SECTION 4
SURFACE WATER MANAGEMENT
DESIGN AND CONSTRUCTION REQUIREMENTS

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4-1 INTRODUCTION

City of Vancouver Surface Water Management Section reviews new development and redevelopment activities and ensures compliance with federal, state and local codes and ordinances to provide water quality treatment and control of stormwater run-off, while also working to protect riparian areas and water bodies within the City limits. To that end, the program provides technical guidance, comprehensive planning, and sound engineering to safely move flood waters and drainage in a manner that prevents negative water quality impacts, provides fish passage and habitat, promotes recreation opportunities, and enhances community aesthetics.

These goals are met through planning and prioritizing capital improvements, acquiring wetland and flood plain properties where needed, developing regional water quality and detention facilities, working with the development community to meet requirements through use of best management practices and best available technology.

Proper design of catch basins, pipes, curbs and other surface water conveyance infrastructure as well as use of water quality and control structures can prevent flooding, reduce maintenance costs and protect the environment. Additionally, erosion prevention, in and adjacent to construction sites, has a great impact on the quality of surface water runoff and protects the long term viability of infiltration systems.

Storm sewer systems and on-site drainage systems are designed to handle surface water from various sources including street, roof and footing drainage. Storm drains in the City of Vancouver are separate from the sanitary sewer system.

This section provides requirements and details for surface water conveyance, water quality and quantity systems, and erosion prevention and sediment control in the City of Vancouver. All requirements and specifications are subject to revision. Standard specification drawings follow the narrative section.

These General Requirements are intended to supplement and clarify the Stormwater Management Manual for Western Washington (*Stormwater Manual)* to provide guidance for and tailor to local conditions. The General Requirements may also adopt measures that are deemed equivalent by the Washington State Department of Ecology.

The General Requirements have been developed to provide engineers with minimum criteria for developing stand alone plans for the construction of required improvements and are not intended to be all inclusive. The following criteria, outlined in this document, will assist engineers in the design of drainage infrastructure per the requirements of the City of Vancouver. If a topic or standard is not addressed in these General Requirements, refer to the *Stormwater Manual* for guidance.

The Washington State Department of Transportation *Highway Runoff Manual* may be used to design stormwater systems for City of Vancouver Transportation and Washington State Department of Transportation projects.

Additional criteria and information is available in the Vancouver Municipal Code (VMC); specifically ordinances VMC 14.24, 14.25, and 14.26, the Western Washington Phase II Municipal Stormwater Permit (Phase II Permit) issued by the Washington State Department of Ecology, Ecology's *Stormwater Manual*, and the Underground Injection Control Program (WAC 173-218 and Section I-4 of the *Stormwater Manual*). See References in Appendix D.

The Vancouver Municipal Code is available on the City's website:
http://www.cityofvancouver.us/vmc

The *Stormwater Manual*, NPDES Phase II Permit and UIC Program Information are available on Washington State Department of Ecology Water Quality Program website:
http://www.ecy.wa.gov/programs/wq/wqhome.html

4-1.01 APPLICABILITY OF VMC 14.24, VMC 14.25, and VMC 14.26

All new development and redevelopment activities shall refer to Figure 3.2 and Figure 3.3 to determine which stormwater requirements will apply to the project. Figure 3.2 and Figure 3.3 from pages 9 and 10 of Appendix 1 of the Phase II Permit are in Appendix A of this document or Figures 2.4.1 and 2.4.2 in Volume I of the Stormwater Manual pages 2-10 and 2-11.

Minimum Requirements that may apply to a new development or redevelopment activity:

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention Plan
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems & Outfalls
5. On-site Stormwater Management
6. Runoff Treatment
7. Flow Control
8. Wetlands Protection
9. Operation and Maintenance

In addition to the applicable Minimum Requirements, all new underground injection control wells shall meet the requirements of Washington State Department of Ecology Underground Injection Control (UIC) Program. Information regarding Ecology's requirements can be found on their website:
http://www.ecy.wa.gov/programs/wq/grndwtr/uic/

4-2 STORMWATER SITE PLAN SUBMITTALS

4-2.01 Introduction

A Stormwater Site Plan is a comprehensive plan and report containing all the technical information and analyses necessary for the City to evaluate proposed new development or redevelopment activities for compliance with stormwater requirements. The contents of the Stormwater Site Plan will vary with the type and size of the project and the individual site characteristics.

Project applicants shall fill out and submit a "Stormwater Applicability Application" which will be utilized to determine the required elements of the stormwater submittal.

This section describes the submittal package that is required for projects within the City of Vancouver. Additional guidance on preparing a Stormwater Site Plan is contained in Vol. I, Ch. 3 of the *Stormwater Manual*.

4-02.02 Preliminary Stormwater Site Plan

In accordance with Minimum Requirement #1, a preliminary stormwater site plan is required for all new development and redevelopment projects that are not exempt from all Minimum Requirements (as described in Section 4-1.01). The purpose of the preliminary stormwater site plan is to allow the City to determine whether a proposal can meet the requirements of Vancouver Municipal Code Chapters 14.24, 14.25, and 14.26.

The preliminary stormwater site plan shall be submitted with the land use application.

The preliminary stormwater plan submittal shall consist of:

1. A preliminary development plan.
2. A preliminary Stormwater Report prepared in the standardized format described in the sections below.

The preliminary stormwater site plan shall identify how stormwater runoff that originates on the site or flows through the site is currently controlled and how this will change with the proposed development or redevelopment project. If the site is within a region covered by a basin plan, the information needed in the preliminary stormwater site plan may be reduced.

The project engineer shall include a statement that all the required information is included in the preliminary stormwater site plan and that the proposed stormwater facilities are feasible. All plans, studies, and reports that are part of the preliminary and final stormwater site plans shall be stamped, signed and dated by the professional civil engineer(s), registered in the state of Washington, responsible for preparation of the report.

The City may waive some or all of the content requirements in the preliminary stormwater site plan if:

1. The development project is included in an approved final stormwater plan that meets the requirements of VMC 14.24, 14.25, and 14.26; or
2. A basin plan exists that makes some of the information irrelevant; or

3. The City determines, upon receipt of a letter of request from the applicant, that less information is required to accomplish the purposes of this chapter.

The waiver of some or the entire preliminary stormwater site plan does not relieve the applicant of the requirement to prepare a final stormwater site plan.

Preliminary Development Plan

The preliminary development plan shall consist of 22-inch x 34-inch or 24-inch x 36-inch drawings for existing and proposed conditions. The preliminary development plan shall show the character of the existing site and proposed features, including but not limited to:

1. Existing and proposed property boundaries, easements, and rights-of-way.
2. Existing and proposed contours with a 2-foot maximum contour interval, unless the City determines a lesser interval is sufficient to show drainage patterns and basin boundaries.
3. Offsite areas contributing runoff to the site.
4. Natural and manmade drainage features on and adjacent to the site, including existing and proposed stormwater facilities.
5. Existing on-site water wells, areas of potential slope instability, structures, utilities, and septic tanks and drain fields.
6. Location of the 100-year floodplain and floodways and shoreline management area limits on and adjacent to the site.
7. Existing water resource features on and adjacent to the site, including streams, wetlands, springs, and sinks.
8. Existing and proposed drainage flow routes for each Threshold Discharge Area (TDA) to and from the site, including bypass flows.
9. Proposed location of structural source control BMPs implemented in accordance with Minimum Requirement #3 – Source Control of Pollution, Section 4-9 and VMC14.26, where applicable.
10. Point of discharge locations from the proposed project site that preserve the natural drainage patterns and existing outfall locations in accordance with Minimum Requirement #4 – Preservation of Natural Drainage Systems and Outfalls.
11. Areas of the project site where on-site stormwater management BMPs will be effectively implemented, in accordance with Minimum Requirement #5 – On-site Stormwater Management), including low impact development BMPs. The plan must show the areas of retained native vegetation, required flow lengths, and vegetated flow paths for proper implementation of these BMPs.
12. All existing drainage facilities, including structural water quality or flow control BMPs and conveyance systems.
13. Existing and proposed Pollution-Generating Pervious Surfaces (PGPS), including lawn, landscaped areas, and pasture areas.

14. Existing areas of the site predominantly covered by native vegetation (i.e., native trees, shrubs, and herbaceous plants as defined by the Washington State Department of Ecology) and areas of native vegetation to be preserved under proposed conditions.

15. Approximate location and size of proposed runoff treatment and flow control facilities implemented in accordance with Minimum Requirements #6 – Runoff Treatment and #7 – Flow Control, and Sections 4-5 and 4-6.

16. The wetland boundary for sites that discharge stormwater to a wetland, either directly or indirectly through a conveyance system.

17. A conceptual grading plan that verifies the constructability of a stormwater facility.

18. A conceptual erosion prevention and sediment control plan showing proposed measures.

The City may require additional site or vicinity information if needed to determine the feasibility of the stormwater proposal.

Preliminary Stormwater Report

The preliminary Stormwater Report is a comprehensive supplemental report that contains all technical information and analyses necessary to determine that the proposed stormwater facilities are feasible. The required contents of the preliminary Stormwater Report are identified below.

A project that triggers only Minimum Requirements #1 through #5 may elect to submit a "Minor Project Narrative" instead of a full Stormwater Report. This document can be found on the City of Vancouver Surface Water website.

Table of Contents

1. List of section headings and their respective page numbers
2. List of tables with page numbers
3. List of figures with page numbers
4. List of attachments, numbered
5. List of references

Map Submittals

All maps shall contain a scale and north arrow.

1. Vicinity Map: All vicinity maps shall clearly show the project site.

2. Soils Map: The soils map shall show soils within the contributing area that drains to the site itself. Soils maps may be obtained from the following sources:
   a. Updated version of the Soil Survey of Clark County, Washington, originally published in 1972, and updated by the Natural Resources Conservation Service (NRCS)
   b. Geographic information system (GIS) maps of soils from Clark County GIS: http://gis.clark.wa.gov/mapsonline/?site=SoilsWetlands&ext=1

c. Washington soil survey data as available on the NRCS website: http://websoilsurvey.nrcs.usda.gov

If the maps do not appear to accurately represent the soils for the site, the applicant is responsible for verifying the actual soils for the site.

3. Other Maps: The following additional maps shall be required in these situations:

a. Wellhead Protection. If the site lies within a 1900’ radius of a public water supply well it is in a Special Protection Area (SPA). A map showing the site in relationship to the SPA is required.

b. Floodplains. If a floodplain mapped by the Federal Emergency Management Agency (FEMA) exists on or adjacent to the site, a map showing the floodplain is required.

c. Shoreline Management Area. If the site contains or is adjacent to a stream or lake regulated under the Washington Shorelines Management Act, a map showing the boundary of the shoreline management area in relation to the site is required.

d. Historic Prairie Conditions. If the site utilizes historic prairie conditions for the pre-developed condition for flow control, provide a map showing the site in relationship to the pre-settlement prairie delineations.

Wellhead Special Protection Areas - Water Resources Protection Program
http://www.cityofvancouver.us/waterprotection

Flood Maps and Shorelines - Clark County MapsOnLine
http://gis.clark.wa.gov/mapsonline/?site=SoilsWetlands&ext=1

Pre-Settlement Prairie Areas in Vancouver, WA
http://www.cityofvancouver.us/publicworks/page/surface-waterstormwater-design-construction-requirements

Section A – Project Overview

1. Describe the site location.

2. Describe the topography, natural drainage patterns, vegetative ground cover, and presence of critical areas (VMC Chapter 20.740).

3. Identify and discuss existing on-site stormwater systems and their functions.

4. Identify and discuss site parameters that influence stormwater system design.

5. Describe drainage to and from adjacent properties.

6. Describe adjacent areas, including streams, lakes, wetland areas, residential areas, and roads that might be affected by the construction project.

7. Generally describe proposed site construction, size of improvements, and proposed methods of mitigating stormwater runoff quantity and quality impacts.

<u>Section B – Minimum Requirements</u>

A. Describe the land-disturbing activity and document the applicable Minimum Requirements for the project site (See Section 4-1.01 and 4-1.02). Include the following information in table format:

1. The amount of existing impervious surface.
2. The amount of new impervious surface.
3. The amount of replaced impervious surface.
4. The amount of native vegetation converted to lawn or landscaping.
5. The total amount of land-disturbing activity.

B. Provide a statement that confirms the Minimum Requirements that will apply to the development activity. For land-disturbing activities where Minimum Requirements #1 through #9 must be met:

1. Provide the amount of effective impervious area in each Threshold Discharge Area (TDA), and document through an approved continuous runoff simulation model (e.g., the Western Washington Hydrologic Model [WWHM]) the increase in the 100-year flood frequency from pre-developed to developed conditions for each TDA.

2. List the TDAs that must meet the runoff treatment requirements listed in Minimum Requirement #6 and Section 4-6.

3. List the TDAs that must meet the flow control requirements listed in Minimum Requirement #7 and Section 4-5.

4. List the TDAs that must meet the wetlands protection requirements listed in Minimum Requirement #8 and VMC 20.740.

<u>Section C – Preliminary Soils Evaluation</u>

The Preliminary Soils Evaluation shall be prepared by a registered professional engineer or engineering geologist proficient in geotechnical engineering or by a registered soil scientist, and shall address (as a minimum) items 1 through 5 outlined in section 4.2 Infiltration Investigation Report of "A Review of Infiltration Standards and Practices in Clark County"(*SWWASCE Infiltration Standards*) SWWASCE 2009. (See Appendix B)

A preliminary report shall be prepared that outlines the findings of the Preliminary Soils Evaluation, discusses the feasibility of the use of infiltration facilities or LID practices which rely upon infiltration, and provides preliminary recommendations for the design and construction of infiltration facilities. The report shall include relevant portions of the soils map from *NRCS National Soil Survey Handbook* (NRCS 2007), the *Soil Survey Manual* (NRCS 1972) or the NRCS Web Soil Survey, and other geologic maps as appropriate. Deviations from this submittal requirement will need City approval.

<u>Section D – Source Control</u>

1. All development activities shall apply the Minimum Standards of VMC 14.26.120.

2. Industrial zoned sites and industrial activities shall the Applicable Source Control BMPs from Vol. IV of the *Stormwater Manual.*

3. Any development activity that includes operations Classified under VMC 14.26.125 shall implement the appropriate Greater Standards of VMC 14.26.130.

Section E – On-site Stormwater Management BMPs

1. On the preliminary development plan or other maps, show the site areas where on-site stormwater management BMPs will be effectively implemented. (See Vol. III, Ch. 3 and Vol. V, Ch. 5 of the *Stormwater Manual*) The plan must show the areas of retained native vegetation and required flow lengths and vegetated flow paths, as required for proper implementation of each on-site stormwater BMP. Arrows must show the stormwater flow path to each BMP.

2. Identify and describe geotechnical studies or other information used to complete the analysis and design of each on-site stormwater BMP.

3. Identify the criteria (and their sources) used to complete analyses for each on-site stormwater BMP.

4. Describe how design criteria will be met for each proposed on-site stormwater management BMP.

5. Describe any on-site application of LID measures planned for the project. Provide a plan that shows the proposed location and approximate size of each LID facility.

6. Identify and describe any assumptions used to complete the analysis.

7. Describe site suitability, including hydrologic soil groups, slopes, areas of native vegetation, and adequate location of each BMP.

Section F – Runoff Treatment Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement #6, Section 4-1.01 and Section 4-1.02 indicate that runoff treatment facilities are required:

1. Document the level of treatment required (basic, enhanced, phosphorus, oil/water separation) based on procedures in Vol. V, Ch. 2 of the *Stormwater Manual*.

2. Provide background and description to support the selection of the treatment BMPs being proposed.

3. Identify geotechnical or soils studies or other information used to complete the analysis and design.

4. Identify the BMPs used in the design, and their sources.

5. Summarize the results of the runoff treatment design, and describe how the proposed design meets the requirements of Section 4-6 and the *Stormwater Manual*.

6. Provide a table that lists the areas of Pollution-Generating Pervious Surfaces (PGPS) and Pollution-Generating Impervious Surfaces (PGIS) for each Threshold Discharge Area (TDA).

Section G – Flow Control Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement #7, Section 4-1.01 and Section 4-1.02 indicate that flow control facilities are required:

1. Describe the site's suitability for stormwater infiltration for flow control, including tested infiltration rates, logs of soil borings, and other information as available.
2. Identify and describe geotechnical or other studies used to complete the analysis and design.
3. If infiltration cannot be utilized for flow control, provide the following additional information:
    a. Identify the areas where flow control credits can be obtained for dispersion, LID or other measures, per the requirements in the *Stormwater Manual.*
    b. Provide the approximate size and location of flow control facilities for each Threshold Discharge Area (TDA) per Vol. III of the *Stormwater Manual*.
    c. Identify the criteria (and their sources) used to complete the analyses, including historic pre-developed and post-developed land use characteristics.
    d. Complete a hydrologic analysis for historic pre-developed and developed site conditions in accordance with the requirements of Section 4-5 and Ch. 2 in Vol. III of the *Stormwater Manual*, using an approved continuous runoff simulation model. Compute pre-developed and post-development flow durations for all subbasins. Provide an output table from the continuous flow model.
    e. Include and reference all hydrologic computations, equations, graphs, and any other aids necessary to clearly show the methodology and results.
    f. Include all maps, exhibits, graphics, and references used to determine existing and developed site hydrology.
4. Submit electronic copies of the WWHM (.wdm, .prj, .usi) project files upon request.

Section H – Wetlands Protection

For projects where stormwater discharges to a wetland, either directly or indirectly through a conveyance system, describe wetland protection measures to be implemented in accordance with Minimum Requirement #8 and VMC 20.740. This narrative shall describe the measures that will maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

4-2.03 Final Stormwater Site Plan

In accordance with Minimum Requirement #1, the final stormwater site plan provides final engineering design and construction drawings for the stormwater aspects of a proposed new development or redevelopment project. The final stormwater site plan shall be submitted to and approved by the City prior to clearing, grading and/or construction. Approval is only for conformance with VMC 14.24, 14.25, and 14.26.

The City may waive some or all of the content requirements in the final stormwater site plan if:

1. The development project is included in an approved final stormwater site plan that meets the requirements of VMC 14.24, 14.25, and 14.26; or
2. A basin plan exists that makes some of the information irrelevant.

Final Stormwater Site Plan Submittal

The final stormwater site plan shall be submitted to obtain civil plan approval once the final decision has been issued for the land use application. The final stormwater site plan shall also be submitted with streamlined applications.

The final stormwater site plan submittal shall include the following:

1. Any easements, covenants, or agreements necessary to allow construction.
2. Final engineering plans that provide sufficient detail to construct the stormwater facilities. The plans shall show all utilities to ensure that conflicts between utility lines do not exist. These plans shall be stamped, signed and dated by the engineer(s), registered in the State of Washington, responsible for hydrologic, hydraulic, geotechnical, structural and general civil engineering design, and by the project engineer responsible for the preparation of the final stormwater plan.
3. The approved preliminary stormwater site plan, with an explanation of any differences between the design concepts included in the preliminary and final stormwater plans.
4. A final development plan (which may be a part of the final engineering plans or a separate plan). See the requirements identified below.
5. A final stormwater report. See the requirements identified below.
6. A Construction Stormwater Pollution Prevention Plan (SWPPP) or an Erosion Prevention and Sediment Control Plan. See Section 4-8.

Final Development Plan Requirements

The final development plan shall be consistent with the preliminary development plan and may be combined with the final engineering plans. In addition to the information required in the preliminary development plan, the final plan requires the following information:

1. Threshold Discharge Area (TDA) delineations, and total impervious and pervious area delineations and acreages by TDA.
2. The acreage of Pollution-Generating Pervious Surfaces (PGPS) and Pollution-Generating Impervious Surfaces (PGIS) used in the hydraulic-hydrologic calculations both on-site and offsite that contribute surface runoff.
3. Directions and lengths of overland, pipe, and channel flow.
4. Outfall points from each TDA and overflow routes for the 100-year storm.

5. On-site conveyance systems, including pipes, catch basins, channels, ditches, swales, and culverts.

6. Primary flow path arrows for drainage under developed conditions, with the calculated flow rates. Cross-reference the flow rates to the hydrological model output file used to calculate the flow rates.

7. The City may require additional site or vicinity information if needed to determine the feasibility of the stormwater proposal.

Final Stormwater Report Requirements

The final Stormwater Report shall be a comprehensive report, supplemental to the final engineering plans, that contains all technical information and analyses necessary to complete the final engineering plans based on sound engineering practices and appropriate geotechnical, hydrologic, hydraulic, and water quality design.

The final Stormwater Report shall be stamped, signed and dated by the professional engineer(s), registered in the State of Washington, responsible for hydrologic, hydraulic, geotechnical, structural and general civil engineering design.

The required contents of the final Stormwater Report, which is part of the final stormwater site plan, are identified below.

Table of Contents

Same as the preliminary Stormwater Report requirements.

Map Submittals

Same as the preliminary Stormwater Report requirements.

Section A – Project Overview

Provide the information from the preliminary Stormwater Report with the following additional elements:

1. Reference the conceptual design proposed in the preliminary stormwater plan.
2. Identify revisions to the conceptual design contained within the final engineering plans.

Section B – Minimum Requirements

Provide the information from Section B of the preliminary Stormwater Report, revised as necessary for the final design. Confirm the applicable minimum requirements identified in the preliminary Stormwater Report. For land-disturbing activities where Minimum Requirements #1 through #9 must be met, provide the required information listed in Section B of the preliminary Stormwater Report, revised to reflect the final design.

Section C – Final Soils Evaluation

The Final Soils Evaluation shall be prepared by a registered professional engineer or engineering geologist proficient in geotechnical engineering and be conducted in conformance with the recommendations outlined in Section 4-5.05 Infiltration Evaluation of these General Requirements and section 4.1 Field Test Method of *SWWASCE*

Infiltration Standards. A final report shall be prepared in conformance with section 4.2 Infiltration Investigation Report of *SWWASCE Infiltration Standards*.

Section D – Source Control

Same as the preliminary Stormwater Report requirements.

Section E – On-site Stormwater Management BMPs

Provide the information from the preliminary Stormwater Report with the following additional elements:

1. Reference the conceptual design proposed in the preliminary stormwater plan.
2. Identify revisions to the conceptual design contained within the final engineering plans.
3. For bioretention systems, provide the following:
    a. The proposed soil matrix for the facility.
    b. The planting plan, listing proposed plant types and locations.
    c. Detail drawings, including the following:
        i. If an underdrain is used, show drain rock, pipe, and filter fabric specifications.
        ii. All stormwater piping associated with the facility, including catch basin, pipe materials, sizes, slopes, and invert elevations.
        iii. Bioretention width, length, side slopes, and maximum design water depth.
        iv. Irrigation system, if installed.
        v. Designs for any retaining walls proposed. Structural walls shall meet City building permit requirements.
4. For permeable pavements, provide the following:
    a. Supporting design calculations showing adequate infiltration rates to accommodate flows from all impervious surfaces directed onto any permeable pavement.
    b. Geotextile specification.
    c. Base material gradation.
    d. Mix design.
    e. Acceptance test procedures.
    f. Detail drawings, including the following:
        i. Geotextile
        ii. Base material
        iii. Wearing layer
5. For reversed slope sidewalks, show the following:
    a. Details on the vegetated surface receiving water from reversed slope sidewalks.

Section F – Runoff Treatment Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement #6, Section 4-1.01 and Section 4-1.02 indicate that runoff treatment facilities are required, provide the information from the preliminary Stormwater Report with the following additional elements:

1. Reference the conceptual runoff treatment design proposed in the preliminary stormwater site plan.

2. Identify revisions to the conceptual runoff treatment design contained in the preliminary stormwater site plan.

3. Complete a detailed analysis and design of all proposed runoff treatment system elements in accordance with Section 4-6, Vol.V of the *Stormwater Manual* and the Underground Injection Control Program. Reference runoff treatment system elements to labeled points shown on the site location map or final development plan.

4. Include and reference all computations, equations, charts, nomographs, detail drawings, and other tabular or graphic aids used to design water quality system elements in the technical appendix.

5. Summarize the results of the runoff treatment design, and describe how the proposed design meets the requirements of Section 4-6, the *Stormwater Manual* and the UIC Program.

Section G - Flow Control Analysis and Design

For land-disturbing activities where the thresholds within Minimum Requirement #7, Section 4-1.01 and Section 4-1.02 indicate that flow control facilities are required:

1. Identify revisions to the conceptual design proposed in the preliminary stormwater site plan.

2. Identify pre-developed conditions, including stream base flows, water surface elevations, hydraulic or energy grade lines, storage volumes, and other data or assumptions used to complete the analyses of pre-developed conditions. Reference the sources of information.

3. Describe any assumptions used to complete the analyses, including flow credits through the use of on-site stormwater BMPs or LID measures.

4. Complete a detailed hydrologic analysis for pre-developed and developed site conditions, in accordance with the requirements of Section 4-5 and Ch. 2 of Vol. III of the *Stormwater Manual*, using an approved continuous runoff simulation model. Compute pre-developed and developed flow durations for all subbasins. Provide an output table from the continuous flow model, including the following:

   a. A table listing the pass/fail rates for each flow level where duration statistics were calculated.

   b. A graph showing the flow rate on the y axis and percent time exceeding on the x axis for pre-developed conditions and post-developed mitigated conditions, from 50 percent of the 2-year flow rate through the 50-year flow rate.

5. Provide a hydraulic analysis of the outlet control structure including any orifices, weirs, elbows, risers and connected pipes. The structure shall also be

analyzed for backwater conditions if needed. All calculations used to determine stage-storage-discharge tables used in the WWHM shall be included.

6. Submit electronic copies of the WWHM (.wdm, .prj, .usi) project files to allow reviewers to run the model and confirm the model results.

7. Refer to labeled points shown on the site location map and development plan.

8. Include and reference all hydrologic and hydraulic computations, equations, rating curves, stage-storage-discharge tables, graphs, and any other aids necessary to clearly show the methodology and results.

9. Include all maps, exhibits, graphics and references used to determine existing and developed site hydrology.

Flow Control System Plan

1. Provide an illustrative sketch of the flow control facility and its appurtenances.

2. Show basic measurements necessary to confirm storage volumes.

3. Show all orifice, weir and flow restrictor dimensions and elevations.

4. The sketch shall correspond with final engineering plans. Alternatively, a final site grading plan that incorporates the above information may be included as an attachment to the final stormwater plan.

5. Provide electronic copies of the drawings used for analysis, measurement, and design inputs for the hydrologic analysis submitted with the final drawing in one of the following approved file formats: Portable Document Format (.pdf), AutoCAD (.dwg, .dxf).

Section H – Wetlands Protection

Same as the preliminary Stormwater Report requirements.

Section I – Other Permits

Construction of roads and stormwater facilities may require additional permits from other agencies. These permits may contain requirements that affect the design of the stormwater system. Approved permits that are critical to the feasibility of the stormwater facility design shall be included in this section.

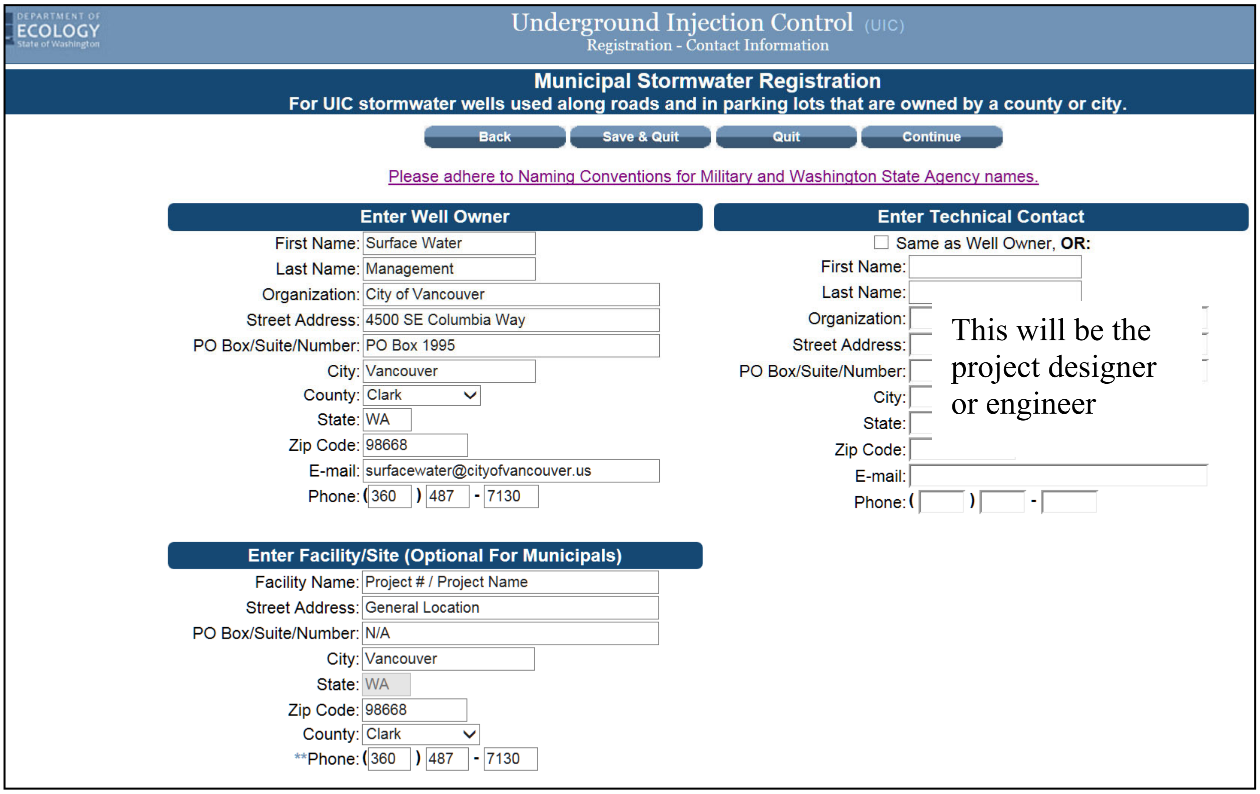
Underground Injection Control (UIC) Regulation (WAC 173-218)

1. Compliance - Provide a narrative demonstrating how the project complies with UIC rules per section I-4 of the *Stormwater Manual*

2. Well Registration - All UIC wells are required to be registered with Washington State Department of Ecology. Proposed *public* UIC wells shall receive Washington State Department of Ecology UIC Program rule authorization *prior* to civil plan approval. Provide a copy of the authorization in the Final Stormwater Report during the plan review process. A copy of the registration application will be accepted if rule authorization notification has not been received from Ecology within 60 days of application for well registration.

Registration forms shall include the following ownership, facility/site information, and NPDES number for proposed *public* UICs.

Ownership, Technical Contact and Project Information:


DEPARTMENT OF ECOLOGY State of Washington

Underground Injection Control (UIC)
Registration - Contact Information

Municipal Stormwater Registration
For UIC stormwater wells used along roads and in parking lots that are owned by a county or city.

Back | Save & Quit | Quit | Continue

Please adhere to Naming Conventions for Military and Washington State Agency names.

Enter Well Owner

First Name: Surface Water
Last Name: Management
Organization: City of Vancouver
Street Address: 4500 SE Columbia Way
PO Box/Suite/Number: PO Box 1995
City: Vancouver
County: Clark
State: WA
Zip Code: 98668
E-mail: surfacewater@cityofvancouver.us
Phone: (360) 487 - 7130

Enter Technical Contact

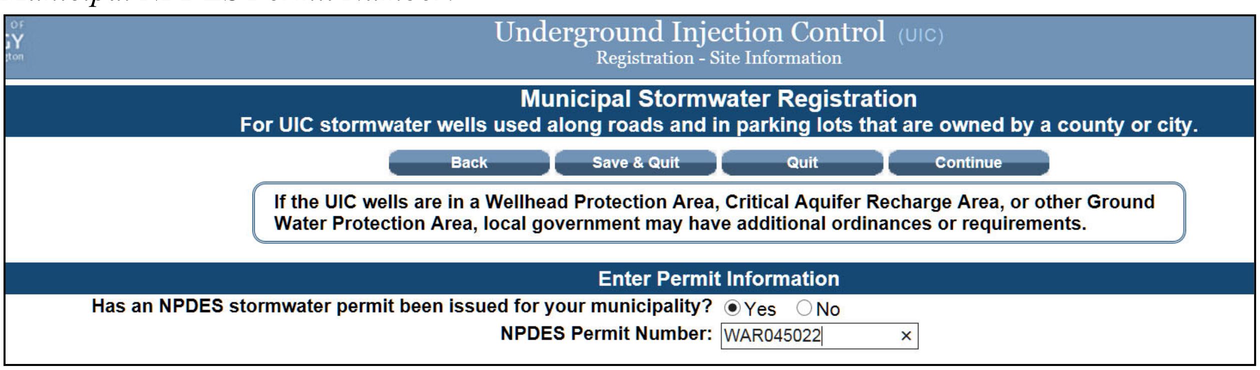
☐ Same as Well Owner, **OR:**
First Name:
Last Name:
Organization:
Street Address:
PO Box/Suite/Number:
City:
State:
Zip Code:
E-mail:
Phone: ( ) -

This will be the project designer or engineer

Enter Facility/Site (Optional For Municipals)

Facility Name: Project # / Project Name
Street Address: General Location
PO Box/Suite/Number: N/A
City: Vancouver
State: WA
Zip Code: 98668
County: Clark
**Phone: (360) 487 - 7130

Municipal NPDES Permit Number:


Underground Injection Control (UIC)
Registration - Site Information

Municipal Stormwater Registration
For UIC stormwater wells used along roads and in parking lots that are owned by a county or city.

Back | Save & Quit | Quit | Continue

If the UIC wells are in a Wellhead Protection Area, Critical Aquifer Recharge Area, or other Ground Water Protection Area, local government may have additional ordinances or requirements.

Enter Permit Information

Has an NPDES stormwater permit been issued for your municipality? ◉ Yes ○ No
NPDES Permit Number: WAR045022

<u>Section J – Conveyance Systems Analysis and Design</u>

1. Reference the conceptual drainage design proposed in the preliminary stormwater site plan.
2. Identify revisions to the conceptual drainage design contained in the preliminary stormwater site plan.
3. Identify the criteria used to complete the analyses and their sources.

4. Identify and discuss initial conditions, including stream base flows, beginning water surface elevations, hydraulic or energy grade lines, beginning storage elevations, and other data or assumptions used to complete the analyses of initial conditions. Reference the sources of information.

5. Describe any assumptions used to complete the analyses.

6. Complete a detailed hydraulic analysis of all proposed collection and conveyance system elements and existing collection and conveyance elements, including outfall structures and outlet protection, which influence the design or are affected by the proposal. Compute and tabulate the following:

    a. Identify design flows and velocities and conveyance element capacities for all conveyance elements within the development.

    b. Identify the 10-year recurrence interval stage for detention facility outfalls. Provide stage-frequency documentation from WWHM.

    c. Compute existing 100-year floodplain elevations and lateral limits for all channels, and verify no net loss of conveyance or storage capacity from development.

    d. Reference conveyance system elements to labeled points shown on the site location map or development plan.

    e. Verify the capacity of each conveyance system element to convey design flow and discharge at non-erosive velocities. Verify the capacity of the on-site conveyance system to convey design flows that result from ultimate build-out of upstream areas.

    f. Include and reference all hydraulic computations, equations, pipe flow tables, flow profile computations, charts, nomographs, detail drawings, and other tabular or graphic aids used to design and confirm the performance of conveyance systems.

    g. Summarize the results of system analyses, and describe how the proposed design meets the requirements.

<u>Section K – Special Reports and Studies</u>

Where site-specific characteristics (such as steep slopes, wetlands, and sites located in wellhead protection areas) present difficult drainage and water quality design problems, the City may require additional information or the preparation of special reports and studies that further address the specific site characteristics, the potential for impacts associated with the development, and the measures that would be implemented to mitigate impacts. Special reports shall be prepared by professionals with expertise in the particular area of analysis, who shall date, sign, stamp, and otherwise certify the report. Subjects of special reports may include but are not limited to:

1. Geotechnical
2. Wetlands
3. Floodplains and floodways
4. Groundwater
5. Structural design
6. Fluvial geomorphology (erosion and deposition)

All special reports and studies shall be included in the technical appendix.

Section L – Operations and Maintenance Manual

The project engineer shall prepare a site-specific operations and maintenance manual for each stormwater control and/or treatment facility to be privately maintained and for those that constitute an experimental system to be maintained by the City following Vol. V Ch. 4 of the *Stormwater Manual* or specified by the City. The manual objective is to provide long-term guidance for each stormwater facility to preserve engineering function and performance. The manual shall adequately relay information to site owners or those actually providing maintenance to implement effective maintenance programs and identify system components.

The manual (included as a technical appendix) shall be written in an orderly and concise format that clearly describes the design and operation of the facility. The manual shall also provide an outline of required maintenance tasks, with recommended frequencies at which each task should be performed. The manual shall contain or reference procedures from the *Stormwater Manual*.

The manual shall include the following information.

1. Narrative for operations and management of the site including description of stormwater system and receiving waters if runoff leaves the site.
2. Itemized list of stormwater facilities and components found on site (e.g. quantity of catch basins, pipe, treatment vaults, ponds, etc)
3. Project specific site map including access for maintenance and location of stormwater facilities including native soil and vegetation protection areas.
4. Specify the ownership of the proposed facilities and clearly indicate long-term maintenance responsibility
5. Outline maintenance funding mechanism guidelines such as 10-15% of capital construction cost is average for routine maintenance including higher costs during plant establishment and media filter replacements. Best practices like street sweeping and catch basin cleaning improve system performance and lower maintenance costs. Indicate life expectancy of facility and estimated costs for eventual replacement.
6. Facility inspection checklists for the specific types of facilities for the site.
7. Special instructions or attachments will be included for emerging technologies not in the *Stormwater Manual* such as proprietary media filters or experimental technologies on public projects.
8. Designate areas for stormwater flow dispersion delineated on site map and locations of easements or separate tracts.
9. Include inspection and maintenance log forms including dates, facility components inspected or maintained as well as proprietary system inspection reports and disposal of waste must be included.
10. Disposal of sediments from stormwater facilities considering activities and pollutants onsite must be included. Facilities in areas used for chemical or hazardous material storage, material handling or equipment maintenance may collect chemicals used in these activities or material from spills and stormwater runoff. Outline indicators (odor, sheen, discoloration) for testing or specialty contractor assessment.

<u>Technical Appendix</u>

All Stormwater Reports shall contain ~~a~~ technical appendices that include~~s~~ all computations completed in the preparation of the Stormwater Report, together with copies of referenced data, charts, graphs, nomographs, hydrographs, stage-storage discharge tables, maps, exhibits, and all other information required to clearly describe the stormwater flow control and runoff treatment design for the proposed development activity. The Operations and Maintenance Manual for private stormwater facilities shall be included in the appendix. The format of the technical appendix shall follow as closely as possible the section format of the Stormwater Report and shall be adequately cross-referenced to ensure that the design may be easily followed, checked and verified. The technical appendix shall also contain all special reports and studies, other than those included as attachments to the Stormwater Report.

Stormwater Site Plan Changes

If the designer must make changes or revisions to the final stormwater plan after final approval, the proposed revisions shall be submitted to the City of Vancouver prior to construction. The submittals shall include the following:

1. Substitute pages for the originally approved final stormwater site plan identifying the proposed changes.
2. Revised drawings, showing any structural changes.
3. Any other supporting information that explains and supports the reason for the change. All revisions shall be stamped, signed and dated by the professional engineer(s), registered in the State of Washington, responsible for hydrologic, hydraulic, geotechnical, structural and general civil engineering design.

4-2.04 Erosion Prevention and Sediment Control Plan Submittal – For project sites below the regulatory threshold

An Erosion Prevention & Sediment Control Plan (EPSCP) is required for any land disturbing activity unless the site is required to prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) as determined by Appendix 1, Section 3 of the most current version of the City's National Pollutant Discharge Elimination System Western Washington Phase II Municipal Stormwater Permit

The plan shall be submitted to and approved by the City prior to demolition, street cuts, clearing, grading, filling or issuance of City permits. Items that are to be included in an EPSCP:

1. Existing and proposed contours for the site and adjacent properties
2. Location of all existing drainage facilities and water resource features
3. Identification of all sensitive lands including wetlands and steep slopes
4. Volumes of cuts and fills
5. Proposed erosion prevention and sediment control BMPs

4-2.05 Site Development/Grading Permit Requirements

Civil plans requesting approval for grading only may be considered for approval based upon the determination of the City's review staff, including the Case Manager, Engineering, Transportation and Building. Grading only civil plans require signature approval from Transportation, Building, Planning, and Surface Water Management. Review and approval by Surface Water Management will only address erosion prevention and sediment control.

No stormwater facilities will be approved with grading only plans. Therefore, not all stormwater facilities need to be shown on the grading only plans. If the plans include a pond or swale the following statement will be placed on the cover and grading sheet of the plans:

> *"This approval is for grading only. No stormwater facilities or drainage structures are approved at this time. Grading of a swale or pond is subject to change with final civil plan approval."*

4-2.06 Easements

Public stormwater facilities that are not located in the public right-of-way shall be in an easement or tract dedicated to the City of Vancouver. The easement shall allow unobstructed access for maintenance by City staff. Buildings, structures and fences are not permitted within public easements. Fences crossing an easement shall provide gates for access by maintenance vehicles.

Public stormwater facilities requiring easements across or on private property include, but are not limited to, storm drain pipes, culverts, ditches, manholes, drywells, infiltration devices, and catch basins. Swales, ponds, and/or water quality and/or quantity structures (vaults) shall be located on a separate parcel or tract dedicated to the City of Vancouver.

Stormwater facilities shall be located next to the public right-of-way where practicable. Easements shall be required from the facility to a public right-of-way for access to facilities by standard maintenance equipment and/or vehicles. Easements may also be required from the facility to the public right-of-way for future connections to the facility.

Public easements shall be a minimum of 15 feet in width. Pipe diameters greater than 36 inches will require an easement width of at least 20 feet. Pipes shall be located at least five (5) feet from the edge of the easement.

Easements shall be provided to the City for access and maintenance of all streams and channels within a development site. Easements shall be a minimum of top width plus 15 feet on one side. Deviations from this requirement will need City approval.

Private stormwater facilities shall have an access and inspection easement dedicated to the City of Vancouver in the form of a "covenant running with the land." Access and inspection easements shall be a minimum width of 15 feet and extend to an accessible public right-of-way. A covenant encompassing the entire site is also acceptable with City approval. The easement is intended to allow access for inspection and verification of maintenance frequency and practices. Private stormwater facilities requiring access and inspection easements include, but are not limited to, storm drain pipes, culverts, ditches, manholes, drywells, infiltration devices, catch basins, swales, ponds, permeable pavements, bioretention facilities, rain gardens, and runoff treatment and flow control facilities.

All existing and proposed stormwater easements shall be shown, noted and specified on civil plans, site plans and plats. All easements and dedications shall be provided to the City prior to final acceptance of the project. Easements shall be of standard form and include a legal description and map. Information regarding easements can be obtained from Community and Economic Development Department located at 415 W. 6th Street (360- 487-7800).

Refer to the Sewer Design section within this manual for specific requirements regarding locating bioretention facilities, biofiltration swales and other surface water facilities within sanitary sewer easements.

Approved language for CIVIL PLANS, SITE PLANS and PLATS:

1. A covenant encompassing the entire site will be dedicated to the City of Vancouver for access and inspection of private storm systems. (Replaces the “Blanket Easement” term.)
2. A (insert Size of Easement) access and inspection easement will be dedicated to the City of Vancouver.
3. An access and inspection easement for the private storm facility will be dedicated to the City of Vancouver. (Use when a private storm facility is on private property.)
4. A (insert Size of Easement) private storm easement (clarify who owns it and who is responsible for it). Example: A 15’ private storm easement dedicated to Lots 1-9 will be owned and maintained by each homeowner.
5. A (insert Size of Easement) public storm easement will be dedicated to the City of Vancouver. (Use when public storm is on private property.)

4-2.07 Railroad Crossings and Other Jurisdictions

The developer shall obtain and make full payment for any permits required from the Washington Department of Transportation, Clark County, or railroad prior to City approval for constructing storm sewer under any highway, railroad track or within another jurisdiction’s right-of-way. The permit should be on behalf of the City of Vancouver. All requirements of the permit shall be met prior to acceptance of any construction. Requirements usually include boring with a steel casing for installation of the storm sewer.

4-3 STORM SEWER SYSTEMS

4-3.01 Public and Private Systems and Facilities

Stormwater systems and facilities which collect, convey, treat and/or infiltrate runoff from public rights-of-way will be publicly owned and maintained, unless it is demonstrated to the satisfaction of the City that the stormwater facility can be adequately maintained by private parties.

Minimum criteria for a private facility accepting runoff from public rights-of-way include but are not limited to the following:

1. The facility is a pond or swale
2. The facility is contained within an exclusive separate tract or parcel
3. An access and inspection easement is dedicated to the City

4. A single party or group, such as a homeowners association, owns and is responsible for the maintenance of the facility

For single family residential developments (specifically high density), on-site shared lot and roof drainage systems must be designed and incorporated into the civil plans for approval.

Private stormwater systems may not be designed to flow into adjacent parcels. Discharge to public right-of-way will only be allowed on a case-by-case basis upon approval from the City.

4-3.02 Location of Stormwater Facilities

Typical location of storm drain lines in the public right-of-way is three (3) feet north or east of center line. Deviations from this standard need approval by the City.

Detention structures such as pipes, vaults and ponds are not allowed within the public right-of-way. These facilities shall be located in a tract dedicated to the City of Vancouver. Private stormwater facilities shall be located next to the public right-of-way where practicable. Approval from Water and/or Sewer Engineering is required for detention facilities that are proposed to be within ten (10) feet of public water and/or sanitary sewer mains.

4-3.03 Capacity and Conveyance

The flow capacity of a storm sewer main is calculated from Manning's formula for open channel flow. See the sanitary sewer design section for the equation. A roughness coefficient of n=0.012 for storm sewer design is acceptable when using flexible pipe. For other pipe types (i.e. concrete, ductile iron) a roughness coefficient of n=0.013 is required for capacity calculations.

Table D-1: Storm Sewer Pipe Capacity and Minimum Slopes

Inside Pipe Diameter (inches)	Minimum Pipe Slope (n=0.012)		Design Capacity	Minimum Pipe Slope (n=0.013)		Design Capacity
	Design	As-Built	n=0.012 (cfs)	Design	As-Built	n=0.013 (cfs)
8	0.0034	0.0029	0.70	0.0039	0.0034	0.70
10	0.0027	0.0022	1.11	0.0030	0.0025	1.10
12	0.0022	0.0017	1.59	0.0025	0.0020	1.59
15	0.0018	0.0013	2.52	0.0020	0.0015	2.50
18	0.0015	0.0010	3.60	0.0017	0.0012	3.64
24	0.0010	0.0007	6.48	0.0011	0.0008	6.40
30	0.0008	0.0005	9.94	0.00088	0.00058	9.88
36	0.0006	0.0004	14.45	0.00065	0.00045	14.15
42	0.0005	0.00035	20.39	0.0005	0.00037	19.35
48	0.0004	0.00026	25.09	0.00045	0.00031	25.29

The Santa Barbara Urban Hydrograph (SBUH) method shall be used to determine peak flow rates for sizing conveyance systems. The peak runoff rate from the design storms to be used for design of stormwater conveyance systems shall be as follows:

1. The 10-year, 24-hour storm: Contributing drainage areas less than 40 acres.
2. The 25-year, 24-hour storm: Contributing drainage areas of 40 acres or more.
3. The 100-year, 24-hour storm:
    a. Culverts with contributing drainage areas greater than 200 acres.
    b. Culverts in areas of flood hazard, as described in FEMA Flood Insurance Rate Maps (FIRM) and reports prepared for the City of Vancouver.

The design storm shall be applied to the entire contributing drainage area projected under full build-out conditions.

Culverts shall be designed in accordance with the "Washington State Department of Transportation Hydraulics Manual" (WSDOT 2013).

Fish passage culverts shall meet the design criteria specified in the "Washington State Department of Fish and Wildlife Fish Passage Design at Road Culverts" (WDFW 2003).

For sites that discharge to a Flow Control-Exempt Surface Water (see Appendix I-E of the *Stormwater Manual*) via a closed channel conveyance, the engineer shall demonstrate that sufficient downstream conveyance capacity exists to accommodate the increased flows from the project. Hydrologic and hydraulic analysis is required when sufficient capacity has not been established.

4-3.04 Pipe Slope

Engineers shall design systems using the minimum design slope in most cases. Minimum as-built slopes are based on slopes required to produce a mean velocity (when flowing full or half full) of at least two (2) feet per second (fps), based upon Manning's "n" valued at not less than 0.012.

The differences between design slopes and as-built slopes represent an allowable tolerance of 0.0005 on pipe diameters of 18 inches or less. Mains installed at a flatter slope than the as-built minimum shall be re-laid by the contractor.

Laterals to inlets and catch basins shall have a minimum slope of 0.02. If shallow storm mains require flatter slopes on laterals, then invert elevations and pipe slopes shall be listed on the stormwater plan and pipe flow capacity calculations shall be included in the Stormwater Report.

4-3.05 Pipe Materials

The following table lists approved pipe materials and their specifications for public storm sewers.

Table D-2: Type of Pipe Material and Specifications

Approved Type of Pipe	Specifications
Corrugated Polyethylene (CPE)	AASHTO M252 or M294 Type S
Concrete Pipe (CP)	C14 Class II or III

Reinforced Concrete Pipe (RCP)	ASTM C76 Class IV or V
Ductile Iron Pipe (DIP)	ANSI A21.51 or AWWA C151
Polyvinyl Chloride (PVC)	AWWA C900, AWWAC905

Notes:
1. CP and RCP are considered rigid pipe. See rigid pipe bedding details.
2. CPE and DIP are considered flexible pipe. See flexible pipe bedding details.
3. Transitions in pipe sizes are only allowed at structures.
4. DIP and PVC only allowed when pipe cover is less than 4-feet.

4-3.06 Pipe Diameter

Public mainline storm sewers shall be a minimum of twelve (12) inches inside diameter. Downstream pipe diameters shall not be reduced except when approved by the City.

Public storm sewer laterals shall be eight (8) or ten (10) inches inside diameter. Larger pipe diameter may be used with large capacity catch basins and when approved by the City.

4-3.07 Pipe Construction Standards

All pipe materials, joints, manholes, and other products associated with conveyance systems shall be designed and constructed in accordance with the latest edition of the Washington State Department of Transportation Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT).

Water settling of backfill material is prohibited.

The Contractor shall provide a television report, tape and tabular as-built of all public storm mains and laterals prior to paving. This TV information shall be submitted to the City Inspector for review. TV inspection shall demonstrate no manufacturing or installation defects, or any debris in the lines, for approval and acceptance by the City.

4-3.08 Depth and Cover

Public storm sewer main lines (including perforated main in infiltration trenches) laid in areas subject to wheel loads shall have a minimum cover of four (4) feet measured from top of pipe to finished grade or be otherwise protected from damage by traffic. This minimum cover may be reduced to three (3) feet if ductile iron or C900 PVC pipe is used.

In addition, if the storm sewer main is in a roadway, right of way or other paved area, the ductile iron pipe must be deep enough so that any installed, or future, laterals will have a minimum clearance between the top of the lateral and the bottom of the roadway section of at least six (6) inches.

4-3.09 Separation

Storm sewers will be designed to provide six (6) inches minimum vertical and three (3) feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits. For crossings of sanitary sewers lines, Washington State Department of Ecology criteria applies.

4-3.10 Manholes

Public manholes are required at the following locations:

1. At every change in grade or alignment of sewer
2. At every point of change in size of sewer or pipe material
3. At each intersection or junction of sewer
4. At intervals of 400 feet or less in developed areas, unless otherwise approved by the City
5. At the end of a main or infiltration pipe system, unless another structure is approved by the City

Manhole spacing may be increased to 600 feet for sewers in excess of 36 inches diameter, subject to approval by the City. Whenever feasible, permanent vehicular access shall be provided to manholes located in easements.

Manholes outside of public right-of-way shall have locking frame and covers (i.e. Camlock). This requirement may be waived for manholes located in paved easements or fenced in areas.

The key consideration in designing and constructing a manhole is to provide safe, convenient access for observations and maintenance.

1. The minimum required inside diameter for a manhole is 48 inches. Manholes built over large diameter pipes, those greater than 24 inches, require a special construction detail.
2. For construction of the mainline, provide a 0.2 foot minimum and 0.4 foot maximum drop in flow line elevation through manholes. Where grade considerations are considered critical, the design engineer may request a waiver. In such cases, the drop may be reduced to 0.1 foot for straight through manholes or to no drop if the pipe is laid through the manhole.

4-4 DRAINAGE OF ROADWAY IMPERVIOUS PAVEMENTS

Drainage design for roadways shall be in accordance with "Hydraulic Engineering Circular No. 22, Urban Drainage Design Manual" (FHWA and NHI 2001). The Santa Barbara Urban Hydrograph (SBUH) method shall be used to determine peak flow rates for sizing collection systems (catch basins and inlets).

Roadway drainage shall not exceed the capacity of the inlet or produce a flow depth of greater than 0.12 feet at the edge of the travel lane for the ten-year storm. The travel lane shall remain open to emergency vehicles and the flow depth of any storm event, up to the one hundred-year storm event, will not exceed 0.5 feet. Flooding in parking lots shall not exceed 1.0 feet.

4-4.01 Catch Basin Locations

Catch basins and inlets are required at the following locations:

1. At any low point in the roadway or curb returns at intersections.

2. Where any roadway transitions from a crown section to a shed section to prevent gutter flow from flowing across the roadway.

3. Such that a maximum of 400 linear feet of paved street is collected by a single catch basin.

4. Inlets shall be used at intersections to prevent street cross flow which could cause pedestrian or vehicular hazards. It is desirable to intercept 100 percent of any potential street cross flow under these conditions. Intersection inlets should be placed on tangent curb sections near corners. Catch basins and inlets shall be placed so that water will not accumulate on walking surfaces per ADA guidelines.

5. In sag vertical curves, where significant ponding may occur, flanking inlets should be placed so that they will limit spread on low gradient approaches to the level point. The flanking inlets are intended to provide relief if the inlet at the low point becomes clogged or if the design spread is exceeded.

6. Grate inlets alone are not recommended for use in sag locations because of the tendency of grates to become clogged. Combination inlets or curb opening inlets are recommended for use in these locations.

7. Combination curb inlets are required on slopes greater than 10 percent or when necessary to prevent bypass flow from crossing an ADA ramp, an intersection or a crown to shed section transition. Curb ramps and their approaches shall be designed so that water will not accumulate on walking surfaces per ADA guidelines.

8. Catch basins should not be placed in areas of expected pedestrian traffic. The engineer should design the roadway low points to avoid placing a catch basin in crosswalks, adjacent to curb ramps, or in the gutter of a driveway. Care should be taken on the part of the engineer to assure that the catch basin will not be in conflict with any existing or proposed utilities.

4-4.02 Catch Basin Construction Standards

All pipe materials, joints, manholes, and other products associated with conveyance systems shall be designed and constructed in accordance with the latest edition of the "Washington State Department of Transportation Standard Specifications for Road, Bridge, and Municipal Construction" (WSDOT).

All catch basins and inlets (city standard or proprietary) specified for city owned public roadways, shall be concrete and must be H-20 loading traffic rated.

Public catch basin laterals shall be connected to a manhole or other accessible structure. Catch basin laterals shall not be connected to the storm main by tee or wye, unless specifically approved by the City. All connections to catch basins shall be water tight.

Catch basin laterals shall be constructed to connect to the basin perpendicular to the basin wall. The lateral shall connect only at the front or side of the basin with no laterals allowed to connect to the catch basin at the corners. If needed, a bend may be used as the first section of pipe outside the basin wall. The maximum bend allowed is 45 degrees.

4-4.03 Catch Basin Traps

Catch basin traps shall be installed on each outlet pipe from any catch basin or curb inlet as shown in Detail D-1.8. The elbow section shall be removable using a bell and spigot joint.

4-5 FLOW CONTROL AND INFILTRATION SYSTEMS

4-5.01 Applicability

Projects must provide flow control to reduce the impacts of stormwater runoff from impervious surfaces and land cover conversions per the applicability thresholds in Section 4-1. That portion of any development project in which the thresholds are not exceeded in a Threshold Discharge Area shall apply On-site Stormwater Management BMPs in accordance with Minimum Requirement #5.

4-5.02 Flow Control

Refer to Vol. I, Ch. 2.5.7 of the *Stormwater Manual* to fulfill Minimum Requirement #7. Flow control facilities shall use Vol. III of the *Stormwater Manual* for design requirements.

The Western Washington Hydrology Model (WWHM) is currently the only continuous simulation hydrologic models approved for use by the City of Vancouver.

4-5.04 Retrofit of Existing Flow Control Facilities

The Western Washington Hydrology Model (WWHM) procedure may be used for a new project site where flow control requirements are to be met using a pond that was originally designed using a peak flow standard and single event methodology. The original flow control release rates for the existing pond are to be added to the flow control targets for the new project. If the existing detention facility is not sized sufficiently for the new flow targets, the pond size will need to be revised.

4-5.05 Infiltration Systems

Stormwater infiltration systems can be used for flow control and runoff treatment where appropriate. Infiltration facilities for flow control are used to convey stormwater runoff into the ground after appropriate treatment. Infiltration facilities for treatment purposes rely on the soil profile to provide treatment.

The following sections describe applicable regulations, soil testing requirements, and general design methodology for new infiltration facilities in Vancouver. Refer to the *Stormwater Manual* and the latest edition of Ecology's “Guidance for UIC Wells that Manage Stormwater” for additional information and requirements for infiltration facilities.

4-5.06 Other Applicable Regulations

Washington State Department of Ecology Underground Injection Control Program
Some infiltration facilities are classified as Underground Injection Control (UIC) wells. UIC wells include drywells and perforated pipes and are regulated under Department of Ecology’s UIC Program (WAC 173-218).

The two basic requirements of the UIC Program are registration of new UIC wells with the Washington State Department of Ecology and protection of groundwater from pollution associated with stormwater runoff.

1. Registration: UIC wells are required to be registered with Washington State Department of Ecology. Registration information can be found on Ecology's website: http://www.ecy.wa.gov/programs/wq/grndwtr/uic/registration/reginfo.html

2. Non-endangerment Standard: New UIC wells are required to meet a non-endangerment standard ensuring discharges from a UIC well will not contaminate groundwater. Department of Ecology's guidelines for meeting this standard are found in "Guidance for UIC Wells that Manage Stormwater". This guidance shall be followed for UIC installation. The guidance has requirements for minimum depth to groundwater (five feet), as well as siting and installation requirements. It also lists activities that are prohibited from using UIC wells. http://www.ecy.wa.gov/pubs/0510067.pdf

Proposed public UIC wells shall receive Washington State Department of Ecology UIC Program rule authorization prior to civil plan approval. Provide a copy of the rule authorization during the plan review process. A copy of the registration application will be accepted if rule authorization notification has not been received from Ecology within 60 days of application for well registration.

Private UIC wells are also required to meet WAC 173-218 and register with Ecology prior to construction. In some cases, prior to civil plan approval, the City may require verification of Ecology's authorization of a proposed private infiltration facility or a demonstration by the applicant that the UIC facility will meet Ecology's water quality standards.

When UIC regulations conflict with City of Vancouver requirements, the more stringent of the regulations shall apply.

Special Protection Areas - Vancouver Municipal Code 14.26 (VMC 14.26)
The City's Water Resources Protection Ordinance specifies that infiltration facilities for Class I and Class II commercial/industrial operations (as defined in VMC 14.26) are not allowed in Special Protection Areas (SPAs). The applicant may petition for relief from this requirement provided no other alternative exists and groundwater protection can be ensured.

If a non-classified commercial or residential facility proposes to infiltrate in an SPA, the City will evaluate proximity and potential impact to the water station and may then require additional stormwater treatment measures. Examples of more stringent water quality measures in an SPA could include a cartridge media filter system, low impact development, a biofiltration swale, or a sand filter.

4-5.07 Infiltration Investigation

Proper evaluation of soils is critical to the placement and design of infiltration facilities. A detailed soils report is required where infiltration systems, or LID practices that utilize infiltration, are proposed to accurately characterize the infiltration rate of the soil and the depth to ground water.

The "Alternative Single-Ring Falling Head Infiltration Test" outlined in 4.1.4 Field Test Method of *SWWASCE Infiltration Standards* is the preferred method for determining infiltration rates in Vancouver. The coefficient of permeability "*k"* shall be calculated using test results per Darcy's Law. Other acceptable test methods include:

- The Pilot Infiltration Test (PIT) outlined in Vol. III, Ch. 3 of the *Stormwater Manual*. The Small-Scale test may be used for sites the meet the criteria for the test.
- The USDA Soil Textural Classification and the ASTM Gradation Testing correlations provided in Ch. 3 of Vol. III of the *Stormwater Manual.* In general these correlations provide conservative long-term infiltration rates, however, the presence of cemented, lithified, or indurated materials may make the use of these correlations unconservative. Therefore, these correlations should only be used if a registered professional engineer or engineering geologist proficient in geotechnical engineering has evaluated the site soils and deemed these correlations appropriate for the site.
- The "Alternative Auger Borehole Falling-Head Infiltration Test Method" outlined in 4.1.6 Alternative Test Methods of *SWWASCE Infiltration Standards* may be used where explorations are conducted by advancing borings, as opposed to test pits. The coefficient of permeability "*k"* shall be calculated when using this method.
- Field test methods, such as the open test pit method discussed in 4.1.6 Specialized Testing for Unique Sites of *SWWASCE Infiltration Standards,* may be used only if the other test methods described above are not feasible or practical.

Regardless of the test methodology utilized, the Infiltration Investigation shall follow the guidelines outlined in 4.1 Field Test Method of *SWWASCE Infiltration Standards* regarding frequency, location, and depth of testing; soil classification and testing; high groundwater characterization; and groundwater mounding analysis.

The City may require additional testing, monitoring or groundwater mounding analysis in areas of known high groundwater or poor infiltration rates.

A final report shall be prepared in conformance with section 4.2 Infiltration Investigation Report of *SWWASCE Infiltration Standards.*

Projects triggering only Minimum Requirements #1 through #5 may have one of the following prepare a soils report to determine if soils suitable for infiltration are present on the site:

- A professional soil scientist certified by the Soil Science Society of America (or an equivalent national program)
- A locally licensed on-site sewage designer
- A suitably trained person working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

Projects triggering Minimum Requirements #1 through #9 must have one of the following prepare a soils report to determine if soils suitable for infiltration are present on the site:

- A licensed geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

4-5.08 Infiltration Design Rates

The design infiltration rate shall be determined by dividing the calculated coefficient of permeability or tested infiltration rate (depending on the testing method) by the appropriate correction factor.

The following table (Table D-3) shall be used to determine the total correction factors to obtain design infiltration rates for infiltration facilities. The maximum allowed design infiltration rate is 250 inches/hour.

Table D-3: Infiltration Rate Correction Factors

Design Condition	Correction Factor (CF)
Base Correction Factor	
The base correction factor is meant to account for soil variability and long-term system degradation due to siltation, crusting, or other factors.	2
Soils Correction Factor	
Additive correction factor recommended by a geotechnical professional as a result of soil or groundwater conditions	As recommended by geotechnical professional
System Design Correction Factors	
If the infiltration facility serves a basin with an impervious area greater than 2 acres and less than 5 acres	Add ½
If the infiltration facility serves a basin with an impervious area greater than 5 acres	Add 1
Infiltration facilities in closed depressions	Add 2
If a sacrificial system is provided and left operational following permanent site stabilization	Subtract ½

Total CF = Base CF + Soils CF + System Design CF

When using WWHM, the Infiltration Reduction Factor is 1/CF.

4-5.09 Infiltration Design Guidelines

UIC's shall be modeled with WWHM, meet the applicable Flow Control requirements and achieve the LID performance standard. An overflow route must be identified in the event that capacity is exceeded.

Infiltration calculations for drywells and perforated pipe trench systems shall follow the recommendations outlined in 5.3 of Infiltration Calculations for Selected Facilities of *SWWASCE Infiltration Standards.*

Public infiltration trenches shall have structures for access and maintenance on both ends of infiltration piping systems, with a minimum of either a drywell or manhole on one pipe end.

4-5.10 Infiltration Facility Setbacks

The base of infiltration facilities shall be a minimum of five (5) feet above seasonal high water or an impermeable layer and meet Washington State Department of Ecology Underground Injection Control Rules water quality standards. A separation down to three (3) feet may be considered if the groundwater mounding analysis, the volumetric water holding capacity, and the design of an overflow and/or bypass structure is adequate to prevent overtopping and meet the site suitability criteria specified in the *Stormwater Manual.*

Infiltration facilities shall be set back a minimum of:

1. 50 feet from the top of any slope greater than 15 percent
2. 20 feet down slope or 100 feet up slope from a building foundation
3. 10 feet from neighboring property line
4. 100 feet from a septic drain field
5. 1,900 feet from a municipal water station (unless prior approval is obtained from the City)

Written justification from an appropriate qualified professional shall be submitted to and approved by the City to reduce these setbacks. Setback reductions shall also meet other applicable local, state and federal requirements.

Refer to the *Stormwater Manual* and the local building code for residential roof downspout systems.

Where infiltration facilities are proposed within 25 feet of the property line, additional topography will be required to be shown on plans outside of the project site.

4-5.11 Construction Observation and Confirmation Testing

A registered professional engineer, engineering geologist proficient in geotechnical engineering, or a designated representative working under their direct supervision, shall observe the construction of the infiltration facility and conduct confirmation infiltration testing on soils exposed at the base of the facility. The purpose of the confirmation infiltration testing is to verify that the infiltration rate and exposed soil conditions are consistent with the assumptions, recommendations, and conclusions presented in the Final Soils Evaluation report. Confirmation testing shall take place prior to installation of the facility (e.g. placement of drain rock, perforated pipe, drywells, etc.) and shall be conducted in accordance with the recommendations outlined in 6.2 Construction Observation and Testing of *SWWASCE Infiltration Standards*.

4-6 RUNOFF TREATMENT

4-6.01 Treatment Facility Sizing

Water Quality Design Storm Volume: The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Vol. III, Ch. 2 of the *Stormwater Manual* for the 6-month, 24- hour storm. Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model may be used.

Flows Requiring Treatment

Runoff from Pollution Generating Impervious Surfaces (PGIS) or Pollution Generating Pervious Surfaces (PGPS) shall be treated per the applicability thresholds in Section 4-1. That portion of any development project in which the above PGIS or PGPS thresholds are not exceeded in a threshold discharge area shall apply On-site Stormwater Management BMPs in accordance with Minimum Requirement #5.

Pollution Generating Impervious Surfaces (PGIS) are impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use; industrial activities (as further defined in the *Stormwater Manual*); or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Erodible or leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage. Metal roofs are also considered to be PGIS unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating).

A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways.

The following are not considered regularly-used surfaces: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, and infrequently used maintenance access roads.

Pollution-Generating Pervious Surfaces (PGPS) are any non-impervious surface subject to vehicular use, industrial activities or storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall, the use of pesticides and fertilizers or loss of soil. Typical PGPS include permeable pavements subject to vehicular use, lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Water Quality Design Flow Rate

1. <u>Preceding Detention Facilities or when Detention Facilities are not required:</u>
The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, shall 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).

2. <u>Downstream of Detention Facilities:</u>
The water quality design flow rate shall be the full 2-year release rate from the detention facility.

3. Alternative methods may be used if they identify volumes and flow rates that are at least equivalent.

Treatment Facility Selection, Design, and Maintenance
Stormwater treatment facilities shall be:

1. Selected in accordance with the process identified in Vol. I, Ch. 4 of the *Stormwater Manual*,
2. Designed in accordance with the design criteria in Vol. V of the *Stormwater Manual*, and
3. Maintained in accordance with the maintenance schedule in Vol. V of the *Stormwater Manual*.

Additional Requirements
The discharge of untreated stormwater from pollution-generating impervious surfaces to ground water is not allowed, except for the discharge achieved by infiltration or dispersion of runoff from residential sites through use of On-site Stormwater Management BMPs.

Treatment-Type Thresholds
Oil Control: Treatment to achieve Oil Control applies to projects that have "high-use sites." High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:

1. An area of a commercial or industrial site subject to an expected Average Daily Traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;
2. An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;
3. An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);
4. A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Phosphorus Treatment: The requirement to provide phosphorous control is determined by the local government with jurisdiction (e.g., through a lake management plan), or the Washington State Department of Ecology (e.g., through a waste load allocation).

Phosphorous treatment is required in the Lacamas watershed above the dam at the south end of Round Lake for all project sites that meet applicability thresholds for runoff treatment.

Enhanced Treatment: Enhanced treatment for reduction in dissolved metals is required for the following project sites that discharge to or infiltrate within ¼ of a mile of fish-bearing streams, lakes, or to waters or conveyance systems tributary to fish-bearing streams or lakes:

1. Industrial project sites,
2. Commercial project sites,
3. Multi-family project sites, and
4. High AADT roads as follows:
    a. Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more
    b. All other roads with an AADT of 7,500 or greater

However, such sites listed above that discharge directly (or, indirectly through a municipal storm sewer system) to Basic Treatment Receiving Waters as specified in Vol. I, Appendix I-C of the *Stormwater Manual*, and areas of the above-listed project sites that are identified as subject to Basic Treatment requirements, are also not subject to Enhanced Treatment requirements.

For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

Basic Treatment: Basic Treatment generally applies to:

1. Project sites that discharge to the ground, UNLESS:
    a. The soil suitability criteria for infiltration treatment are met; (see Vol. III, Ch. 3 of the *Stormwater Manual* for soil suitability criteria), or
    b. The project uses infiltration strictly for flow control – not treatment - and the discharge is within ¼-mile of a phosphorus sensitive lake (use a Phosphorus Treatment facility), or within ¼ mile of a fish-bearing stream, or a lake (use an Enhanced Treatment facility).
2. Residential projects not otherwise needing phosphorus control as designated by the US Environmental Protection Agency, the Washington State Department of Ecology, or by the City of Vancouver; and
3. Project sites discharging directly to salt waters, river segments, and lakes listed in Vol. I, Appendix I-C of the *Stormwater Manual*; and
4. Project sites that drain to streams that are not fish-bearing, or to waters not tributary to fish-bearing streams;
5. Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites that do not involve pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals) other than parking of employees' private vehicles.

For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

4-6.02 Additional Requirements for Public Facilities

Fencing Requirements – Some swale, pond or facility locations may require fencing. Fencing shall be required along the top of vertical wall sections and as specified through

Surface Water Management site review. Fencing shall be vinyl coated black, green or brown as best blends into the surroundings. Fence height shall be 48 inches unless otherwise approved.

Aesthetics – The City encourages creativity to design swales and filter strips to reflect a natural setting and add visual appeal to the development. While the swale must remain functional, accessible and maintainable, consider options to make the facility more aesthetically pleasing such as the use of perimeter plant material and meander of the flow line.

Maintenance Accessibility - Public facilities require adequate space to provide for safe maintenance operations. All aspects related to the safe operation and maintenance of facilities (i.e. access roads, vehicle parking and maneuvering space, traffic constraints, etc.) will be reviewed and approved with the design of the facility. Vaults used for public drainage will require hatch access doors; manhole access ports are not allowed on vaults.

4-6.03 Emerging Technologies

For privately owned and maintained systems, the City allows use of all Ecology Technology Assessment Protocol (TAPE) approved technologies that have General Use Level Designation (GULD) and Conditional Use Level Designation (CULD).

For publicly owned and maintained systems the City has conditionally approved alternative methods for stormwater quality treatment for public impervious areas. Those currently approved are Contech StormFilter (StormFilter manholes may be allowed on a case by case basis) and Filterra. Design must meet Ecology's General Use Level Designation (GULD) criteria and standards.

StormFilters using zeolite-perlite-granulated carbon media (ZPG) when designed downstream of a detention facility shall be designed based on the 2-year release rate and with mass loading considerations. Whichever design yields the higher number of cartridges shall be used.

4-6.04 Oil/Water Separators

The following development activities shall require spill control (SC) type oil/water separators (Pre-Sedimentation Manholes - Standard Plan D-2.1):

1. Restaurants,
2. Multifamily residential projects creating parking spaces for twenty-five or more vehicles,
3. Other activities where the risk of oil spill or illegal dumping of oil or grease is significant.

If a commercial or industrial site has a risk of discharging high concentrations of free oil, an API or coalescing plate oil/water separator will be required to provide treatment, spill protection, and grit removal. Facilities that would be candidates for an oil/water separator include petroleum storage yards, automotive maintenance facilities, manufacturing areas, and fueling operations. A schematic of an API type 3-stage separator is shown in the Sanitary Sewer section, Standard Plan S-4.3.

For inflows from small drainage areas, such as maintenance shops, a coalescing plate type separator offers a smaller footprint for the same treatment capacity and may be preferred due to space limitations. Oil/water separators shall be designed in accordance with the *Stormwater Manual*.

4-7 ON-SITE STORMWATER MANAGEMENT (LOW IMPACT DEVELOPMENT)

Project Thresholds

Projects triggering only Minimum Requirements #1 through #5 shall either:

a. Use On-site Stormwater Management BMPs from List #1 for all surfaces within each type of surface in List #1; or
b. Use any Flow Control BMP(s) desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth.

Projects triggering Minimum Requirements #1 through #9 shall either:

a. Use the LID BMPs from List #2 for all surfaces within each type of surface in List #2; or Use any Flow Control BMPs desired to achieve the LID Performance Standard, and apply BMP T5.13: Post-Construction Soil Quality and Depth

Flow Control Exempt Projects

Projects qualifying as Flow Control exempt in accordance with the TDA Exemption in 4.7 Minimum Requirement #7: Flow Control shall either:

a. Use the LID BMPs from List #3 for all surfaces within each type of surface in List #3; or
b. Use any Flow Control BMP(s) desired to achieve the LID Performance Standard and apply BMP T5.13: Post-Construction Soil Quality and Depth.

LID practices shall be designed to the *Stormwater Manual.* The most current edition of the Low Impact Development Technical Guidance Manual for Puget Sound (*LID Manual*) may be used for design guidance. All uses of LID practices shall meet applicable regulations and requirements, and may require specific approval from other City departments (for example Urban Forestry, Transportation or Building).

4-7.01 Bioretention Areas

Bioretention areas in City of Vancouver right-of-way require specific approval by the City of Vancouver Transportation department.

Bioretention systems may meet the requirements for basic and enhanced treatment when soil is designed in accordance with the requirements below and at least 91% of the influent runoff volume, as estimated by an approved continuous runoff model, is infiltrated.

All bioretention facilities must be modeled using the bioretention element in WWHM2012.

An assumed twelve (12) inches per hour infiltration rate may be used for bioretention soil mixes (BSM) that follow the general guidelines below.

The aggregate portion of the BSM should be well-graded and meet the gradation in table D-5. According to ASTM D 2487-98 (Classification of Soils for Engineering Purposes (Unified Soil Classification System)), well-graded sand should have the following gradation coefficients:

- Coefficient of Uniformity (Cu = D60/D10) equal to or greater than 4, and
- Coefficient of Curve (Cc = (D30)2/D60 x D10) greater than or equal to 1 and less than or equal to 3.

Bioretention Soil Mix safety factors must be applied per Vol. V Ch. 7 of the *Stormwater Manual.*

Bioretention soil mixes must contain 35 % - 40% compost by volume.

Table D-5: Guideline for Bioretention Soil Mix Mineral Aggregate Gradation

Sieve Size	Percent Passing
3/8”	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

Compost must meet the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220 and be produced at a composting facility that is permitted by the jurisdictional health authority.

Compost for bioretention facilities must meet requirements in in the Stormwater Manual Volume V.

Compost used in bioretention areas should be stable, mature and derived from organic waste materials including yard debris, wood wastes or other organic materials that meet the intent of the organic soil amendment specification. Biosolids and manure composts can be higher in bio-available phosphorus than compost derived from yard or plant waste and therefore are not allowed in bioretention areas due to the possibility of exporting bio-available phosphorus in effluent.

Bioretention soil mix shall be placed on top of the native soil for public facilities unless an underdrain is required per the SWMMWW.

Filter fabric is not allowed in public bioretention facilities unless it is an impermeable liner required to protect groundwater, basements, etc. Filter fabrics may clog due to the downward migration of fines from the bioretention soil mix (BSM).

Infiltration trenches shall not be placed under the bioretention facility for public facilities.

Street trees planted in bioretention facilities must be approved by the City’s Urban Forester.

All bioretention facilities (public and private) must have mulch per City details B-7.0 and B-7.1 to prevent weed growth and retain moisture.

City bioretention detail notes B-1.0, B-7.0, B-7.1 must be added to the plans when bioretention facilities are proposed.

Maximum ponding level in all facilities is 1 foot.

Infiltration facility setback requirements in Section 4-5.10 must be met if the bioretention facility contributing area exceeds 5000 square feet of impervious area.

If the catchment area exceeds 2,000 square feet or the bioretention area is on a roadway classified as an arterial and flow is concentrated, bioretention must be preceded by a presettling technique per City detail B-2.1 or B-2.2. The presettling is intended to remove larger solids, but not expected to meet water quality treatment goals or sizing guidelines for pretreatment facilities.

If concentrated flows are entering the cell, engineered flow energy dissipation (e.g., rock pad or flow dispersion weir) must be incorporated.

A minimum two-inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance is required.

Until the upstream catchment area is thoroughly stabilized, flow diversion and erosion control measures must be installed to protect the bioretention area from sedimentation.

Private rain gardens are not permitted within five (5) feet from property lines (excluding the property line abutting the right-of-way).

4-7.02 Permeable Pavements

Permeable pavement systems may be applied to privately owned and maintained driveways, parking areas, sidewalks and roads.

Permeable pavement in City of Vancouver right of ways requires specific approval by City of Vancouver Public Works Pavement Management Division. Permeable pavement systems proposed as storm water facilities within the public right of way will need to submit for a road modification as outlined in VMC 11.80.160. Approval of the road modification for permeable pavements will be required prior to project submittal. Road modification requests will only be considered for proposals in non-arterial roadways with Average Daily Traffic (ADT) of fewer than 400 vehicles.

The road modification application must be stamped by an engineer with experience in surface water and permeable pavement. The application must demonstrate that site conditions or constraints preclude the use of other LID practices to meet *Stormwater Manual* requirements and *UIC* regulations. The application must include a traffic count conducted within one year of the date of the application.

The proposed permeable pavement design must meet the design life requirements for the classification of roadway. Permeable cement concrete is currently the only acceptable permeable pavement that is approved in the public right of way. ACI 522.113 is the current national standard for specification of pervious concrete pavement. Proposals for permeable asphalt designs shall utilize the current WSDOT / APWA local region guidelines for materials and construction.

Modeling runoff from areas of permeable pavement surfaces must conform to requirements in the *Stormwater Manual*; or subsequent Ecology and City of Vancouver approved revisions.

Basic, phosphorous and enhanced water quality treatment requirements may also be met with permeable pavement facilities when the underlying soil meets the treatment soil requirements outlined in Vol. III of the *Stormwater Manual*, or an 18 inch sand layer or engineered amended soil layer is added. It must be shown that at least 91% of the runoff volume (the water quality design storm), as estimated by an approved continuous runoff model is infiltrated.

Permeable pavements installed on slopes have an increased potential for lateral flows through the storage reservoir aggregate. This reduces the storage and infiltration capacity of the pavement system. For longitudinal slopes greater than two (2) percent, the subbase must be designed to create subsurface ponding to detain subsurface flow and increase infiltration. Ponding may be provided using design features such as terracing berms (check dams). The berms must not extend to the elevation of the surrounding ground. They must also be designed to provide sufficient space to pass water from upgradient to lower gradient basins without causing flows to surface.

4-8 EROSION PREVENTION & SEDIMENT CONTROL

The Erosion Prevention & Sediment Control Ordinance (VMC 14.24) contains the requirements for all land disturbing activities and Title 22 of the Vancouver Municipal Code contains the administrative enforcement ordinance applicable to all erosion control measures and best management practices.

The current *Stormwater Manual,* Vol. II – Construction Stormwater Pollution Prevention, shall be the BMP manual used when preparing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP) or Erosion Prevention & Sediment Control Plan (EPSCP).

An Erosion Prevention & Sediment Control Plan (EPSCP) is required for any land disturbing activity unless the site is required to prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) as determined by Appendix 1 – Section 3 of the most current version of the City's National Pollutant Discharge Elimination System (NPDES) Western Washington Phase II Municipal Stormwater Permit. (See Appendix A)

A City of Vancouver Abbreviated Construction SWPPP is required for sites that disturb less than an acre.

Washington State Department of Ecology regulatory requirements are the responsibility of the Developer, Engineer, Contractor and/or Owner. Construction projects must apply for coverage under the NPDES Construction Stormwater General Permit through the Washington State Department of Ecology if:

1. The project disturbs one (1) or more acres of land through clearing, grading, excavating, or stockpiling of fill material including the cumulative acreage of the entire project whether in a single or in a multiphase project, and
2. There is any possibility that stormwater could run off the site during construction and into surface waters or conveyance systems leading to surface waters of the state.

Construction site operators must apply for a permit 60 days prior to discharging stormwater. Information about the permit requirements is available at Ecology's website: http://www.ecy.wa.gov/programs/wq/stormwater/construction/index.html

4-9 WATER RESOURCES PROTECTION

4-9.01 General Protections

All operations are required to observe the Minimum Standards of the City's Water Resources Protection Ordinance, VMC 14.26. The Minimum Standards are:

1. Precautions to prevent accidental releases of hazardous materials
2. Hazardous Materials Management protective of human health and the environment
3. Leaks and Spills containment, proper clean-up, and notification to the City of Vancouver
4. Oil/Water Separator inspection, cleaning and maintenance according to the Applicable Operational BMPs in the *Stormwater Manual*
5. Pesticide and Fertilizer Management application and management according to the Applicable Operational BMPs in the *Stormwater Manual*
6. Stormwater Treatment Systems cleaning and maintenance according to the Applicable Operational BMPs in the *Stormwater Manual*
7. Decommissioning Water Wells in accordance with Washington Administrative Code WAC 173-160-381
8. Operation Closure shall include removal and proper disposal of all hazardous materials
9. Mobile Washing and Pressure Cleaning shall be performed according to the Applicable Operational BMPs in the *Stormwater Manual*. Wastewater from such operations shall be captured and directed to an approved discharge location.

If an operation will manage materials that could be hazardous to ground or surface waters, it will be considered a "Classified" facility subject to the Greater Standards and Best Management Practices of the City's Water Resources Protection Ordinance, VMC 14.26. The ordinance is available on the City's website: http://www.cityofvancouver.us/vmc/502/30211/1426100-purpose?throbber=1

Floor drains inside work areas will not be permitted unless approved by City of Vancouver Pretreatment for connection to sanitary sewer. For a Pretreatment application call (360) 487-7130.

Washington State Department of Ecology regulatory requirements are the responsibility of the Developer, Engineer, Contractor and/or Owner. Facilities conducting industrial activities that discharge stormwater to a surface waterbody or to a storm sewer system that drains to a surface waterbody shall apply for coverage under the Industrial Stormwater General Permit through the Washington State Department of Ecology. Information about the permit requirements is available at Ecology's website: https://ecology.wa.gov/regulations-permits/permits-certifications/stormwater-general-permits/industrial-stormwater-permit

4-9.02 Special Protection Areas

The Water Resources Protection Ordinance designates all areas within 1900 feet of Vancouver's municipal water wells as Special Protection Areas. The City will not approve the following development projects within a Special Protection Area:

1. Bulk petroleum fuel operations, such as gas stations.
2. Class II operations which are those operations which store or manage over 2200 lbs of 86 hazardous chemicals defined in the Ordinance.
3. Septic systems, unless a sewer connection is not available *and* the septic design poses no significant risk of groundwater contamination.
4. Heating oil tanks, unless a connection to another source of fuel or energy is impracticable *and* the tank poses no significant risk of groundwater contamination.
5. Direct infiltration facilities such as drywells, ponds, trenches and perforated pipe (as defined in VMC 14.26) unless no reasonable alternative exists *and* the facility poses no significant risk of groundwater contamination. This restriction does not apply to infiltration of residential roof runoff.

The applicant may seek relief from the prohibition for new septic systems, heating oil tanks or infiltration facilities by filing with the City a request for relief accompanied by an analysis prepared by a qualified professional the meets to the City's satisfaction ~~of~~ the lack of potential for groundwater contamination at the site. This analysis may include a soils and groundwater evaluation if deemed necessary by the City.

Refer to the City water protection website for the most current Water Protection Critical Area and Special Protection map.

4-9.03 Storm Drain Markers

New storm drains shall be labeled with circular metal medallions which say "PROTECT WATER * ONLY RAIN IN DRAIN". Medallions shall be affixed to dry surfaces with rivets and a high quality polyurethane sealant. Medallion kits with installation instructions are available for purchase at the City's Permit Counter located at 415 W. 6th Street (360-487-7800).

4-9.04 Fueling Islands

Fueling areas must be designed to capture potential petroleum spills and to minimize or eliminate stormwater on the fueling pad. The concrete fueling area should be sloped to allow spills to flow toward a below-ground solid wall vault which serves as a dead-end sump. The fueling island shall be covered by a canopy which extends beyond the edges of the sloping fuel pad to prevent rain and snow from collecting on the pad.

Canopied fueling islands are **not permitted** to drain their pads to either the storm system or to sanitary sewer. For fueling island requirements and dead-end sump details see Standard Plan D-4.0.

If a fueling area serves vehicles over 10 feet in height, a canopy may not be practical. At those facilities the storm system shall be equipped with emergency spill control which shall include an easily-accessible shutoff valve in the drainage area piping. Only uncontaminated stormwater can be discharged to the storm system.

4-9.05 Sole Source Aquifer

The Environmental Protection Agency has designated the Troutdale Aquifer, which underlies Vancouver and Portland, a "Sole Source Aquifer" (SSA). The designation protects an area's groundwater by requiring EPA to review federally funded projects to ensure that they will not endanger the water source.

Any development project in the City incorporating federal funding requires an SSA report to be prepared and submitted to the EPA for review. Such projects are also required to comply with the City's Water Resources Protection ordinance, VMC 14.26. For a copy of an SSA report checklist contact Water Protection at (360) 487-7130.

4-9.07 Fleet Washing Facilities

Equipment and vehicle washing facilities shall be designed to discharge the wash and rinse waters directly to sanitary sewer. Washwater discharges shall not be directed to the storm system. For a Pretreatment application to discharge to sanitary sewer call (360) 487-7130.

4-9.08 Above-Ground Storage Tanks

Above-ground Storage Tanks (ASTs) shall be designed with a secondary containment area that contains spills and allows leaks to be more easily detected. The containment area surrounding the tank shall hold 110% of the contents of the largest tank. Secondary containment for ASTs shall be impermeable to the materials being stored. Methods include berms, dikes, liners, vaults, and double-walled tanks. A manually controlled sump pump or a manually activated valve shall be installed to control discharges of rain water accumulating in the secondary containment area. Any discharge shall be inspected for petroleum or chemicals prior to being dispensed. *(Federal AST Requirements under 40 CFR Part 112.)*

ASTs shall be designed with corrosion protection for the tank. Options include elevating tanks, resting tanks on continuous concrete slabs, installing double-walled tanks, cathodically protecting the tanks, internally lining tanks, inspecting tanks according to American Petroleum Institute standard, or a combination of the options listed above. All underground piping to the tank shall be double-walled and/or located above ground and/or cathodically protected to allow for inspections to identify potential for failure. To maximize system safety, the floors, containment area, and sump pump pit shall be sealed with a coating appropriate for the materials being stored (e.g., petroleum resistant coating).

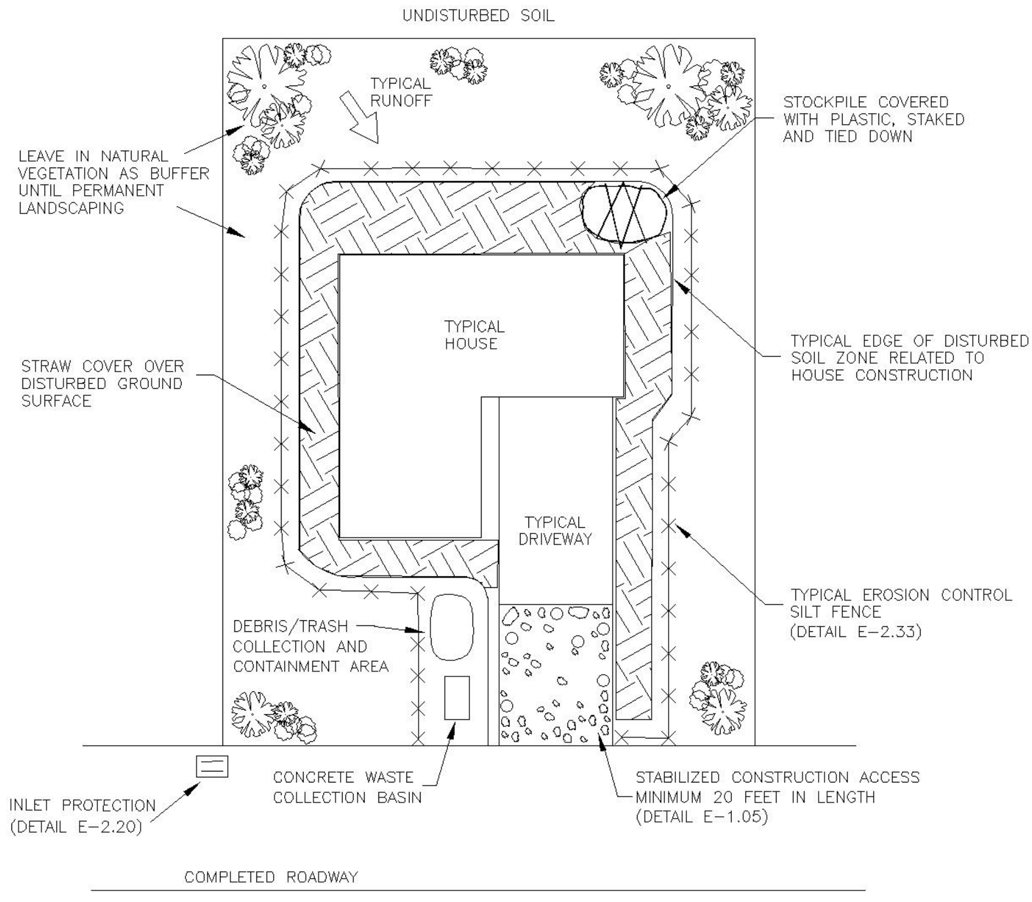
ASTs shall be routinely monitored to ensure they are not leaking. An audit of a newly installed tank system by a professional engineer can identify and correct problems such as loose fittings, poor welding, and poorly fit gaskets. After installation, the tank system shall be inspected monthly to ensure it is in good condition. Depending on the permeability of the secondary containment area, more frequent containment area checks may be necessary. Areas to inspect include tank foundations, connections, coatings, tank walls, and the piping system. Integrity testing should be done periodically by a qualified professional and in accordance with applicable standards.

4-9.09 Trash Dumpster/Compactor Enclosures/Areas

Catch basins located within trash enclosure areas shall not connect to storm water systems.

4-10 SMALL PROJECTS – LESS THAN 2,000 SQUARE FEET NEW HARD SURFACE AREA

Infiltration Systems: The City requires that all roof run-off be infiltrated on site except for areas of poor infiltration, high groundwater, steep slopes or lots with more than three (3) feet of fill. A template that is based on the size of the roof, rainfall and the infiltration rate of the soil has been developed to determine the size of the infiltration system. In areas with marginal infiltration rates (less than 2"/hour), the infiltration system shall be designed by a Professional Engineer. Below is a sample site plan for erosion prevention and sediment control for a small site or single family residence which creates or replaces less than 2,000 square feet.



SAMPLE SITE PLAN
SINGLE FAMILY RESIDENCE
EROSION PREVENTION & SEDIMENT CONTROL

4-11 DEFINITION OF TERMS

The following terms are a sub-set of the terms defined in Section 1 and are included below for convenience.

Area Drain/Field Inlet: A structure used to collect storm water in ditches, swales or lawns often with an angled grate to prevent clogging with debris.

Best Management Practices (BMPs): The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices approved by the Washington State Department of Ecology that, when used singly or in combination, control, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.

Catch Basin/Curb Inlet/Combination Curb Inlet: A structure used to collect surface water runoff from streets and paved areas, having a sump base designed to retain grit, sediment and debris, before flowing into the storm sewer. A catch basin has a grate level with the pavement, a curb inlet has an opening in the curb and gutter and a combination curb inlet incorporates the features of both.

Categorical Industry: An industry which has been defined as categorical by the definitions provided in the Clean Water Act's Code of Federal Regulations (40 CFR). These are typically required to sample for pollutants specific to the nature of the industry and to maintain compliance with the categorical guidelines.

Culvert: A pipe or concrete box which permits the natural flow of water from creeks, open channels or ditches under a roadway or embankment.

Design Storm: A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff for a hypothetical storm of interest or concern for the purposes of analyzing existing drainage, designing new drainage facilities or assessing other impacts of a proposed project on the flow of surface water. (A hyetograph is a graph of percentages of total precipitation for a series of time steps representing the total time during which the precipitation occurs.)

Detention Facility: A facility (e.g. pond, vault, pipe) in which surface and stormwater is temporarily stored and released at a controlled rate.

Drywell: Precast concrete manhole with perforations and installed with drain rock for exfiltration of surface water runoff or other drainage to the subsurface.

Effective Impervious Surface: Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces on residential development sites are considered ineffective if the runoff is dispersed through at least one hundred feet of native vegetation.

Emerging Technologies: Treatment technologies that have not been evaluated with approved protocols, but for which preliminary data indicate that they may provide a necessary function(s) in a stormwater treatment system. Emerging technologies need additional evaluation to define design criteria to achieve, or to contribute to achieving, state performance goals, and to define the limits of their use.

Erosion and Sediment Control: Any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site and/or enter the stormwater system.

Flow control BMP or Facility: A drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.

Grading: Excavating, filling or embanking of earth materials.

Hard Surface: An impervious surface, a permeable pavement, or a vegetated roof.

Impervious Surface: A non-vegetated surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development, and/or a non-vegetated surface area which causes water to run off the surface in greater quantities or at an increased rate of flow than the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, gravel parking lots, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration or stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling.

Land-disturbing Activity: Any activity that results in a movement of earth or a change in the existing soil cover (both vegetative and nonvegetative) and/or existing soil topography. Land-disturbing activities include, but are not limited to, demolition, reconstruction, construction, clearing, grading, filling excavation and related activities. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land-disturbing activity.

Low Impact Development (LID): A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.

Low Impact Development (LID) Best Management Practices: The distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to, bioretention, rain gardens, permeable pavements, roof downspout controls, dispersion, soil quality and depth, vegetated roofs, minimum excavation foundations, and water re-use.

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking, and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Federal Clean Water Act, for the discharge of pollutants to surface waters of the state from point sources. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.

New Development: Land disturbing activities, including Class IV General Forest Practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of hard surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.

New Impervious Surface: Impervious surface created on or added to a site or structural development including construction, installation, or expansion of a building or other structure. New impervious surfaces may also include existing impervious surface that is removed and replaced. To be considered new, the removal and replacement activity must result in significant changes in impervious surface locations, grade, and/or drainage system features, and/or must involve construction, installation, or expansion of a building or structure after complete or substantial intentional demolition.

Operations and Maintenance Manual: A document prepared to explain the proper specific operational and maintenance details of facilities installed as required by the Stormwater Manual.

Outfall: The point where water flows from a manmade conduit, channel, or drain into a water body or other natural drainage feature.

Pervious Surface: A surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.

Pollution/Pollutants: Such contamination, or other alteration of the physical, chemical or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.

Pollution-generating Hard Surface/PGHS: Those hard surfaces considered to be a significant source of pollutants in stormwater runoff. See the listing of surfaces under pollution-generating impervious surface.

Pollution-generating Impervious Surface/PGIS: Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use; industrial activities or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall; metal roofs unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating); or roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.

Pollution-generating Pervious Surface/PGPS: Any non-impervious surface subject to vehicular use, industrial activities or storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall, use of pesticides and fertilizers, or loss of soil. Typical PGPS include permeable pavement subject to vehicular use, lawns and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf).

Predevelopment Condition: The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Redevelopment: On a site that is already substantially developed (i.e., has 35% or more of existing impervious surface coverage), the creation or addition of hard surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure; replacement of hard surface that is not part of routine maintenance activity; and land disturbing activities.

Regional Facility: A city owned, designed, and constructed facility used for detention, retention and/or water quality of stormwater runoff from large areas of land or basins.

Replaced Hard Surface: For structures, the removal and replacement of hard surfaces down to the foundation. For other hard surfaces, the removal down to bare soil or base course and replacement.

Replaced Impervious Surface: For structures, the removal and replacement of any exterior impervious surfaces or foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.

Source Control BMP – A structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. The *Stormwater Manual* separates source control BMPs into two types. Structural Source Control BMPs are physical, structural, or mechanical devices, or facilities that are intended to prevent pollutants from entering stormwater. Operational BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. See Vol. IV of the Stormwater Manual for details.

Storm Sewer: A sewer that is designed to carry stormwater and surface water runoff or drainage, but typically excludes domestic wastewater and industrial wastes. Storm drains are enclosed conduits that transport surface and stormwater runoff toward points of discharge.

Stormwater Facility: A constructed component of a stormwater drainage system, designed or constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to, pipes, swales, ditches, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, infiltration devices, catch basins, oil/water separators, and biofiltration swales, bioretention, vegetated roofs and permeable pavements.

Stormwater Manual: Stormwater Management Manual for Western Washington prepared by the Washington State Department of Ecology Water Quality Program, December 2019, Publication No. 19-10-021, 5 volumes, and as hereafter amended.

Stormwater Permit: The of the City of Vancouver's National Pollutant Discharge Elimination System (NPDES) Western Washington Phase II Municipal Stormwater Permit issued August 1, 2019, by the Washington State Department of Ecology.

Stormwater Pollution Prevention Plan (SWPPP): A plan that identifies best management practices to identify, reduce, eliminate and/or prevent stormwater contamination and water pollution.

Stormwater Site Plan: A comprehensive report containing all of the technical information and analyses necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics. Guidance on preparing a Stormwater Site Plan is contained in Section 4-2.

Threshold Discharge Area (TDA): An on-site area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath).

Treatment BMP or Facility: A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are wetponds, oil/water separators, biofiltration swales, and constructed wetlands.

Underground Injection Control/UIC: Manmade subsurface fluid distribution system designed to discharge fluids into the ground; consisting of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension. Subsurface infiltration systems include drywells, pipe or french drains, drain fields, and other similar devices.

4-12 SURFACE WATER STANDARD PLAN DETAIL SHEETS

Surface Water Standard Plan Numbers and Description

D-1.0	Construction Notes for Storm Sewers
D-1.1	Standard Catch Basin Detail
D-1.2	Standard Curb Inlet Detail
D-1.3	Standard Combination Curb Inlet Detail
D-1.4	G-2 Catch Basin Detail
D-1.5	Sloped Field Inlet Detail
D-1.6	Standard Area Inlet Detail
D-1.7	Standard Grate Detail
D-1.8	Catch Basin Trap Detail
D-2.0	Standard Manhole Detail
D-2.1	Pre-Sedimentation/Separator Manhole Detail
D-2.2	Standard Pre-Cast Drywell
D-2.3	Standard Sewer Cleanout Detail
D-2.4	Manhole Cover and Frame Standard Detail
D-2.5	Storm Stub Detail
D-3.1	Standard Pipe Bedding Detail
D-3.2	Trench Backfill Detail
D-4.0	Standard Fueling Island Detail

Erosion Prevention Standard Plan Numbers and Description

E-0.10	Symbols
E-0.20	Sample Site Erosion Control Detail
E-1.00	Erosion Prevention & Sediment Control Notes
E-1.05	Stabilized Construction Entrance
E-1.06	Wheel Wash
E-1.22	Nets and Blankets
E-1.23	Plastic Covering
E-1.30	Surface Roughing
E-1.31	Gradient Terraces
E-2.00	Interceptor Dike & Swale
E-2.01	Grass-Lined Channels
E-2.04	Pipe Slope Drains
E-2.06	Level Spreader
E-2.07	Check Dam
E-2.20a	Inlet Protection Details
E-2.20b	Inlet Protection Details
E-2.30	Straw Bale Barrier
E-2.31	Brush Barrier
E-2.33	Silt Fence
E-2.35	Straw Wattles
E-2.40	Sediment Trap
E-2.41	Sediment Pond
E-2.45	Siltation Trench Behind Curb
E-2.46	Sediment Bag Detail

SURFACE WATER MANAGEMENT

DESIGN AND CONSTRUCTION REQUIREMENTS

APPENDIX A

Western Washington Phase II Municipal

Stormwater Permit - Appendix 1

APPENDIX 1 - Minimum Technical Requirements for New Development and Redevelopment

Section 1. Exemptions

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

Forest Practices

Forest practices regulated under Title 222 WAC, except for Class IV-General forest practices that are conversions from timberland to other uses, are exempt from the provisions of the Minimum Requirements.

Commercial Agriculture

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

Oil and Gas Field Activities or Operations

Construction of drilling sites, waste management pits, and access roads, as well as construction of transportation and treatment infrastructure such as pipelines, natural gas treatment plants, natural gas pipeline compressor stations, and crude oil pumping stations are exempt. Operators are encouraged to implement and maintain Best Management Practices to minimize erosion and control sediment during and after construction activities to help ensure protection of surface water quality during storm events.

Pavement Maintenance

The following pavement maintenance practices are exempt:

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

The following pavement maintenance practices are not categorically exempt, and are subject to the Minimum Requirements that are triggered when the thresholds identified for new or redevelopment projects are met per Section 3: Applicability of the Minimum Requirements.

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

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 4.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP).

Section 2. Definitions Related to Minimum Requirements

Arterial

A road or street primarily for through traffic. The term generally includes roads or streets considered collectors. It does not include local access roads which are generally limited to providing access to abutting property. See also RCW 35.78.010, RCW 36.86.070, and RCW 47.05.021.

Bioretention BMPs

Engineered facilities that treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for flow attenuation. Refer to BMP T7.30: Bioretention for Bioretention BMP types and design specifications.

Certified Erosion and Sediment Control Lead (CESCL)

An individual who has current certification through an approved erosion and sediment control training program that meets the minimum training standards established by Ecology (see BMP C160: Certified Erosion and Sediment Control Lead). A CESCL is knowledgeable in the principles and practices of erosion and sediment control. The CESCL must have the skills to assess site conditions and construction activities that could impact the quality of stormwater and, the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. Certification is obtained through an Ecology approved erosion and sediment control course. Course listings are provided online at Ecology's website.

Commercial agriculture

Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

Converted vegetation (areas)

The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation (e.g., Himalayan blackberry, scotch broom) are converted to lawn or landscaped areas, or where native vegetation is converted to pasture.

Discharge point

The location where a discharge leaves the Permittee's MS4 through the Permittee's MS4 facilities/BMPs designed to infiltrate.

Effective impervious surface

Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces are considered ineffective if:

1. The runoff is dispersed through at least one hundred feet of native vegetation in accordance with BMP T5.30: Full Dispersion;
2. Residential roof runoff is infiltrated in accordance with BMP T5.10A: Downspout Full Infiltration; or
3. Approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.

Erodible or leachable materials

Wastes, chemicals, or other substances that measurably alter the physical or chemical characteristics of runoff when exposed to rainfall. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage.

Hard surface

An impervious surface, a permeable pavement, or a vegetated roof.

Highway

A main public road connecting towns and cities.

Impervious surface

A non-vegetated surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A non-vegetated surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of Minimum Requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling.

Land disturbing activity

Any activity that results in a change in the existing soil cover (both vegetative and nonvegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices, including landscape maintenance and gardening, are not considered land-disturbing activity. Stormwater facility maintenance is not considered land disturbing activity if conducted according to established standards and procedures.

Low Impact Development (LID)

A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.

Low Impact Development Best Management Practices (LID BMPs)

Distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to:

- BMP T7.30: Bioretention,
- BMP T5.14: Rain Gardens,
- BMP T5.15: Permeable Pavements,
- BMP T5.10A: Downspout Full Infiltration,
- BMP T5.10B: Downspout Dispersion Systems,
- BMP T5.10C: Perforated Stub-out Connections
- BMP T5.30: Full Dispersion,
- BMP T5.13: Post-Construction Soil Quality and Depth,
- BMP T5.19: Minimal Excavation Foundations,
- BMP T5.17: Vegetated Roofs, and
- BMP T5.20: Rainwater Harvesting.

Low Impact Development (LID) Principles

Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff.

Maintenance

Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and results in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include replacement of dysfunctional facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. One example is the replacement of a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway. In regard to stormwater facilities, maintenance includes assessment to ensure ongoing proper operation, removal of built-up pollutants (i.e., sediments), replacement of failed or failing treatment media, and other actions taken to correct defects as identified in the BMP design guidance within Volume V of the SWMMWW. See also Pavement Maintenance exemptions in Section 1: Exemptions.

Native vegetation

Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas fir, western hemlock, western red cedar, alder, big-leaf maple, and vine maple; shrubs such as willow, elderberry, salmonberry and salal; and herbaceous plants such as sword fern, foam flower, and fireweed.

New development

Land disturbing activities, including Class IV-general forest practices that are conversions from timberland to other uses; structural development, including construction or installation of a building or other structure; creation of hard surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.

New impervious surface

A surface that is:

- changed from a pervious surface to an impervious surface (e.g. resurfacing by upgrading from dirt to gravel, a bituminous surface treatment (“chip seal”), asphalt, concrete, or an impervious structure); or
- upgraded from gravel to chip seal, asphalt, concrete, or an impervious structure; or
- upgraded from chip seal to asphalt, concrete, or an impervious structure.

  Note that if asphalt or concrete has been overlaid by a chip seal, the existing condition should be considered as asphalt or concrete.

On-site stormwater management BMPs

As used in this appendix, a synonym for Low Impact Development BMPs.

Outfall

A point source as defined by 40 CFR 122.2 at the point where a discharge leaves the Permittee’s MS4 and enters a surface receiving waterbody or surface receiving waters. Outfall does not include pipes, tunnels, or other conveyances which connect segments of the same stream or other surface waters and are used to convey primarily surface waters (i.e., culverts).

Permeable pavement

Pervious concrete, porous asphalt, permeable pavers, or other forms of pervious or porous paving material intended to allow passage of water through the pavement section. It often includes an aggregate base that provides structural support and acts as a stormwater reservoir.

Pervious Surface

Any surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.

Pollution-generating hard surface (PGHS)

Those hard surfaces considered to be a significant source of pollutants in stormwater runoff. See the listing of surfaces under pollution-generating impervious surface.

Pollution-generating impervious surface (PGIS)

Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to any of the following:

- vehicular use;
- industrial activities (as further defined in the glossary of the SWMMWW);
- storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall;
- metal roofs unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating); or
- roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.

Pollution-generating pervious surface (PGPS)

Any pervious surface subject to any of the following:

- vehicular use,
- industrial activities (as further defined in the glossary of the SWMMWW);
- storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall,
- use of pesticides and fertilizers, or
- loss of soil.

Typical PGPS include permeable pavement subject to vehicular use, lawns and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf).

Pre-developed condition

The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Project

Any proposed action to alter or develop a site.

Project site

That portion of a property, properties, or right of way subject to land disturbing activities, new hard surfaces, or replaced hard surfaces.

Rain garden

A non-engineered shallow landscaped depression, with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. See BMP T5.14: Rain Gardens.

Receiving waterbody or receiving waters

Naturally and/or reconstructed naturally occurring surface water bodies, such as creeks, streams, rivers, lakes, wetlands, estuaries, and marine waters, or groundwater, to which a MS4 discharges.

Redevelopment

On a site that is already substantially developed (i.e., has 35% or more of existing hard surface coverage), the creation or addition of hard surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure; replacement of hard surface that is not part of a routine maintenance activity; and land disturbing activities.

Replaced hard surface

For structures, the removal and replacement of hard surfaces down to the foundation. For other hard surfaces, the removal down to bare soil or base course and replacement.

Replaced impervious surface

For structures, the removal and replacement of impervious surfaces down to the foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.

Site

The area defined by the legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.

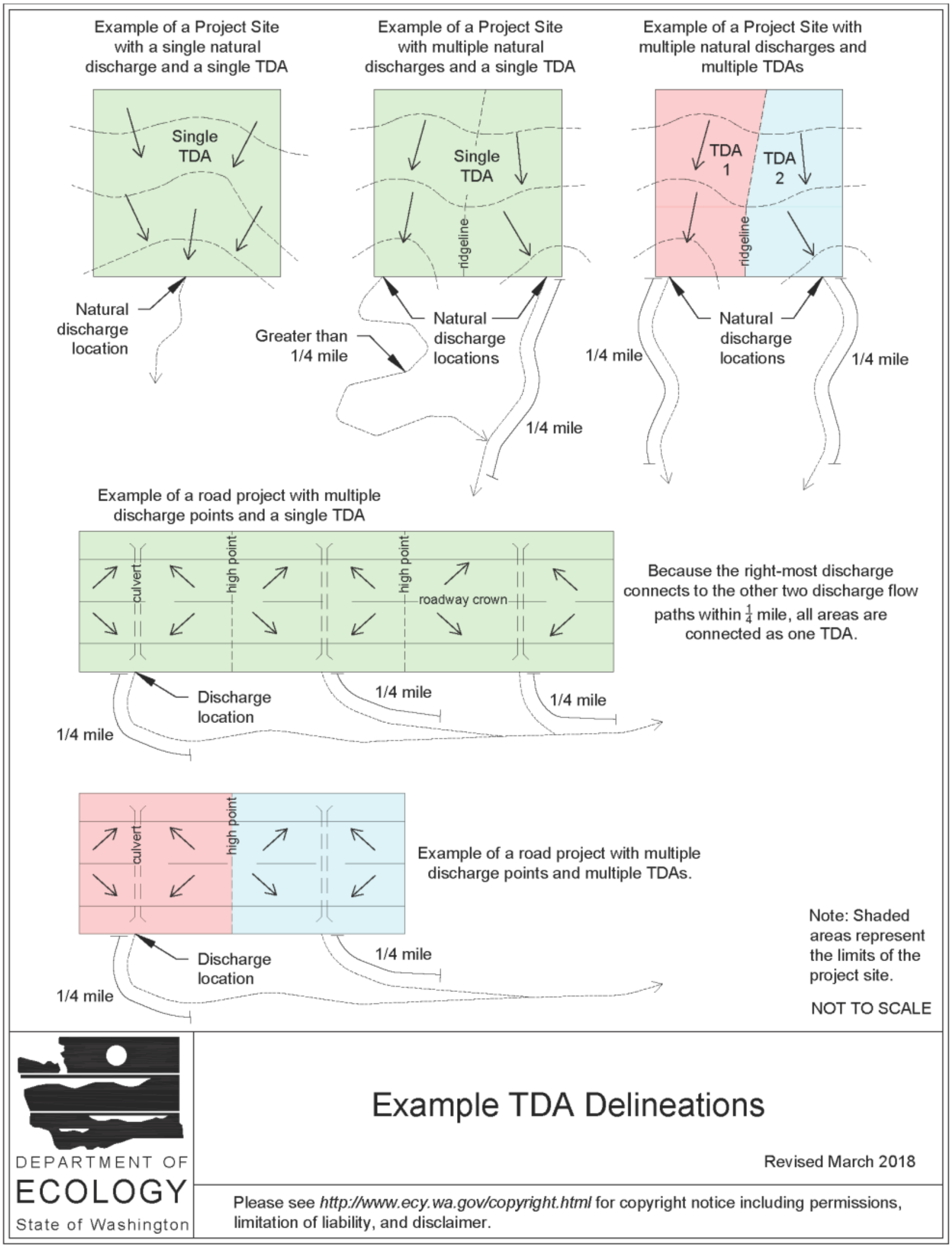
Source control BMP

A structure or operation intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. The SWMMWW separates source control BMPs into two types. *Structural Source Control BMPs* are physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. *Operational Source Control BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV of the SWMMWW for details.

Threshold Discharge Area

An area within a project site draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). The examples in Figure 1: Example TDA Delineations below illustrate this definition. The purpose of this definition is to clarify how the thresholds of this appendix are applied to project sites with multiple discharge points.

Figure 1: Example TDA Delineations



Vehicular Use

Regular use of an impervious or pervious surface by motor vehicles. The following are subject to regular vehicular use:

- roads,
- un-vegetated road shoulders,
- bike lanes within the traveled lane of a roadway,
- driveways,
- parking lots,
- unrestricted access fire lanes,
- vehicular equipment storage yards, and
- airport runways.

The following are not considered subject to regular vehicular use:

- sidewalks not subject to drainage from roads for motor vehicles,
- paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles,
- restricted access fire lanes, and
- infrequently used maintenance access roads.

Wetlands

Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands.

Section 3. Applicability of the Minimum Requirements

3.1 Minimum Requirement Thresholds

Not all of the Minimum Requirements apply to every new development or redevelopment project. The applicability varies depending on the project type and size. This section identifies thresholds that determine the applicability of the Minimum Requirements to projects. Use the flow charts in Figure 2: Flow Chart for Determining Whether the Permittee Must Regulate the Project, Figure 3: Flow Chart for Determining Requirements for New Development, and Figure 4: Flow Chart for Determining Requirements for Redevelopment to determine which of the Minimum Requirements apply. The Minimum Requirements themselves are presented in Section 4: Minimum Requirements.

Use the thresholds in Sections 3.2 and 3.3 at the time of application for a subdivision, plat, short plat, building permit, or other construction permit. The plat or short plat approval shall identify all stormwater BMPs that are required for each lot. For projects involving only land disturbing activities, (e.g., clearing or grading), the thresholds apply at the time of application for the permit allowing or authorizing that activity. Note the exemption in Section 1: Exemptions for Forest Practices other than Class IV General.

Figure 2: Flow Chart for Determining Whether the Permittee Must Regulate the Project

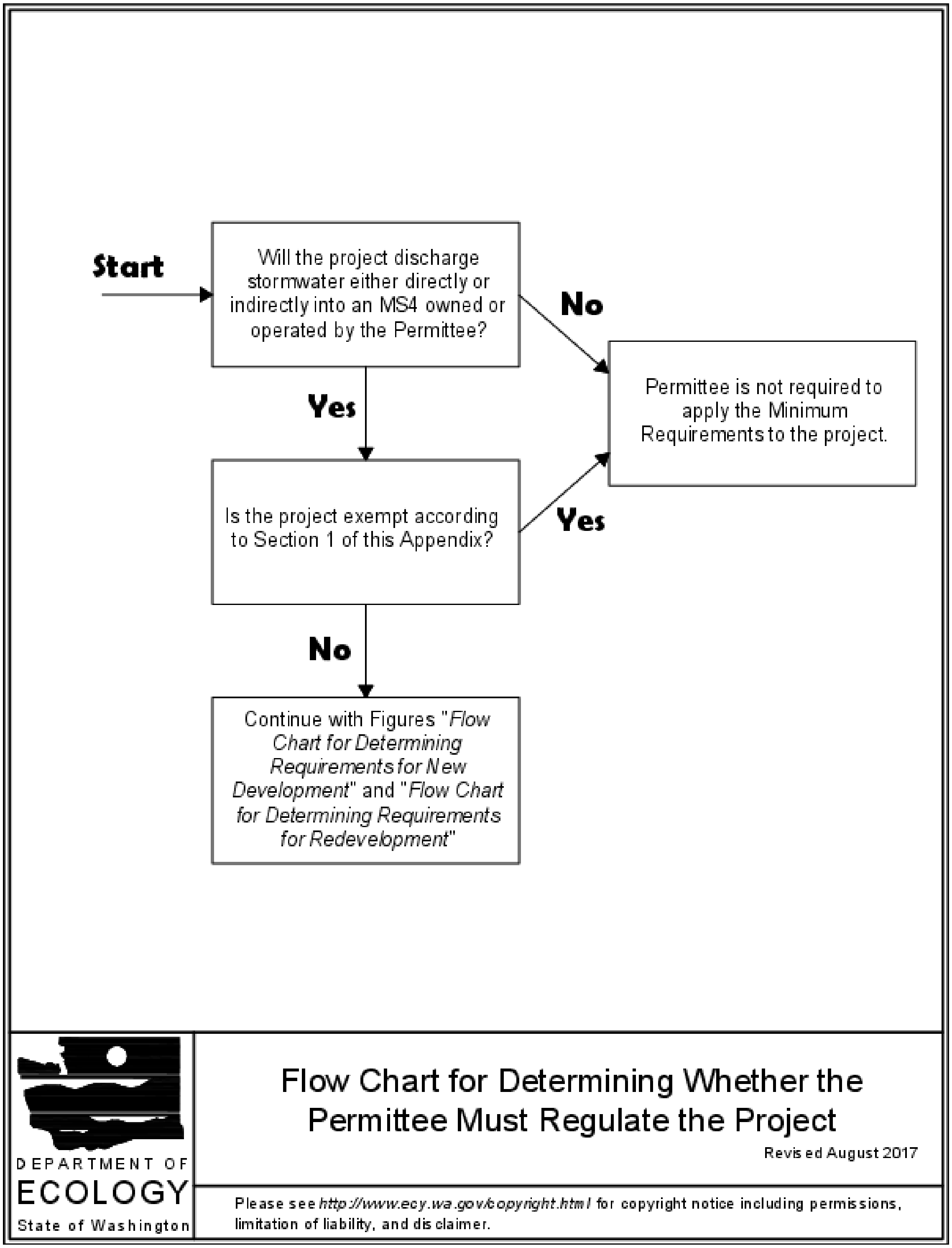


Figure 3: Flow Chart for Determining Requirements for New Development

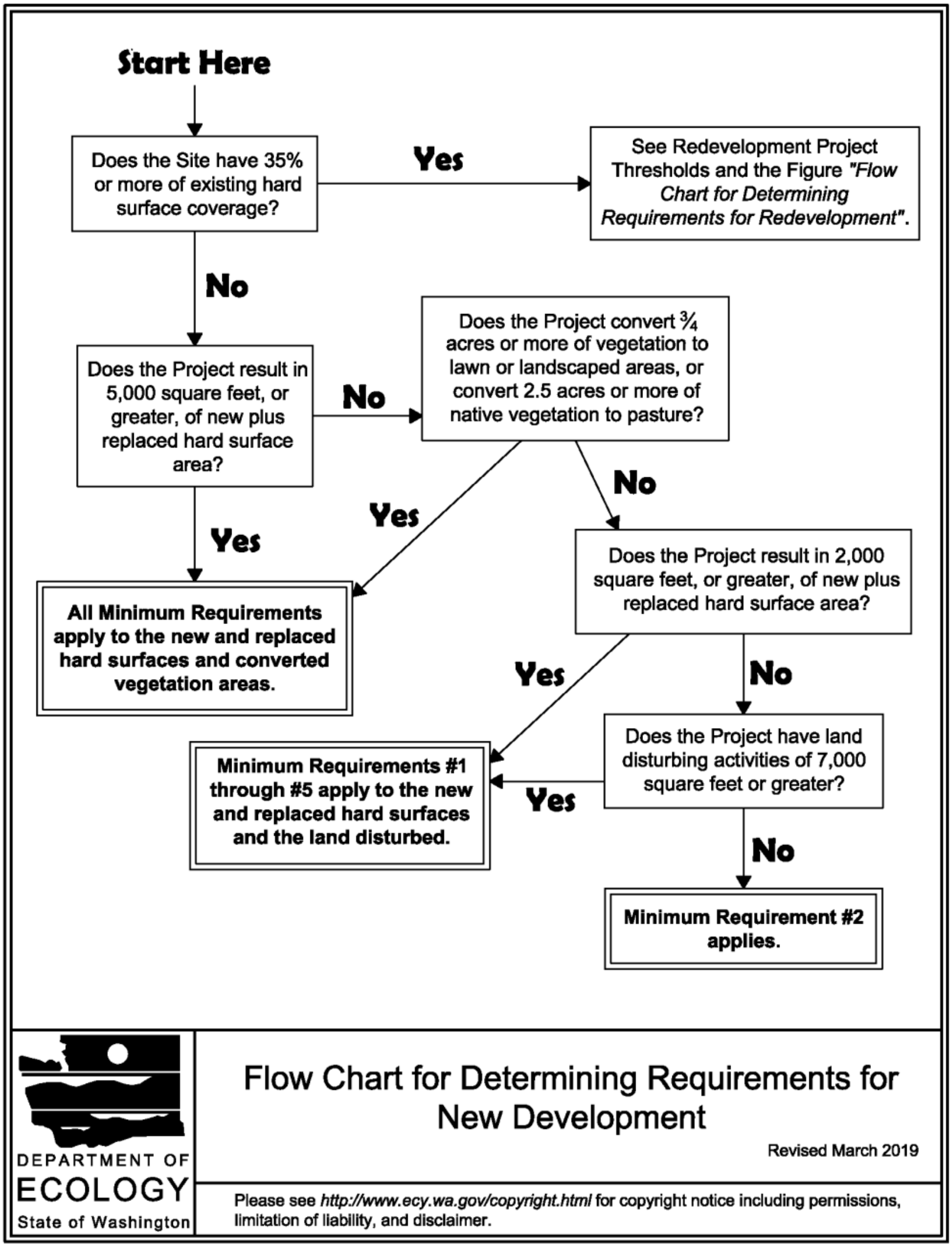
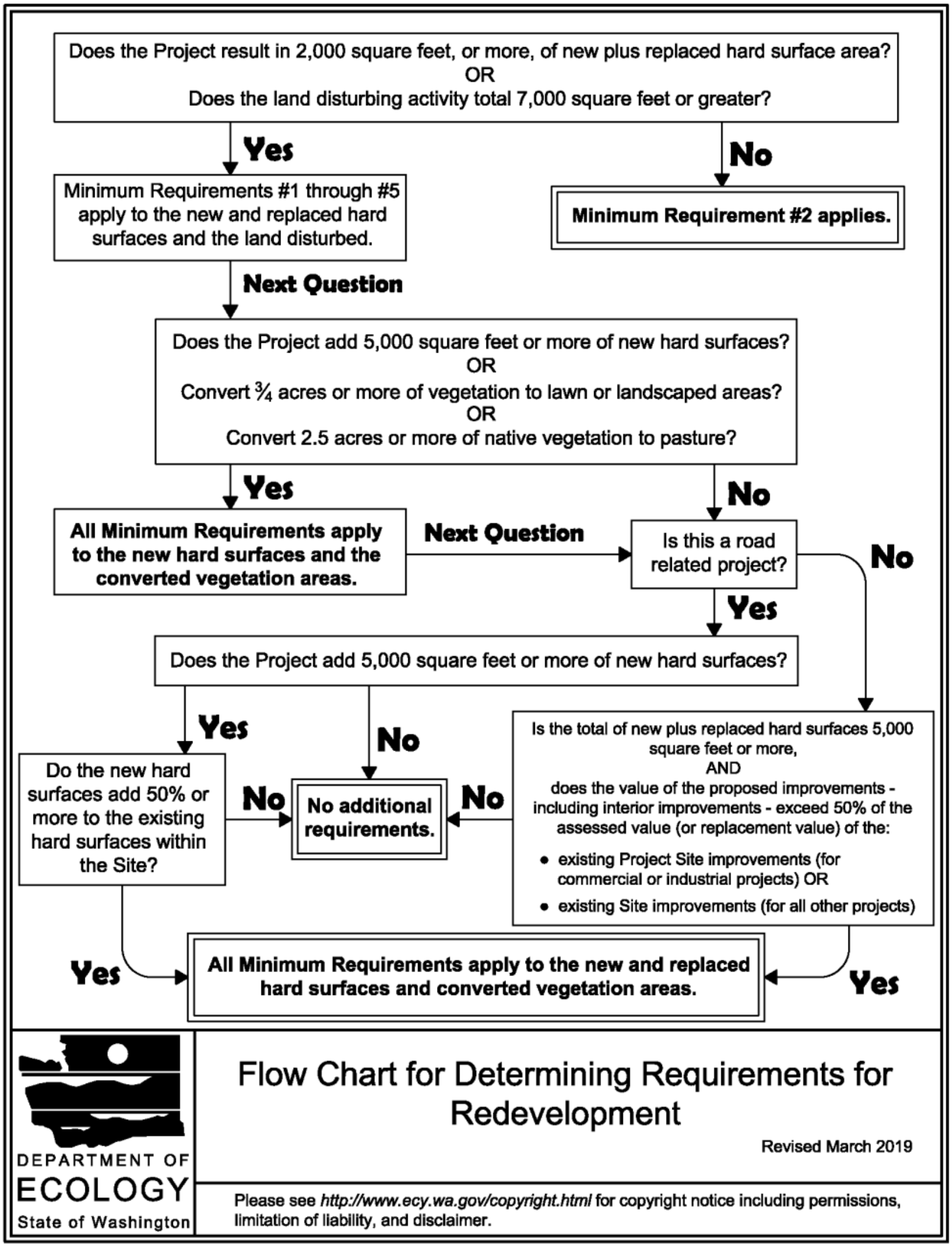


Figure 4: Flow Chart for Determining Requirements for Redevelopment



3.2 New Development Project Thresholds

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

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

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

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

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

3.3 Redevelopment Project Thresholds

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

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

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

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

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

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

3.4 Additional Requirements for Redevelopment

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

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

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

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

The Permittee may grant a variance/exception to the application of Minimum Requirement #7 to replaced impervious surfaces if such application imposes a severe economic hardship. See Section 6: Exceptions/Variances.

SECTION 4. MINIMUM REQUIREMENTS

This Section describes the Minimum Requirements for stormwater management at new development and redevelopment sites. Section 3: Applicability of the Minimum Requirements, should be consulted to determine which of the Minimum Requirements apply to any given project. Figure 3: Flow Chart for Determining Requirements for New Development and Figure 4: Flow Chart for Determining Requirements for Redevelopment, should be consulted to determine whether the Minimum Requirements apply to new surfaces, replaced surfaces, or new and replaced surfaces.

4.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

The Permittee shall require a Stormwater Site Plan from all projects meeting the thresholds in Section 3.1 of this Appendix. Stormwater Site Plans shall use site-appropriate development principles, as required and encouraged by local development codes, to retain native vegetation and minimize impervious surfaces to the extent feasible. Stormwater Site Plans shall be prepared in accordance with the guidance in *III-3 Stormwater Site Plans* in the SWMMWW.

4.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP)

Permittees may choose to allow compliance with this Minimum Requirement to be achieved for an individual site if the site is covered under and fully implementing the requirements of Ecology's *Construction Stormwater General Permit - National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Stormwater Discharges Associated with Construction Activity*.

Project Thresholds

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

Permittees must require a Construction Stormwater Pollution Prevention Plan (SWPPP) for all projects which result in 2,000 sq. ft. or more of new plus replaced hard surface area, or which disturb 7,000 sq. ft. or more of land.

Projects below those thresholds (listed above) are not required to prepare a Construction SWPPP, but must consider all of the Construction SWPPP Elements (listed below) and develop controls for all Construction SWPPP Elements that pertain to the project site. The Permittee may develop an abbreviated Construction SWPPP format to meet the Construction SWPPP requirement under this permit for project sites that will disturb less than 1 acre.

General Requirements

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

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

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

Seasonal Work Limitations: From October 1 through April 30, clearing, grading, and other soil disturbing activities may only be authorized by the Permittee if silt-laden runoff will be prevented from leaving the site through a combination of the following:

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

Based on the information provided and/or local weather conditions, the Permittee may expand or restrict the seasonal limitation on site disturbance.

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

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

Construction SWPPP Elements

Element 1: Preserve Vegetation / Mark Clearing Limits

a. Before beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees to be preserved within the construction area.

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

Element 2: Establish Construction Access

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

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

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

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

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

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

Element 3: Control Flow Rates

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

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

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

Element 4: Install Sediment Controls

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

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

b. Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.

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

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

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

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

Element 5: Stabilize Soils

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

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

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

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

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

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

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

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

h. Minimize the disturbance of steep slopes.

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

Element 6: Protect Slopes

a. Design and construct cut-and-fill slopes in a manner to minimize erosion. Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, reducing slope steepness, and roughening slope surfaces (for example, track walking).

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

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

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

     OR

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

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

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

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

Element 7: Protect Drain Inlets

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

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

Element 8: Stabilize Channels and Outlets

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

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

     OR

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

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

b. Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent stream banks, slopes and downstream reaches at the outlets of all conveyance systems.

Element 9: Control Pollutants

Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants. The project proponent must:

a. Handle and dispose of all pollutants, including waste materials and demolition debris that occur on site in a manner that does not cause contamination of stormwater.

b. Provide cover, containment, and protection from vandalism for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. On-site fueling tanks must include secondary containment. Secondary containment means placing tanks or containers within an impervious structure capable of containing 110% of the volume contained in the largest tank within the containment structure. Double-walled tanks do not require additional secondary containment.

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

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

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

f. Use BMPs to prevent contamination of stormwater runoff by pH-modifying sources. The sources for this contamination include, but are not limited to: recycled concrete stockpiles, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, concrete pumping and mixer washout waters.

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

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

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

j. Uncontaminated water from water-only based shaft drilling for construction of building, road, and bridge foundations may be infiltrated provided the wastewater is managed in a way that prohibits discharge to surface waters. Prior to infiltration, water from water-only based shaft drilling that comes into contact with curing concrete must be neutralized until pH is in the range of 6.5 to 8.5 (su).

Element 10: Control Dewatering

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

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

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

d. Other dewatering treatment or disposal options may include:

    i. Infiltration

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

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

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

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

Element 11: Maintain BMPs

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

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

Element 12: Manage the Project

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

b. Inspect, maintain and repair all BMPs as needed to assure continued performance of their intended function.

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

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

Element 13: Protect Low Impact Development BMPs

The primary purpose of On-Site Stormwater Management is to reduce the disruption of the natural site hydrology through infiltration. BMPs used to meet 4.5 Minimum Requirement #5: On-Site Stormwater Management (often called LID BMPs) are permanent facilities.

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

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

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

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

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

4.3 Minimum Requirement #3: Source Control of Pollution

All known, available and reasonable Source Control BMPs must be required for all projects approved by the Permittee. Source Control BMPs must be selected in accordance with *III-1.1 Choosing Your Source Control BMPs*, and designed and maintained in accordance with Volume IV of the SWMMWW.

4.4 Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

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

4.5 Minimum Requirement #5: On-Site Stormwater Management

The Permittee must require Stormwater Management BMPs in accordance with the following thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff on site to the extent feasible without causing flooding or erosion impacts.

Compliance Options by Project Type

All projects that require Minimum Requirement #5 (as detailed in Section 3: Applicability of the Minimum Requirements) must employ Stormwater Management BMPs as detailed below. The compliance options for the project depend on the amount of improvements proposed, location of the project, size of the parcel the project is on, and whether or not the project is Flow Control exempt.

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

Projects that Trigger Only Minimum Requirements #1 - #5

Projects that are not Flow Control exempt that trigger only Minimum Requirements #1 through #5 (per Section 3: Applicability of the Minimum Requirements) shall either:

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

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

Projects that Trigger Minimum Requirements #1 - #9

Projects that are not Flow Control exempt that trigger Minimum Requirements #1 through #9 (per Section 3: Applicability of the Minimum Requirements) have the compliance options shown in Table 1: Minimum Requirement, #5 Compliance Options for Projects Triggering Minimum Requirements #1 - #9.

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

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

Flow Control Exempt Projects

Projects qualifying as Flow Control exempt in accordance with the TDA Exemption in 4.7 Minimum Requirement #7: Flow Control shall either:

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

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

If the project has multiple TDAs, all TDAs must be Flow Control exempt per the TDA Exemption in 4.7 Minimum Requirement #7: Flow Control for the project to use the options listed here.

Compliance Methods

LID Performance Standard

The LID Performance Standard compliance method for Minimum Requirement #5 requires modeling the proposed Flow Control BMPs to demonstrate the flow reduction as described below.

Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. Refer to the Flow Control Performance Standard Section in 4.7 Minimum Requirement #7: Flow Control, for information about the assignment of the pre-developed condition. Project sites that must also meet 4.7 Minimum Requirement #7 must match flow durations between 8% of the 2-year flow through the full 50-year flow.

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

The List Approach

The List Approach compliance method for Minimum Requirement #5 requires evaluating the BMPs in Table 2: The List Approach for MR5 Compliance.

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

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

Feasibility shall be determined by evaluation against:

- Design criteria, limitations, and infeasibility criteria identified for each BMP in Volume V of the SWMMWW; and
- Competing Needs Criteria as listed in *I-3.4.5 MR5: On-Site Stormwater Management* in the SWMMWW

Table 2: The List Approach for MR5 Compliance

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

Notes for using the List Approach:

1. Size BMP T5.14A: Rain Gardens and BMP T7.30: Bioretention used in the List Approach to have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it.
2. When the designer encounters BMP T5.15: Permeable Pavements in the List Approach, it is not a requirement to pave these surfaces. Where pavement is proposed, it must be permeable to the extent feasible unless BMP T5.30: Full Dispersion is employed.

4.6 Minimum Requirement #6: Runoff Treatment

The Permittee must require Runoff Treatment BMPs in accordance with the following thresholds, standards, and requirements to remove pollutants from stormwater runoff.

TDA Thresholds

Each TDA within a project that requires Minimum Requirement #6 (as detailed in Section 3: Applicability of the Minimum Requirements) must be reviewed to determine if Runoff Treatment BMPs are required for the TDA to be in compliance with Minimum Requirement #6.

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

When assessing a TDA against the following thresholds, only consider the types of surfaces (e.g. new hard surfaces, replaced hard surfaces, converted vegetation areas) that are subject to Minimum Requirement #6, per the Project Thresholds in Section 3: Applicability of the Minimum Requirements.

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

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

Runoff Treatment Performance Goal Thresholds

1. Oil Control

Oil Control BMPs are required for areas that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. These types of areas include:

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

2. Phosphorus Treatment

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

- Those waterbodies reported under section 305(b) of the Clean Water Act, and designated as not supporting beneficial uses due to phosphorous or other water quality criteria related to excessive phosphorus;
- Those listed in Washington State's Nonpoint Source Assessment required under section 319(a) of the Clean Water Act due to nutrients.

3. Enhanced Treatment

Enhanced Treatment BMPs are required for the types of project sites listed below that:

a. Discharge directly to fresh waters designated for aquatic life use or that have an existing aquatic life use; or
b. Discharge to conveyance systems that are tributary to fresh waters designated for aquatic life use or that have an existing aquatic life use; or
c. Infiltrate stormwater within ¼ mile of a fresh water designated for aquatic life use or that has an existing aquatic life use.

The types of project sites are:

- Industrial project sites,
- Commercial project sites,
- Multifamily residential project sites, and
- High AADT roads as follows:
    - Within Urban Growth Areas:
        - Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more;
        - All other roads with an AADT of 7,500 or greater.
    - Outside of Urban Growth Areas:
        - Roads with an AADT of 15,000 or greater unless the site discharges to a 4th Strahler order stream or larger;
        - Roads with an AADT of 30,000 or greater if the site discharges to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

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

- Areas that discharge directly, or indirectly through a municipal separate storm sewer system, to a water listed in Appendix III-A: *Basic Treatment Receiving Waters* in the SWMMWW.
- Landscaped areas of industrial, commercial, and multi-family project sites that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals).

- Parking lots of industrial and commercial project sites, dedicated solely to parking of employees' private vehicles that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals).

For TDAs with a mix of land use types, Enhanced Treatment BMPs are required when the runoff from the areas subject to the Enhanced Treatment Performance Goal comprises 50% or more of the total runoff from the TDA.

4. Basic Treatment

Areas that must provide Phosphorus Treatment BMPs or Enhanced Treatment BMPs do NOT have to provide additional Basic Treatment BMPs to meet the Basic Treatment Performance Goal.

If Phosphorus Treatment BMPs or Enhanced Treatment BMPs are not provided, Basic Treatment BMPs are required before discharging runoff off site through either infiltration or surface flow.

For TDAs with a mix of land use types, Basic Treatment BMPs are required when the runoff from the areas subject to the Basic Treatment Performance Goal comprises 50% or more of the total runoff from the TDA.

Runoff Treatment BMP Sizing

Size Runoff Treatment BMPs for the entire area that drains to them, even if some of those areas are not pollution-generating, or were not included in the Project Thresholds decisions (See Section 3: Applicability of the Minimum Requirements) or the TDA Thresholds decisions of this Minimum Requirement.

Runoff Treatment BMPs are sized by using either a volume (the Water Quality Design Volume) or a flow rate (the Water Quality Design Flow Rate), depending on the Runoff Treatment BMP selected. Refer to the selected Runoff Treatment BMP to determine whether the BMP is sized based on a volume or a flow rate. See below for details about the Water Quality Design Volume and the Water Quality Design Flow Rate used to size Runoff Treatment BMPs.

Water Quality Design Volume

The Water Quality Design Volume may be calculated by either of the following methods:

- *Continuous Simulation Method:* Using an approved continuous runoff model, the Water Quality Design Volume shall be the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record.
- *Single Event Hydrograph Method:* The Water Quality Design Volume shall be the volume of runoff predicted by the Natural Resource Conservation Service (NRCS) curve number equations (as detailed in *III-2.3 Single Event Hydrograph Method* in the SWMMWW). The precipitation depth used in the equations shall be as predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm).

Water Quality Design Flow Rate

The Water Quality Design Flow Rate is dependent on the location of the Runoff Treatment BMP relative to Detention BMP(s):

- *Upstream of Detention BMPs or when there are no Detention BMPs:* The Water Quality Design Flow Rate shall be the flow rate at or below which 91% of the total runoff volume, as estimated by an approved continuous runoff model, will be treated.

Ecology has assigned design criteria for Runoff Treatment BMPs to achieve the BMP's Runoff Treatment Performance Goal (e.g., Basic Treatment Performance Goal, Enhanced Treatment Performance Goal, etc.) at the Water Quality Design Flow Rate. At a minimum, 91% of the total runoff volume, as estimated by an approved continuous runoff model, must pass through Runoff Treatment BMP(s) at or below the approved hydraulic loading rate for the BMP(s).

- *Downstream of Detention BMPs:* The Water Quality Design Flow Rate shall be the full 2-year release rate from the Detention BMP.

Runoff Treatment BMP Selection, Design, and Maintenance

Runoff Treatment BMPs shall be:

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

Additional Requirements

The (direct or indirect) discharge of untreated stormwater from pollution-generating hard surfaces to groundwater must not be authorized by the Permittee, except for infiltration or dispersion of runoff through LID BMPs per The List Approach in 4.5 Minimum Requirement #5: On-Site Stormwater Management.

4.7 Minimum Requirement #7: Flow Control

The Permittee must require Flow Control BMPs in accordance with the following thresholds, standards, and requirements to reduce the impacts of stormwater runoff from hard surfaces and land cover conversions.

TDA Exemption

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

- Direct discharge to the exempt receiving water does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types “S”, “F”, or “Np” in the Permanent Water Typing System, or from any category I, II, or III wetland.
- If flow splitters or conveyance elements are applied to route natural runoff volumes from the TDA to any downstream Type 5 stream or category IV wetland, then:
  - Design of the flow splitters or conveyance elements must be based on approved continuous simulation modeling analysis. The design must assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
  - Flow splitters or conveyance elements that deliver flow to category IV wetlands must also be designed using approved continuous simulation modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with

permitting jurisdiction.

- The TDA must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water line of the exempt receiving water.
- The conveyance system between the TDA and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) from contributing areas of the Site, and the existing condition from contributing off-site areas.
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

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

TDA Thresholds

Each TDA within a project that requires Minimum Requirement #7 (as detailed in Section 3. Applicability of the Minimum Requirements) must be reviewed to determine if Flow Control BMPs are required for the TDA to be in compliance with Minimum Requirement #7.

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

When assessing a TDA against the following thresholds, only consider the types of surfaces (e.g. new hard surfaces, replaced hard surfaces, converted vegetation areas) that are subject to Minimum Requirement #7, per the Project Thresholds in Section 3. Applicability of the Minimum Requirements.

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

- TDAs that have a total of 10,000 square feet or more of effective impervious surfaces, or
- TDAs that convert ¾ acres or more of native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture, and from which there is a surface discharge in a natural or man-made conveyance system from the TDA, or
- TDAs that through a combination of effective hard surfaces and converted vegetation areas cause a 0.15 cubic feet per second (cfs) or greater increase in the 100-year flow frequency as estimated using an approved continuous simulation model and 15-minute time steps.

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

Flow Control Performance Standard

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

- Reasonable, historic information is provided that indicates the site was prairie prior to settlement (modeled as pasture in the approved continuous simulation model); or,
- The drainage area of the immediate stream and all subsequent downstream basins have had at least 40% total impervious area (TIA) since 1985. In this case, the pre-developed condition to be matched shall be the existing land cover condition. *Figure I-3.4: Basins with 40% Total Impervious Area as of 1985* in the SWMMWW depicts those areas which meet this criterion. Where basin-specific studies determine a stream channel to be unstable, even though the above criterion is met, the pre-developed condition assumption shall be the "historic" land cover condition, or a land cover condition commensurate with achieving a target flow regime identified by an approved basin study.

Alternative Flow Control Performance Standard

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

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

See the SWMMWW for details on how an Alternative Flow Control Performance Standard may be established.

Additional Requirement

Flow Control BMPs shall be selected in accordance with *III-1.3 Choosing Your Flow Control BMPs*, and designed and maintained in accordance with Volume V of the SWMMWW.

4.8 Minimum Requirement #8: Wetlands Protection

The Permittee must require Stormwater Management BMPs in accordance with the following thresholds, standards, and requirements to reduce the impacts of stormwater runoff to wetlands.

TDA Thresholds

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

Each TDA within a project that requires Minimum Requirement #8 (as detailed in Section 3: Applicability of the Minimum Requirements), must be reviewed to determine what Level(s) of Wetland Protection must be applied to the TDA to comply with Minimum Requirement #8. The Level(s) of Wetland Protection that must be applied are dependent upon:

- The category of wetland that the TDA is discharging to,
- Whether or not the TDA triggers the requirement for Flow Control BMPs per the TDA Thresholds in 4.7 Minimum Requirement #7: Flow Control,
- Whether or not the wetland is a depressional or impounded wetland,
- Whether or not the project proponent has legal access to the wetland,
- The wetland habitat score,
- Whether or not the wetland provides habitat for rare, endangered, threatened, and/or sensitive species, and
- Presence of a breeding population of native amphibians.

Refer to Figure 5: Flow Chart for Determining Wetland Protection Level Requirements, to determine what Level(s) of Wetland Protection must be applied to comply with Minimum Requirement #8.

Levels of Wetland Protection

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

General Protection

General Protection includes general practices that benefit wetlands of all types.

Protection from Pollutants

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

Wetland Hydroperiod Protection

Wetland Hydroperiod Protection includes measures to avoid excessive hydrologic alteration of existing wetlands from development. There are two methods within Wetland Hydroperiod Protection:

- **Method 1: Monitoring and Wetland Stage Modeling**

  This method requires data collection specific to the wetland, as well as continuous simulation modeling to demonstrate that the proposed project will not negatively alter the wetland hydrology.

- **Method 2: Site Discharge Modeling**

  This method requires continuous simulation modeling of the runoff from the TDA to demonstrate that the changes in total discharge volume to the wetland will remain similar to the pre-development condition.

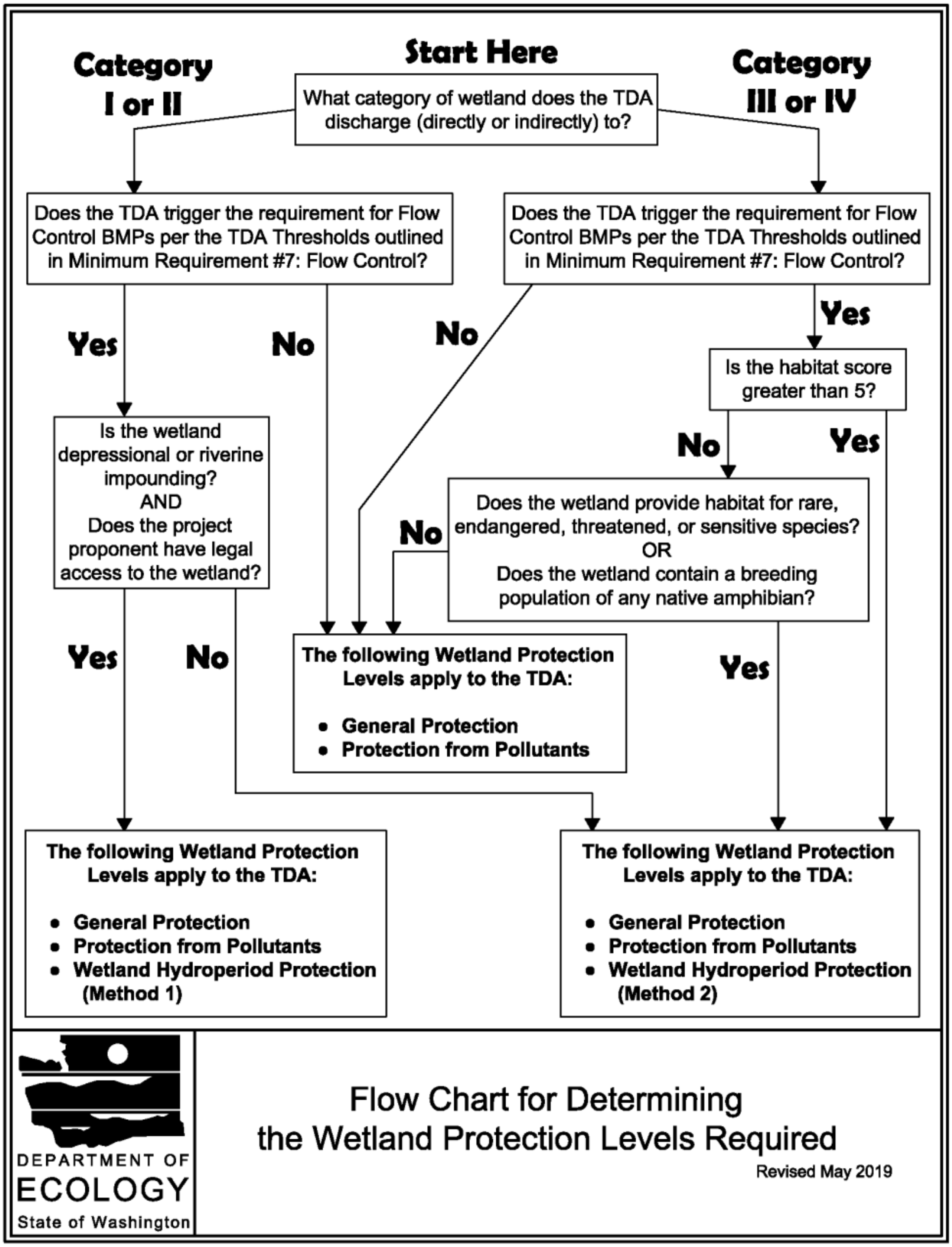
Additional Requirements

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

- Necessary conveyance systems as approved by the Permittee; or

- As allowed in *I-C.6 Compensatory Mitigation of Wetlands* in the SWMMWW.

Figure 5: Flow Chart for Determining Wetland Protection Level Requirements



4.9 Minimum Requirement #9: Operation and Maintenance

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

SECTION 5. ADJUSTMENTS

Adjustments to the Minimum Requirements may be granted by the Permittee provided that written findings of fact are prepared that address the following:

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

SECTION 6. EXCEPTIONS/VARIANCES

Exceptions/variances (exceptions) to the Minimum Requirements may be granted by the Permittee following legal public notice of an application for an exception or variance, legal public notice of the Permittee's decision on the application, and written findings of fact that document the Permittee's determination to grant an exception. Permittees shall keep records, including the written findings of fact, of all local exceptions to the Minimum Requirements.

Project-specific design exceptions based on site-specific conditions do not require prior approval from Ecology. The Permittee must seek prior approval from Ecology for any jurisdiction-wide exception.

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

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

- The feasibility for the owner to alter the project to apply the Minimum Requirements.

In addition, any exception must meet the following criteria:

- The exception will not increase risk to the public health and welfare, nor be injurious to other properties in the vicinity and/or downstream, and to the quality of waters of the state; and
- The exception is the least possible exception that could be granted to comply with the intent of the Minimum Requirements.

SECTION 7. ALTERING THE MINIMUM REQUIREMENTS WITH BASIN PLANS

Basin Plans provide a mechanism by which the Minimum Requirements and implementing BMPs can be evaluated and refined based on an analysis of a basin or watershed. Basin Plans may be used to develop control strategies to address impacts from future development and to correct specific problems whose sources are known or suspected. Basin Plans can be effective at addressing both long-term cumulative impacts of pollutant loads and short-term acute impacts of pollutant concentrations, as well as hydrologic impacts to streams, wetlands, and groundwater resources.

Basin Plans may be used by the Permittee to revise the default standards of the following Minimum Requirements:

- 4.5 Minimum Requirement #5: On-Site Stormwater Management,
- 4.6 Minimum Requirement #6: Runoff Treatment,
- 4.7 Minimum Requirement #7: Flow Control, and/or
- 4.8 Minimum Requirement #8: Wetlands Protection.

In order for a Basin Plan to serve as a means of revising the standards of one or more of the Minimum Requirements listed above, the following conditions must be met:

- The Basin Plan must be formally adopted by all jurisdictions with responsibilities under the plan;
- All ordinances or regulations called for by the Basin Plan must be in effect; and
- The Basin Plan must be reviewed and approved by Ecology.

Basin Plans may also be used to demonstrate an equivalent level of Runoff Treatment, Flow Control, and/or wetland protection through the construction and use of regional stormwater facilities.

Basin Plans will require the use of continuous runoff computer models and field work to verify and support the models. Permittees who are considering the use of Basin Plans to revise the default standards of one or more of the Minimum Requirements are encouraged to contact Ecology early in the planning stage.

Some examples of how Basin Plans can alter the Minimum Requirements are given in within the guidance for each Minimum Requirement in the SWMMWW. See *I-3.4 Minimum Requirements (MRs)* in the SWMMWW.

SURFACE WATER MANAGEMENT

DESIGN AND CONSTRUCTION REQUIREMENTS

APPENDIX B

A Review of Infiltration Standards and Practices in Clark County (SWWASCE Infiltration Standards 2009)

A Review of Infiltration Standards and Practices in Clark County

July 31, 2009

Prepared by

Infiltration Standards Review Committee
Southwest Washington Branch, Oregon Section
American Society of Civil Engineers

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Executive Summary

The Southwest Washington Branch of the American Society of Civil Engineers formed the Infiltration Standards Review Committee in 2005 to review current standards and practices in the design and construction of infiltration facilities in Clark County and the City of Vancouver. The Committee consists of representatives from Clark County, the City of Vancouver, and local engineers and geologists with experience in soil testing and/or the design of infiltration systems.

Particular concerns raised to the Committee included the failures of a handful of infiltration systems around the County. These were located within areas consisting primarily of mixed sands and silts. Because of this correlation, the Committee focused on the testing and evaluation of these soil complexes, though most of the recommendations are applicable in all areas of the County.

This paper contains background information and the Committee's recommendations on the following:

- Infiltration Testing & Reporting of Results
- Design of Infiltration Facilities
- Construction of Infiltration Facilities

Recommendations are based on the best science available and the members' experience with projects in Clark County.

1.0 Introduction

As the urban and suburban areas of Clark County advance north from the gravelly, well-drained soils of Vancouver, development has moved into areas where surface drainages are not immediately available and soils are not as well suited to infiltration as areas in the south and east portions of the City. Several infiltration facilities installed within these areas have failed to perform according to the original design or tested infiltration rate. Generally, these facilities are distributed through a broad area characterized by fine-grained soils (primarily silts and sands). As a result, both Clark County and the City of Vancouver have placed limitations on the design of stormwater infiltration systems in these areas.

The Southwest Washington Branch of the American Society of Civil Engineers (ASCE) was approached by one of its members in the spring of 2004 to review current standards from Clark County and other jurisdictions in the area, to research alternative standards, and to make recommendations for revisions to city and county codes relating to the design of stormwater infiltration facilities. In response, the Infiltration Standards Review Committee was formed. Several members of the engineering community were approached and a group was selected to provide a cross-section of individuals involved in testing and design. A short biography of each member is included as an appendix to this report. Regular meetings began in April of 2005 and continued through August 2007. An initial public review draft of this paper was finalized on August 31, 2007. After receiving and reviewing comments and suggestions, the Review Committee reconvened, updated and revised several text sections, and finalized the paper in July 2009.

This report is intended to summarize the Infiltration Standards Review Committee's findings and recommendations and is structured as follows:

- Section 2 - Background description of the infiltration process
- Section 3 - Factors that affect infiltration processes
- Section 4 - Process for evaluating site soils for infiltration suitability and design rates
- Section 5 - Design of infiltration systems
- Section 6 - Construction of stormwater infiltration systems and protection of those systems during infrastructure and building construction.

2.0 Background

Development processes convert areas covered with native vegetation to impervious areas such as roofs, roads, parking lots, and sidewalks and pervious areas such as landscaping and lawns. All of these areas contribute to increases in the quantity of runoff (both flow rate and the total volume) and limit the ability of stormwater to infiltrate into the soil surface. The effects of this additional runoff are compounded by changes to the hydrology, including reducing the travel time to the receiving waters and increasing the frequency and duration of streamflows (and greater flow velocities). The accompanying reduction in groundwater recharge impacts aquifers and near-surface flows which support dry weather streamflow.

In order to offset the effect that new development has on the natural hydrology, stormwater runoff is collected, detained, treated, and disposed in a controlled manner. One method of stormwater disposal is via infiltration of the water into the native soil subgrade. Common infiltration systems include: drywells, infiltration trenches or galleries, infiltration swales, pervious pavements, and infiltration ponds. There are two basic processes involved in the design of infiltration systems: the pre-design soils evaluation and subsequent sizing and layout of the system. The soils evaluation is typically completed by a geotechnical engineer or geologist and then summarized in a geotechnical or infiltration report. The soils evaluation generally includes site-specific characterization of subsurface soil conditions; estimation of the high groundwater level; and evaluation of the soil's infiltration rate (the speed at which water moves through the soil). The sizing and layout of the infiltration system is then completed by the project civil engineer based upon information provided by the geotechnical/infiltration report, runoff characteristics of the development, design storms, development patterns, etc.

Clark County has a history of failures of stormwater infiltration facilities and these failures are becoming more common, or at least more apparent, as larger and denser developments are constructed within the County limits. The "failure" of an infiltration system generally involves an inability of the facility to dispose of the quantity of water for which it was designed. Major failures may result in the system overflowing and flooding streets and private or public properties.

Failures of infiltration systems are usually the result of poor or improper design and/or construction. Design errors can occur either during the soils evaluation or sizing of the system. The most common errors associated with the soils evaluation include insufficient number of tests, improper or inadequate characterization of the soil's infiltration properties, tests not completed at the actual system location (horizontal or vertical), and underestimation of the high groundwater level, though other factors may also exist. A common error during the sizing of the system is a design that does not size the infiltration facility to store and dispose of runoff from short, intense storms (i.e. "microbursts") which results in temporary flooding that may be significant. Common construction-related problems include poor erosion control that causes excessive sedimentation or clogging, and smearing or compaction of the infiltrative soil subgrade that reduces infiltration rates. Regardless of the cause, these incidents often result in damage to public and private properties and a perception on the public's part that engineers and regulators are not fulfilling their professional obligations.

3.0 Factors That Affect Infiltration

3.1 Soils and Geology

Soil conditions are a frequent contributor to infiltration system underperformance. The majority of Clark County's problem facilities have been concentrated in a region around the northern limits of the City of Vancouver associated with particular soil types resulting from patterns of ancient flood deposition. Most of these "problem" soils consist of layered structures of fine sands and silts; examples of these are Hillsboro, McBee, Gee, and Dollar soils, as classified by the Natural Resource Conservation Service (formerly Soil Conservation Service), and generally shown as the orange area on the map included with this report. While these may be suitable for infiltration via properly designed systems, their fine structure is susceptible to clogging by sediments or migration of fine particles within the native soils and special care should be taken during the design of facilities located in these areas.

The characteristics of soils found in Clark County are shaped by Late Pleistocene age Missoula Flood depositional history. Permeability, among other soil engineering properties, is strongly influenced by the gradation of soils distributed by floods over the low-lying area of the County. As can be noted on the included map, soils are generally distributed in concentric bands or zones of coarse-grained to fine-grained soil from east to west, and south to north across the county. This distribution of soil is a result of the flow velocity and depositional energy associated with the Missoula Floods that inundated the County and surrounding areas several times during the last continental ice age advance about 15,000 to 13,500 years ago.

The glacial floods generally had the highest velocity and highest capacity to transport sediment in the southern and eastern part of the County adjacent to the Columbia River. As the floods inundated the Columbia and Willamette River systems, sediment-laden water spread beyond the river channels to form a broad temporary lake. In this temporary lake, deposition energy dropped, and the finer grained material (i.e. clay, silt, fine sand, and micaceous particles) that remained in suspension spread into the central, northern and western parts of the county beyond the zone of coarser sands and gravels. Here the fine-grained material dropped out of suspension to form broad, thin sedimentary beds that now represent the medium- to fine-textured near-surface soils of the area.

The fine-grained soils are locally interspersed with lenses or layers of medium-grained sand that were deposited under local pulses or surges of glacial flood waters that formed during draining of the temporary glacial lakes. Many of the sand lenses take the form of thin discontinuous sheets or shallow channels that are bedded within the fine-grained soils.

Within the fine-grained deposits, several soil units have been observed to yield occasional field permeability rates that indicate adequate capacity to dispose of concentrated storm water through subsurface infiltration methods. However, it is these medium- to fine-textured soils that have the highest incidence of storm water system failures in the County. In particular, storm water infiltration management systems in some areas of Hillsboro soils have a poor track record of long-term performance. Many of the failures appear to be due to poor construction practices and lack of erosion control methods during construction. Due to their fine texture, these soils are predisposed to caking and sealing of permeable soils as a result of particle migration. However, some storm water infiltration facility failures are probably due to improper understanding of the complexly layered soil and overestimation of bulk soil permeability.

It is generally accepted that the primary challenge of infiltration system evaluation and design in the Hillsboro and other silt and sand loam type soil is characterizing the complexly layered nature of the medium- to fine-textured soils. An inadequate understanding of the three-dimensional distribution of these soils has resulted in some system designs being based on the higher, short-term permeability rates obtained in medium-grained sand lenses, as opposed to the rates obtained in the fine-grained soil mass.

3.2 Sedimentation and Caking

Sediment consists of soil particles that are carried by the stormwater into the system. During heavy flows, sediment can include both coarse- and fine-grained materials. Treatment systems, such as grass-lined biofiltration swales or sedimentation basins are utilized to allow sediment to settle out of the stormwater. However, clay and micaceous fines are particularly problematic in that these small and light-weight soil particles remain suspended in water even after passing through many types of treatment systems. Also, wave action on small bodies of water or heavy flows can re-mobilize fines into suspension. Some of these particles literally float into suspension in initially clear water. Over time, the suspended particles can accumulate as a thin, nearly impervious cake on the prepared bottoms of infiltration systems. Such conditions lead to premature failure of infiltration systems. In extreme cases, system failure can occur over one rainy season. Attempts to rehabilitate the pond bottoms and infiltration systems by excavating the clay and mica-caked soils are rarely successful long-term solutions.

It is difficult to predict the degree of caking or clogging that clay, silt, and micaceous sediment can inflict on an otherwise well-designed storm water infiltration system. The presence of excessive sediment is often the result of poor erosion and sediment control during construction, though can also occur due to lack of maintenance or inadequately designed treatment systems.

3.3 Topography and Grading

Grading, filling, and in some cases excavating, can dramatically impact soil permeability, response to erosion, or susceptibility to caking. In general, installing infiltration systems in graded or filled soils is not acceptable, except in special circumstances. Common design cases where filling is acceptable include placement of washed drain rock in drywell backfill or placement of engineer-approved granular soil to protect pond or infiltration trench bottoms. Generally disturbing, grading, compacting, or tracking of construction equipment across soil intended for infiltration impairs the soil's ability to infiltrate water as intended.

Changes in soil stress from foundations, retaining walls, embankments such as berms or dams, and similar loads placed on soils can reduce soil permeability. If the designer does not consider changes in soil stress and its impact on soil permeability, failure of the system could occur.

The introduction of concentrated water near slopes can reduce stability by initiating subsurface seepage pressure and local reduction of effective stress through saturation of inter-granular space between soil particles. Excessive erosion, soil creep, or other soil slope problems can occur due to introduction of subsurface water. While these concerns may not affect the performance of the infiltration system, they should be considered when planning ponds or siting infiltration systems in proximity to slopes.

3.4 Groundwater

When groundwater levels are too close to the base of an infiltration system, the system can be flooded or groundwater "mounding" may occur. Groundwater mounding is a phenomenon where the groundwater table is locally elevated due to the introduction of water from an external source, such as an infiltration system. Mounding is essentially the opposite of the "drawdown" that occurs adjacent to a well pumping groundwater. Flooding or mounding can significantly reduce or essentially stop infiltration. Mischaracterization of the high groundwater table, the presence of an unidentified groundwater table, or a seasonally perched groundwater level can cause an infiltration system to fail as flooding or mounding occurs.

Seasonal perched groundwater, or evidence of such in the form of mottled, gleyed, or oxidized soil textures likely denotes a site or soil condition not generally appropriate for infiltration of storm water. Exceptions may apply in cases of wetland enhancement or other environmental restoration concepts. Evidence of seasonal perched groundwater can sometimes be nearly imperceptible and can lead to erroneous site characterization. Likewise, in certain pervious soils, seasonally fluctuating static groundwater levels can be misinterpreted during the dry season. Generally, geotechnical infiltration evaluations conducted during the wet season when groundwater should be at its higher elevations have a greater degree of confidence in establishing the actual perched and static groundwater levels that should be considered in the design. Depending on the annual rainfall totals, groundwater levels generally reach their highest elevations in late spring. The lowest groundwater levels are often recorded from September to November.

3.5 Testing and Reporting

Testing and reporting practices vary widely depending upon individual consultants and design professionals. Some test methods currently in use may not be appropriate for the type of facility proposed or the soils present in certain areas of concern. The lack of a standardized testing and reporting method creates difficulty for the reviewing agency and compromises the reproducibility, comparison, and evaluation processes. Recommendations for testing practice and reporting requirements are discussed later in this document.

3.6 Development Patterns and other Factors

Topographic, development and regulatory pressures contribute to the placement of infiltration facilities in this region. As the City of Vancouver's Urban Growth Boundary and the semi-urban development within Clark County continue to expand, increased development and density are required to meet Growth Management Act targets and limit urban sprawl. This results in more concentrated development with higher impervious surface coverage (roofs, roads, driveways, etc.) and leads to increased runoff from developed sites. Intensive development increases the detention volume required to offset the increased runoff rates while simultaneously reducing the area available for the placement of such detention facilities.

Many of the development sites within this region have traditionally been semi-rural; frequently, these sites are isolated from surface streams which might otherwise accept stormwater discharges from development. This isolation may be due to topography or intervening undeveloped properties. Storm sewers are also not available in these previously undeveloped areas. In order to avoid increasing the rate of runoff or concentrating runoff onto adjoining properties where no stream or drainage path exists, infiltration is sometimes the only alternative for the disposal of stormwater. However, many of these semi-rural areas are located in regions with fine-grained soils which, as previously discussed, have low infiltration rates and are susceptible to failure.

As its benefits (flow control, temperature reduction, groundwater recharge, etc.) in the natural environment become better understood, an increasing emphasis on infiltration is being incorporated into stormwater management guidance documents such as the 2005 Stormwater Management Manual for Western Washington. Infiltration is listed as the preferred method for the disposal of stormwater runoff where feasible. More stringent water quality standards implemented in response to the EPA Storm Water Phase II rules are also likely to encourage the use of infiltration or soil contact for temperature control and pollutant removal.

Increased development density to meet growth management goals can also result in potential conflicts with infiltration system location. As the most readily usable land is more densely developed, the area available for locating stormwater infiltration facilities is reduced. Those facilities must then be installed closer to areas which can be damaged by groundwater, such as foundations, potentially unstable slopes, or road subgrades. Increasing the number of infiltration facilities without proper protection also increases the risk of groundwater contamination due to pollutants entering runoff from human activities. These potential risks increase the complexity of the analysis and design required before these facilities are constructed.

In combination, these pressures result in the installation of infiltration systems in less-than-ideal conditions. Throughout the remainder of this report, specific recommendations relating to suitable soil identification, infiltration rate testing, design assumptions and procedures, and construction will be made to more uniformly ensure that installed systems continue to function over the life of the facilities.

4.0 Soils Evaluation

Proper evaluation of soils is critical to placement of infiltration facilities in marginal conditions. The soils evaluation process can be separated into the following two primary components: (1) field testing by an accurate and verifiable test method, and (2) presentation of results in a standardized reporting format. These components are discussed in the following text.

4.1 Field Test Method

Adequate understanding of the infiltration test method process requires discussion of the following items:

- definition of applicable standard terms,
- description of current infiltration testing methods,
- explanation of differences between infiltration and percolation,
- definition of a recommended infiltration test method,
- discussion of alternative test methods, and
- identification of specialized testing for unique sites.

These items are presented below.

4.1.1 Definition of Terms

Several of the most relevant terms used in the soil infiltration mechanistic and testing processes are defined below (Oram, 2005, Ferguson, 1994):

Infiltration – The one-dimensional (usually downward) entry of water into the immediate soil surface.

Infiltration Rate – The rate at which water penetrates the soil surface, expressed as velocity. It is a one-dimensional volume flux of water flowing into a two-dimensional soil surface area. The infiltration rate is constrained by the capacity of the soil and the rate at which water is applied to the surface. The infiltration rate of a given soil varies under saturated and unsaturated conditions. Because storm water management design must consider long-term conditions, the saturated infiltration rate is of primary interest to engineering professionals. Under saturated soil conditions, the infiltration rate is essentially equivalent to the soil coefficient of permeability, defined below. In this document, the term "infiltration rate", as defined by the measured and calculated coefficient of permeability, refers specifically to the assumed rate at which water will infiltrate vertically into a saturated soil.

Allowable Design Infiltration Rate – The final infiltration rate used by design engineers to size infiltration systems. It is calculated by applying correction factors to the infiltration rate defined above to compensate for soil variation, long-term system degradation, and other factors.

Percolation – The simultaneous three-dimensional vertical and lateral movement of water through soil by gravity.

Drawdown Rate – The direct raw field measurement of the rate of water drop during a given in situ infiltration test, expressed as velocity.

Coefficient of Permeability (also called Hydraulic Conductivity) – A quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient, expressed as velocity. As described later, the coefficient of permeability is calculated based upon the observed drawdown rate and configuration of the infiltration test apparatus. The coefficient of permeability commonly varies in the horizontal and vertical directions. Due to the effects of gravity, the vertical coefficient of permeability is the primary component of interest in the soil infiltration process. As described above, the saturated vertical soil coefficient of permeability may be assumed to equal the soil infiltration rate. Therefore, when discussing saturated vertical flow conditions in this document, the terms "coefficient of permeability" and "infiltration rate" are equal. The calculated coefficient of permeability is the infiltration rate. These terms should not be confused with the drawdown rate previously defined.

4.1.2 Description of Current Infiltration Testing Methods

Several different test methods are currently used to estimate local soil infiltration rates:

Surface Water Design Manual (King County, 1990)

The "King County Method" (or a modified version) uses a water-filled, 48-inch-long standpipe embedded six inches into the soil. King County abandoned this method shortly after adopting it in their 1990 Surface Water Design Manual, but it is still used by many jurisdictions and practitioners.

Falling Head Methods (EPA, 1980)

Modified falling head methods (based on 1980 EPA Falling Head Percolation Test method) are conducted through pipes of various lengths and diameters placed in pits excavated by a backhoe or through the casing of a hollow-stem auger boring rig. These tests are easy to conduct but can produce significantly varying test results depending on the standpipe length and test apparatus configuration.

Double-Ring Infiltrometer (EPA, 1997)

The double-ring infiltrometer method (EPA/600) uses an instrumented double-ring configuration to confine an inner plume of infiltrating water in a one-dimensional vertical direction. The double-ring infiltrometer test is typically used for soils with very low infiltration rates. The test is time-consuming, expensive, and can be subject to considerable error if installed incorrectly.

Stormwater Management Manual for Western Washington (DOE, 2005)

The Stormwater Management Manual for Western Washington (2005) [the Manual] has been adopted by many agencies for use in the design of stormwater treatment and disposal systems. Section 3.3.6 of the Manual discusses three methods for estimating infiltration rates for design of infiltration facilities:

- USDA Soil Textural Classification
- ASTM Gradation Testing at Full Scale Infiltration Facilities
- In-situ Infiltration Measurements

The first two methods consist of correlations between material gradations and long-term infiltration. However, the data used to develop these correlations were primarily based upon field data associated with infiltration ponds in the Puget Sound area. The use of infiltration ponds is unusual in Clark County, and the infiltration rate correlations are likely to be highly conservative for the more commonly used infiltration trenches and galleries.

For in-situ infiltration measurements, the Manual recommends use of a Pilot Infiltration Test (PIT Method). The PIT method uses a large open pit or trench flooded with a large volume of water over an extended period of time. This method may be assumed to provide fairly accurate infiltration rate estimates, but it is costly, time-consuming, and not practicable for many difficult-to-access sites. Safety concerns and the necessary disturbance of the PIT Method often also combine to prohibit its regular use.

The Manual also indicates that small-scale field tests, such as falling head or double-ring infiltrometer tests "are not recommended unless modified versions are determined to be acceptable by Ecology or the local jurisdiction" (DOE, 2005). The recommended procedure outlined in this section of this report is meant to provide an acceptable modified test method that is practical, cost-effective, and produces a reasonable estimate of soil infiltration rates.

4.1.3 Differences between Infiltration and Percolation

It is important that infiltration systems be designed based upon the soil *infiltration* rate and not the *percolation* rate. There are several important differences between infiltration and percolation. Percolation flow is multi-dimensional whereas infiltration is one-dimensional. Percolation is typically of interest to designers and practitioners under short-term, non-steady-state, unsaturated conditions. Infiltration is relevant for long-term, steady-state, saturated flow environments. Percolation rates are often used for unsaturated flow applications such as residential septic wastewater disposal trenches where flow volumes are limited and short-term. Infiltration is more representative of high volume, long-term subsurface injection of concentrated storm water. Percolation rates are not directly correlated to, or a component of, saturated flow equations (Oram, 2005). Percolation tests do not directly measure the coefficient of permeability or infiltration rate. Comparison tests have indicated that percolation tests may over-estimate the infiltration rate by 40 percent to more than 1,000 percent (Oram, 2005).

4.1.4 Alternative Infiltration Test Method

A successful estimation of the soil infiltration rate, indicated by the coefficient of permeability, depends upon a precise and accurate infiltration test method. An appropriate test method should:

- Be consistent, dependable, reviewable, and reproducible;
- Restrict flow to the vertical dimension;
- Prevent leaking or piping;
- Include an appropriate pre-soak phase to ensure saturated flow conditions;
- Be applicable and useful for Clark County soils;
- Have easily and accurately obtainable test measurements, parameters, and equation inputs; and
- Allow for precise and clear calculation of the coefficient of permeability.

For practical purposes, the test method would also have the following desirable characteristics:

- Not excessively difficult to install or operate; and
- Not excessively burdensome, time-consuming, or costly;

Infiltration testing can be conducted under steady-state (constant head) or non-steady-state (falling head) conditions. Constant head tests are often performed in a controlled laboratory environment, whereas falling head tests are usually conducted in the field. Either method is acceptable provided saturated conditions are maintained.

Finally, infiltration tests can also be performed with single-ring or double-ring devices. While there remains some dispute in the geotechnical community regarding the efficacy and accuracy of single-ring tests when compared to double-ring tests, if installed correctly, single-ring tests can provide reasonable soil coefficient of permeability estimates (Oram, 2005). Because single-ring test apparatus tend to be less complex and easier to install, many experienced professionals prefer some version of the single-ring test. Therefore, a modified single-ring falling-head infiltration method that meets the above requirements is defined in the following section.

Presentation of the mechanisms and processes of infiltration, discussion of the differences and significances of falling head/constant head and single-ring/double-ring tests, and mathematical derivation of the test method equations are provided in Appendix A.

Alternative Single-Ring Falling-Head Infiltration Test Procedure

1. Test Frequency and Location. Conduct one or more infiltration tests at each proposed infiltration location for ponds, subsurface galleries, reservoirs, or drainage trenches; or conduct one infiltration test for each proposed drywell location. Ideally, tests are conducted at the proposed depth and location of the final system, however, future system locations are often not known or accessible during the field testing. Therefore, as a minimum the tests should be conducted in the general vicinity of the future system and in soil conditions similar to those into which the infiltration system will discharge. The geotechnical engineer/geologist should determine the actual number of tests based upon the variability of subsurface soil and groundwater conditions, and degree of certainty related to the future location of the infiltration system(s).

2. Soil Classification and Testing. Qualified personnel should prepare a detailed soil log of the test pit or test exploration area in accordance with USCS specifications. Collect representative soil samples from the test location. Classify the soil according to ASTM D2487 and D2488 procedures. Perform appropriate laboratory testing (typically grain size distribution tests) as needed to verify soil classification.

3. Test Procedure. The test procedure is based in large part upon mathematical equations derived from Darcy's Law for saturated flow in homogeneous isotropic media. The mathematical derivations, presented in detail in Appendix A, conclude with the following equation for determining the soil coefficient of permeability [the equation is designated "equation (3)" in Appendix A; for simplicity of reporting, the same notation will be used here]:

$$k = \frac{L}{t} \ln \frac{h_1}{h_2} \qquad (3)$$

where

k = coefficient of permeability (in/hr)

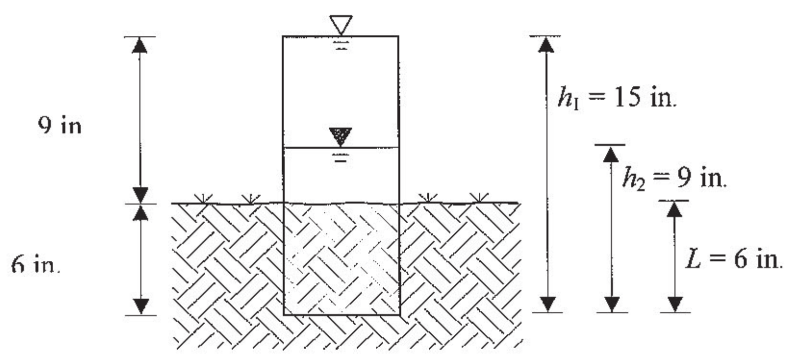
L = length of flow through the soil specimen in the pipe (in)

t = time (hr)

h_1 = initial head (in)

h_2 = final head (in)

The recommended test configuration and procedure described below has been developed using equation (3) so that the observed drawdown rate can be divided in half to achieve the approximate coefficient of permeability. However, different test configurations can be used to fit varying site conditions or test depths. In all cases, the coefficient of permeability should be calculated using equation (3) and the principles outlined in the following procedure. The test configuration and relevant parameters are shown below:



The infiltration test procedure should begin by embedding a 6-inch-diameter, 15-inch-long, rigid standpipe 6 inches (L, as noted in equation [3] and the above figure) into the ground at the depth and location of the proposed test. The standpipe should be as thin-walled as practicable, and the pipe should be carefully pressed or inserted vertically into the soil. Saturate or pre-soak the soil by maintaining measurable water in the standpipe for at least four hours. A four-hour pre-soak phase is assumed to allow adequate soil saturation to properly measure and calculate the coefficient of permeability. This should be verified by ensuring that the cumulative water drop in inches during the saturation period exceeds the standpipe embedment depth (L).

After the saturation period, fill the pipe to the top (i.e., the pipe will contain a 9-inch vertical column of free water). [Note that although the tube contains 9 inches of water, the initial system head (h_1) is 15 inches because head is measured from the top of the free water surface to the bottom of the soil specimen inside the pipe.] Perform as many repeated 6-inch drawdown trials as can be completed in a 1-hour time period (i.e., allow the water in the tube to drop from 15 to 9 inches [h_1 to h_2], and then repeat the process). Conclude the field test and record the following parameters: field observed drawdown rate, L, t, h_1, and h_2.

If the water level does not drop 6 inches in a 1-hour time period, the test can be concluded after one hour by recording the drawdown rate as the drop over the 1-hour time period. The applicable test parameters (L, t, h_1, and h_2) should also be recorded. In this case, h_2 would equal h_1 minus the amount of water drop observed over the 1-hr time period.

If desired, 6-inch drawdown trials may be performed during the saturation period. If 3 consecutive 6-inch drawdown trials indicate the rate has stabilized to within 5 percent variation between all 3 trials, the test may be concluded and the average rate of the three tests may be recorded as the drawdown rate. The applicable test parameters should also be recorded.

4. Explore below the Test Depth. Explore at least six feet below the test depth (typically the proposed facility base elevation) or deeper if site conditions or the proposed facility design warrant.. Record the presence or absence of heavy mottling, groundwater, confining clay/silt layers or bedrock that could impede vertical gradient and ability to infiltrate. If such conditions are present, the geotechnical engineer/geologist should consider greater depths of exploration. Additionally, if the proposed system has a depth of influence greater than six feet, such as the case for wide systems, then greater depths of exploration may be required (as discussed below). Representative soil samples should be collected from below the test depth. Classify the soils and conduct laboratory testing as described in Item 2 above.

5. Groundwater. Note the depth to and elevation of the groundwater table, seeps, or perched water. Also, identify signs of seasonal groundwater tables, such as mottled, gleyed, or oxidized soil textures.

   If the seasonal high groundwater elevation is not clearly identifiable through direct ofservation of water levels, interpretation of soil characteristics (e.g. mottling, etc.), review of local well logs or the *Southwest Clark County Generalized Water Table Altitude and Depth to Groundwater Mapping* (Clark County GIS, September 2005), or if the consequences of infiltration system failure are high, then piezometers should be installed to monitor groundwater elevations through at least one wet season prior to design of the permanent stormwater facilities. The placement and number of piezometers shall be recommended by the geotechnical professional in concert with the civil engineer. This determination shall be based on site characteristics and concerns, including:

   - Coefficient of permeability (measured or estimated);
   - Structure of proposed facility (pond/pipe gallery vs. drywell or single trench);
   - Anticipated depth to groundwater;
   - Potential risk due to facility failure;
   - Anticipated size of drainage catchment or runoff volume;
   - Proximity to wetlands or other topographic features; and
   - Surrounding topography (such as the lack of an overflow path).

   If the vertical distance to the groundwater table is less than fifteen feet from the stormwater facility base and piezometers are not installed, the geotechnical professional shall provide discussion in the Infiltration Investigation Report (as outlined in section 4.2 below) explaining the rationale for not installing piezometers.

6. Groundwater Mounding Analysis. Groundwater mounding analysis shall be completed if deemed appropriate by the geotechnical professional or civil engineer. Particular attention to mounding should be paid to systems where the base of the facility is wider than the system is deep (e.g. infiltration ponds or galleries, or a series of parallel, closely-spaced trenches). We recommend the following guidelines be utilized to help determine whether or not a mounding analysis is warranted:
   a. If groundwater depth is less than five feet below the base of the facility, a mounding analysis is required by the Underground Injection Control (UIC) Rules.
   b. If groundwater depth is between five and fifteen feet, evaluate the proposed system performance considering the factors listed in 5. Above. If a decision is made not to perform a mounding analysis, provide discussion in the Infiltration Investigation Report (as outlined in section 4.2 below) explaining the rationale for not conducting the analysis.
   c. If groundwater is greater than fifteen feet, a mounding analysis will generally only be required for wide systems, low permeability soils or other unusual site conditions or facility design parameters..

   If a mounding analysis is warranted, the appropriate mounding analysis method shall be selected using the same factors to determine the depth of study required. Potential modeling methods include Hantush, numerous commercially available programs (e.g. MODFLOW, MODRET SEEP/W), and a number of other analytical methods.

7. Calculate the Coefficient of Permeability. After the field test procedure has been performed and the relevant test parameters recorded, the coefficient of permeability should be calculated using equation (3). As described previously, the coefficient of permeability obtained from equation (3) is the approximate rate at which water can be expected to infiltrate vertically into a given soil surface under long-term saturated flow conditions. This value should be reported by the geotechnical engineer/geologist as the soil coefficient of permeability for the tested location.

8. Test Limitations. It should be noted that coefficient of permeability calculations identified above are based upon ideal homogenous isotropic media. Because Clark County soils are often fluvially deposited, stratified, and interbedded, they are frequently neither homogenous nor isotropic. This may result in permeability coefficients that vary with depth and direction. Groundwater mounding or an elevated seasonal groundwater table may also affect the infiltration rate. In rare cases, the soil's ability to infiltrate water may be determined by its horizontal rather than vertical coefficient of permeability. The design professional should verify whether these are reasonable assumptions to allow for an approximate estimate of the soil coefficient of permeability. If not, then specialized testing or analysis may be required.

   Because infiltration systems can be expected to undergo long-term degradation of infiltration capacity as a result of siltation, debris collection, and soil crusting, the unfactored calculated coefficient of permeability should not be used in the design of infiltration systems. Correction factors as discussed later in this document should be applied to the calculated coefficient of permeability to determine the allowable design infiltration rate.

9. Modification to the Suggested Test Method. The suggested test configuration described above has been strategically designed to produce an observed drawdown rate that is

approximately twice the coefficient of permeability. This is due to careful selection of the test configuration and geometry and may provide the benefit of simplicity and standardization. It is important to note that the coefficient of permeability will equal approximately half the observed drawdown rate only when full 6-inch drawdown trials are conducted and the relevant test parameters equal those indicated in the standpipe schematic shown under Item 3 of the test procedure section. However, the test configuration, standpipe length, embedment depth, etc. can be modified as desired by an experienced geotechnical professional, provided equation (3) is used to calculate the coefficient of permeability. This provides the professional consultant with flexibility to modify or tailor the test configuration based upon site-specific conditions. When modifying the test configuration or procedure, the consultant should consider the following implications of various modifications:

- Standpipe diameters smaller than six inches may be adversely affected by the presence of large gravels or cobbles.
- Standpipe embedments of less than six inches in some granular soils may result in an inadequate seal around the pipe, and subsequent seepage around the pipe tip, which may result in overestimate of the coefficient of permeability.
- Excessive head in the standpipe may result in overestimate of the coefficient of permeability. It is recommended that the head be limited to one-half the height of the anticipated water depth in the proposed infiltration system (e.g. a field test for a pond with a maximum retained water depth of 3 feet should have a maximum head of 1.5 feet).

4.1.5 Borehole Test Method

While the falling head method described above is a locally appropriate alternative method for infiltration testing, in some environments it is neither feasible nor practical. Examples of such environments may include cohesionless soils where open test pits pose a collapse hazard, systems at depths deeper than the reach of standard construction excavation equipment, or developed sites with existing asphalt or concrete pavements. In such situations infiltration testing is often conducted in exploratory hollow-stem auger boreholes by geotechnical engineers and geologists. Auger borehole infiltration testing is an acceptable alternative to the suggested method, provided the test method and calculation of the coefficient of permeability follow the procedure recommended below.

Alternative Auger Borehole Falling-Head Infiltration Test Procedure

1. Test Frequency and Location. Follow the recommendations identified above for the suggested standard method.

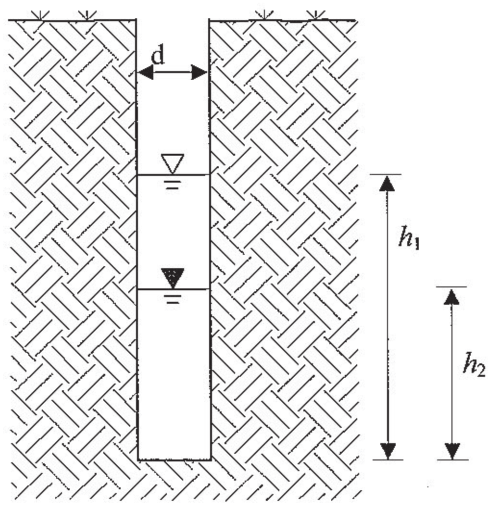
2. Soil Classification and Testing. Follow the recommendations identified above for the suggested standard method.

3. Test Procedure. Advance an auger borehole to the desired elevation of the infiltration test. The auger method must be hollow-stem or the boring must be cased to prevent lateral leakage. Sample subsurface soils at depth to confirm that appropriately granular soils are present at or below the auger tip. Log the boring in accordance with USCS specifications and collect a soil sample from the zone at which the infiltration test is performed. Classify soil as described in item (2) above.

As the tip of the auger reaches the test zone, apply down pressure to the drill pipe and advance the auger slightly into the soil to form a seal. Withdraw the inner plug and rod from the hollow stem auger to expose the test zone soil inside the auger. Measure and record the inner auger diameter (d). Pour water into the standpipe or auger and saturate the soils, as described previously.

After the pre-soak period, establish an initial head of water in the auger (h_1). Depending upon the soil gradation, range of expected infiltration rates, and proposed depth of retained water in the future infiltration system the head level may vary based upon the geotechnical professional's recommendations. However, an initial head in excess of four feet or greater than the future depth of retained water in the system is not recommended. Also, water levels should not rise above joints between auger sections, so that water does not leak out of the joints and skew drawdown readings.

Begin conducting the infiltration test by recording the time (t) required for the head in the auger to drop from the initial head (h_1) to the final head (h_2). Refill the standpipe or auger and conduct multiple test runs until relatively constant rates are achieved (less than 5 percent variation between 3 consecutive trials). An electric water level probe, indicator rod with pegs set at a six inch interval, or a float and tape may be used to aid in accurately measuring drop in head over elapsed time. The auger borehole test configuration and relevant parameters are indicated below:



After relatively constant drawdown rates are observed as described above, the final test parameters are recorded (d, h_1, h_2, and t).

4. Explore below the Test Depth. Follow the recommendations identified above for the suggested standard method.

5. Groundwater. Record groundwater observations in accordance with the recommendations identified above for the suggested standard method.

6. Groundwater Mounding Analysis. Conduct groundwater mounding analysis as described above for the suggested standard method.

7. Calculate the Coefficient of Permeability. After the field test procedure has been performed and the relevant test parameters recorded, the coefficient of permeability should be calculated using equation (4) (Lambe and Whitman, 1969). Equation (4) applies only for coefficient of permeability calculations using the auger borehole method. The value obtained from equation (4) should be reported by the geotechnical professional as the soil coefficient of permeability for the tested location.

$$k = \frac{\pi \cdot d}{11t} \ln \frac{h_1}{h_2} \tag{4}$$

where

k	=	coefficient of permeability (in/hr)
d	=	diameter of borehole (in)
t	=	time (hr)
h_1	=	initial head (in)
h_2	=	final head (in)

8. Test Limitations. The test limitations described above for the suggested standard method also apply to the auger borehole method. In addition, the borehole method assumes flush soil at the bottom of the auger and groundwater levels sufficiently below the depth of the test. Soil swelling, segregation, or consolidation are assumed to be negligible. Hydraulic loss in the auger is also assumed to be negligible. Furthermore, proper performance of this test method requires a tight seal at the base of the borehole, so that lateral flow or upwards "piping" of water does not occur. This method also assumes homogenous soils with directional isotropy (i.e., the horizontal and vertical coefficients of permeability are constant and equal). The design professional should verify whether these are reasonable assumptions to allow for an approximate estimate of the soil coefficient of permeability. If not, then specialized testing or analysis may be required.

   Due to the higher potential for inaccurate field test results (e.g. lateral seepage or upward piping, etc.) from the borehole method, we suggest a minimum Soil Correction Factor (as discussed in Sections 4.2 and 5.7) of 2 be applied to the resulting coefficient of permeability.

4.1.6 Specialized Testing for Unique Sites

Unique sites, such as those with very low or highly variable infiltration rates or shallow groundwater, may require specialized testing procedures and methods of analysis (such as pump tests or mounding analyses). In these cases, this specialized work should be based upon a plan and assessment agreed upon by the applicant and the local regulatory authority.

This paper was prepared to primarily address the design and evaluation of infiltration systems that discharge into relatively fine-grained materials which have demonstrated problems in the past. As previously mentioned, eastern Clark County has coarse-grained soil deposits (primarily sand with variable amounts of gravel and cobbles) which readily infiltrate. Failures of infiltration systems in these materials are rare. Unfortunately, characterization of infiltration properties into these coarse-grained soils is difficult to complete utilizing the single-ring falling-head infiltration test procedure described herein. Furthermore, the grain size distribution correlations in the Manual are often highly conservative for these granular materials.

A relatively common local test methodology for granular soils is to observe the percolation rate (e.g. multi-dimensional flow) via open test pit draw-down measurements. The results obtained from such readings should not be construed as a measurement of hydraulic conductivity, permeability, or infiltration rate, as defined in this paper. Section 4.1.3 of this paper discusses the differences between percolation and infiltration rates and the wide variations which can result between the two. When conducting open test pit draw-down measurements in coarse-grained soils with high draw-down rates, the geotechnical professional should to the extent possible follow the Manual guidelines for the PIT methodology. When access, safety, economic, or water supply considerations do not allow for a full-scale PIT test, the geotechnical professional should clearly outline the test methodology utilized and provide appropriate Soils Correction Factor to account for the variations in the measurements from the standard test methodologies outlined herein or in the Manual. We suggest a minimum Soils Correction Factor (as discussed in Sections 4.2 and 6.7) of 5 be applied when utilizing this method, though depending upon site conditions other values may be appropriate.

4.2 Infiltration Investigation Report

As described previously, an important component of developing an appropriate soils evaluation and infiltration testing process involves defining a standardized method of reporting the investigation and testing results. A comprehensive standard report format would assist the reviewing regulatory agency in understanding and confirming the test results, and likely lead to improved storm water management facility performance and reduced likelihood of system failure. The following text presents recommended content for a standard infiltration investigation report.

1. Introduction and Purpose – Provide a project introduction and describe the purpose and scope of the investigation.

2. Site Location, and Site Description – Provide a description of the site and location. Describe physical characteristics (e.g., existing improvements, topography, drainage patterns, signs of past grading, etc.) and visual observations.

3. Site Soil Conditions – Describe the soil conditions at the site. Reference Soil Survey of Clark County, Washington (United States Department of Agriculture, Soil Conservation Service [USDA SCS], November 1972) to determine USDA soil types present at the site. Briefly describe relevant characteristics, including permeability and available water capacity, of any soil type present at the site.

4. Regional Geology – Briefly discuss geology at the site and in the vicinity. Reference Geologic Map of the Vancouver Quadrangle, Washington and Oregon (Washington Division of Geology and Earth Resources, Open File Report 87-10, Revised November 1987) or other local geologic maps or references to determine the geologic units present at the site.

5. Groundwater – Describe local and regional groundwater conditions. Reference water well logs, other geotechnical reports, and published geologic or hydrogeologic maps that cover the

site vicinity. Described surface and subsurface water observed at the site. Provide an estimate of the seasonal high groundwater table elevation.

6. Field Exploration Activities – Discuss the field portion of the investigation, including the number of infiltration tests performed and any additional explorations performed during the investigation. Describe soil layers encountered and the characteristics of each layer. Describe spatial variability (both lateral and vertical) of soil conditions and any potential effects of such variability on the performance of infiltration systems. Indicate the maximum depth of exploration and depth to groundwater, if encountered, for each exploration.

7. Infiltration Analysis/Test Method Description – Describe the method of infiltration analysis. Include the test depth, test geometry, the duration of the saturation period, and the number of trials performed at each infiltration test location. Discuss any deviations from the methods described in this paper. Note any anomalies in the test procedure or results.

8. Results, Recommendations, and Conclusions – The results of the infiltration investigation should be clearly presented. The results section should include (preferably in tabular form) the test location, test depth (and elevation, if available), measured drawdown rate, calculated coefficient of permeability, test location, depth to groundwater (if encountered), total depth explored, and USCS soil classifications for each test location.

The report should include a discussion of site conditions that may influence installation or long-term performance of the proposed infiltration system(s) and provide necessary recommendations for design and construction. The report should clearly denote the recommended unfactored coefficient of permeability for use in the design of the proposed infiltration system. If different rates are to be used at different portions of the site, the areas should be clearly delineated on the site plan. The estimated seasonal high groundwater elevation at each proposed infiltration system location should be provided. The geotechnical professional should indicate if supplemental monitoring or exploration are required during the wet season to verify groundwater elevation estimates, or if groundwater mounding is a relevant design consideration.

As discussed later in Section 5.7 of this report, a base correction factor of 2 is initially applied to the recommended unfactored infiltration rate (coefficient of permeability) to account for basic soil variability, sedimentation potential, facility design features, etc. The geotechnical professional shall provide a recommendation for a Soils Correction Factor. If high quality field testing procedures were followed, uniform test results were obtained, and uniform site conditions are present, this value may be zero (0). However, if unusual circumstances, such as highly variable soil conditions, indeterminate groundwater elevation, layered soils, etc., are present, the geotechnical professional should provide an appropriate Soils Correction Factor based upon the geotechnical professional's expertise, local experience, and site knowledge to be applied to the unfactored infiltration rate. As previously mentioned, we suggest minimum Soils Correction Factors of 2 and 5 be used for the borehole and open test pit methods, respectively.

9. Figures – Provide a general area map indicating the location of the subject site in relation to surrounding area. Include a site plan indicating the subject site boundaries and the locations of all infiltration tests and other explorations. The site plan should include topographic contours in minimum 2-foot increments if available. If site-specific topographic surveys are not available, then the contour data available from the Clark County GIS department should be utilized. If available, include the development plan for reference.

10. Exploration Logs with USCS/ASTM Soil Classifications – Include a log for each exploration excavated at the site. Logs should include elevation of explorations, classifications,

and descriptions of all soil layers encountered at the site. The maximum depth of each exploration should be indicated along with depth(s) to groundwater or groundwater seeps, if encountered. Infiltration test results should be indicated on the corresponding exploration log at the depth the test was performed.

11. Laboratory Test Reports – Provide laboratory analytical reports for each sample submitted for analysis.

5.0 Design of Infiltration Systems

5.1 Selection of Design Storm

5.1.1 Background

Drainage facilities are designed to prevent excessive accumulations of water and to minimize property damage and other adverse impacts to traffic, utility service, and the health, safety and welfare of the public. However, it is not possible to eliminate all risk of flooding and it is seldom economically justifiable to do so. The selection of the design storm involves balancing the cost of the constructed facilities with the risk factors associated with flooding. The risk of flooding is usually expressed as a flood frequency, a statistical measure of likelihood of a flood of a given magnitude occurring within any given year. For example, the "100-year storm" is a potential storm event which has a 1% chance of occurring in any year. Currently, most jurisdictions in Clark County require that infiltration systems be designed to limit flooding during the 100-year, 24-hour storm.

In order to properly size drainage facilities, engineers and hydrologists have developed predictive models to estimate the amount of water that will run onto or off of a site for storms of varying storm frequencies. This is generally done by simulating the effect of an idealized "design storm" as it falls over a watershed characterized by its size and soil/cover condition. More rainfall will run off of highly urbanized areas, where a large percentage of the land is covered by pavement, roofs and other hard surfaces, than will run off of an area of equal size covered with trees, grasses, or permeable soils such as sands and gravels. The predictive hydrologic models used to estimate peak stormwater flows can be broadly classified into two categories: single event rainfall models and continuous flow models.

5.1.2 Single Event Rainfall Models

In single event rainfall models, such as the Rational Method, SCS TR-20, and the Santa Barbara Unit Hydrograph (SBUH), the peak flow rate used to design stormwater management facilities is estimated to be the maximum rainfall runoff produced by a single "design storm." These values are developed by the statistical analysis of recorded rainfall gathered by the National Weather Service and others, which are published and available to the design community. These values are typically presented in the form of an isopluvial map, on which varying amounts of rainfall are shown superimposed over a map for a given storm frequency. As required by County Code and City Ordinance, the majority of infiltration designs in Clark County and the City of Vancouver are based upon a 100-year, 24-hour design storm. Designers use rainfall depths found from isopluvial maps which are available from the County's Community Development Department. This design storm is used for the most common condition, where the facility is located in a drainage basin which has an overflow route to a stream, ditch, or pipe system. If the system has an overflow, the applicant's engineer reviews the overflow system being utilized to ensure that the additional drainage will not have an adverse impact to downstream property owners.

Some portions of the County are located in closed depressions, where there is not a route for high flows to leave the basin. This condition presents a higher risk of flooding and a more conservative design storm is used for the design of infiltration systems. The risk of flooding is more dependent on volume rather than flow, and the 100-year, 7-day design storm is typically used. In the closed depression analysis, the size and connectivity of the basin to other depressions and low spots in the local area must be considered.

5.1.3 Continuous Event Rainfall Models

In these types of hydrologic models, the response of a given watershed is modeled using long-term rainfall records directly. It is thought that this method will more accurately reflect the actual hydrologic conditions of the site and will more accurately predict flows and their impacts before and after development. This modeling philosophy forms the basis of the Western Washington Hydrologic Model, which is anticipated to form the basis of future revisions to Clark County design standards. In this method, there is no "design storm," but drainage facilities are sized by a statistical analysis of the modeled results.

5.2 Location of Stormwater Infiltration Facilities

Placement of stormwater infiltration systems is often critical to site success. First, locating the facility near the soils with the best coefficient of permeability results in the most economical system for the project. This is balanced against the desired site development pattern. Placement of infiltration systems near foundations, deep utilities, slopes, or in areas where pavement structures can be weakened can compromise the long-term viability of a development site. When infiltration facilities are proposed proximate to these features, the geotechnical professional should approve the proposal. Once the facility type and location have been determined, the facility size and configuration can be determined.

Current restrictions on the placement of stormwater facilities often make it difficult or impossible to site stormwater infiltration facilities on a development. Examples of these restrictions include prohibition of these systems within the public right-of-way, inflexible setbacks from property lines, foundations, and septic systems, and minimum infiltration rates. This is especially true in medium density single family residential development where reduced setbacks and smaller lots are permitted in order to encourage increased density. This group's recommendation is that more latitude be given to the design professionals to locate stormwater facilities within the project, subject to the review and approval of the geotechnical professional involved.

5.3 Infiltration Calculations for Selected Facilities.

Structures for the infiltration of stormwater generally fall into three categories: drywells, trench systems (with or without pipes), and ponds. Each has particular design requirements and concerns.

5.3.1 Drywells

Drywells typically consist of perforated manhole sections placed into soil horizons which support infiltration. Stormwater infiltrates through the drain rock surrounding the sides and base (if present) of the drywell. Infiltration through the drywell is calculated at the perimeter of the drain rock (at the rock-soil interface). We recommend that infiltration through drywells should be calculated by one of the following methods to compensate for potential loss of infiltration capacity through compacted base rock and the typical reduction in the lateral coefficient of permeability:

1. Apply an additional correction factor (after the application of the other factors mentioned later in this paper) to the coefficient of permeability used for infiltration through the sides of the drywell or

2. Reduce the area available for infiltration to one-half of the height of the drywell section.

It should be noted that the cone (if present) and solid wall manhole sections do not factor into the depth of the drywell for infiltration purposes, though the entire drywell can be used for storage if appropriate.

5.3.2 Trench Infiltration Systems

The trench infiltration system is identified by a long narrow system with a perforated pipe and rock layer that surrounds the pipe. This arrangement provides greater area along the system's walls and base. Application of the tested coefficient of permeability across the entire height of the wall may not accurately reflect what is happening due to the pressure gradient of the water in the system. There is also evidence that the horizontal coefficient of permeability is less than the vertical coefficient in many soils, further limiting the potential for infiltration through the sides of the trench. Currently, regulators allow the entire wall height to be used in the analysis, but with the pressure gradient the whole wall is not infiltrating at the same rate.

The recommendation is that the allowable infiltration be reduced by one of two methods:

1. Apply an additional correction factor (after the application of the other factors mentioned later in this paper) to the coefficient of permeability used for infiltration through the sides of the trench or

2. Reduce the area available for infiltration to one-half of the height of the trench (base to invert of pipe or the base to the top of the soil strata available for infiltration).

When applied in conjunction with the other correction factors listed later in this report, these measures are expected to be sufficient to predict the long-term horizontal infiltration capacity of the system.

Another issue that arises is the distance between parallel trenches. For multiple trenches in septic design EPA has required a minimum spacing of 10 feet. A clear spacing of twice the depth between the base of the perforated pipe and the base of the trench (or twice the depth available for infiltration in systems with constraints due to soil layering or other factors) should be sufficient to prevent interference in most soils. Where this cannot be provided, the effective area available for infiltration along the sides of the trenches should be reduced to one-half of the clear distance between the trench walls.

In storm events where the system is already saturated or difficult soil conditions exist, however, it may be difficult to obtain a hydraulic gradient sufficient to move the required water. Additional investigation may be required in special circumstances to determine the extent of the difficult soil conditions as previously described.

Calculation of storage volume within trench systems is relatively straightforward. Typically, a void ratio of 1/3 is assumed for locally produced drain rock. Volume within pipes and manholes or drywells is generally assumed to be available for storage; the exception to this is the sump of a sedimentation manhole.

In fine-grained soils, the design of infiltration trenches should include filter fabric geotextile over the top of the trench and, if the soils along the sides of the trench are stratified, along the sides of the trench through fine-grained layers.

5.3.3 Galleries and Ponds

In galleries and infiltration ponds, discharge through the bottom of the facility is most significant and usually dwarfs the sidewalls of the infiltration facility. In addition, the large areas excavated for these facilities tend to expose more variable and heterogeneous soils, with a greater chance of encountering localized areas of reduced infiltration capacity. As these facilities are inundated, the fine particles may be re-suspended and more evenly distributed. There is concern that this process of re-suspension of fine particles during periods of inundation leads to the eventual "caking" of the bottoms of these facilities. As the fine sediment settles and drops to the bottom of the system it causes a layer of fine particulate matter or sediment to drop onto, or be forced by pressure head into, the soil stratum. This material often settles in a uniform manner across the bottom of the facility and onto the gallery floor. This layer of caking can have a significant impact to the gallery depending on soil type that is encountered for infiltration. In coarse-grained soils it may reduce the rate of infiltration. In fine-grained soils it may significantly reduce the rate or stop infiltration from occurring. For this reason, a sacrificial layer of sand or filter fabric should be considered in the design of infiltration ponds.

5.4 Design for Long-Term Protection of Infiltration Facilities and Other Property

In areas of fine-grained soils, it is critical that the design of stormwater treatment systems which drain to infiltration facilities make provisions for removal of sediments prior to the infiltration facility. This will reduce the potential for clogging and extend the life of the system. Additional erosion control measures should also be identified for use during the construction of the infrastructure improvements and the homes or other structures to be built as discussed later in this document.

Appropriate BMPs for sediment removal include:

- Sediment Trap (typically used during construction)
- Sedimentation Manhole/Vortex Separator (CDS, Vortechnics, or equal)
- Stormwater Filter System (StormFilter or equal)
- Presettling Basin

The design of ponds for easy maintenance, such as the inclusion of a sacrificial sand layer, sedimentation manhole or filter system, and/or an access road, will extend the functional life of the facility without significantly increasing the construction cost in most instances. Where sufficient pretreatment cannot be incorporated into the design of the storm sewer system, an additional correction factor should be added. See Volume 3 of the *Stormwater Management Manual for Western Washington*, Chapter 3.3.6, for additional discussion and Chapters 3.5 and 6 of Volume 5 for information on pretreatment BMPs. This is of particular importance during the construction of infrastructure and other structures on the development site.

Education of builders, homeowners or other users within the drainage basin of the facility is also necessary to reduce the potential for inadvertent contamination of the infiltration system. This should include erosion control practices for use during small construction or maintenance projects, characteristics of the stormwater facilities, and other information depending on the location and type of facility.

For all projects relying on infiltration, a second "sacrificial" system should be provided to be used until the majority of the project is built out. The system should be sized for the 2-year design storm and be separated from the main system to the maximum extent feasible. Runoff should be prevented from entering the permanent system until all exposed soils are permanently stabilized.

Additional benefits can be achieved if the sacrificial system can be located "inline" between the potential sediment source and the permanent infiltration system or designed so that the sacrificial system fills prior to overflowing into the permanent system. Sacrificial systems can be located in areas subject to future development, subject to the removal of accumulated sediments and confirmation of unsuitable material removal by a geotechnical engineer. The design of infiltration systems should detail how the main system is to be protected during construction and provide recommendations on the following:

- When the system can be put into service.
- Maintenance that must be performed prior to putting into service, such as
    - Vactoring sediment traps & catch basins
    - Sweep Streets
    - Installation of filter cartridges

The sacrificial system should be left open to provide any infiltration capacity still available.

5.5 Emergency Overflow

An emergency overflow route should be identified in case of system failure or overload. The Technical Information Report should, at a minimum, clearly identify a flow route that storm water can take from the facility without negatively impacting housing or posing a risk to the public. A piped overflow is preferred, however if necessary, a cross-country or even pumped systems can be identified. The report shall qualitatively address the capability of the overflow route to convey the anticipated flow from the development area.

5.6 Stormwater Facility Size

In order to minimize the effects of failed systems on downstream properties, the use of smaller systems distributed through the project is generally preferred to a single large system; this is evident in the correction factor recommendations later in this document. Vancouver's emphasis on individual lot downspout system reflects this philosophy; areas with limited infiltration capacity may not be able to take advantage of these systems due to required setbacks and the size of the individual system which might be required. Testing during construction should not necessarily be required at each individual lot system location, but inspection should be performed by the geotechnical professional after excavation to ensure that the soil type is consistent with that described in the site investigations.

5.7 Correction Factors

The allowable design infiltration rate is determined by dividing the calculated coefficient of permeability by appropriate correction factors defined in the following table. These correction factors compensate for expected adjustments to infiltration system performance from the effects of long-term system degradation, soil variability, physical setting characteristic, and facility design features.

Additive Correction Factors Based on Design Conditions

Design Condition	Correction Factor
Base Correction Factor	
The base correction factor is meant to account for soil variability and long-term system degradation due to siltation, biofouling, crusting, or other factors.	2
Soils Correction Factor	
Additive correction factor recommended by geotechnical professional as a result of soil or groundwater conditions.	As recommended in Infiltration Report
Basin Size Correction Factor	
If the infiltration facility serves a basin having a runoff volume for the 100-year, 24-hour storm event which is greater than 50,000 cubic feet, but less than 150,000 cubic feet	Add 1/2
If the infiltration facility serves a basin having a runoff volume for the 100-year, 24-hour storm event which is greater than 150,000 cubic feet	Add 1
System Design Correction Factors	
If an overflow system is not available or provided	Add 1/2
If a sacrificial system is provided and left operational following permanent site stabilization	Subtract 1/2

As an example, consider a site in which:

- The geotechnical professional measures a coefficient of permeability of 8 inches per hour and recommends an additive correction factor of 1 due to variable site conditions (limited strata for infiltration, for example).
- Runoff entering the facility during the 100-year, 24-hour storm is 76,000 cubic feet.

- Overflows from the system run to the adjacent street, from which they flow into a storm sewer system discharging to a local stream.
- A sacrificial system is provided and left open after construction has been completed.

In this instance, the Correction Factor applied to the coefficient of permeability would be 2+1+1/2-1/2, or 3. The resulting design coefficient would be 8/3, or 2.67 inches per hour. The correction factors for medium and large infiltration facilities (Runoff Volume Correction Factors) are intended to reduce the risk of property damage due to failure of these systems and to encourage the use of smaller, distributed systems. The designer also has the option of increasing the correction factor beyond those listed where warranted by site conditions. The designer and the geotechnical professional should rely on each other to determine when additional correction factors are warranted.

5.8 Additional Issues to be Considered During Design

Pipe perforation design can also influence the ability of an infiltration facility to dispose of water adequately. The engineer should confirm that the perforation size and pattern specified is sufficient to pass the anticipated design flow.

Recommended notes and specifications for the construction of infiltration systems are included as Appendix B. These notes should be incorporated into engineering plans for these types of facilities. The notes may be modified by the design engineer to reflect specific site conditions.

6.0 Construction of Infiltration Systems and Sediment Control

Sediment control is necessary to protect permanent infiltration facilities from clogging during all phases of construction. This protection must continue until the entire tributary area is effectively stabilized and erosion is no longer a threat.

6.1 Construction of Infiltration Systems

On development sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP (storm water pollution prevention plan) is the protection of the infiltration facilities from fine sediments during the construction phase and protection of groundwater from other pollutants. The plan should emphasize minimizing ground disturbance and maintaining existing vegetation during construction. Generally, plans which are developed and fully implemented in accordance with Volume 2 of the *Stormwater Management Manual for Western Washington* are sufficient to protect these facilities.

Permanent infiltration trench systems should not receive untreated run-off until the entire contributing drainage area to the infiltration system has received final stabilization and permanent water quality treatment BMPs are in place and functioning. As previously discussed, alternative drainage such as a temporary infiltration pond, a sacrificial infiltration trench or a sacrificial drywell are recommended. Treatment technologies such as Chitosan-Enhanced Sand Filtration (CESF) have been used to treat construction runoff prior to infiltration in a permanent facility with approval from the Department of Ecology. Permanent infiltration facilities should not be made operational until all proposed project improvements which produce surface runoff are complete, especially re-vegetation and landscaping. In the cases of projects with individual lots remaining undeveloped, these lots must contain and infiltrate their runoff through individual sediment traps acting as infiltration ponds until permanent improvements and landscaping are established.

An alternative to this approach is to serve the undeveloped lots with a shared sediment trap or pond on an undeveloped tract or lot. At the completion of all construction, the sediment trap must be cleaned out (taking care that no sediment enters the drainage system) and filled in, and the flow routed to the permanent drainage system.

Use of permanent infiltration ponds for sedimentation basins during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration ponds 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. Additional maintenance may be necessary during the construction period to remove accumulated sediment and maintain the intended infiltration rate. Final grading of the infiltration facility should 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.

Runoff from fully stabilized areas may be discharged to the permanent treatment system and infiltration facility without a sediment removal BMP. Full stabilization means concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion. The Local Permitting Authority should inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

6.2 Construction Observation & Testing

During the construction of the infiltration facility, the geotechnical professional of record should be retained to observe the excavation and confirm that the soils are consistent with those tests on which the design was based. This observation must take place prior to the placement of any filter fabric or drain rock specified on the plans.

In addition to the observation, additional infiltration tests should be performed to confirm the original tests through the base of the facility. This is especially important in layered soils with mixed silt and sand. If the tested coefficient of permeability determined at the time of construction is at least two-thirds (2/3) of the uncorrected coefficient of permeability used to determine the design rate, construction should be allowed to proceed. If the tested rate does not meet this requirement, additional testing, excavation, and/or design revision may be necessary to ensure that the system will dispose of the necessary stormwater.

6.3 Dry Utility/Joint Trench Installation (CATV, Gas, Electricity, Phone)

Erosion control measures must be maintained during installation of behind the curb utilities such as power, gas, phone, and cable TV. Implementation of Erosion and sediment practices during site construction has improved significantly over the last several years, but trenching for these "dry" utilities has been a major source of erosion and sediment deposition after major construction has been completed. Trench lines are often dug along the entire length of a project and are left open for days with trench spoil piles left unprotected.

Utility construction in new and existing areas should require an erosion/sedimentation control plan to address this problem. The plan should identify a competent person (certified in erosion control) who is in charge of erosion control for the project. Erosion control measures must be in place and inspected by the Local Permitting Authority prior to starting construction. The following measures would be required:

- All downstream catch basins would be protected with a temporary BMP.
- Trench spoils should be placed on the uphill side of trench or on the lot side of the trench (not next to curb) if flat.
- The length of open trench should be limited so that trenches will be completed within 7 days during dry months and 3 days during wet months.
- Water from trenches may not be pumped into any storm system.
- Sediment tracked onto roadways should be shoveled and/or swept up immediately during wet weather or at the end of day during dry weather.
- Trenches should be stabilized after completion with hydro-seeding or a sufficient layer of straw (2-inch minimum covering all disturbed area) or other appropriate cover.

The project should be inspected after completion to insure all trenches have been properly stabilized. The developer will be ultimately responsible for ensuring erosion control measures are installed and maintained and may be fined for violations.

Currently, there is no mechanism for inspection and enforcement of erosion and sediment control during utility construction. Additional scrutiny and clear direction needs to be provided to the department in charge of this part of site development.

6.4 Homebuilding or Construction of Other Structures

Homebuilders must create a small site SWPPP for single-family home sites. The plan must be implemented and approved by the Local Permitting Authority inspector prior to any site construction. The builder will be ultimately responsible for insuring erosion control measures are installed and maintained and may be fined for any violations on site. This may include repair or replacement of infiltration facilities clogged by sediment-laden runoff.

6.5 Post-development Homeowner Improvements

Stockpiling of materials (top soils, bark dust, etc.) should not be allowed within the paved right-of-way. Stockpiles onsite should be protected from runoff, especially if placed in a driveway that drains to the street.

Homeowners should be notified of erosion control requirements when obtaining a building or plumbing permit for any ground-disturbing project. This should include stating the homeowner's responsibility for contractors that may work on their property and that they may be fined for erosion from the project. At this time, there is not a mechanism in place at any of the reviewing agencies to trigger this type of notification

7.0 Conclusion

The Infiltration Standards Review Committee acknowledges that certain soil types present in Clark County present challenges to the professionals responsible for testing and designing systems to successfully discharge concentrated stormwater via infiltration facilities. In order to provide guidance for regulators and designers, the members of this committee have brought their technical expertise together in a collaborative effort to attempt to standardize procedures to assess soil infiltration capacity, design systems to utilize that capacity, and protect those systems from damage during and following construction. Application of these procedures to new designs will reduce the risk of future property damage resulting from infiltration system failure and reduce the maintenance and replacement frequency for these systems while meeting the development and environmental protection goals of the public. It is the committee's hope that this information will be used to support decisions to change city and county codes to address current problems with the existing stormwater and erosion control codes.

In the body of this report, the Committee has made specific recommendations in the following areas:

- Soil testing and evaluation methods
- Reporting requirements
- Application of tested rates to the design of stormwater infiltration facilities
- Configuration of treatment and infiltration facilities to protect systems and extend their design life
- Construction methods and practices necessary to protect facilities from sedimentation throughout their design life.

Incorporation of these recommendations in the stormwater design standards will result in the design and installation of facilities with a significantly reduced risk of failure.

Appendix A: Mechanisms and Processes of Soil Infiltration

The infiltration process begins with addition of water to a given soil surface. A wetting front moves through the soil based upon the amount of water applied and the ability of the soil to accept flow. Initially the soil voids are unsaturated and the flow is multi-dimensional. Pore pressure may be negative. However, after sufficient time elapses to achieve steady-state conditions, the soil becomes saturated and the flow becomes primarily one-dimensional (vertical) under the influence of gravity. As indicated below, the infiltration rate is then defined by the soil coefficient of permeability and hydraulic gradient of the system in accordance with Darcy's Law for saturated flow in homogenous isotropic media. Although soils are variable in nature and characteristics, they are assumed to be homogenous and isotropic to allow for an approximate solution (Das, 2005). The volume of flow is represented by the following equation:

$$Q = -kAi \qquad (1)$$

where

Q	=	flow (volume) (in^3/hr)
k	=	coefficient of permeability (in/hr)
A	=	cross-sectional area of flow (in^2)
i	=	$\Delta H/\Delta L$ (hydraulic gradient) (unitless)
ΔH	=	change in head (in)
ΔL	=	length of flow over which head is lost (in)

The average infiltration rate, defined as the one-dimensional volume flux of water flowing through a two-dimensional surface area, can be obtained by dividing the flow, Q, by the cross-sectional area of flow, A. This infiltration rate is often referred to as the Darcy flux, q_w. Therefore,

$$q_w = -ki \qquad (2)$$

The vertical infiltration rate ultimately achieves a steady state condition approaching the coefficient of permeability as the lower bound. This is because the coefficient of permeability equals the infiltration rate when the hydraulic gradient is one. Although some lateral or horizontal flow will occur near the edges of the infiltration source during saturated steady-state conditions, infiltrating flow will generally tend to be vertical. This is particularly applicable for subsurface infiltration galleries, basins, or trenches with significant horizontal surface area. Therefore, according to the current state of the practice, the infiltration rate can be best represented by the soil vertical coefficient of permeability (Ferguson, 1994; Oram, 2005; Minton, 2006). Stated in different terms, under the assumptions outlined above, the coefficient of permeability measures the raw infiltration rate. Appropriate correction factors, discussed earlier in this document, should be applied to the infiltration rate prior to design use.

Several test methods have been used by geotechnical design professionals to estimate the soil coefficient of permeability. Standard ASTM methods are available for testing of samples in an analytical laboratory setting. However, the difficulty in obtaining, transporting, preparing, and testing undisturbed samples, particularly those with appreciable sand content, effectively limits the use and accuracy of laboratory testing. More commonly, design consultants devise and use field testing methods to allow for direct in situ analysis. While field testing can be performed with steady-state constant head assumptions, in situ testing more commonly uses falling head or non-steady state conditions. Falling head methods are acceptable provided saturated flow conditions are maintained. If Darcy's Law is integrated over time to accommodate falling head conditions and re-arranged to solve for the coefficient of permeability, the following equation emerges:

$$k = \frac{L}{t} \ln \frac{h_1}{h_2} \qquad (3)$$

where

k	=	coefficient of permeability (in/hr)
L	=	length of flow (in) through the soil specimen in the pipe
t	=	time (hr)
h_1	=	initial head (in)
h_2	=	final head (in)

Equation (3) can be used with a properly developed falling head test method to estimate the in situ coefficient of permeability in most external environments.

EXAMPLE

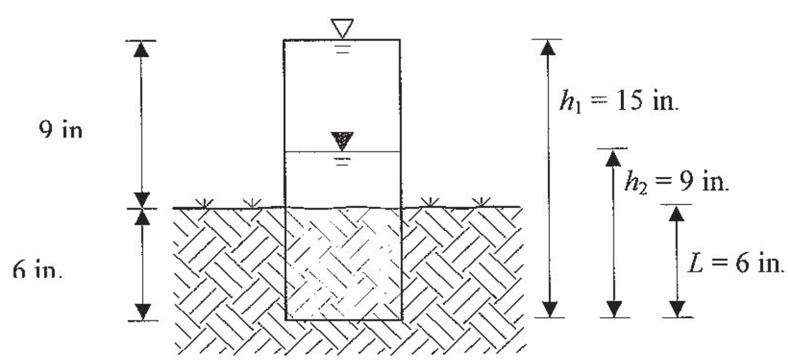
Given the infiltration test configuration shown below and the following observed field test data, determine the soil coefficient of permeability:

Average field observed rate of three 6-inch drawdown trials (change of head of six inches) after a 4-hour saturation period: 6 inches in 0.25 hr (i.e., approximate drawdown rate of 24 in/hr)

$L = 6$ inches

$h_1 = 15$ inches

$h_2 = 9$ inches



Inserting the relevant parameters into equation (3) results in a calculated coefficient of permeability, **k = 12.26 in/hr**.

<u>Discussion of Results:</u>

The coefficient of permeability obtained from equation (3) is the approximate rate at which water can be expected to infiltrate vertically into a given soil surface under long-term saturated flow conditions. Stated differently, under saturated conditions, the coefficient of permeability equals the infiltration rate. This value should be reported by the geotechnical professional as the soil coefficient of permeability for the tested location. To compensate for variable soil conditions and long-term system degradation, an appropriate correction factor should then be applied to the coefficient of permeability to arrive at the design infiltration rate.

The suggested test configuration described above has been strategically designed to produce an observed drawdown rate that is approximately twice the coefficient of permeability. This is readily apparent in the above example by observing that the calculated coefficient of permeability value of 12.26 in/hr is approximately half of the field observed drawdown rate of 24 in/hr. This is due to careful selection of the test configuration and geometry and may provide the benefit of simplicity and standardization. It is important to note that the coefficient of permeability will equal approximately half the observed drawdown rate only when full 6-inch drawdown trials are conducted and the relevant test parameters equal those indicated in the standpipe schematic shown above. However, the test configuration, standpipe length, embedment depth, etc. can be modified as desired by an experienced geotechnical professional, provided equation (3) is used to calculate the coefficient of permeability.

Appendix B: Infiltration Basins Notes and Specifications

The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. A program should schedule rough excavation of the basin with the rough grading phase of the project to permit use of the material as fill in earthwork areas. The partially excavated basin, however, cannot serve as a sedimentation basin unless the base is left at least two feet above the permanent base elevation for reasons explained below.

Specifications for basin construction should state: (1) the earliest point in progress when storm drainage may be directed to the basin, and (2) the means by which this delay in use is to be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.

1. Initial basin excavation should be carried to within 1 foot of the final elevation of the basin floor. Final excavation to the finished grade should be deferred until all disturbed areas on the watershed have been stabilized or protected. The final phase excavation should remove all accumulated sediment. Relatively light tracked equipment is recommended for this operation to avoid compaction of the basin floor. After the final grading is completed, the basin must provide a well-aerated, highly porous surface texture. Alternatively, the initial basin excavation could be carried to two feet above the final elevation for temporary (construction) use, then the remaining excavation completed once the remainder of the site has been permanently stabilized.

2. Infiltration basins in fine-grained soils may be lined with a 6- to 12-inch layer of filter material such as coarse sand (AASHTO Std. M-43, Sizes 9 or 10) to help prevent the buildup of impervious deposits on the soil surface. The filter layer can be replaced or cleaned when it becomes clogged. When a 6-inch layer of coarse organic material is specified for discing (such as hulls, leaves, stems, etc.) or spading into the basin floor to increase the permeability of the soils, the basin floor should be soaked or inundated for a brief period, then allowed to dry subsequent to this operation. This induces the organic material to decay rapidly, loosening the upper soil layer.

3. Establishing dense vegetation on the basin side slopes and floor is recommended, especially when the coefficient of permeability is less than 10 in/hr. A dense vegetative stand will not only prevent erosion and sloughing, but will also provide a natural means of maintaining relatively high infiltration rates. Erosion protection of inflow points to the basin shall also be provided.

4. Selection of suitable vegetative materials for the side slope and all other areas to be stabilized with vegetation and application of required lime, fertilizer, etc. shall be done in accordance with the NRCS Standards and Specifications or your local Standards and Specifications for Soil Erosion and Sediment Control.

5. Grasses of the fescue family are recommended for seeding primarily due to their adaptability to dry sandy soils, drought resistance, hardiness, and ability to withstand brief inundations. The use of fescues will also permit long intervals between mowings. This is important due to the relatively steep slopes which make mowing difficult. Mowing twice a year, once in June and again in September, is generally satisfactory. Clippings should be removed during or after mowing. Refertilization with 10-6-4 ratio fertilizer at a rate of 500 lb per acre (11 lb per 1000 sq ft) may be required the second year after seeding.

Group Resumes

Michael Barrette, P.E. - Clark County

Michael Barrette, P.E. has worked on all aspects of construction beginning as a Laborer Operator, Inspector, Design Engineer, Project Manager, and Review Engineer. He graduated from Oregon State University with a Bachelors of Science Civil Engineering Degree in 1995. Michael has been working in the civil engineering field as a public employee for approximately 11 years. His areas of expertise revolve around road and storm system design and construction.

Due to relocation to Texas, Michael Barrette was unable to complete his tenure with this committee, but his input and assistance are valued by the remaining committee members.

Bob Blakemore, P.E. - JBAK Consultants

No resume provided.

Richard Drinkwater, P.E. - Clark County

Richard Drinkwater, PE - Clark County, Department of Community Development, Engineering Services. Mr. Drinkwater has been employed with Clark County for the past 10 years, with responsibilities which included review of private development and capital improvement projects. Prior to his employment with Clark county, he spent years in private practice and at other public agencies. Mr. Drinkwater has been employed in engineering and land surveying for the past 43 years. He is licensed in Washington, Oregon, Alaska, Idaho and Nevada as a professional civil engineer and also holds licenses as a professional land surveyor in Oregon, Idaho and Nevada. He is currently a member of America Society of Civil Engineers, Professional Land Surveyors of Oregon and has held numerous officer positions in professional societies throughout his career.

Eric E. Golemo, P.E. - Sturtevant, Golemo, and Associates, Inc.

Eric Golemo has 12 years of experience in civil engineering and land planning. Mr. Golemo is the co-founder of Sturtevant, Golemo & Associates and is currently the director of Engineering. His responsibilities include project management, plan review, engineering design, contract administration, and client management. He has designed or supervised the design of stormwater facilities, single and multi-family developments, short plats, commercial projects, and public works projects in Southwest Washington.

He is a member of the American Society of Civil Engineers and has served as an officer in the Southwest Washington branch. He is active in the Development Engineering Advisory Board. He has served on numerous committees or work groups reviewing and providing feedback on code creation and revisions in Clark County, the City of Vancouver, Washougal, and La Center.

Paul Knox, P.E. - Hopper Dennis Jellison, PLLC

Paul brings over twelve years of diverse experience and talents to the transportation department. While working for Clark County, Paul reviewed land use approval applications for compliance with county development standards. This process has made him very aware of local standards and procedures. He was responsible for preparing staff reports and represented the county in public hearings and meetings, which gives him familiarity with the Public Involvement processes required with many complex projects.

As a water resources engineer, Paul prepared and stamped final design plans, conducted water resources studies, designed master plans and feasibility studies for water, sewer and drainage projects. He performed hydrologic and hydraulic evaluations for existing and proposed bridge projects. Additionally, Paul supervised design and survey departments, prepared and stamped final design plans, reports, specifications, and cost estimates for land development and commercial private projects.

R. Warren Krager, R.G., C.E.G. – Chinook Geoservices, Inc.

Mr. Krager is a registered professional Geologist and Registered Engineering Geologist in Oregon, Washington, and Idaho with over 20 years of local experience conducting engineering geologic and geotechnical studies. He has conducted and overseen numerous field investigations throughout Clark County to evaluate infiltration capacity of soils for a variety of planned storm water infiltration disposal methods. Professional society affiliations include membership in the Association of Environmental and Engineering Geologists (AEG) for more than 16 years with a recent five year term as Oregon Section Board member officer rotation, including Oregon Section Chair. He also attends most ASCE-Oregon Geotechnical Group professional society meetings. As a geotechnical consultant Mr. Krager actively markets and conducts geotechnical investigations throughout the Pacific Northwest for a broad spectrum of design professionals, developers, government agencies, contractors, and other interests.

Lance Lehto, P.E., M.S. - Columbia West Engineering, Inc.

Lance Lehto has 13 years of experience in geotechnical and environmental engineering. In 1999, Mr. Lehto founded Columbia West Engineering, Inc., a geotechnical and environmental engineering and construction materials testing firm based in Vancouver, Washington. The firm provides professional services for a variety of commercial, industrial, residential, and regulatory agency clients located throughout western Washington and Oregon. As president of the company, Mr. Lehto's responsibilities include project engineering, engineering design, field exploration and investigation, comprehensive company management and leadership, contract negotiation, report preparation and review, and employee supervision and management. Mr. Lehto is a licensed professional engineer in Washington and Oregon, and a member of the American Society of Civil Engineers and Chi Epsilon, a Civil Engineering honor society.

Charles E. McMurry, P.E. - Olson Engineering, Inc.

Charles (Chad) McMurry joined Olson Engineering, Inc. in 1996. Mr. McMurry's responsibilities include project management, plan review, engineering design, estimating, contract administration, specification preparation, and construction inspection. His experience includes single and multi-family residential development, commercial and industrial site development, and public transportation and water system improvements. His work at Olson Engineering has included the design of sanitary sewer, water and street improvements, the design of stormwater treatment and disposal systems, erosion control, stormwater permitting, preparation of Environmental Impact

Statements and public water system design and permitting. He is a member of the American Society of Civil Engineers and has served as President of the Southwest Washington Branch.

Michael J. Swanson, P.E. - City of Vancouver

Mr. Swanson has been with the City's Surface Water Management Department for more than seven years, where his responsibilities have included the review of development and capital improvement projects for compliance with City code. Prior to his work at the City, he spent eight years as a design engineer in the private sector with a firm in Clark County, specializing in stormwater facility design.

Daniel J. Trisler, P.E. – GeoDesign, Inc.

Dan Trisler has more than 14 years of experience involving soil mechanics, slope stability analysis, foundation and retaining system design, and hazards evaluations in support of various public and private developments. Dan leads GeoDesign's Vancouver office and his responsibilities include project management, engineering analysis, contract administration, report preparation and review, supervision of field and engineering personnel, specification preparation, and construction observations. Dan has conducted and overseen numerous infiltration studies for commercial, retail, residential, and transportation-related developments. He is a licensed civil engineer practicing geotechnical engineering in Washington, Oregon, Idaho, and California. He holds a master's degree in geotechnical engineering and bachelor's degree in civil engineering, both from Cornell University. He is a member of the American Society of Civil Engineers.

Peter A. Tuck, P.E. – Olson Engineering, Inc.

Peter Tuck has 17 years of experience in civil engineering. As Engineering Director for Olson Engineering, Inc., Peter has been responsible for planning, directing, and coordinating all project production and administration for the last 12 years. He has designed or supervised the design of hundreds of stormwater systems across the county, including infiltration systems for water quality treatment and disposal of stormwater runoff. His professional associations have included the following:

- Member of American Society of Civil Engineers
- Member of Clark County Drainage Ordinance Committee, 1997-1998
- Member of Burnt Bridge Water Shed Rates Sounding Committee
- Institute of Engineers Australia – Chartered Professional Engineer
- Member of ASCE Drainage Review Committee, 1995 –1998
- Member of Clark Co. Stormwater & Erosion Control Task Force, 1999-2001
- Clark County Clean Water Commission, 2000 – 2002

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An Approach for Estimating Infiltration Rates for Stormwater Infiltration Dry Wells, Joel W. Massman, Washington State Department of Transportation, April 2004.

Definition of Terms

Several of the most relevant terms used in the soil infiltration mechanistic and testing processes are defined below (Oram, 2005, Ferguson, 1994):

Infiltration – The one-dimensional (usually downward) entry of water into the immediate soil surface.

Infiltration Rate – The rate at which water penetrates the soil surface, expressed as velocity. It is a one-dimensional volume flux of water flowing into a two-dimensional soil surface area. The infiltration rate is constrained by the capacity of the soil and the rate at which water is applied to the surface. The infiltration rate of a given soil varies under saturated and unsaturated conditions. Because storm water management design must consider the long-term condition, the saturated infiltration rate is of primarily interest to engineering professionals. Under saturated soil conditions, the infiltration rate is essentially equivalent to the soil coefficient of permeability, defined below. In this document, the term "infiltration rate", as defined by the measured and calculated coefficient of permeability, refers specifically to the assumed rate at which water will infiltrate vertically into a saturated soil.

Allowable Design Infiltration Rate – The final infiltration rate used by design engineers to size infiltration systems. It is calculated by adding necessary correction factors to the infiltration rate defined above to compensate for soil variation and long-term system degradation.

Flux - The amount of flow of a given substance through a unit area per unit of time (ft./sec.)

Flow - The volume of a given substance passing through a given surface area per unit of time. The integration of flux over a unit area yields the flow.

Percolation – The simultaneous three-dimensional vertical and lateral movement of water through soil by gravity.

Drawdown Rate – The direct raw field measurement of the rate of water drop during a given in situ infiltration test, expressed as velocity.

Coefficient of Permeability (also called Hydraulic Conductivity) – A quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient, expressed as velocity. As described later, the coefficient of permeability is calculated based upon the observed drawdown rate and configuration of the infiltration test apparatus. The coefficient of permeability commonly varies in the horizontal and vertical directions. Due to the effects of gravity, the vertical coefficient of permeability is the primary component of interest in the soil infiltration process. As described above, the saturated vertical soil coefficient of permeability may be assumed to equal the soil infiltration rate. Therefore, when discussing saturated vertical flow conditions, the terms "coefficient of permeability" and "infiltration rate" are equal. The calculated coefficient of permeability is the infiltration rate.

Geotechnical Professional - A Geologist or Professional Engineer licensed in the State of Washington with training and experience in the investigation and engineering evaluation of earth materials, including rock, soil, and groundwater and their interaction with civil engineering works.

ASCE Clark County Soil Conditions Map

As part of the preparation of this document, a map outlining general soil conditions pertaining to infiltration was prepared by Clark County GIS. A reduced copy of this map has been provided on the following page. The full-size version (a 12 MB download) is available by contacting Chad McMurry at Olson Engineering, (360) 695-1385 or chad@olsonengr.com.

SURFACE WATER MANAGEMENT

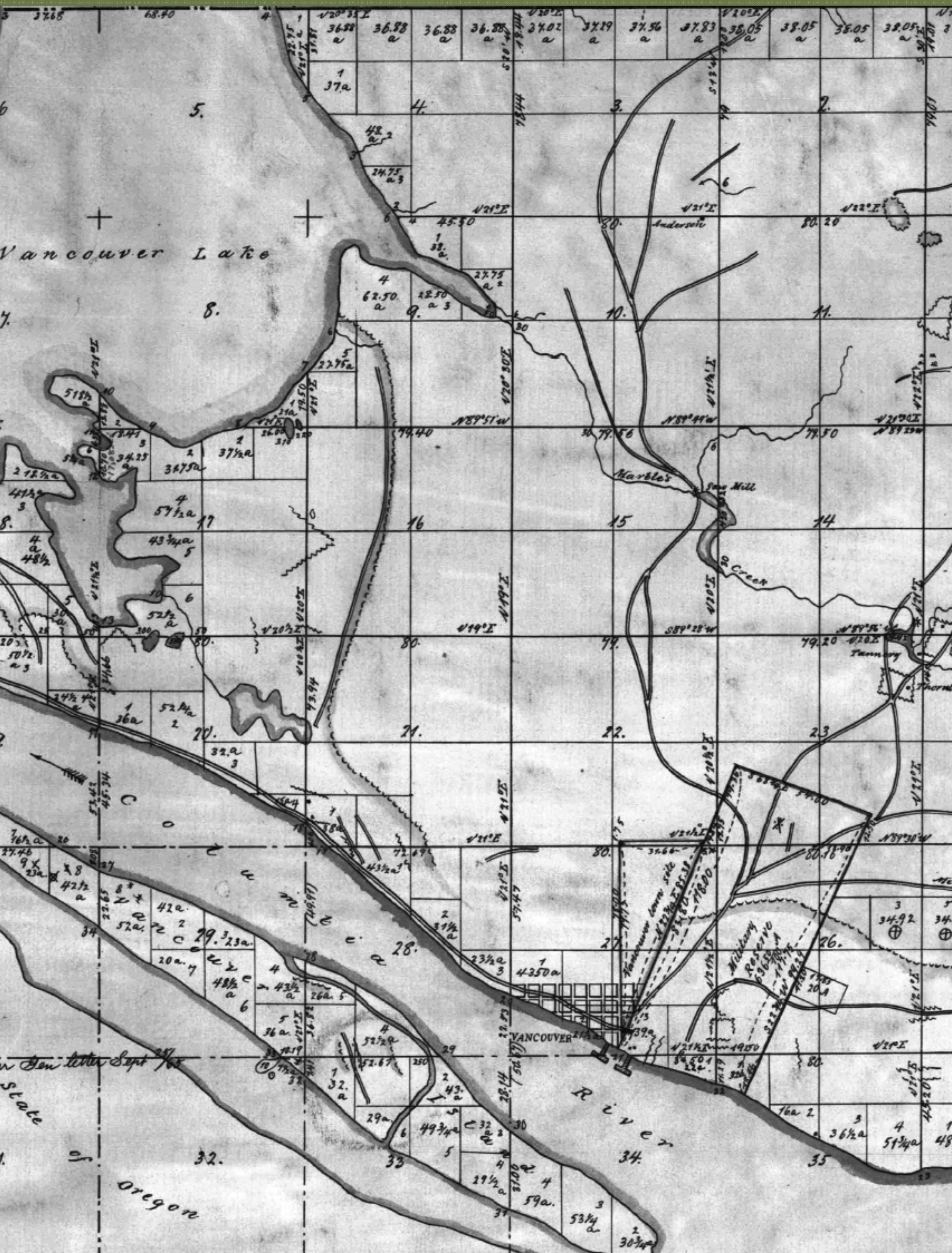
DESIGN AND CONSTRUCTION REQUIREMENTS

APPENDIX C

Pre-Settlement Prairie Areas in Vancouver, WA

Pre-Settlement Prairie Areas in Vancouver, WA

August 2009



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otak

Pre-Settlement Prairie Areas in Vancouver, WA

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City of Vancouver
Surface Water Management

Prepared by:

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Tim Kraft, PE
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Otak Project No.: 15444
August 2009

Pre-Settlement Prairie Areas in Vancouver, WA
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Pre-Settlement Prairie Areas in Vancouver, WA

Executive Summary

The City of Vancouver retained Otak, Inc. to document prairie areas near Vancouver that existed prior to European settlement. New development or redevelopment projects situated within historic prairies are permitted to use a pre-developed site condition of "field" rather than "forest" to meet Ecology's latest stormwater regulations. Documentation of historic prairies in the Vancouver area involved two key tasks: research and mapping. Research was conducted to determine the physical location of the prairies, as well as to verify that they existed prior to European settlement. Once compiled, source material—including maps and first hand accounts—were evaluated and used for mapping. For the final product, two maps were produced showing where historic prairies were located with respect to modern-day features such roads, highways, and political boundaries. The first map shows historic prairies within the Vancouver urban growth area, and the second map shows all historic prairies found throughout Clark County while researching Vancouver prairies. The two prairie maps produced with this report are included in Appendix B at the back of this report.

Research conducted for this project found sixteen prairies which existed in Clark County prior to European settlement, with eight of these prairies located within the Vancouver urban growth area. The eight prairies which fall within the urban growth area are shown in the table below.

Pre-Settlement Prairies within the Vancouver Urban Growth Area	
Lower Plain	First Plain
Fort Plain	Second Plain
Mill Plain	Third Plain
Lacamas Prairie/Camas Plain	Fourth Plain

Native Americans used the prairies for hunting game, and also named and maintained them. Early records of some prairies are available as part of the records kept with Fort Vancouver, which include first-hand descriptions and maps. Additional records, such as survey cadastral maps, corroborate these prairie areas and show several other prairie and wetland areas located throughout the greater Clark County area. The final maps produced for this report shows all the prairies that were documented, as well as wetland areas which may exhibit prairie characteristics.

In addition to the maps, GIS shapefile information of prairies and wetland areas was provided to the City of Vancouver together with this report. The maps and shapefile information produced with this report will assist new development or redevelopment projects in determining if they fall within the boundaries of a historic prairie area.

Pre-Settlement Prairie Areas in Vancouver, WA

Introduction

Purpose

This report discusses the efforts associated with mapping prairie/grassland areas that existed prior to European settlement within Vancouver, Washington, as well as the greater Clark County, Washington area.

Background

The Washington State Department of Ecology's latest NPDES Phase II MS4 permit requires permittees to regulate stormwater such that runoff rates from new development and redevelopment projects do not exceed runoff rates from a pre-developed condition. New projects will be required to assume a forested pre-developed site condition, unless historic evidence exists indicating that the site was not forested prior to European settlement. In response to this requirement, this report has been prepared to document non-forested (i.e., prairie) areas throughout Vancouver that existed prior to European settlement. Documentation of historic prairie areas will allow new development or redevelopment projects situated within them to use a pre-developed site condition of field rather than forest to meet stormwater regulations.

Approach

Documenting historic prairies in the Vancouver area involved two key tasks: research and mapping. Research was conducted to determine the physical location of the prairies, as well as to verify that they existed prior to European settlement. Once compiled, source material—including maps and first hand accounts—were evaluated and used for mapping. The mapping task involved using ArcGIS and Autodesk Map 3D software programs to delineate historic prairies based on information provided by source material. For the final product, two maps were produced which show where the historic prairies were located with respect to modern-day features such roads, highways, and political boundaries. The following sections of this report provide a more in-depth discussion of the activities performed for research and mapping.

Research

Sources

Confirming the presence and location of historic prairies in the vicinity of Vancouver involved consulting available resources such as published reports, history books, historic maps, and noted historians. Review of source information focused on identifying settlement dates and locations, as well as descriptions of pre-settlement landscape. Where prairie and other non-forested areas were identified, corroborating information was sought among the other sources. The following sources provided useful information regarding the historic prairies near Vancouver.

- Reports
    1) The National Park Service website includes a report titled "Fort Vancouver: Cultural Landscape Report" for the Fort Vancouver National Historic Site, available at: http://www.nps.gov/history/history/online_books/fova/clr/clr.htm. This report provides detailed information concerning the history of Fort Vancouver and its environs, and includes historic maps and documents.
    2) The Washington Natural Heritage Program report titled "Southwestern Washington Prairies: Using GIS to Find Rare Plant Habitat in Historic Prairies" available at: http://www.dnr.wa.gov/Publications/amp_nh_sw_prairies.pdf. This report discusses efforts to locate historic grasslands in southwestern Washington to evaluate the possibility of reintroducing native plant species.
- Books
    1) The book Naming Clark County by local historian and City of Vancouver Council member Pat Jollota, provides historical information associated with the naming of historic features such as prairies.
- Historic Maps
    1) A post 1844 map by H.N. Peers showing the location of the plains in the vicinity of Fort Vancouver, including Lower Plain, Fort Plain, First Plain, Second Plain, Third Plain, Fourth Plain, and Mill Plain (Taylor, 1992).
    2) An 1859 map by Richard Covington showing the location of the plains in the vicinity of Fort Vancouver (Taylor, 1992). This map shows the location of First Plain, Second Plain, Third Plain, and Mill Plain.
    3) Cadastral maps drawn in the 1850's for each township and range in the territory. These maps depict prairie areas in addition to other surveyed features.
    4) The 1888 Map of Clarke County complied by R.A. Habersham. This map shows prairie areas throughout Clark County, and is available at the Clark County Historical Museum.
- Historians
    1) Otak and City of Vancouver staff met with former Clark County Historical Museum Curator and current city council member Pat Jollota on July 15, 2009 to discuss historic prairies. Ms. Jollota provided background information on maps and cited additional resources that could be used to delineate and document historic prairies.

Findings

Historical Background

Abundant information is available regarding early settlement in the Vancouver area. Historical records associated with Fort Vancouver comprise the majority of this information, as the fort was the first major European settlement in the area. Fort Vancouver was established in 1824 by the Hudson's Bay Company (an English company) and was the center of the company's trade operations on the Pacific Coast through its heyday in the 1840's, after which its prominence steadily declined until the fort was abandoned to the Americans in 1860 (Taylor & Erigero, 1992). Profuse records were kept in conjunction with Fort Vancouver, many of which are currently available at libraries and online. These records include several maps and descriptions of plain areas near the fort. Such documents provide valuable information concerning the historic landscape of Vancouver, and support the prairie delineations that were produced in conjunction with this report.

Overview of Prairie Areas

There is overwhelming evidence that prairie areas existed throughout the region prior to European settlement. A number of prairie areas were maintained by Native Americans who used them to hunt game. The Native Americans had names for several of the prairies in Vancouver, which were later given English names by European and American settlers (Jones & Jones, 2005). Native American names for the prairie areas surrounding Fort Vancouver are presented in Table 1 alongside the English names. Note that the terms "plain" and "prairie" is used interchangeably in this report, as the former is the term used by the English and the latter is the term used by the French (Jollota, 2002). Settlers were inclined to inhabit prairie areas because the land was clear of trees and could be easily converted to agricultural purposes. An example of this practice includes Fort Vancouver, which was established at Jolie Prairie in part because it was clear of trees. Jolie Prairie was renamed to Fort Plain following construction of the fort (Taylor & Erigero, 1992).

Table 1. Native American and English Names for Prairies near Vancouver

Native American Name	English Name
Alaek-ae ("turtle place")	Fort Plain (formerly Jolie Prairie)
Wahwaikee ("acorn")	First Plain
Pahpoopahpoo ("burrowing owls")	Second Plain
Heowheow	Third Plain
Kolsas	Fourth Plain
Simsik	Fifth Plain

In general, prairie areas in the vicinity of Fort Vancouver include Fort Plain, Lower Plain, Mill Plain, First Plain, Second Plain, Third Plain, Fourth Plain, Fifth Plain, and Camas Plain. These prairies are referred to and described in multiple first-hand accounts, and are shown on several maps from the mid 1800's. There is general consensus between the historic documents as to the location of these prairies.

Other prairies areas in Clark County situated outside the immediate vicinity of Fort Vancouver are less well documented. These prairies include Bear Prairie, Yacolt Prairie, Fern Prairie, Chelatchie Prairie, and several other non-forested open areas. To verify the historic presence and location of these prairies, 1850's era cadastral maps of Clark County were evaluated. These maps show the general land features—including prairies—for each township and range. The concept of using these maps to locate historic prairie areas was borrowed from the Natural Heritage Report, which utilized the same methodology (Caplow & Miller, 2004).

Historic Prairie Citations

The following citations provide descriptions—including some first-hand accounts—of prairies in the vicinity of Fort Vancouver.

- Fort Plain/Jolie Prairie

  > "After seeing the site for the new post, George Simpson recorded in his journal:
  >
  > > The place we have selected is beautiful as may be inferred from its Name and the Country so open that from the Establishment there is good travelling on Horseback to any part of the interior; a Farm to any extent may be made there, the pasture is good and innumerable herds of Swine can fatten so as to be fit for the Knife merely on nutricious Roots that are found here in any quantity and the Climate so fine that Indian Corn and other Grain cannot fail of thriving...The distance from the Harbour is the only inconvenience but that is of little importance being now a secondary Establishment ... ...at the Jolie Prairie or Belle vue Point where the New Fort is situated it may be from time to time enlarged without the trouble of felling a tree. [30]" (Taylor & Erigero, 1992, p. 2-1c)

- Lower Plain

  > "Lower Plain, west and northwest of Fort Plain, was an immense open plain, roughly triangular in shape, bounded on the east by the finger of forest separating it from Fort Plain; the forest extended to the northern edge of the plain. In the north of the plain was "Big Lake," (now Vancouver Lake) a somewhat circular lake, approximately two miles in diameter at that time, from which the "Lake River" sprang, forming the northwest boundary of the plain as it ran to the Columbia River, which formed the south and southwest edge of the plain. A finger of the lake extended south (it shows southeast on the 1844 map), forming a narrow strip of open meadow to the east of it, between one-half and three-quarters of a mile in width, in which fenced fields were laid out, certainly by the mid 1830s. Throughout most of this period, cattle, horses and sheep were pastured in the unfenced open plain, which stretched in a narrow band between river and forest for miles down river to the junction with the Lewis River. There were two more lakes on the plain:

Chalifoux Lake, and another, smaller lake to the north of it. In the southeast corner, a dairy, with enclosures and structures, and a piggery with enclosures and structures, and several cultivated fields along the river were located." (Taylor & Erigero, 1992, p. 2-2c)

- Mill Plain

"Mill Plain, approximately three miles east of the Fort Plain, was an opening in the forest, approximately four miles long and three-quarters of a mile wide, which included the Mill Plain Farm, consisting, in 1844, of enclosed fields and barns. About one and one-half miles south of Mill Plain Farm, and about two and one-half miles from the edge of Fort Plain, was the Gristmill, located near the Columbia River, on a north-south stream feeding the river. About one mile east of the gristmill, was the sawmill, also on a stream feeding into the Columbia. To the northeast of Fort Plain was a series of forest openings making up the Back Plains, of which Fourth Plain was by far the largest First Plain was about two miles from the north edge of Fort Plain; Second Plain a mile beyond that, Third Plain approximately one-half mile beyond Second Plain, and Fourth Plain about a mile beyond Third Plain. The Camas Plain was at least another mile beyond." (Taylor & Erigero, 1992, p. 2-2c)

- Back Plains (First through Fifth Plain and Camas Plain)

"The appearance of the country between Fort Vancouver and the Back Plains during this period is best described in the 1853-54 report of the U.S. Pacific railway survey expedition:

> From this stream [Burnt Bridge Creek] the country along the trail breaks into small openings or plains having no timber on them. They vary from a half to several miles in extent, are very level, as well as the adjacent country, and are separated from each other by narrow strips of woods. Kolsas, the largest of these plains, about seven miles from Vancouver, is six or seven miles long, and three or four in breadth, and connects on the south with a swampy arm of Camas plain, which stretches off to the eastward, in which direction there is a large tract of the same character of country lying along Mill creek, and running down towards the Columbia. From Kolsas the trail bears to the northeast for six miles to a plain called Simsik, about a mile and a half long. The country between Vancouver and Simsik is similar in character--heavily timbered with fir, spruce, and a dense undergrowth of maple and hazel bushes. The soil is sandy and gravelly, especially the open plains; the soil in the woods between Kolsas and Simsik is the best. The country up to Simsik is quite level; leaving Simsik east of north the country becomes hilly and broken along the trail, the hills becoming higher and more rocky as we approach the Cathlapoot'l river. Between these points the trail crosses several branches of the Cathlapoot'l...the main stream uniting with the Cathlapoot'l four miles from its junction with the Columbia. [1128]" (Taylor & Erigero, 1992, p. 2-3d3)

- Native American Prairie Names

> "The lower Klickitat Trail prairies mapped by McClellan and Cooper were called Alaek-ae ("turtle place"), Wahwaikee ("acorn"), Pahpoopahpoo ("burrowing owls"), Heowheow, Kolsas, and Simsik by the Indians according to J. F. Minter's records. Hudson's Bay Company settlers re-named these prairies "Fort Plain," "First Plain," "Second Plain," "Third Plain," "Fourth Plain," and "Fifth Plain," respectively.[10] Cooper noted that First Plain through Fifth Plain were covered with good grass for horses, and eight edible berry species; he asserted that "berries form the chief food of the natives at this season (late summer)." Most of the plant species that Cooper identified in these prairies were early succession species favored by browsing animals such as deer and elk. Cooper and others observed that the prairies were circular or oval in shape, with "sharply defined borders," suggesting a controlled burn pattern of lighting vegetation from field periphery to center to avoid setting fire to adjacent woodlands." (Jones & Jones, 2005, p. 12)

Maps

Several maps were used to delineate historic prairies in the vicinity of Vancouver. These maps are presented and discussed below.

- 1844 Peers Map
  This 1844 map provides a "Sketch of the Environs of Fort Vancouver…" by H.N. Peers. This map is included in Appendix A. Prairies shown on this map include Lower Plain, Fort Plain, Mill Plain, First Plain, Second Plain, Third Plain, and Fourth Plain (Taylor & Erigero, 1992).

- 1859 Covington Map
  This 1859 map by Richard Covington shows the area in the vicinity of Fort Vancouver. This map is included in Appendix A. Prairies shown on this map include Lower Plain, Fort Plain, Mill Plain , First Plain, Second Plain, and Third Plain (Taylor & Erigero, 1992). This map shows general agreement with the Peers map, although there are some minor differences between the shapes of First, Second, and Third Plain.

- Cadastral Maps:
  Cadastral maps for 23 Township and Range areas were used to delineate historic prairies in the vicinity of Vancouver. The majority of these maps were drawn between 1852 and 1860, while three were drawn later in the late 1890's. These maps were downloaded from the Bureau of Land Management website (Bureau of Land Management, 2009). Appendix A shows the map used for Township 2N Range 2E. The cadastral maps show general agreement with the Covington and Peers maps, although there are some differences, including delineations of wetland areas on the cadastral maps. Additionally, the borders of some prairies—including First, Second, and Third plain—are not clearly defined on the cadastral maps.

- 1888 Clarke County Map
  This 1888 map compiled by R.A. Habersham is available at the Clark County Historical Museum, and includes delineations of prairie areas throughout Clark County. A portion of this map is included in Appendix A. The portion shown in Appendix A includes delineations of Lacamas Plain, Fourth Plain, Fifth Plain, Mill Plain, Fern Prairie, Bear Prairie, and other unnamed prairies located in the southwest region of the county. There is general agreement of prairie delineations between the cadastral maps and the 1888 map, although there is less ambiguity concerning the prairie borders on the 1888 map. Additionally, there are slight differences in the shape of some prairies between the 1888 map and the cadastral map. For instance, Mill Plain is shown on the 1888 map as having a "finger" that stretches to the northeast, whereas this finger is not evident on the cadastral maps.

Mapping

The production of maps showing the location of historic prairies within the vicinity of Vancouver is discussed in this section of the report. The final maps are presented in Appendix B.

Methodology

Mapping of historic prairie areas in the vicinity of Vancouver was performed using Autodesk Map 3D and ArcGIS software programs. To begin, geo-referenced GIS shapefile information of Clark County was imported into Autodesk Map 3D. Shapefile layers included stream, lakes, roads, and political boundaries. Using the shapefile linework as a backdrop, the historic maps presented earlier in this report were imported into Autodesk Map 3D, then scaled and rotated to match the shapefile layers. For the cadastral maps, township and range lines were imported into Map 3D to help align and scale each of the 23 cadastral maps covering Clark County. Once the maps were imported into Map 3D, prairie areas and wetland areas shown on the maps were traced with polylines according to an order of precedence (see the assumptions section below for discussion on the order of precedence). After prairie and wetland areas were traced, the polylines were imported into ArcGIS and given attribute information. Final maps were produced in ArcGIS.

Assumptions

The following assumptions were used to delineate prairie areas:

- Order of Precedence
  Prairie areas were traced from historic maps based on an order of precedence. This order includes:
  1) 1850's Cadastral Maps (1^{st} priority)
  2) 1859 Covington Map (2^{nd} priority)

3) 1844 Peers Map (3rd priority)
4) 1888 Clark County Map (4th priority)

The 1850's cadastral maps were the primary resource for delineating prairies because they are the product of survey work and contain good spatial accuracy. They also provide complete coverage of the county, showing prairie and wetland areas throughout. Furthermore, except for the Peers map, the cadastral maps were the oldest maps used for this study.

The three other maps were used to supplement the prairie delineations. This occurred most often when the exact borders of prairie areas were unclear on the cadastral maps. For example, First, Second, and Third Plain are not well defined on the cadastral maps, but are clearly shown on the Peers and Covington maps. Likewise, Lacamas Prairie is shown on the 1888 map, but only intermittent prairie borders are shown on the cadastral maps. The primary source map used to delineate each of the major prairie areas is presented in Table 2 below. Note that the Peers Map was not used since the spatial accuracy was poor, making the Covington Map a better source for delineating prairies in the region covered by these two maps. Also, several unnamed prairie areas were delineated using the cadastral maps which are not included in Table 2.

Table 2. Map Sources for Named Prairies

Prairie	Primary Source Map
Fort Plain	Cadastral Maps
Lower Plain	Cadastral Maps
Mill Plain	Cadastral Maps
First Plain	Covington Map
Second Plain	Covington Map
Third Plain	Covington Map
Fourth Plain	Cadastral Maps
Fifth Plain	Cadastral Maps
Camas Plain/Lacamas Prairie	1888 Maps
Fern Prairie	1888 Maps
Bear Prairie	1888 Maps
Yacolt Prairie	Cadastral Maps
Chelatchie Prairie	Cadastral Maps

- Land Clearing
  Prairie areas were delineated using the assumption that the mapped prairie borders comprise the extent of the native prairies, and that these borders were not expanded by agricultural land clearing activities conducted by early settlers. This assumption is

supported by the fact that agricultural fields are shown on the cadastral maps using different symbols as compared to the prairie borders. In cases where it appears that an agricultural field has expanded the border of a native prairie, the original border was approximated and delineated.

- Wetlands
  The cadastral maps use different symbols to distinguish between open prairie areas and wetlands. Accordingly, areas mapped for this report are separated into two categories: wetlands and prairies. While it is possible for wetlands to exhibit prairie characteristics, wetlands were delineated separate from prairies because—for most of the wetlands—no supporting documentation was found to characterize the landscape. Notable exceptions include Fifth Plain and Lacamas Prairie/Camas Plain. Although Fifth Plain is mapped using wetland symbols on the cadastral map, it was delineated as a prairie because it is referred to as a plain by historic documentation. A portion of Lacamas Prairie/Camas Plain was dealt with in similar fashion. Further review of wetland areas may warrant equating historic wetland areas with prairies for stormwater analysis purposes.

Results

The final two maps produced for this report show all the prairies and wetland areas that were documented with this report. These maps are included in Appendix B, one of which focuses on the Vancouver area, and the other showing all of Clark County. These maps show where historic prairies were located with respect to modern-day features such roads, highways, and political boundaries, and are included in Appendix B. In addition to the maps, GIS shapefile information of prairies and wetland areas was provided to the City of Vancouver together with this report. The maps and shapefile information produced with this report will assist new development or redevelopment projects in determining if they fall within the boundaries of a historic prairie area.

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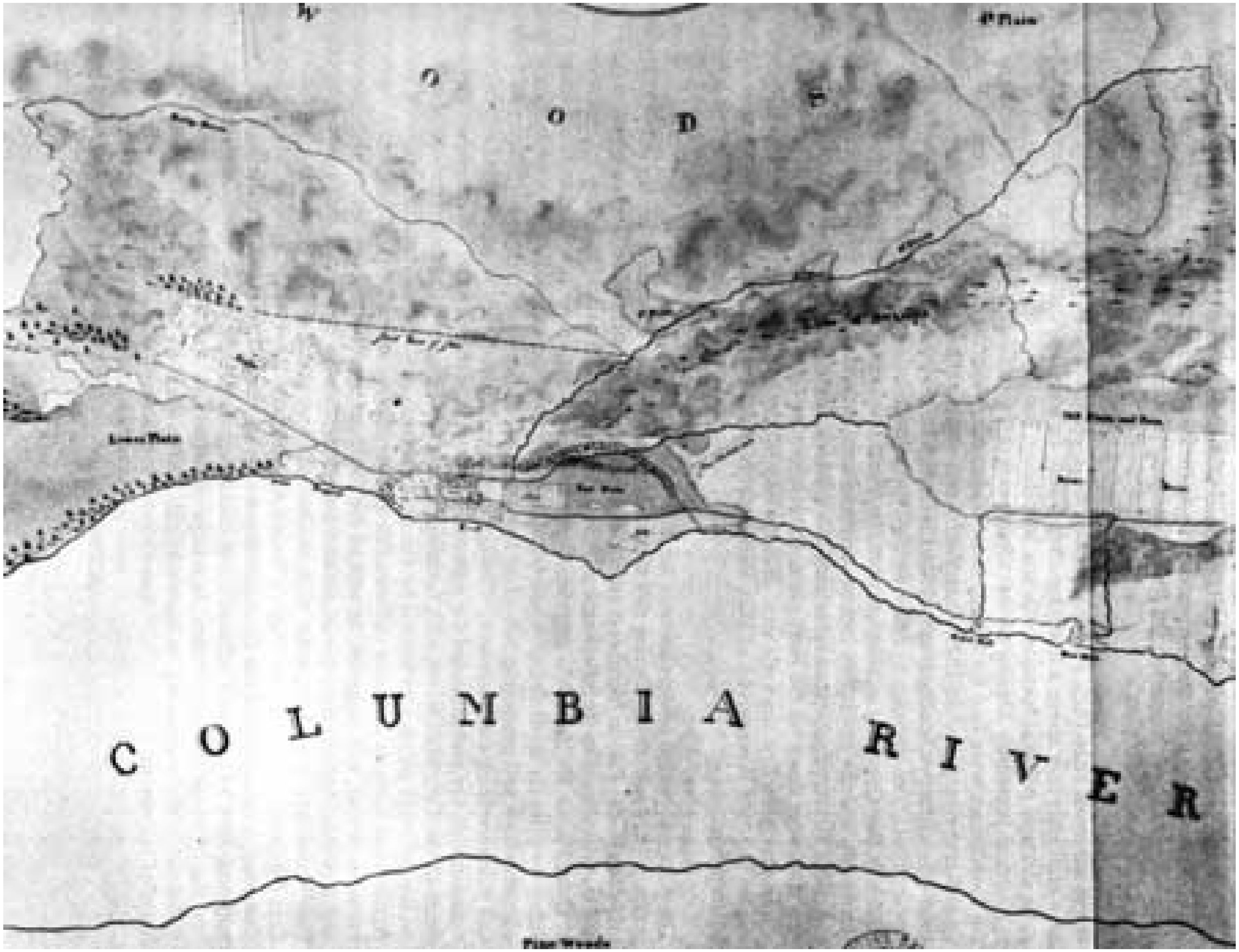
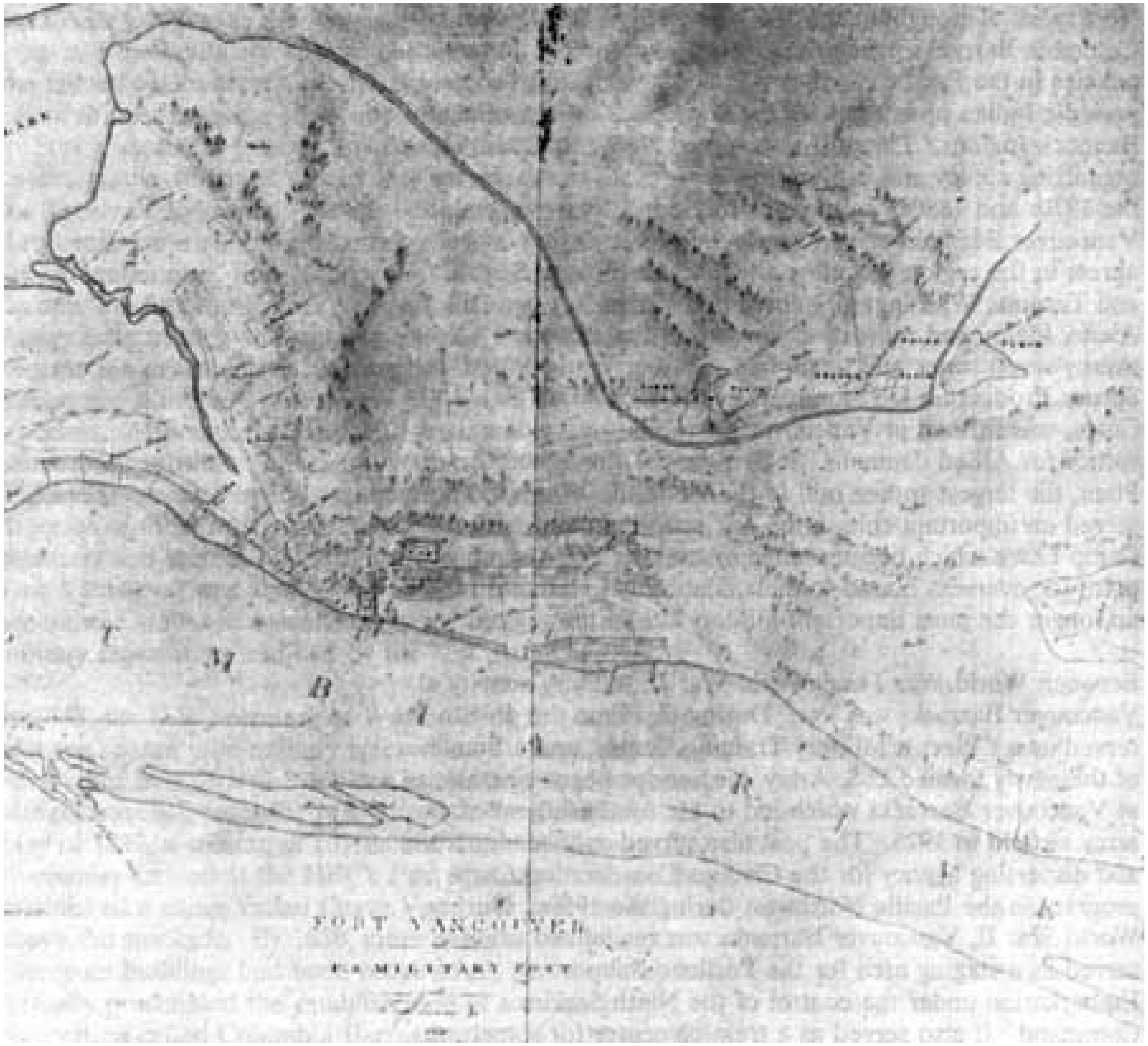
Appendices

Appendix A — Historic Maps

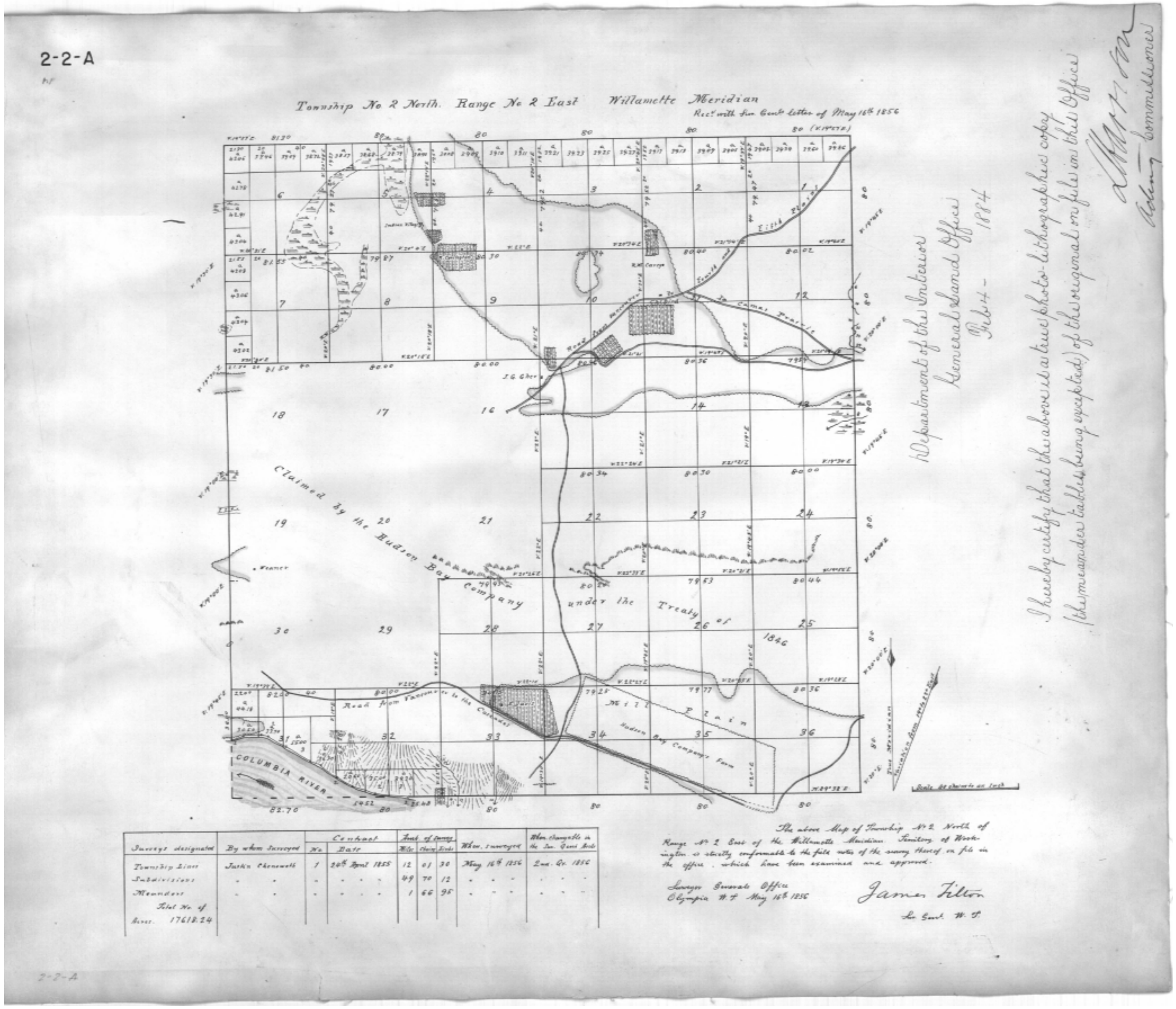
otak



1844 H. N. Peers Map. Credit: Hudson's Bay Company Archive Provincial Archives of Manitoba.



1859 Covington Map. Credit: Fort Vancouver N.H.S. photo file.

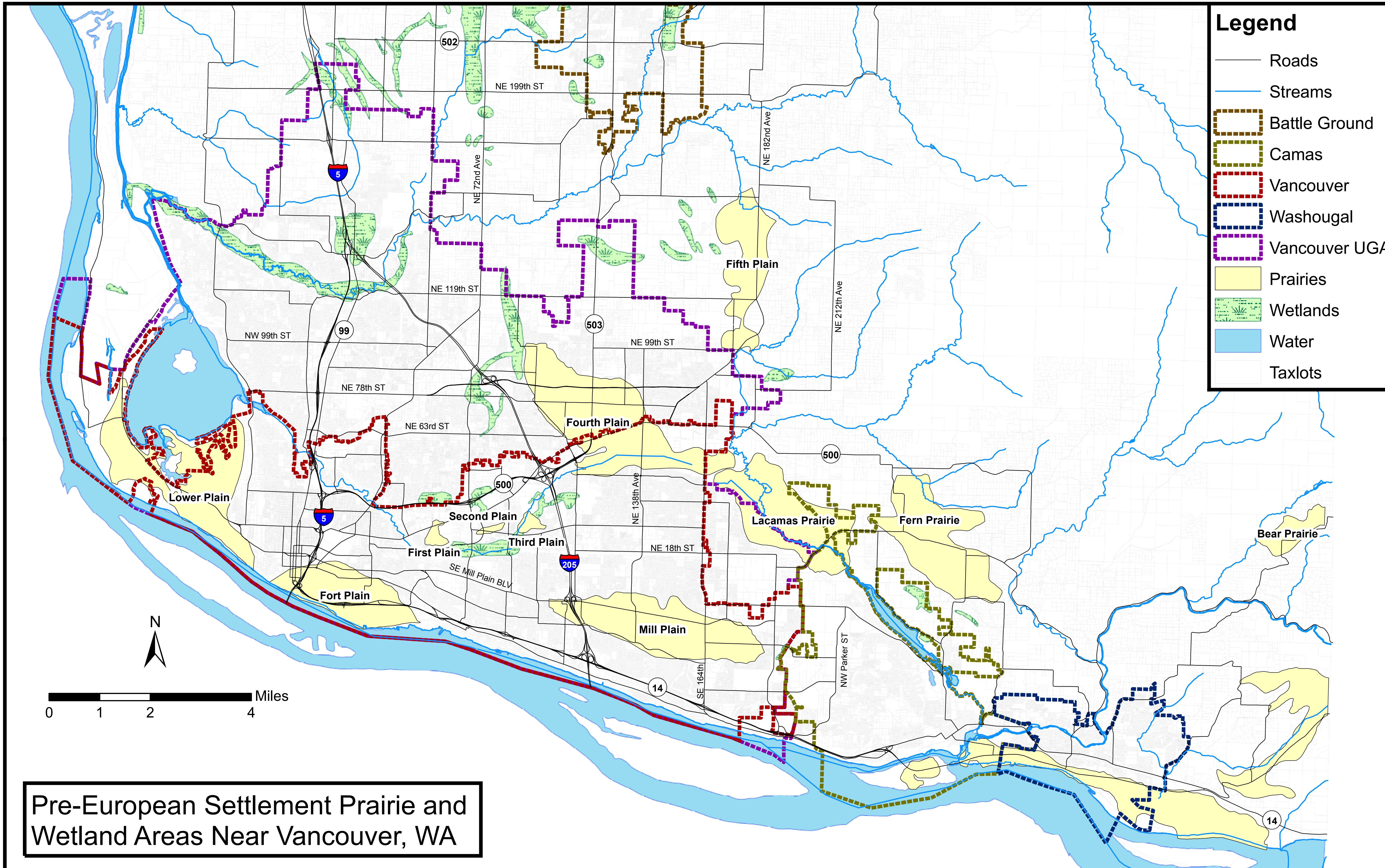


Example Cadastral Map for Township 2N Range 2E showing Fourth Plain and Mill Plain.

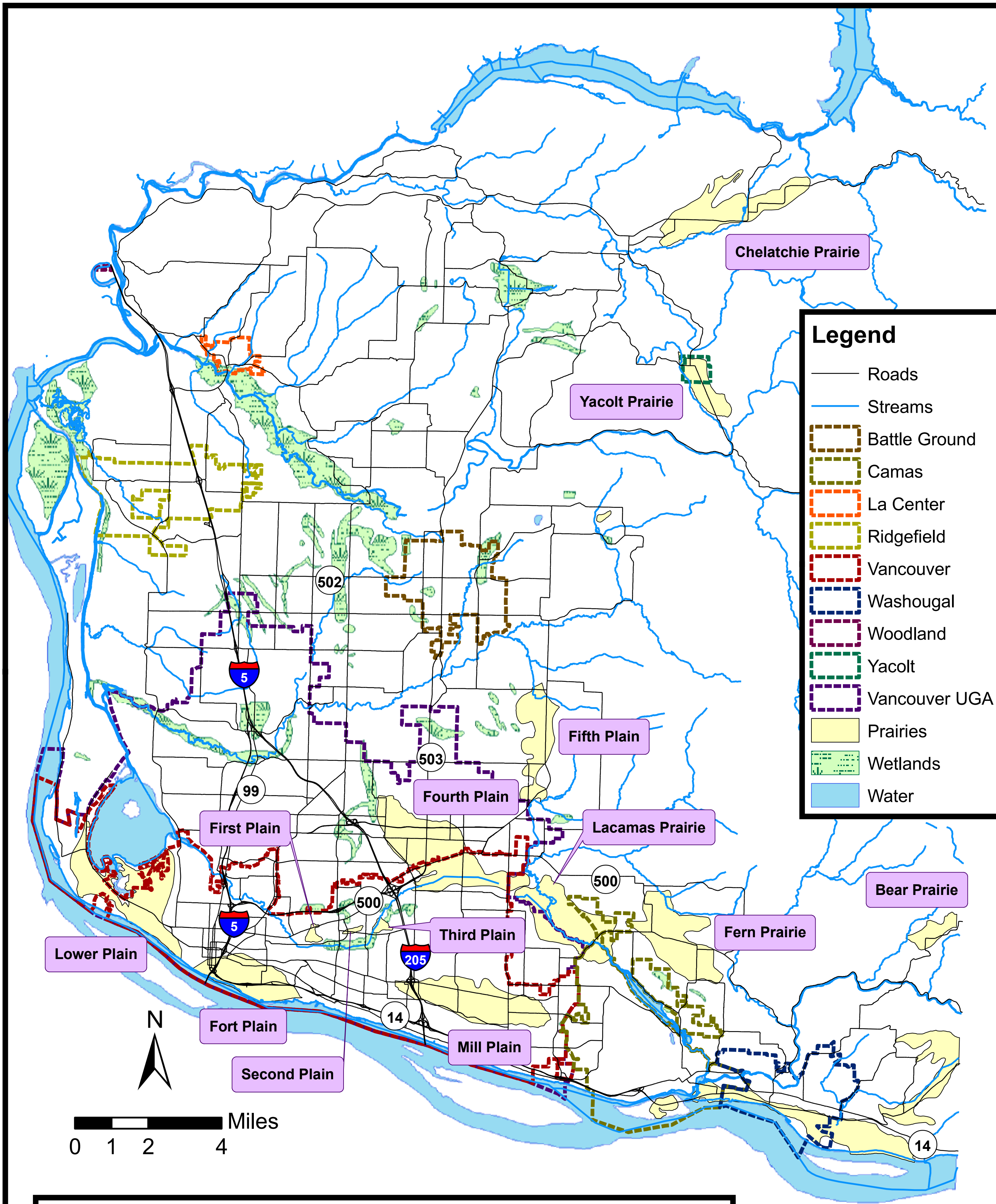
A portion of the1888 Map of Clarke County. Credit Clark County Historical Museum

Appendix B — Prairie Areas Maps

otak



Pre-European Settlement Prairie and Wetland Areas Near Vancouver, WA



Pre-European Settlement Prairie and Wetland Areas In Clark County, WA

SURFACE WATER MANAGEMENT

DESIGN AND CONSTRUCTION REQUIREMENTS

APPENDIX D

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http://www.cityofvancouver.us/vmc

VMC 14.24 Erosion Control
VMC 14.25 Stormwater Control
VMC 14.26 Water Resources Protection
VMC 20.740.120 Critical Areas Protection - Frequently Flooded Areas
VMC 20.740.140 Critical Areas Protection - Wetlands
VMC 20.760 Shoreline Management Area
VMC 20.770 Tree, Vegetation & Soil Conservation

Additional City of Vancouver Information

Engineering Review - Development Review Services
http://www.cityofvancouver.us/publicworks/page/general-requirement-standards-details-water-sanitary-sewer-stormwater

Flood Maps and Shorelines - Environmental Planning
http://www.cityofvancouver.us/ced/page/environmental-planning
http://gis.clark.wa.gov/mapsonline/?site=SoilsWetlands&ext=1

Wellhead Special Protection Areas - Water Resources Protection Program
http://www.cityofvancouver.us/publicworks/page/water-resources-protection-program

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Washington State Department of Ecology. Construction Stormwater General Permit.
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Chapter 173-218 WAC. Underground Injection Control Program. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-218

Chapter 173-350-220 WAC. Composting Facilities. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-350-220

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SURFACE WATER MANAGEMENT

DESIGN AND CONSTRUCTION REQUIREMENTS

APPENDIX E

Operations and Maintenance Manual

Content Checklist

FINAL Stormwater Report Requirements

OPERATIONS AND MAINTENANCE MANUAL – CONTENT CHECKLIST

City of Vancouver Washington

Final stormwater reports must include an operation and maintenance manual following the format and content requirements of City of Vancouver's Surface Water General Requirements Section 4. The content checklist below is provided to assist applicants and engineers in preparing a complete Operations and Maintenance Manual that addresses these requirements. It is the project engineer's responsibility to prepare a manual meeting the General Requirements. The engineer must verify all items have been addressed or included in the report.

Project name: ___________________________________ Project Number: __________________

Applicant Use	Item Description	Staff Use
OPERATIONS & MAINTENANCE MANUAL		
☐	Narrative for operations and management of the site including description of stormwater system and receiving waters for runoff that leaves site	☐
☐	Itemized list of stormwater facilities and components found on site (quantity of catch basins, pipe, treatment vaults, ponds, etc)	☐
☐	Project site map including access for maintenance and location of facilities including native soil and vegetation protection areas	☐
☐	Specify the ownership of the proposed facilities and clearly indicate long-term maintenance responsibility	☐
☐	Funding guidelines for maintenance including planning for higher costs during plant establishment, media filter replacements and facility life expectancy. Estimate costs for average routine maintenance, eventual replacement and how best practices like street sweeping and catch basin cleaning can reduce costs.	☐
☐	Inspection checklists for specific facilities on the site using Ecology's *Western Washington LID O&M Guidance* or *Stormwater Manual* Vol V	☐
☐	Special instruction or attachments for emerging technology or proprietary ("brand-name") systems	☐
☐	Flow dispersion areas delineated with locations of easements or separate tracts.	☐
☐	Disposal guidance on sediments removed from stormwater facilities including relevant materials anticipated to be handled on site, indicators of contaminants and proper disposal.	☐
☐	Log forms including dates, components inspected or maintained, waste disposal and proprietary system reports	☐

<table>
<tr><th colspan="3">WATER RESOURCE PROTECTION (POLLUTION SOURCE CONTROL PROGRAM)</th></tr>
<tr><td colspan="3">Minimum standards</td></tr>
<tr><td>☐</td><td>Precautions to prevent accidental releases</td><td>☐</td></tr>
<tr><td>☐</td><td>Hazardous materials management protective of human health and the environment</td><td>☐</td></tr>
<tr><td>☐</td><td>Leaks and spills containment, proper cleanup and notification to the City of Vancouver</td><td>☐</td></tr>
<tr><td>☐</td><td>Oil/water separator inspection, cleaning and maintenance according to guidance in Stormwater Manual</td><td>☐</td></tr>
<tr><td>☐</td><td>Pesticide and Fertilizer Management application and management according to guidance in Stormwater Manual</td><td>☐</td></tr>
<tr><td>☐</td><td>Decommissioning water wells in accordance with WAC 173-160-381</td><td>☐</td></tr>
<tr><td>☐</td><td>Operation closure shall include removal and proper disposal of all hazardous materials</td><td>☐</td></tr>
<tr><td>☐</td><td>Mobile washing and pressure cleaning shall be performed according to guidance in Stormwater Manual. Wastewater from such operations shall be captured and directed to an approved discharge location.</td><td>☐</td></tr>
<tr><td colspan="3">Greater standards for Classified Facilities
<u>Class I</u>- Annually manage 220lbs of hazardous materials defined in 40 CFR 302.4 CERCLA or
<u>Class II</u>- Annually manage 2200lbs leachable constituents from Toxicity Characteristic List in WAC 173-303-090(8) or Halogenated Solvent List in VMC 14.26.165</td></tr>
<tr><td>☐</td><td>Best management practices for preventing release of hazardous material to soil or water resources including container management, condition, identification and compatibility as well as containment. Loading area containment, prevention and washing and operation closure practices.</td><td>☐</td></tr>
<tr><td>☐</td><td>Spill and Emergency Response Plan (SERP) including prevention, emergency response procedures and certification by operation’s authorized representative.</td><td>☐</td></tr>
<tr><td>☐</td><td>Operational inspection plan including a schedule, annual log of malfunction or deterioration and hazard mitigation.</td><td>☐</td></tr>
<tr><td>☐</td><td>Training program providing at least annual employee information about location of hazardous materials, how to prevent the releases, detect releases, locate the SERP and safely respond to releases.</td><td>☐</td></tr>
<tr><td>☐</td><td>Closure plan outlining types and quantities of hazardous materials, plan for removal, decontamination, estimated costs and certification by operation’s authorized representative.</td><td>☐</td></tr>
<tr><td>☐</td><td>Records plan including inspection, training, cleaning and maintenance events, to be kept on site for at least 3 years and available to the City upon request.</td><td>☐</td></tr>
</table>