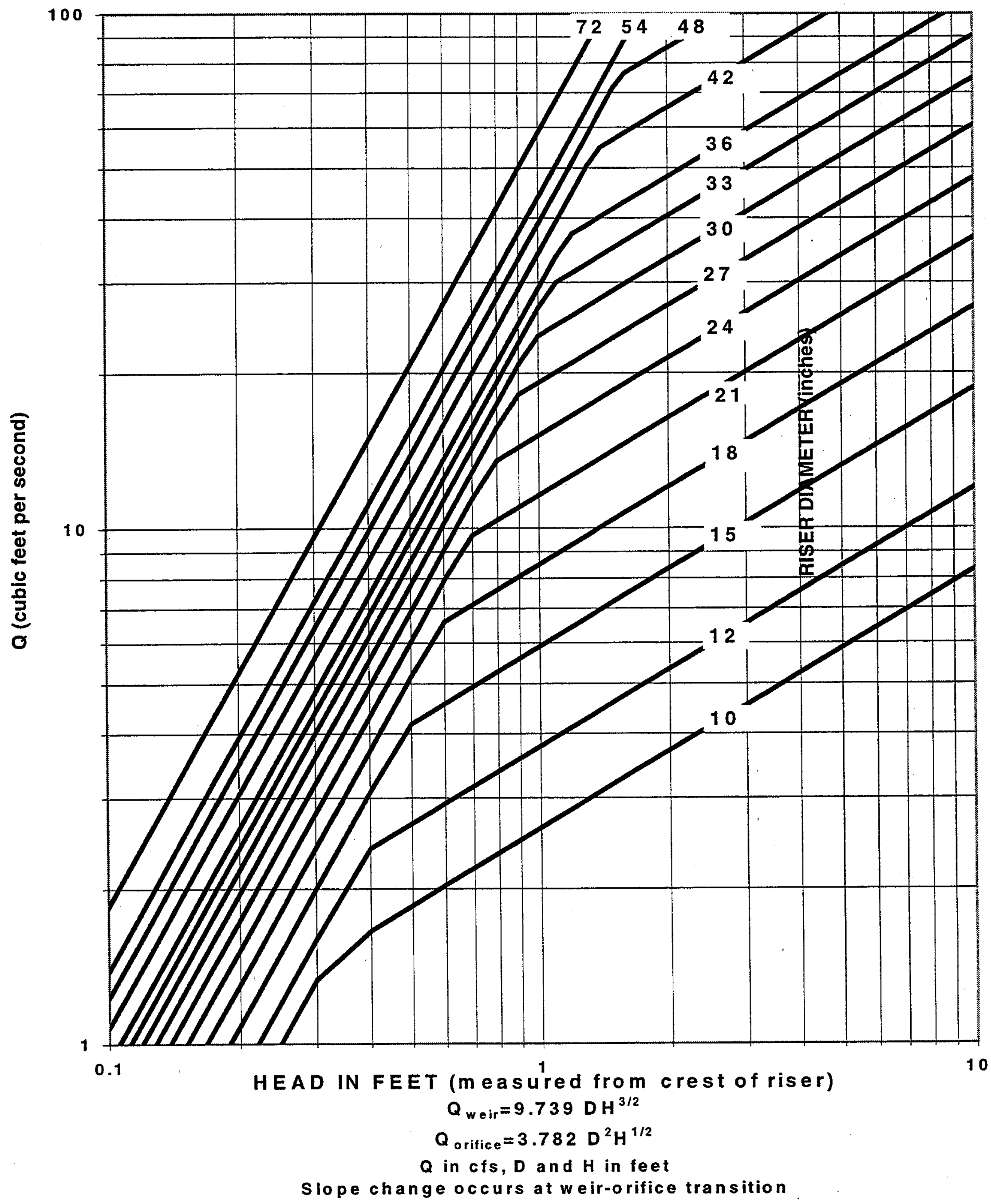


Figure 4.23 – Riser Inflow Curves

Principal Spillway: Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the pre-developed 10-year peak flow (Q_{10}). Use Figure 4.23 to determine this diameter (h = 1-foot). *Note: A permanent control structure may be used instead of a temporary riser.*

Emergency Overflow Spillway: Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow using the method contained in Volume III.

Dewatering Orifice: Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s(2h)^{0.5}}{0.6\text{x}3600Tg^{0.5}}$$

where 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. The size and number of perforations in the tubing should be large enough so that the tubing does not restrict flow. The orifice should control the flow rate.

- Additional Design Specifications

  The pond shall be divided into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of one foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by treated 4"x 4"s can be used as a divider. 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, one-foot intervals shall be prominently marked on the riser.

If an embankment of more than 6 feet is proposed, the pond must comply with the criteria contained in Volume III of the 2005 *Stormwater Management Manual for Western Washington* regarding dam safety for detention BMPs.

- The most common structural failure of sedimentation basins is caused by piping. Piping refers to two phenomena: (1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels; and, (2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.

  The most critical construction sequences to prevent piping will be:

  - Tight connections between riser and barrel and other pipe connections.
  - Proper soil compaction of the embankment and riser footing.
  - 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

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. Very high turbidities can be reduced to levels comparable to what is found in streams during dry weather. 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 protect streams from the impact of turbid stormwater discharges, especially when construction is to proceed through the wet season.
- **Formal written approval from Ecology (as applicable) and the City of Lacey is required for the use of chemical treatment regardless of site size. Ecology's written approval is not required if the selected treatment chemical is on Ecology's approved list (see http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html for approved BMPs) . The intention to use Chemical Treatment should 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 (as applicable) and the City of Lacey.**
- The SEPA review authority 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 will be necessary and may result in project approval delay**.**

Design and Installation Specifications

- See Appendix 4B 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 following protocol shall be used to evaluate chemicals proposed for stormwater treatment at construction sites. Authorization to use a chemical in the field based on this protocol does not relieve the applicant from responsibility for meeting all discharge and receiving water criteria applicable to a site.

- Treatment chemicals must be approved by EPA for potable water use.
- Petroleum-based polymers are prohibited.
- Prior to authorization for field use, jar tests shall be conducted to demonstrate that turbidity reduction necessary to meet the receiving water criteria can be achieved. Test conditions, including but not limited to raw water quality and jar test procedures, should be indicative of field conditions. Although these small-scale tests cannot be expected to reproduce performance under field conditions, they are indicative of treatment capability.
- Prior to authorization for field use, the chemically treated stormwater shall be tested for aquatic toxicity. Applicable procedures defined in Chapter 173-205 WAC, Whole Effluent Toxicity Testing and Limits, shall be used. Testing shall use stormwater from the construction site at which the treatment chemical is proposed for use or a water solution using soil from the proposed site.
- The proposed maximum dosage shall be at least a factor of five lower than the no observed effects concentration (NOEC).
- The approval of a proposed treatment chemical shall be conditional, subject to full-scale bioassay monitoring of treated stormwater at the construction site where the proposed treatment chemical is to be used.
- Treatment chemicals that have already passed the above testing protocol do not need to be reevaluated. Contact the Department of Ecology Southwest Regional Office or the local permitting authority for a list of treatment chemicals that have been evaluated and are currently approved for use.

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 may not be possible to fully incorporate all of the classic concepts into the design because of practical limitations at construction sites. Nonetheless, it is important to recognize the following:

- The right chemical must be used at the right dosage. A dosage that is either too low or too high will not produce the lowest turbidity. There is an optimum dosage rate. This is a situation where the adage “adding more is always better” is not the case.
- The coagulant must be mixed rapidly into the water to insure 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.
- Since the volume of the basin is a determinant in the amount of energy per unit volume, the size of the energy input system can be too small relative to the volume of the basin.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. The discharge should be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge.

Treatment System Design: Chemical treatment systems shall be designed as batch treatment systems using either ponds or portable trailer-mounted tanks. Flow-through continuous treatment systems are not allowed at this time.

A chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The treatment system shall use a minimum of two lined treatment cells. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than six feet high require special engineering analyses. Portable tanks may also be suitable for some sites.

The following equipment should be located in an operations shed:

- the chemical injector;
- secondary containment for acid, caustic, buffering compound, and treatment chemical;
- emergency shower and eyewash, and
- monitoring equipment, which consists of a pH meter and a turbidimeter.

Sizing Criteria: The combination of the storage pond or other holding area and treatment capacity should be large enough to treat stormwater during multiple day storm events. It is recommended that at a minimum the storage pond or other holding area should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in Volume 3, Chapter 2. If no hydrologic analysis is required for the site, the Rational Method may be used.

Primary settling should be encouraged in the storage pond. A forebay with access for maintenance may be beneficial.

There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by two hours of settling.

The permissible discharge rate governed by potential downstream effect can be used to calculate the recommended size of the treatment cells. The following discharge flow rate limits shall apply:

- If the discharge is directly or indirectly to a stream, the discharge flow rate shall not exceed 50 percent of the peak flow rate of the 2-year, 24-hour event for all storm events up to the 10-year, 24-hour event.
- If discharge is occurring during a storm event equal to or greater than the 10-year, 24-hour event, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.
- Discharge to a fish-bearing stream should not increase the stream flow rate by more than 10 percent.
- If the discharge is directly to a lake, a major receiving water listed in Volume I, or to an infiltration system, there is no discharge flow limit.
- 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.
- Runoff rates shall be calculated using the methods presented in Volume 3, Chapter 2 for the predeveloped condition. If no hydrologic analysis is required for the site, the Rational Method may be used.

Maintenance Standards

Monitoring: The following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site:

<u>Operational Monitoring</u>

- pH, conductivity (as a surrogate for alkalinity), turbidity and temperature of the untreated stormwater
- Total volume treated and discharged
- Discharge time and flow rate
- Type and amount of chemical used for pH adjustment

- Amount of polymer used for treatment
- Settling time

Compliance Monitoring

- pH and turbidity of the treated stormwater
- pH and turbidity of the receiving water

Biomonitoring

Treated stormwater shall be tested for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. **The performance standard for acute toxicity is no statistically significant difference in survival between the control and 100 percent chemically treated stormwater ("whole effluent"). Biomonitoring is not required for polymers on Ecology's "approved" list.**

Acute toxicity tests shall be conducted with the following species and protocols:

- Fathead minnow, Pimephales *promelas* (96 hour static-renewal test, method: EPA/600/4-90/027F). Rainbow trout, Oncorhynchus mykiss (96 hour static-renewal test, method: EPA/600/4-90/027F) may be used as a substitute for fathead minnow.
- Daphnid, *Ceriodaphnia* dubia, *Daphnia pulex,* or *Daphnia magna* (48 hour static test, method: EPA/600/4-90/027F).

All toxicity tests shall meet quality assurance criteria and test conditions in the most recent versions of the EPA test method and Ecology Publication # WQ-R-95-80, Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.

Bioassays shall be performed on the first five batches and on every tenth batch thereafter, or as otherwise approved by Ecology. Failure to meet the performance standard shall be immediately reported to Ecology.

Discharge Compliance: Prior to discharge, each batch of treated stormwater must be sampled and tested for compliance with pH and turbidity limits. These limits may be established by the water quality standards or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. Turbidity must not exceed 5 NTUs above the background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point. 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. It is often possible to discharge treated stormwater that has a lower turbidity than the receiving water and that matches the pH.

Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training: Facility operators shall demonstrate proficiency to the satisfaction of the local permitting authority.

Standard BMPs: Chemical treatment shall not be used alone or in lieu of appropriate erosion prevention practices.

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 may be incorporated into the site away from drainages.

BMP C251: Construction Stormwater Filtration

Purpose

Filtration removes sediment from runoff originating from disturbed areas of the site.

Conditions of Use

- Traditional 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.
- Unlike chemical treatment, the use of construction stormwater filtration does not require approval from Ecology.
- Filtration may also be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.

Design and Installation Specifications

Background Information

- Filtration with sand media has been used for over a century to treat water and wastewater. The use of sand filtration for treatment of stormwater has developed recently, generally to treat runoff from streets, parking lots, and residential areas. The application of filtration to construction stormwater treatment is currently under development.

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. Filters should be sequenced from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process Description. Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The 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.

If large volumes of concrete are being poured, pH adjustment may be necessary.

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.

Appendix 4A
Resource Materials for Erosion & Sediment Control

Association of General Contractors of Washington, Water Quality Manual.

Clark County Conservation District, Erosion and Runoff Control, January 1981.

King County Conservation District, Construction and Erosion Control, December 1981.

King County Department of Transportation Road Maintenance BMP Manual (Final Draft), May 1998.

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.

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Appendix 4B
Required Standard Notes for Erosion Control Plans

The following Standard ESC Notes are required for use in erosion & sediment control plans. They are followed by additional Standard Notes for BMPs that are required for plans showing specific types of BMPs Plans shall also identify with phone numbers the persons or firms responsible for the preparation of (design engineer) and maintenance of (CESCL) the erosion & sediment control plan.

Standard ESC Notes

- A Certified Erosion and Sediment Control Lead (CESCL) is required for all construction projects. The named person or firm shall be on-site or on-call at all times. For this site, the person/firm is ____ and their telephone numbers are: (office:) _____-______-________(cell:)______-______-_________.
- Approval of this erosion & sediment control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g. size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).
- The implementation of these ESC plans and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the applicant/contractor until all construction is completed and approved and vegetation/landscaping is established.
- The clearing limit boundaries 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.
- 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 ensure that sediment and sediment-laden water do not enter the drainage system, roadways, or violate applicable surface water, ground water, or discharge standards.
- The ESC facilities shown on this plan are the minimum 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.
- The ESC facilities on active sites shall be inspected daily by the applicant/contractor--and maintained, repaired, or augmented as necessary--to ensure their continued functioning.
- The ESC facilities on inactive sites shall be inspected monthly and within 48 hours following a major storm event (≥ 1” rainfall in 24 hours) by the applicant/contractor — and maintained, repaired, or augmented as necessary — to ensure their continued functioning.

- Storm drain inlets operable during construction shall be protected so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment. 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 catch basin. All catch basins and conveyance lines shall be cleaned prior to project completion and acceptance. The cleaning operation shall not flush sediment-laden water offsite without treatment.

- 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 ensure that all paved areas are kept clean for the duration of the project.

- Roads shall be cleaned thoroughly as needed to protect downstream water resources or stormwater infrastructure. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area.

- From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days. Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast. Linear construction activities, such as right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall comply with these requirements. These stabilization requirements apply to all soils on site, whether at final grade or not. The local permitting authority may adjust these time limits if it can be shown that a development site's erosion or runoff potential justifies a different standard.

- From October 1 through April 30, clearing, grading, and other soil-disturbing activities shall only be permitted if shown to the satisfaction of the local permitting authority that the transport of sediment from the construction site to receiving waters will be prevented.

- Soil stockpiles must be stabilized and protected with sediment-trapping measures.

- All pollutants, including waste materials and demolition debris, that occur on site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chopped and spread on site.

- Maintenance and repair of heavy equipment and vehicles and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted using spill prevention measures, such as drip pans. Report all spills to 911.

- Water from most dewatering operations shall be discharged into a sediment trap or pond. Clean, non-turbid water may be discharged to state surface waters, provided the discharge does not cause erosion or flooding. Highly turbid or contaminated dewatering water from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam shall be handled separately from stormwater and properly disposed.

Standard Notes for BMPs

(A) Place the following standard notes on plans for projects with **construction entrances**:

Construction Entrance Notes

1. Material shall be 4" to 6" quarry spalls and may be top-dressed with 1" to 3" rock. (STANDARD SPECIFICATIONS).

2. The rock pad shall be at least 12 inches thick and 100 feet long. Width shall be the full width of the vehicle ingress and egress area. Smaller pads may be approved for single-family residential and small commercial sites.

3. Additional rock shall be added periodically to maintain proper function of the pad.

4. If the pad does not adequately remove the mud from the vehicle wheels, the wheels shall be hosed off before the vehicle enters a paved street. The washing shall be done on an area covered with crushed rock and wash water shall drain to a sediment retention facility or through silt fence.

(B) Place the following standard notes on drawings showing **silt fences**:

Silt Fence Notes

1. Filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely fastened at both ends to post.

2. Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground (minimum of 30 inches).

3. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier.

4. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the original ground surface.

5. The standard strength filter fabric shall be stapled or wired to the fence, and 20 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

6. When extra-strength filter fabric and closer post spacing is used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts with all other provisions of above notes applying.

7. Filter fabric fences shall not be removed before the upslope area has been permanently stabilized.

8. Filter fabric fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

(C) Place the following standard notes on drawings showing **straw/hay bales**:

Straw/Hay Bale Notes

1. Bales shall be placed in a single row, lengthwise, on the contour, with ends of adjacent bales tightly abutting one another.

2. All bales shall be either wire-bound or string-tied with bindings oriented around the sides rather than the tops and bottoms of the bales. This will prevent rapid deterioration of the bindings.

3. The barrier shall be entrenched and backfilled. A trench shall be excavated the length and width of the proposed barrier to a depth of at least 4 inches. After the bales are staked and cracks between bales chinked as necessary, the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.

4. Each bale shall be anchored by at least two stakes or rebars driven through the bale. The first stake in each bale shall be driven towards the previously laid bale in order to force the bales together.

(D) Place the following standard notes on drawings showing **gravel filter berms**:

Gravel Filter Berm Notes

1. Berm material shall be 3/4 to 3-inch well-graded gravel or crushed rock with less than 5% fines.

2. Spacing of berms:

Distance Between Berms (Feet)	Max Slope (%)
300	5
200	10
100	>10

3. Berm dimensions: 1-foot high with 3:1 side slopes; 8 lineal feet per 1 cfs runoff based on the 10-year frequency storm.

(E) Place the following standard notes on drawings showing **sandbag berms**:

Sandbag Berm Notes

1. The height of the berm shall be a minimum of 18 inches measured from the top of the existing ground at the upslope toe to the bottom of the berm.

2. The width of the berm shall be at least 48 inches at the bottom and 18 inches at the top.

3. Sandbags shall be 24 to 30 inches in length, 16 to 18 inches in width, and 6 to 8 inches in thickness. Each sandbag shall weigh between 90 and 125 pounds.

4. Suitable materials for sandbags are polypropylene, polyethylene, or polyamide woven fabric, minimum unit weight 4 ounces per square yard, mullin burst strength exceeding 300 psi, and ultraviolet stability exceeding 70 percent.

5. Coarse grade sand shall be used.

(F) Place the following standard notes on drawings showing **triangular sediment filter dikes**:

Triangular Sediment Filter Dike Notes

1. If the slope exceeds 10 percent, the length of the slope above the dike shall be less than 50 feet.

2. All dikes shall be placed on the contour and shall be placed in a row with the ends tightly abutting the adjacent dike. Filter material shall lap over ends 6 inches to cover dike to dike junction; each junction shall be secured by shoat rings.

3. In general, each side of the triangle shall be a minimum of 18 inches.

4. Nonwoven polypropylene, polyethylene or polyamide geotextile fabric may be used as filter material. This material shall have a minimum unit weight of four and one-half (4.5) ounces per square yard, mullin burst strength exceeding 250 psi, ultraviolet stability exceeding 70 percent, and equivalent opening size exceeding 40. The fabric cover and skirt shall be a continuous wrapping of the fabric; the skirt shall be a continuous extension of the upstream face.

(G) Place the following standard notes on drawings showing **inlet protection**:

Inlet Protection Notes

1. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks shall abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches, and 12 inches wide. The row of blocks shall be at least 12 inches but no greater than 24 inches high.

2. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the blocks. Use hardware cloth or comparable wire mesh with 1/2-inch openings.

3. Pile stone against the wire mesh to the top of the blocks. Use 3/4-to 3-inch gravel.

4. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 ft beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with 1/2-inch openings. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh.

5. Place 3/4-inch gravel over the wire mesh. The depth of stone shall be at least 12 inches over the entire inlet opening. Extend the stone beyond the inlet opening at least 18 inches on all sides.

6. If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced.

(H) Place the following standard notes on drawings showing **pipe slope drains**:

Pipe Slope Drain Notes

1. The soil around and under the pipe and entrance section shall be thoroughly compacted.

2. The flared inlet section shall be securely connected to the slope drain with watertight connecting bands.

3. Slope drain sections shall be securely fastened together with watertight fittings, and be securely anchored into the soil.

4. Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1" higher of all points then the top of the inlet pipe.

5. The area below the outlet must be stabilized with a rip-rap apron (see Chapter 6, Outfalls, for the appropriate protection).

(I) Place the following standard notes on drawings showing **stairstepped cut slopes**:

Stairstepped Cut Slopes Notes

1. Graded areas with slopes greater than 3:1 but less than 2:1 shall be roughened before seeding.

2. Graded areas steeper than 2:1 shall be stair-stepped with benches.

(J) Place the following standard notes on drawings showing **erosion control blankets**:

Erosion Control Blanket Notes

1. Where soil is highly erodible, net shall only be used in conjunction with an organic mulch such as straw and wood fiber.

2. Jute net shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches wide shall weigh an average of 1.2 lbs/linear yard. It must be so applied that it is in complete contact with the soil.

3. Netting shall be securely anchored to the soil with No. 11 gauge wire staples at least 6 inches long.

(K) Place the following standard notes on drawings showing **temporary dikes and swales**:

Temporary Dikes and Swales Notes

1. Seed and mulch shall be applied within 5 days of dike construction (see vegetation).

2. The upslope side of the dike shall provide positive drainage to the dike outlet.

3. No erosion shall occur at the dike outlet. Provide energy dissipation measures as necessary.

4. Sediment laden runoff must be released through a sediment trapping facility such as a pond, trap, or silt fence as appropriate to drainage area size.

(L) Place the following standard notes on drawings showing **temporary gravel outlets**:

Temporary Gravel Outlet Notes

1. Gravel shall be 5/8-inch minus washed rock. A layer of filter fabric shall be embedded in the gravel.

2. Minimum length in feet of the gravel outlet structure shall be equal to six times the number of acres of contributing drainage area.

3. The invert of the gravel outlet shall not be less than 6 inches lower than the minimum elevation of the top of the dike.

4. Water shall be discharged from the gravel outlet onto an already stabilized area or into a stable watercourse.

5. The gravel outlet structure shall be inspected and repaired after each runoff-producing rain. The gravel must be replaced when the structure ceases to function as intended due to sediment accumulation among the gravel.

(M) Place the following standard notes on drawings showing **check dams**:

Check Dam Notes

1. 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.

2. Rock check dams shall be constructed of 2-to 4-inch diameter rock. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.

3. Log check dams shall be constructed of 4- to 6-inch diameter logs. The logs shall be embedded into the soil at least 18 inches.

4. In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

5. Check dams shall be checked for sediment accumulation after each significant rainfall. Sediment shall be removed when it reaches one half of the original dam height or before.

(N) Place the following standard notes on drawings showing **plastic covering**:

Plastic Covering Notes

1. Plastic sheeting shall have a minimum thickness of 6 mills and shall meet the requirements of STANDARD SPECIFICATIONS Section 9-14.5.

2. Covering shall be installed and maintained tightly in place by using sandbags or tires on ropes with a maximum 10-foot grid spacing in all directions. All seams shall be taped or weighted down full length and there shall be at least a 12 inch overlap of all seams.

3. Clear plastic covering shall be installed immediately on areas seeded between November 1 and March 31 and remain until vegetation is firmly established.

4. When the covering is used on un-seeded slopes, it shall be kept in place until the next seeding period.

5. Plastic covering sheets shall be buried two feet at the top of slopes in order to prevent surface water flow beneath sheets.

6. Proper maintenance includes regular checks for rips and dislodged ends.

(O) Place the following standard notes on drawings showing **mulching**:

Mulching Notes

1. Mulch materials used shall be ____, and shall be applied at the rate of ____.

2. Mulches shall be applied in all areas with exposed slopes greater than 2:1.

3. Mulching shall be used immediately after seeding or in areas which cannot be seeded because of the season.

4. All areas needing mulch shall be covered by November 1.

(P) Place the following standard notes on drawings showing **seeding:**

Seeding Notes

1. Seed mixture shall be ________________________________, and shall be applied at the rate of _____ ______________________________per acre.

2. Seed beds planted between May 1 and October 31 will require irrigation and other maintenance as necessary to foster and protect the root structure.

3. For seed beds planted between October 31 and April 30, armoring of the seed bed will be necessary. (e.g., geotextiles, jute mat, clear plastic covering).

4. Before seeding, install needed surface runoff control measures such as gradient terraces, interceptor dikes, swales, level spreaders and sediment basins.

5. The seedbed shall be firm with a fairly fine surface, following surface roughening. Perform all cultural operations across or at right angles to the slope.

6. Fertilizers are to be used according to suppliers recommendations. Amounts used should be minimized, especially adjacent to water bodies and wetlands.

(Q) Place the following standard notes on plans for projects where **topsoil will be stockpiled**:

Topsoil Stockpiling Notes

1. Stockpiles shall be stabilized (with plastic covering or other approved device) daily between November 1 and March 31.

2. In any season, sediment leaching from stock piles must be positively prevented.

3. Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.

4. Previously established grades on the areas to be topsoiled shall be maintained according to the approval plan.

(R) Place the following standard notes on plans for projects where **sod is to be placed**:

Sod Placement Notes

1. Sod shall be machine cut at a uniform soil thickness of 3/4-inch at the time of curing. Measurements for thickness shall exclude top growth and thatch.

2. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended by the end of a 3 foot section.

3. Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

4. Sod shall be harvested, delivered and installed within a period of 36 hours.

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Appendix 4C
Background Information on Chemical Treatment

Coagulation and flocculation have been used for over a century to treat water. It is used less frequently for the treatment of wastewater. The use of coagulation and flocculation for treating stormwater is a very recent application. Experience with the treatment of water and wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as turbidity in NTUs. Their small size, often much less than 1 µm in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Largely because of these two factors, small size and negative charge, these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Polymers, as well as inorganic chemicals such as alum, speed the process of clarification. The added chemical destabilizes the suspension and causes the smaller particles to agglomerate. The 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.

<u>Coagulation:</u> Coagulation is the first step. It is the process by which negative charges on the fine particles that prevent their agglomeration are disrupted. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and are not readily separated by clarification until flocculation occurs.

<u>Flocculation:</u> Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such that they bind and continually grow to form "flocs." As the size of the flocs increases they become heavier and tend to settle more rapidly.

<u>Clarification:</u> 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. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase water’s viscosity and density, thus slowing down the rate at which the particles settle.

The conditions under which clarification is achieved can affect performance. Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water such as that which occurs during batch clarification provides a good environment for 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. Given that flocs are relatively 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 fairly modest velocities.

Coagulants: Polymers are large organic molecules that are made up of subunits linked together in a chain-like structure. Attached to these chain-like structures are other groups that carry positive or negative charges, or have no charge. Polymers that carry groups with positive charges are called cationic, those with negative charges are called anionic, and those with no charge (neutral) are called nonionic.

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.

Application Considerations: 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.

Polymer Batch Treatment Process Description: Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to a storage pond or other holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the storage pond. The pH is adjusted by the application of acid or base until the stormwater in the storage pond is within the desired pH range. When used, acid 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 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.

Once the stormwater is within the desired pH range, the stormwater is pumped from the storage pond to a treatment cell as polymer is added. The polymer is added upstream of the pump to facilitate rapid mixing.

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 and turbidity. If both are acceptable, the treated water is discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Facilities should be designed to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladders, or steps extending from the bottom to the top.

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. Baking soda has been used to raise both the alkalinity and the pH. Although lime is less expensive than baking soda, if overdosed lime can raise the pH above 8.5 requiring downward adjustment for the polymer to be effective. Baking soda has the advantage of not raising the pH above 8.3 regardless of the amount that is added. Experience indicates that the amount of baking soda sufficient to raise the alkalinity to above 50 mg/L produces a pH near neutral or 7.

Alkalinity cannot be easily measured in the field. Therefore, conductivity, which can be measured directly with a hand-held probe, has been used to ascertain the buffering condition. It has been found through local experience that when the conductivity is above about 100 µS/cm the alkalinity is above 50 mg/L. This relationship may not be constant and therefore care must be taken to define the relationship for each site.

Experience has shown that the placement of concrete has a significant effect on the pH of construction stormwater. If the area of fresh exposed concrete surface is significant, the pH of the untreated stormwater may be considerably above 8.5. Concrete equipment washwater shall be controlled to prevent contact with stormwater. Acid may be added to lower the pH to the background level pH of the receiving water. The amount of acid needed to adjust the pH to the desired level is not constant but depends upon the polymer dosage, and the pH, turbidity, and alkalinity of the untreated stormwater. The acid commonly used is sulfuric although muriatic and ascorbic acids have been used. Pelletized dry ice has also been used and reduces the safety concerns associated with handling acid.

Appendix 4D
Construction Inspection Report Form

Project Name: ____

Project Number: ____

Location (address, or other):

____

____

____

Pond Information:

1. Type: ____

2(a). After pond construction, have infiltration tests and/or soil logs been completed?

____

2(b). Indicate test results and compare with design criteria (pre-construction soils information). Do the post-construction values indicate a need to modify system design? Explain.

____

3. Outlet Type
   Filter,
   Oil Water Separator, Single orifice,
   Oil Water Separator, Multiple orifice,
   Slot,
   V-notch,
   Other

4. Outlet works at correct elevation(s), filter fabric installed properly (if needed), etc.

____
____
____

5. Spillway at correct elevation, slope, adequately armored, etc.

____
____
____

Conveyances:

1. Channels properly graded, sloped, planted, etc.

____
____
____

2. Sewers at proper grade, inlets as designed, trenches as designed, pipe bedding properly prepared, backfilling procedures correct, materials as specified, etc.

____
____
____

Roof Leaders:

1. Do roof leaders drain to infiltration trenches or as shown on the approved plans.

____
____

Erosion Control:

1. Erosion facilities in place at the specified time relative to other construction.

____

2. Construction entrance pad as specified.

____

3. Did facilities keep sediment, mud, etc., out of water bodies, wetlands, and from crossing the property boundary.

____

____

____

4. Are permanent erosion control measures in place and as designed.

____

____

____

Signature and Seal:

I, or someone under my direct supervision, have adequately inspected the project during construction and to the best of my knowledge the project was built according to the approved plans and specifications except as noted above.

Signature/Date ____

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Chapter 5 – Hydrologic and Hydraulic Analysis

This chapter presents the concepts and rationale for flow and water quality controls, and defines the minimum computational standards required for designing flow control and treatment BMPs and stormwater conveyance systems. Section 5.1 addresses hydrologic methodologies required for determining design runoff rates and volumes for flow control and treatment BMPs. Section 5.2 addresses methodologies for analysis and design of conveyance systems. Certain methods are required, as noted, in certain situations. Engineers have some discretion in others. In all instances, the City of Lacey may require more extensive analysis or use of a different methodology if the situation is deemed to warrant it. WWHM is the default analysis method. The project engineer must obtain pre-approval to use alternative methods.

5.1 HYDROLOGIC ANALYSIS

Hydrologic analysis is used to compute design peak runoff rates, volumes and flow durations for comparison of pre- and post-development conditions, and for conveyance system design.

Minimum Computational Standards

The minimum computational standards depend on the type of information required and the size of the drainage area to be analyzed, as follows:

1. For the purpose of designing runoff treatment and flow control BMPs, the most current version of the Western Washington Hydrology Model (WWHM) with Thurston County enhancements is the standard requirement. The WWHM software can be downloaded from Ecology's website:

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

   Alternatively, for very large or complicated sites, a calibrated continuous simulation hydrologic model based on the EPA's HSPF (Hydrologic Simulation Program-Fortran), may be used subject to prior approval of the City of Lacey.

2. Where the downstream conveyance is not subject to a flooding issue (as identified in the Site and Vicinity Analysis), single-event methods may be used for conveyance sizing with prior approval of the City of Lacey, if no detention is modeled in the basins. Approved single-event methods include Santa Barbara Urban Hydrograph (SBUH) and NRCS TR-55 methods.

Table 5.1 summarizes the uses of the approved runoff computation methods accepted by the City of Lacey.

Table 5.1 Acceptable Uses of Approved Runoff Computation Methods

Required Analysis	Hydrologic Design Method		
	Single-Event: SBUH, TR-55	Continuous-Simulation: WWHM	HSPF
Peak Flow Conveyance Sizing, Downstream Analysis	OK, if no detention storage is modeled	OK	OK
Water Quality BMP Sizing	Not Applicable	Required	OK
Flow Control	Not Applicable	Required	OK
Closed Depressions	Not Applicable	Required	OK
Wetland Hydroperiod	Not Applicable	Required	OK

NOTE: Uses marked "OK" require approval of the Lacey Drainage Manual Administrator prior to use.

5.1.1 Western Washington Hydrology Model

This section summarizes the assumptions made in creating the Western Washington Hydrology Model and discusses limitations of the model. Consult the WWHM Users Manual for detailed instructions in use of the model. Users should ensure that they have the most current Thurston County-specific version.

The WWHM has been created for the specific purpose of sizing stormwater control facilities for new developments in Western Washington. The WWHM can be used for a range of conditions and developments; however, certain limitations are inherent in this software. Some of the main limitations are:

- Backwater or tailwater control situations are not explicitly modeled.
- WWHM does not address snowmelt and is therefore less applicable to sites at elevations subject to significant snowfall (above 1,500 ft above mean sea level).
- In using WWHM it is assumed that the pre-development land condition is forest (the default condition), although the user has the option of specifying pasture if it can be demonstrated that pasture vegetation was native to the pre-development site, or had been converted to pasture/agriculture by 1978.
- Groundwater flow is not computed. It is assumed that no groundwater flow from small catchments reaches the surface to become runoff.

- Forest and pasture vegetation areas are only appropriate for separate undeveloped parcels dedicated as open space, wetland buffer, or park within the total area of the development. Development areas shall be designated as forest or pasture only where tracts, covenants or other legal restrictions protect these areas from future disturbances.

The WWHM computes the predevelopment 2- through 100-year flow frequency values and computes the post-development runoff 2- through 100-year flow frequency values from the outlet of the proposed stormwater facility. The model uses pond discharge data to compare the pre-development and post-development peak flows and durations and determines if the flow control standards have been met.

There are three criteria by which flow duration values are compared:

1. If the post-development flow duration values exceed any of the pre-development flow levels between 50% and 100% of the 2-year pre-development peak flow values (100 Percent Threshold) then the flow duration requirement has not been met.
2. If the post-development flow duration values exceed any of the pre-development flow levels between 100% of the 2-year and 100% of the 50-year pre-development peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration requirement has not been met.
3. If more than 50 percent of the flow duration levels exceed the 100 percent threshold then the flow duration requirement has not been met.

Flow Control for Wetlands

Core Requirement #8 specifies that discharges to wetlands must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated beneficial uses. Criteria for determining maximum allowed exceedances in alterations to wetland hydroperiods are provided in Guide Sheet 2B from Volume I, Appendix D of Ecology's 2005 *Stormwater Management Manual for Western Washington*. Wetland hydroperiod computations are not included in the WWHM (but may be included in future versions). They can be performed using a detailed continuous simulation model (HSPF) or the Water Level Fluctuation measurements and criteria in Appendix 5A.

Flow Control for Closed Depressions

The analysis of closed depressions requires careful assessment of the existing hydrologic performance in order to evaluate the impacts a proposed project will have. The procedures below shall be followed.

<u>Analysis and Design Criteria:</u>

The infiltration rates used in the analysis of closed depressions must be determined according to the procedures in Chapter 6. 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 is feasible). 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 prepare an average surface infiltration rate.

Projects proposing to modify or compensate for replacement storage in a closed depression must meet the design criteria for detention ponds as described in Chapter 6.

<u>Methods of Analysis</u>**:**

Closed depressions are analyzed using WWHM. Two cases are possible:

1) where the pre-developed condition produces no overflow from the depression, and
2) where the pre-developed condition produces overflow.

Note that where there is a flooding potential, concern about rising ground water levels, property rights/ownership/use issues, or sensitive area ordinances and rules, this analysis may not be sufficient. In such cases, Lacey may require additional analysis and impose more stringent requirements.

> ***Case 1*: *Pre-developed Condition produces No Overflow*** The 100-year storm flow from the drainage basin tributary to the closed depression is routed into the closed depression, using only infiltration as outflow. Under this scenario, there is no overflow from closed depression. Determine the pre-development high water level. *The post-development high water level shall be no more than 0.1 feet higher than the predevelopment level, unless the development has acquired ownership or discharge rights to the closed depression. Absent ownership or discharge rights, excavate additional storage volume in the closed depression (subject to all applicable requirements, for example, providing a defined overflow system) needed to achieve the 0.1-foot maximum water level increase standard.*

> ***Case 2: Pre-developed Condition produces Overflow*** The 100-year storm flow from the drainage basin tributary to the closed depression is routed into the closed depression, using only infiltration as outflow. Under this scenario, pre-development runoff causes overflows from closed depression. *Use WWHM to match pre- and post-development flows and durations, determining how much storage must be added to the closed depression. Design an appropriate flow control and overflow structure.*

Modeling On-Site Stormwater Management and Low Impact Development Techniques in WWHM

Use of On-Site Stormwater Management is required as described in Core Requirement #5 and Chapter 6. Low Impact Development techniques, as described in the *Low Impact Development Technical Guidance for Puget Sound* (Puget Sound Action Team, February 2005), are encouraged to reduce impacts of development on water resources. Use of these techniques can result in reductions in the size of required stormwater facilities, by segregating pollution-generating surfaces from non-pollution generating surfaces, and by reducing runoff discharge rates under the developed condition. WWHM may be used to model the effects of on-site stormwater management/LID techniques as described below.

Lacey intends to encourage Low Impact Development practices, and require them where practical. Full Credit (no modeling required) for dispersion, meeting all flow control and water quality requirements, will be allowed under the combinations of native vegetation preservation, percent effective impervious surface and allowable lawn/landscape shown in Table 5.2.

Table 5.2 Full Dispersion Criteria for Modeling Credits

Percent Native Vegetation Preserved	Maximum Allowed Effective Impervious Percent	Maximum Allowed Lawn/Landscape Percent[1]
65	10	35
60	9	40
55	8.5	45
50	8	50
45	7	55
40	6	60
35	5.5	65

1 The Percent Landscape Allowed for modeling can not exceed 100% minus the % Native Vegetation Preserved

Developments that maintain these ratios may disperse runoff into the native vegetation area in accordance with BMPs described in Chapter 6. The only impervious areas not considered “effective” are those routed into an appropriately sized dry well or infiltration facility that meets the flow control standard and does not overflow into the native vegetation area. The native vegetation area must be protected from future development. In the event the native area is developed, the entire site must be retrofit to meet flow control and water quality standards.

“Partial” credits, which may result in decreases in design flows or water quality volumes, can be obtained for other practices, as described below and in the Roof Downspout Control and Dispersion BMP descriptions in Chapter 6. The “credit” is expressed as a change in the way a project is modeled in WWHM, resulting in reduced flows or volumes.

Roof downspout infiltration controls (as designed per the methods in Chapter 6) can be modeled directly in WWHM. Dispersion controls designed per Chapter 6 can also be modeled directly by WWHM. Dispersion not designed using or meeting the criteria in Chapter 6 cannot be modeled as “dispersed” in WWHM.

Modeling in WWHM of LID practices is described in some detail in the 2005 Ecology *Stormwater Management Manual for Western Washington* (Volume III, Appendix III-C). The following Table 5.3 summarizes modeling representations pre-approved by Lacey. Modeling of LID practices is in continual development as more experience is gained with LID practices. Alternative approaches to modeling LID practices will be considered if the project proponent demonstrates the appropriateness of the alternative approach to the City of Lacey’s satisfaction. Note that modeling of LID practices is being incorporated in newer versions of WWHM, which may make flow credits no longer applicable.

Table 5.3 LID Techniques Represented in WWHM3	
LID Technique	**Model Representation**
Alternative Pavement	
Publicly Maintained Porous Asphalt or Concrete	Grass
Privately Maintained Porous Asphalt or Concrete	50% grass; 50% impervious
Paving Blocks	50% grass; 50% impervious
Grid/Lattice Systems	Grass
Paving Blocks	50% grass; 50% impervious
Green Roof	
3-8 inches soil medium	50% saturated lawn; 50% impervious
> 8 inches soil medium	50% saturated pasture; 50% impervious
Bioretention Areas (Rain Gardens)	
Cell design	Model as detention pond
Swale (without underdain)	Model as detention pond
Amended soil *(BMP 6.5)*	If native topsoil is amended with compost and replaced, reduce design water quality volume by factor proportional to amended / replaced soil contribution to runoff.

5.1.2 NRCS-based Methods (TR-55, SBUH)

The use of NRCS (Natural Resource Conservation Service)-based methods (TR-55, SBUH) shall conform to requirements as described in this section. The use of computer programs implementing these methods must incorporate the assumptions detailed in this section.

The Project Engineer shall verify that a particular modeling approach will be acceptable. The Project Engineer shall provide clear and complete information (e.g., input and output files, annotation of key outputs, and discussion of results) to enable the jurisdiction to conduct its review.

5.1.2.1 Design Storm Hyetographs

The NRCS Type 1A hyetograph with 15 minute steps shall be used in Lacey, with the design storm volumes as shown in Table 5.4 below.

Table 5.4 Lacey Design Storm Volumes	
24-hour Rainfall Return Frequency (years)	Precipitation (inches)
0.5	1.79
2	2.80
5	3.75
10	4.35
25	5.10
50	5.65
100	6.15

Note: The 7-day, 100-year storm volume is 12 inches.

5.1.2.2 Estimates of Interception

If interception (the volume of precipitation trapped on vegetation) is modeled, the values shown in Table 5.5 shall be used.

Table 5.5 Interception Values for Various Land Covers	
Land Cover	Interception (inches)
Heavy Forest	0.15
Light open Forest	0.12
Pasture and shrubs	0.10
Lawn	0.05
Bare Ground	0.03
Pavement	0.02

Note: Values shown are about 1/2 of those for dry antecedent conditions found in references

5.1.2.3 Hydrologic Soil Groups

The two primary soil associations found in the Lacey area are the Spanaway-Nisqually association and the Alderwood-Everett association. Soils within those associations are highlighted in bold print in Table 5.6 below.

For purposes of runoff computations using NRCS methods, soils in Lacey have the Hydrologic Soil Group designations as listed in Table 5.6.

Topsoil imported for landscaping increases runoff from HSG A and B soils. If it can be reasonably predicted that landscaping will require importation of topsoil to cover Class A or B soils, that area shall be considered Class C for modeling purposes.

Table 5.6 Hydrologic Soil Group (HSG) of Soils in Lacey and Vicinity

Soil	HSG	Soil	HSG	Soil	HSG
Alderwood	**C**	Hydraquents	D	Puyallup	B
Baldhill	**B**	**Indianola**	**A**	Rainier	C
Baumgard	B	Jonas	B	Raught	B
Bellingham	**C**	**Kapowsin**	**D**	Riverwash	D
Boistfort	B	Katula	C	Salkum	B
Bunker	B	Lates	C	Scamman	D
Cagey	**C**	Mal	C	Schneider	B
Cathcart	B	Mashel	B	Semiahmoo	C
Centralia	B	Maytown	C	Shalcar/Variant	D
Chehalis	B	**McKenna**	**D**	**Skipopa**	**D**
Delphi	B	Melbourne	B	**Spana**	**D**
Dupont	D	**Mukilteo**	**C/D**	**Spanaway**	**B**
Dystric Xero.	C	Newburg	B	Sultan	C
Eld	**B**	**Nisqually**	**B**	Tacoma	D
Everett	**A**	**Norma**	**D**	Tenino	C
Everson	**D**	Olympic	B	Tisch	D
Galvin	D	Pheeney	C	Vailton	B
Giles	**B**	Pilchuck	C	Wilkeson	B
Godfrey	D	Prather	C	Xerorthents	C
Grove	A	Puget	D	**Yelm**	**C**
Hoogdal	**C**				

Sources: Soil Survey of Thurston County, Washington, Soil Conservation Service, 1990, and TR-55 Model manual, 210-VI-TR55, Second Edition, June 1986.

NOTE: Soils highlighted in **bold print** are commonly found in the Lacey area.

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.).*

5.1.2.4 Runoff Curve Numbers

Runoff Curve Numbers (CNs) for computing runoff from various land covers using NRCS methods are to be selected from Table 2.2 of Volume III of the 2005 DOE Manual (included in Appendix 5A, source: SCS 1986 TR-55 Urban Hydrology for Small Watersheds, Second Edition).

The CNs are for 24-hour duration storms and for typical antecedent soil moisture conditions.

CNs can be area-weighted when they apply to pervious areas of similar CN (within 20 CN points). High CNs (e.g. impervious areas) are not to be area-weighted with low CNs.

5.1.2.5 Estimates of Overland Flow Rates

If overland flow rate is calculated on the basis of Manning's roughness coefficient, the roughness coefficients found in Section 5.2.3 (Table 5.8) for various types of channel linings may be used.

5.1.2.6 Estimates of Impervious Surface

Impervious surface for residential subdivisions may be estimated by calculating the impervious surface for roads and other features to be built during site development, and adding to that the impervious surface for each lot. The impervious surface estimates for lots must be estimated based on maximum lot coverage allowable by zoning code unless restricted to a lesser percentage by covenant

Impervious area for commercial lots shall be estimated at the maximum percent impervious allowed by zoning code unless a lower percent impervious can be guaranteed through covenants, easements, and other such instruments.

5.2 HYDRAULIC ANALYSIS/CONVEYANCE DESIGN

5.2.1 Design Criteria

Design of drainage structures shall meet the following design event criteria:

- Conveyance systems shall be designed, at a minimum, for the 10-year 24-hour event.
- Drains and culverts passing under public roads and arterial streets shall be designed for the 25-year event.
- Culverts for and bridges over natural channels shall be designed to convey the 100-year event.
- For pipe or swale systems, there shall be no surface flooding for the design event, and excess flows for flows up to the 100-year event runoff shall be conveyed in a non-destructive manner.
- In the urban area inside of the long-term urban growth management boundary, the outside driving lane of public roads and streets must not have water over more than 50% of the lane width for the 25-year, 24-hour storm event.

The City may require an increased level of protection and/or freeboards on a case-by-case basis.

5.2.2 Preferred Conveyance Methods

Grass-lined or other open-channel surface drainage systems are preferred, according to the following hierarchy (in order of most to least preferred):

1. Overland flow or vegetated swales;
2. Rock-armored or paved channels;
3. Storm drain systems.

The Project Engineer must justify the use of either 2 or 3 in the above list. Factors that may be used to justify the use of a less-preferred conveyance system include, but are not necessarily limited to, the following:

- Road widening uses all land available for open channels;
- Rolling terrain would require deep cuts;
- Traverse of an unstable or steep slope;
- Unstable flow velocities/depths;
- Applicable street standards prohibit preferred conveyance;
- Lack of adequate space.

If there is no practical alternative to storm drains (as determined by the City based on information provided by the proponent), inlets shall be placed, to the maximum extent practical, within grass "islands" protected from traffic in off-street parking situations to provide some biofiltration before runoff enters the system. Vegetation surrounding catch basins must be protected from traffic.

5.2.3 Design Methods and Criteria

This section describes methods and criteria for sizing of storm sewers, channels, revetments, and other drainage structures in the conveyance system. Setbacks and easements for conveyances are found in Chapter 2.

5.2.3.1 Design Criteria for Channels

<u>Channel Lining</u>

Channels shall be designed according to criteria in Table 5.7. Channels must be stabilized against erosion in compliance with minimum standards for erosion control set forth in Chapter 4. Channels shall be designed to not suffer erosion or scour damage for the conveyance system Design Event (Section 5.2.1). Table 5.7 provides minimum criteria to prevent damage.

Table 5.7 Design Criteria – Open Channels

Channel Lining	Maximum Design. Velocity (fps)	Maximum Design Slope H/V	Minimum Filter Blanket (Inches)
Vegetation	5	3	NA
Geotextile	***	***	NA
Lattice Block Paving Systems	12	2	***
Quarry Spalls, 18" Dia.	15**	2	4
Hand-placed Rip Rap, 2' thick	12	2	4
Gabions	30	***	4
Concrete	30	Design	NA

* see Guide for determining gradation of sand and gravel filters, SMN-1, Soil Conservation Service, 1986
** see Riprap Design, Journal of Hydraulics, ASCE, July 7, 1989
*** per manufacturer's instructions

If the velocity at design flow is greater than five feet per second, the channel and embankment shall be protected from erosion as necessary, through appropriate lining and/or check structures.

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.

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.

Open-channel conveyances shall be designed by one of the following methods (see Appendix 5B):

- Manning's Equation (for uniform flow depth, flow velocity, and constant channel cross-section; or
- Backwater Method (utilizing the energy equation or a computer program).

Manning's Roughness

Channel roughness is dependent upon the channel lining and condition. The Project Engineer may select the appropriate Manning's "n" value from Table 5.8. Additional discussion of roughness values may be found in Chow's *Open Channel Hydraulics*, 1959.

Table 5.8 Manning "n" Values for Various Channel Linings (full flow)

Channel Lining Material	"n"
Concrete	0.012
Short Grass	0.030
Stony bottom/weedy banks	0.035
Cobble bottom/grass banks	0.040
Dense vegetation, as high as flow	0.080
Dense woody brush as high as flow	0.120
Biofiltration swale	0.150

5.2.3.2 Check Structures

Check structures for purposes of velocity control in ditches may be of rock construction as shown in Appendix 5B. The Project Engineer shall consider check structures, channel armor or other suitable means to protect channels from scour and erosion.

5.2.3.3 Culverts

Culverts may be designed using nomographs or other design aids (such as computer applications). Design methodology, computations and backup documentation shall be submitted for review.

Shallow fords may be substituted for culverts on residential driveway crossings of swales.

Culverts for fish bearing channels must conform to Washington Department of Fisheries and Wildlife regulations for fish passage.

The maximum design water surface elevation in the backwater behind culverts for the conveyance system Design Event shall be below top of channel. Maximum design water surface for culverts that convey streams shall be below the culvert crown.

The minimum diameter culvert under public roads and streets is 12 inches.

Inlets and outlets shall be protected from erosion by rock lining, riprap, or bio-stabilization. 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.

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 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.

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.

5.2.3.4 Storm Sewers

Flow Analysis

The Design Event for storm sewers is given in Section 5.2 above. If the Administrator or designee determines that, as a result of the Project, runoff for any event through the 100-year, 24-hour event would cause damage or interrupt vital services, the Administrator or designee may require a computer backwater (pressure sewer) analysis. Submit results in tabular and graphic format showing hydraulic and energy gradient.

Design Manning Roughness "n"

Suggested values for friction factors using the Manning formula are shown in Table 5.9. Other values may be accepted if justification is documented.

Table 5.9 Manning "n" Values for Pipes

Pipe Material	"n"
Concrete	0.013
Annular CMP or Pipe Arch	
2-2/3 x ½ corrugation	0.024
3 x 1 corrugation	0.027
6 x 2 corrugation	0.030
Helical CMP	0.024
Spiral Rib	0.016
Ductile iron (cement lined)	0.013
Plastic	0.010

Source: Chow's *Open Channel Hydraulics*, 1959, and others

Minimum Diameter, Slope, and Velocity

The minimum diameter for storm sewer on private property is four inches. The minimum diameter in the public right-of-way is 12 inches, except laterals connecting catch basins to main lines may be eight inches. The Administrator or designee may waive these minima in cases where topography, design flows and existing drainage systems make it impractical to meet the standard.

Maximum Slopes and Velocities

Maximum slopes and velocities shall be as shown in Table 5.10. Anchor spacing shall be as shown in Table 5.11. If velocities exceed 15 feet per second for the conveyance system Design Event, provide anchors at bends and junctions.

Table 5.10 Maximum Pipe Slopes and Velocities

Pipe Material	Pipe Slope Above Which Anchors Required	Maximum Allowed Slope	Maximum Full Flow Velocity (fps)
PVC	20%	30%	30
CMP	20%	30%	30
Concrete/Ductile Iron	20%	20%	30
HDP	20%	unlimited	unlimited

Table 5.11 Pipe Anchor Spacing

Slope Percent	Anchor Spacing (feet, on-centers)
20% ≤ Slope ≤ 35%	36
35% ≤ Slope ≤ 50%	24
50% ≤ Slope ≤ 100%	16
Slope ≥100%	Design

5.2.3.5 Trash Racks

Where open channels or ponds discharge into storm drains, trash racks are required on all storm sewer system inlet pipes of 18 inches diameter or larger. Trash racks must be removable with ordinary hand tools.

5.2.3.6 Cover Requirements, Trench Design, Pipe Strength

When calculating pipe loading for pipes over 24 inches in diameter or over 10 feet in depth, submit proof of pipe suitability for the design condition. Assume pipe trench will be opened at 45 degrees to the trench bottom unless trench configuration can be predicted with certainty (e.g., trench boxes will be specified).

5.2.3.7 Manholes and Catch Basins

When design flow will be above 10 cubic feet per second (cfs), catch basin and manhole inlet capacities must be discussed in the Drainage and Erosion Control Plan and capacities must be shown on the work map. Inlet capacity limitations may be used to divide flow between channels or gutters and storm sewers.

See WSDOT "Standard Specifications" 7-05 for construction and material requirements for catch basins and manholes. Also, see WSDOT "Standard Plans" B-1 through B-12 for detailed diagrams.

<u>Sizing</u>

Catch basin or manhole diameter shall be determined by the number and size of penetrations as described in Standard Specifications.

<u>Manhole/Catch Basin Message</u>

Each catch basin or grated manhole in a storm drainage system must have a message pertaining to pollution prevention. Refer to the City of Lacey's *Development Guidelines and Public Works Standards* for details of the applicable standard message.

<u>Flow Restrictor Manholes</u>

Flow restrictor manholes are to be designed in a manner similar to those shown in Appendix 5B. 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 or may use thin-plate slotted weirs in place of orifices.

Discharge through multiple orifices is computed using WWHM3, which embodies appropriate orifice and weir equations.

<u>Flow Splitters</u>

Flow splitters are to be designed as flow restrictor control manholes using WWHM3.

<u>Changes of Pipe Size or Direction</u>

Pipe direction changes or size increases or decreases are allowed only at manholes and catch basins. (On private property, for four-inch and six-inch diameter pipe, clean-outs at junctions are permissible). Curvilinear pipe may be installed in strict accordance with manufactures instructions which shall be attached to the Drainage and Erosion Control Plan and shall be available on the job site.

<u>Inlets</u>

See Standard Plans and Standard Specifications for construction and material requirements and for detailed diagrams.

5.2.3.8 Outfalls

All discharges to streams or other surface water bodies are designated as 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 due to concentrated discharges from pipe systems and culverts, both on-site and downstream. Outfall systems include rock splash pads, flow dispersal trenches, gabions or other energy dissipaters, and tightline systems.

Outfalls to streams, wetlands or other waters of the State may be subject to review through the SEPA process, Shorelines Management Act and other applicable regulations. Outfalls also may be subject to hydraulic project permitting requirements of the Washington Department of Fish and Wildlife, Washington Department of Natural Resources, or the U.S. Army Corps of Engineers, which shall take precedence where more restrictive than those stated herein.

Outfalls shall be designed to pass the peak flow from the Design Event for conveyances 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.

The standard for outfall design is as shown in Figure 5B.1 in Appendix 5B. 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 Drainage Manual Administrator's satisfaction.

For sites where the Project Engineer determines and the Drainage Manual Administrator agrees that the standard is impractical because of lack of space, danger of erosion, etc., see alternate outfall designs shown in Appendix 5B. Other outfall designs will be allowed upon approval of the Administrator or designee.

Outfalls with flow velocity under 12 feet per second and discharge under two cfs for the conveyance system Design Event are to be provided (at minimum) with a splash pad (e.g., rock, gabions, concrete).

Outfalls where flow is two cfs or greater or velocity is 12 feet per second or greater for the conveyance system Design Event, an engineered energy dissipater is required. Examples are gabion splash blocks, 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 Tables 5.10 and 5.11) must be anchored (see standard detail Appendix 5B) 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 (HDPE) pipe may be laid on the surface or in a shallow trench, anchored, protected against sluicing, and hand compacted.

HDPE 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 HDPE 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.

HDPE 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.

HDPE 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 1600 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 (see outfall detail in Appendix 5B). See Table 5.12 for minimum rock protection at outfalls.

Due to HDPE 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 in Appendix 5B. 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 Project Engineer shall also refer to Volume V, Section 4.5.3 ("Outfall Systems") of the *Stormwater Management Manual for Western Washington* (2005) for additional design information.

Table 5.12 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 - 12	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
12^+	Engineered Design	As required	As required	As required	Crown + 1 foot

Source: Thurston County Drainage Design and Erosion Control Manual

Footnotes:

(1) Rock lining shall be quarry spalls with gradation as follows:

Passing 8-inch square sieve:	100%
Passing 3-inch square sieve:	40 to 60% maximum
Passing 3/4-inch square sieve:	0 to 10% maximum

(2) Riprap shall be reasonably well graded with gradation as follows:

Maximum stone size:	24 inches (nominal diameter)
Median stone size:	16 inches
Minimum stone size:	4 inches

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

Flow Dispersal Trench

The flow dispersal trenches shown in Figures 5B.2 and 5B.3 in Appendix 5B should only be used when an outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists, the natural (existing) discharge is unconcentrated, and the 100-year peak discharge rate is less than or equal to 0.5 cfs. Other flow dispersal BMPs are described in Chapter 6.

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 5B.6). 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.

5.2.3.9 Off-Street Parking Design

Lacey encourages for all off-street pavements the use of grass-pavement combinations such as lattice blocks (see Appendix 5C), geotextiles, or other such semi-pervious pavements and/or dispersion systems. Such systems will improve the quality of runoff, reduce the Proponent's investment in drainage systems, reduce the monthly utility rate payments, and improve the aesthetics of the development.

Modeling "credits" in WWHM for such features are described in Section 5.1.1 above (Table 5.3).

Islands in parking lots shall be used as vegetation-lined conveyance and/or storage facilities whenever practical. Sheet flow over pavement is preferred in lieu of catch basins and pipes. The second preference is slotted drains or fords. When catch basins are unavoidable it is preferred that they be placed in grass islands so that some biofiltration occurs before runoff enters the drain.

5.2.3.10 Conveyance Materials

All components of conveyance facilities including drains, manholes, catch basins, and outfalls, shall be as specified in the Standard Specifications. Corrugated polyethylene shall meet AASHTO M294S.

Contact the jurisdiction regarding preferences for or restrictions on the use of galvanized steel, PVC, high density polyethylene, double-walled (smooth interior) corrugated polyethylene, other plastic, or fiberglass pipe.

Appendix 5A
Runoff Curve Number Guidance

(excerpted from Volume III, Chapter 2 of the Washington State Department of Ecology's 2005 *Stormwater Management Manual for Western Washington*)

Runoff Parameters

All storm event hydrograph methods require input of parameters that describe physical drainage basin characteristics. These parameters provide the basis from which the runoff hydrograph is developed. This section describes only the key parameter of curve number that is used to estimate the runoff from the water quality design storm.

Curve Number

The NRCS (formerly SCS) has, for many years, conducted studies of the runoff characteristics for various land types. After gathering and analyzing extensive data, NRCS has developed relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. The relationships have been characterized by a single runoff coefficient called a "curve number." The 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.

NRCS has developed "curve number" (CN) values based on soil type and land use. They 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 5A.1 shows the hydrologic soil group of most soils in the state of Washington and provides a brief description of the four groups. For details on other soil types refer to the NRCS publication mentioned above (TR-55, 1986).

Table 5A.1 shows the CNs, by land use description, for the four hydrologic soil groups. These numbers are for a 24-hour duration storm and typical antecedent soil moisture condition preceding 24-hour storms.

The following are important criteria/considerations for selection of CN values:

Many factors may affect the CN value for a given land use. For example, the movement of heavy equipment over bare ground may compact the soil so that it has a lesser infiltration rate and greater runoff potential than would be indicated by strict application of the CN value to developed site conditions.

CN values can be area weighted when they apply to pervious areas of similar CNs (within 20 CN points). However, high CN areas should not be combined with low CN areas. In this case, separate estimates of S (potential maximum natural detention) and Q_d (runoff depth) should be generated and summed to obtain the cumulative runoff volume unless the low CN areas are less than 15 percent of the subbasin.

Separate CN values must be selected for the pervious and impervious areas of an urban basin or subbasin. For residential districts the percent impervious area in Table 5A.1 must be used to compute the respective pervious and impervious areas. For proposed commercial areas, planned unit developments, etc., the percent impervious area must be computed from the site plan. For all other land uses the percent impervious area must be estimated from best available aerial topography and/or field reconnaissance. The pervious area CN value must be a weighted average of all the pervious area CNs within the subbasin. The impervious area CN value shall be 98.

Example: The following is an example of how CN values are selected for a sample project.

Select CNs for the following development:

Existing Land Use	-	forest (undisturbed)
Future Land Use	-	residential plat (3.6 DU/GA)
Basin Size	-	60 acres
Soil Type	-	80 percent Alderwood, 20 percent Ragnor

Table 5A.1 shows that Alderwood soil belongs to the “C” hydrologic soil group and Ragnor soil belongs to the “B” group. Therefore, for the existing condition, CNs of 70 and 55 are read from Table 5A.1 and areal weighted to obtain a CN value of 67. For the developed condition with 3.6 DU/GA the percent impervious of 39 percent is interpolated from Table 5A.1 and used to compute pervious and impervious areas of 36.6 acres and 23.4 acres, respectively. The 36.6 acres of pervious area is assumed to be in Fair condition (for a conservative design) with residential yards and lawns covering the same proportions of Alderwood and Ragnor soil (80 percent and 20 percent respectively). Therefore, CNs of 90 and 85 are read from Table 5A.1 and areal weighted to obtain a pervious area CN value of 89. The impervious area CN value is 98. The result of this example is summarized below:

On-Site Condition	Existing	Developed
Land use	Forest	Residential
Pervious area	60 ac.	36.6 ac.
CN of pervious area	67	89
Impervious area	0 ac.	23.4 ac.
CN of impervious area	--	98

Table 5A.1
Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas

Sources: TR 55, 1986, and Stormwater Management Manual, 1992.

Cover type and hydrologic condition.	CNs for hydrologic soil group 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 Appendix C 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 shall be selected for pervious & impervious portions of the site or basin
1.5 DU/GA		20	
2.0 DU/GA		25	
2.5 DU/GA		30	
3.0 DU/GA		34	
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	
PUD's, condos, apartments, commercial businesses, industrial areas & & subdivisions < 50 acres	%impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site	

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 CN's may be computed for other combinations of open space cover type.

[2]Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in this manual, 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.

SCS Curve Number Equations for determination of runoff depths and volumes

The rainfall-runoff equations of the SCS curve number method relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity, as follows:

$$Q_d = (P - 0.2S)^2 / (P + 0.8S) \qquad \text{for } P \geq 0.2S$$

and

$$Q_d = 0 \qquad \text{for } P < 0.2S$$

Where:

Q_d = runoff depth in inches over the area,
P = precipitation depth in inches over the area, and
S = potential maximum natural detention, in inches over the area, due to infiltration, storage, etc.

The area's potential maximum detention, S, is related to its curve number, CN:

$$S = (1000 / CN) - 10$$

The combination of the above equations allows for estimation of the total runoff volume by computing total runoff depth, Q_d, given the total precipitation depth, P. For example, if the curve number of the area is 70, then the value of S is 4.29. With a total precipitation for the design event of 2.0 inches, the total runoff depth would be:

$$Q_d = [2.0 - 0.2\,(4.29)]^2 / [2.0 + 0.8\,(4.29)] = 0.24 \text{ inches}$$

This computed runoff represents inches over the tributary area. Therefore, the total volume of runoff is found by multiplying Q_d by the area (with necessary conversions):

Calculating the design volume for wetpool treatment facilities

Total runoff Volume (cu. ft.)	=	3,630 (cu. ft./ac. in.)	x	Q_d (in)	x	A (ac)

If the area is 10 acres, the total runoff volume is:

3,630 cu. ft./ac. in. x 0.24 in. x 10 ac. = 8,712 cu. ft.

This is the design volume for treatment BMPs for which the design criterion is based on the volume of runoff.

Appendix 5B
Conveyance and Outfall Design Guidance

Open Channel Flow – Hydraulic Analysis

Two hydraulic analysis methods are used to analyze and design conveyance systems:

- The Uniform Flow Analysis Method, commonly referred to as the Manning's equation, is used for the design of open conveyances and new pipe systems, 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 is used to analyze the capacity of both proposed and existing pipe systems when a pipe is surcharged. If the City 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' unsurcharged capacity, a backwater (pressure sewer) analysis shall be required (a backwater profile analysis computer program, such as the King County Backwater (KCBW) computer program, is recommended). 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:

$$V = \frac{1.486\,(R^{0.67})(S^{0.5})}{n}$$

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):

$$Q = \frac{1.486}{n}(A)(R^{0.67})(S^{0.5})$$

Where A = cross-sectional area of flow (square feet).

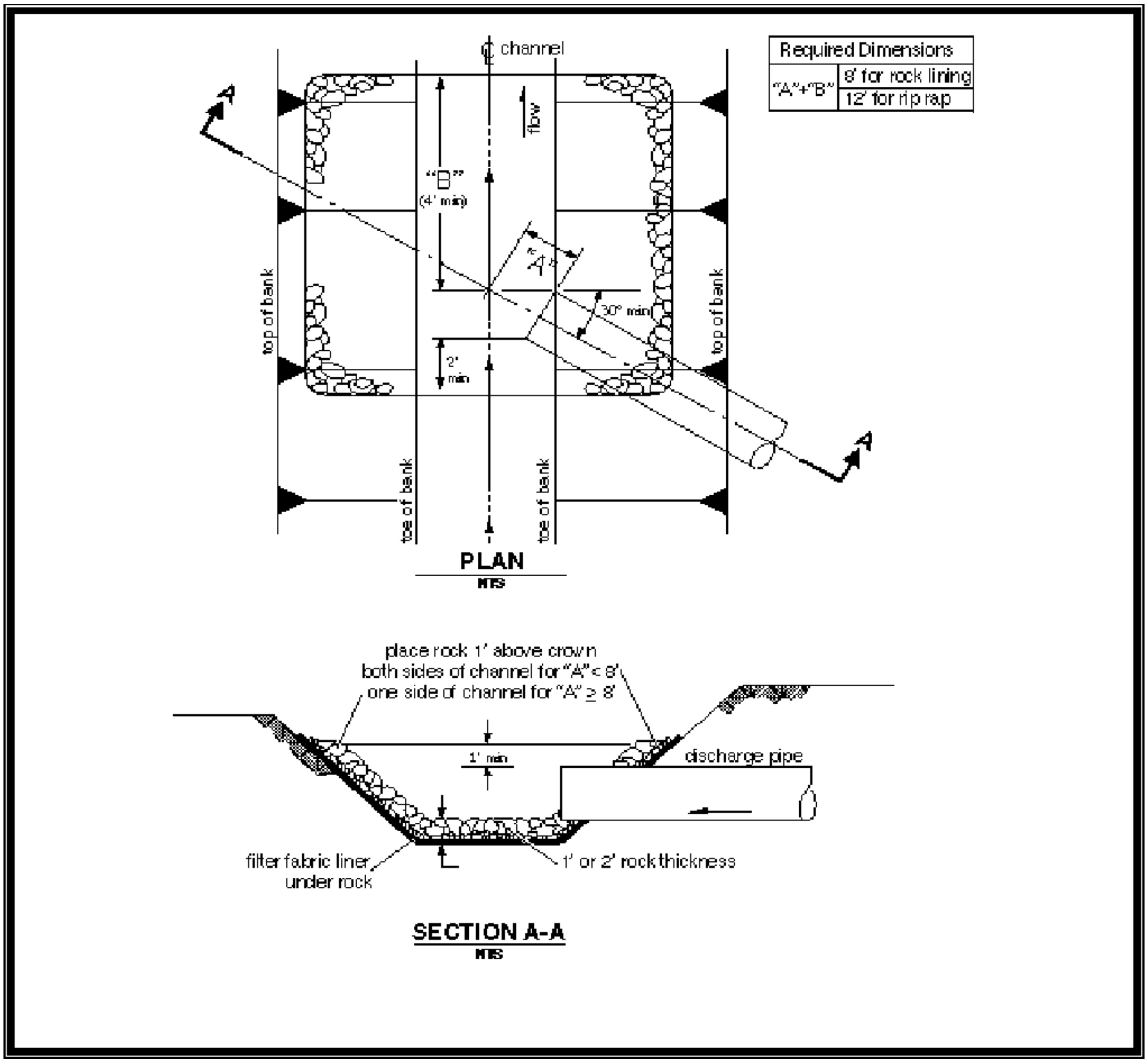


Figure 5B.1: Pipe/Culvert Outfall Discharge Protection.

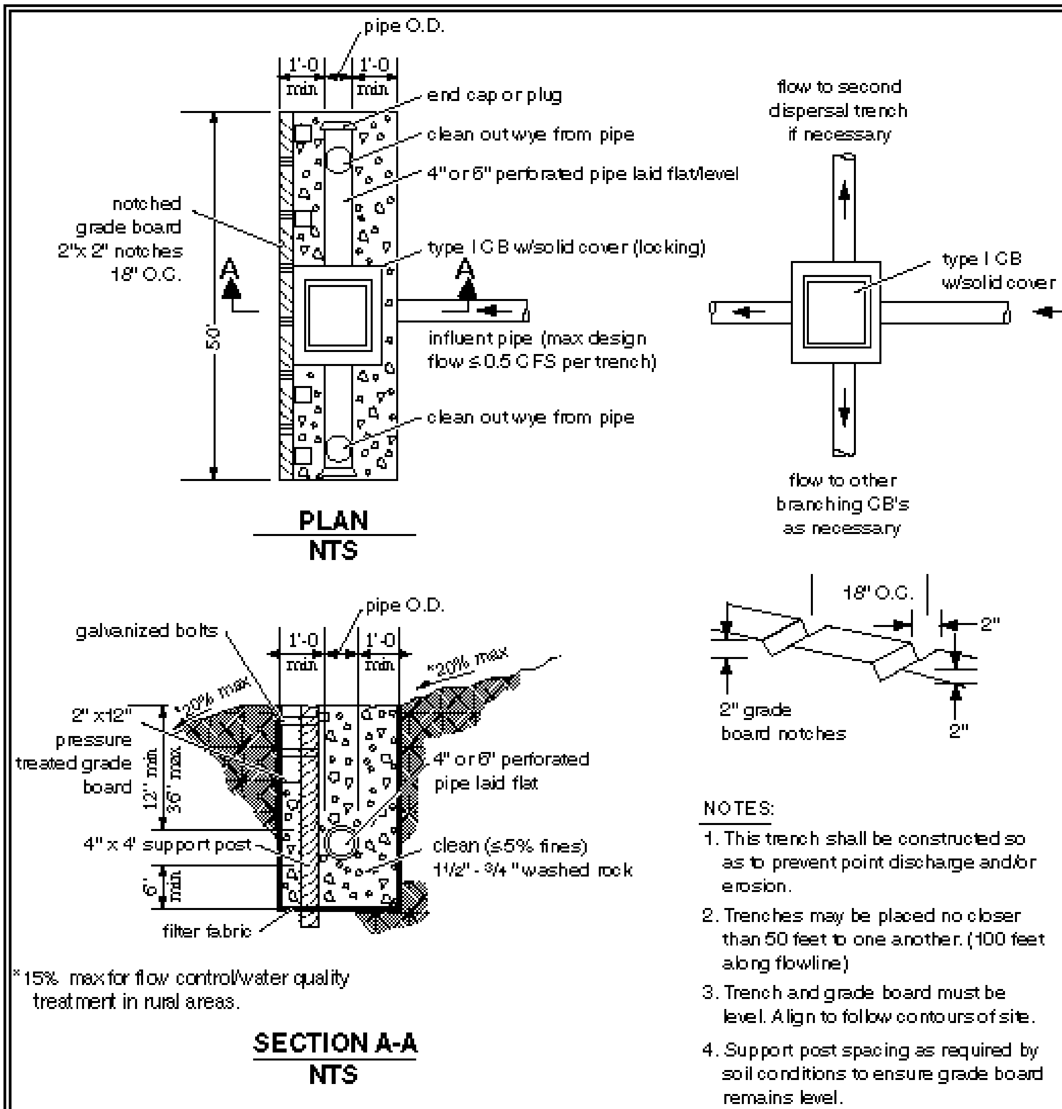


Figure 5B.2: Flow Dispersal Trench

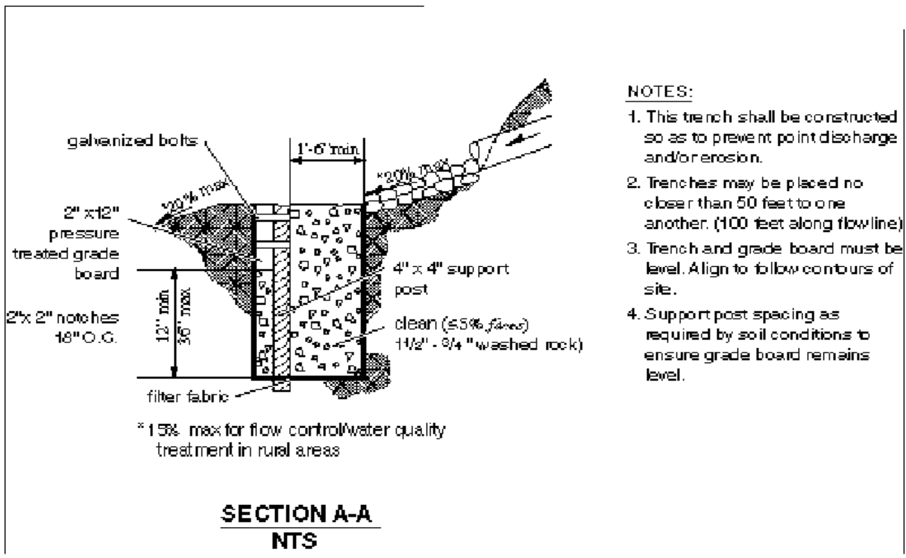


Figure 5B.3: Alternative Flow Dispersal Trench

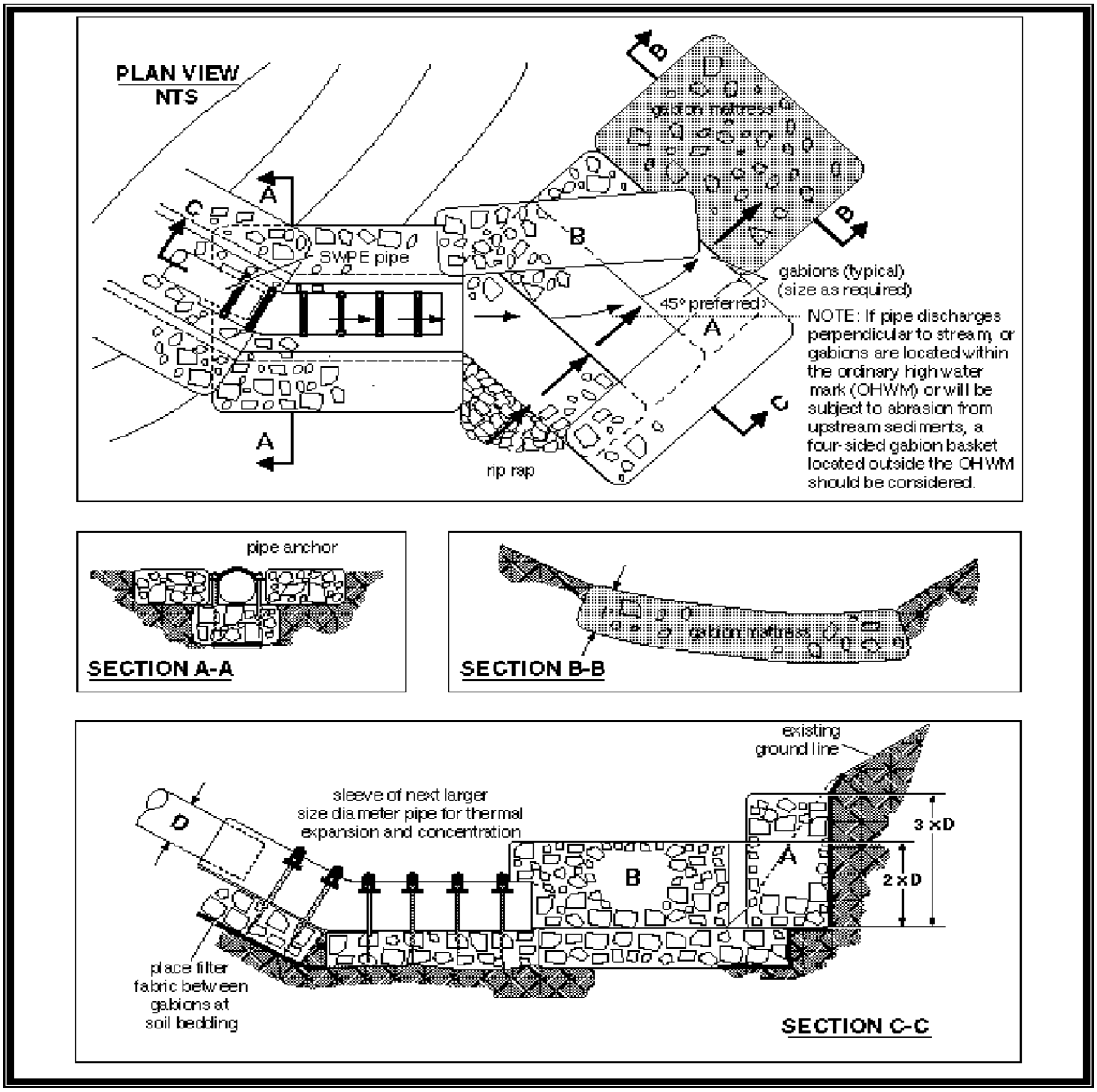
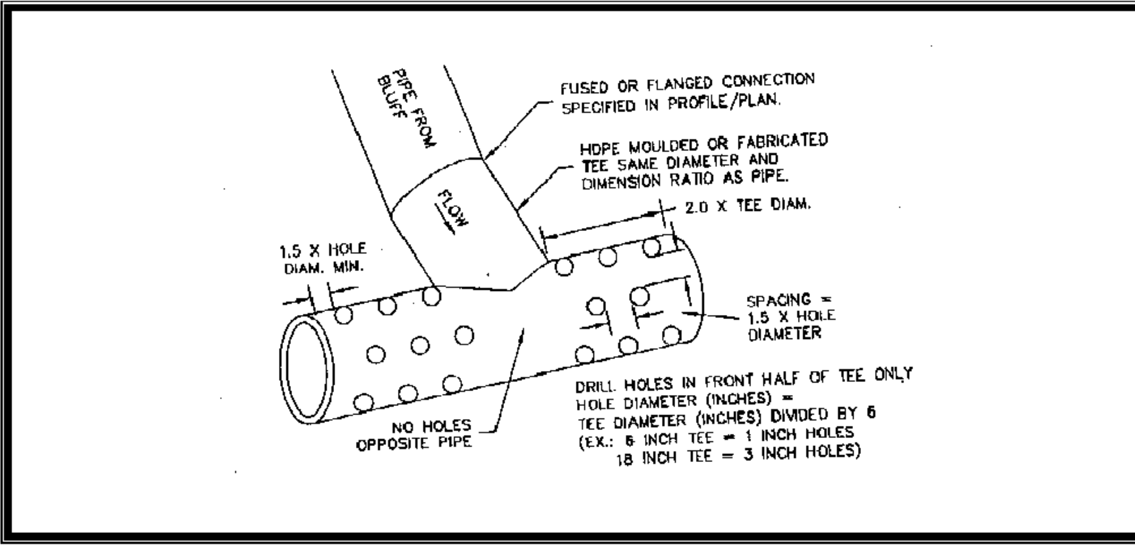


Figure 5B.4: Gabion Outfall Detail



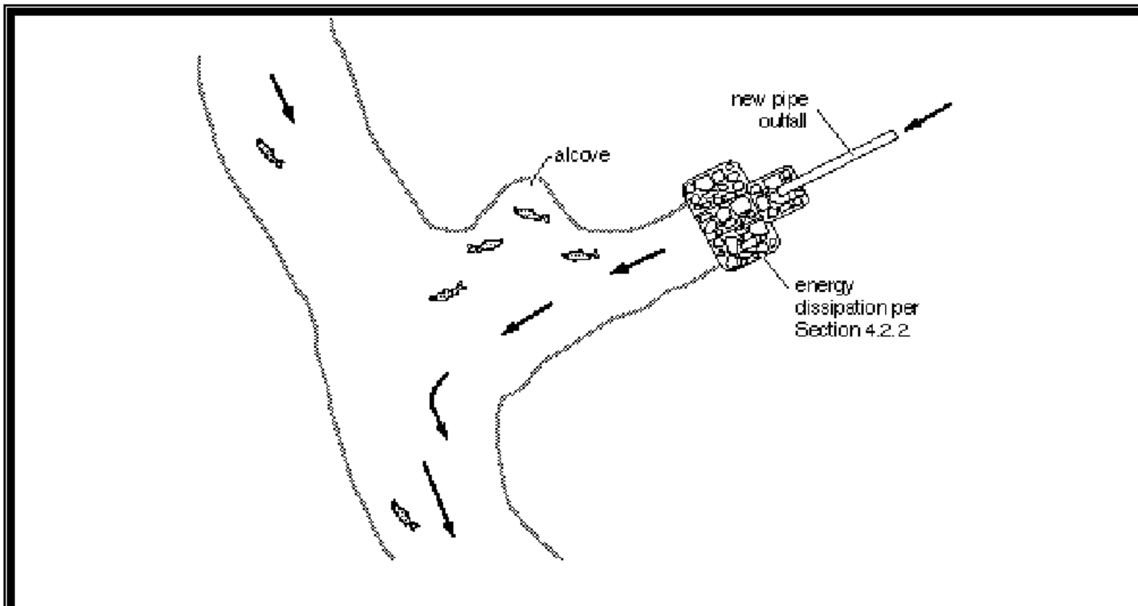


Figure 5B.5: Diffuser Tee (example of energy-dissipating end feature)

Figure 5B.6: Fish Habitat Improvement at New Outfalls.

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 the figures below. Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the facility are also acceptable.

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 below or an equivalent design may be used.

- As an alternative to using a solid top plate, 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.

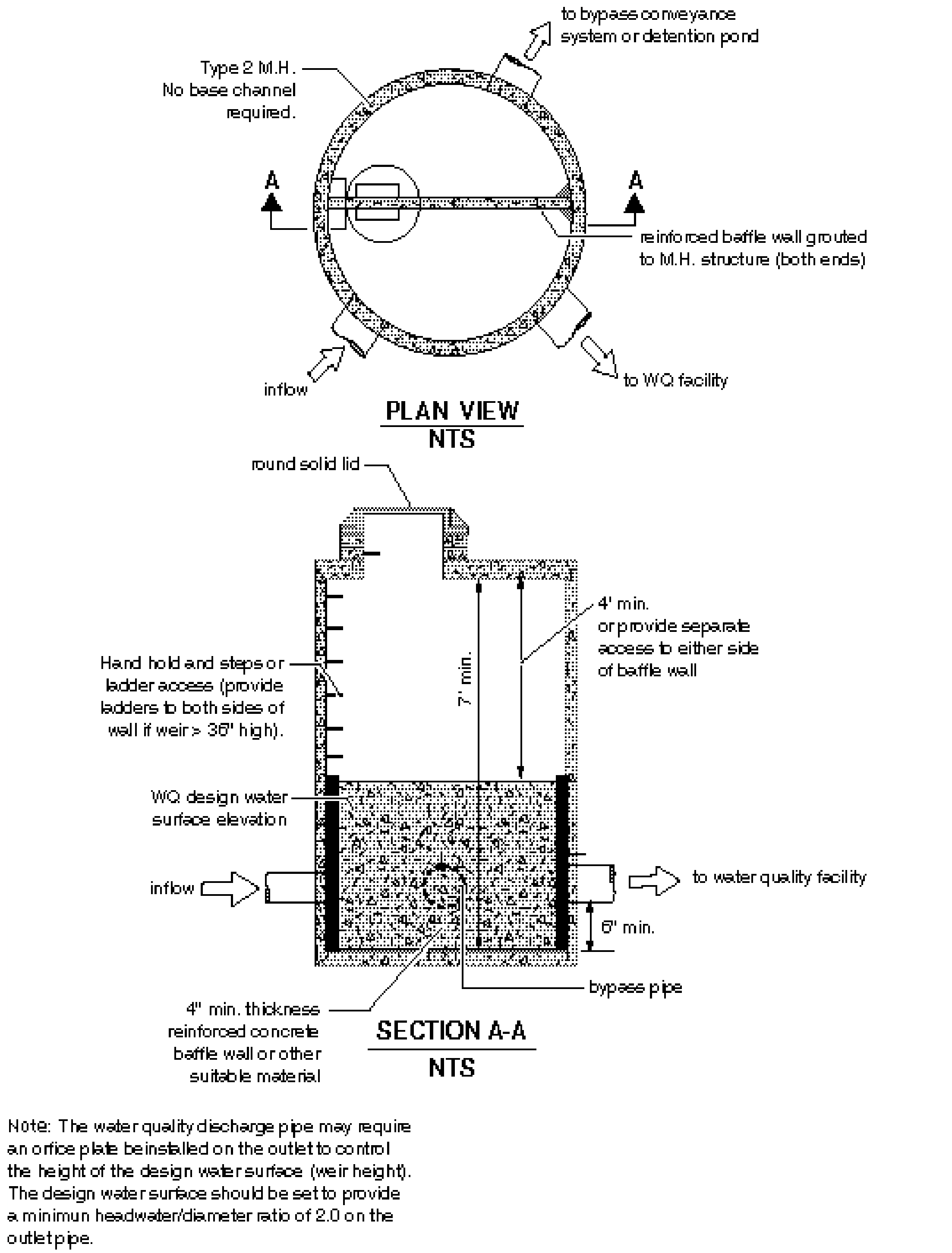
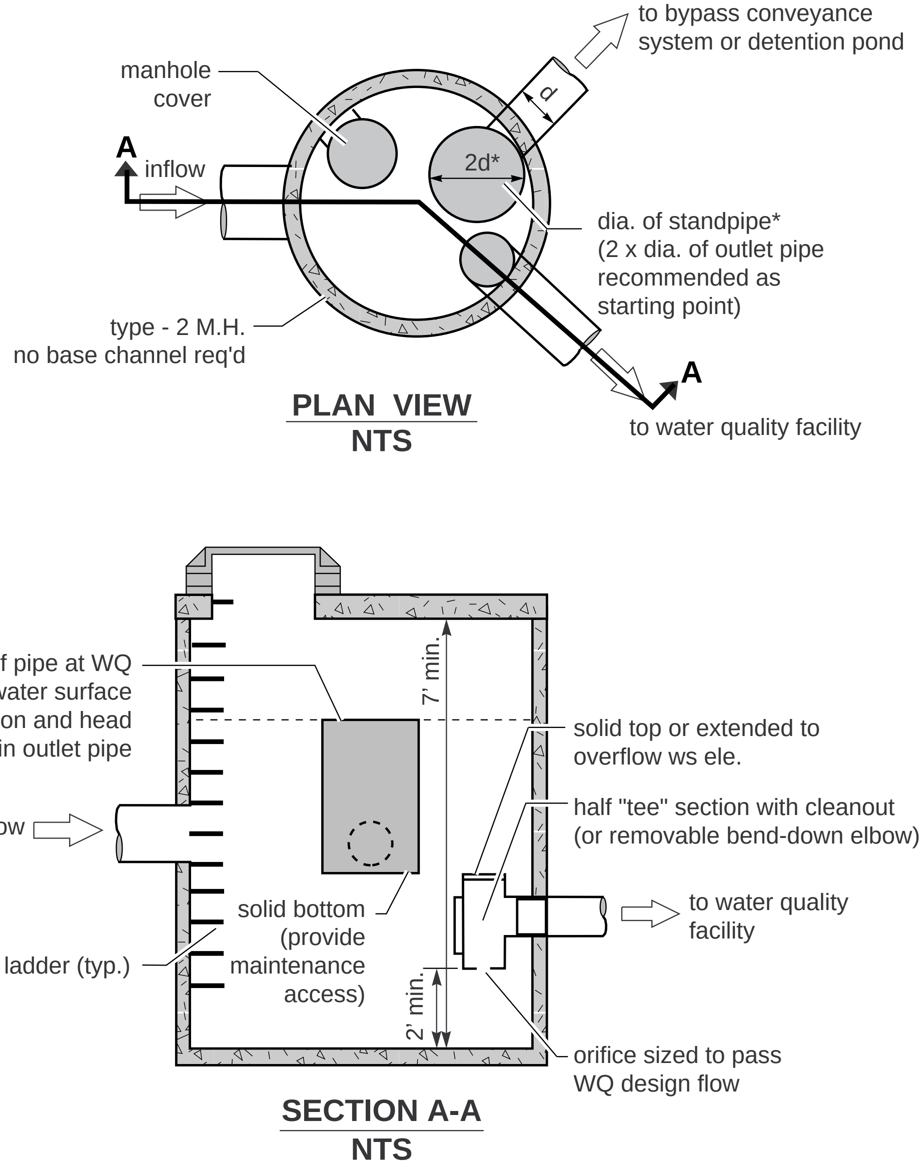


Figure 5B.7: Flow Splitter, Option A



* **NOTE:** Diameter (d) of standpipe should be large enough to minimize head above W.Q. design W.S. and to keep W.Q. design flows from increasing more than 10% during 100-year flows.

Figure 5B.8: Flow Splitter, Option B