WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stormwater Management in Washington State

Volume I
Minimum Technical Requirements

August 1999
(Draft)

Publication No. 99-11
(A revised portion of Publication No. 91-75)

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Minimum Technical Requirements

Prepared by:

Washington State Department of Ecology
Water Quality Program

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The manual, which is close to 700 pages, is now divided into five volumes. Three volumes are now available for review, the remaining two volumes will be done by the end of September, 1999.

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Objective of the Manual

The objective of this manual is to provide guidance on the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment, such that they comply with water quality standards and protect beneficial uses of the receiving waters.

Development and Geographic Scope of This Manual

The Ecology stormwater manual was originally developed for the Puget Sound Basin in response to a directive of the Puget Sound Water Quality Management Plan. The technical manual was intended to provide technical guidance and to define minimum requirements for implementing local stormwater management programs.

The original 1992 manual was prepared by Ecology staff, with significant contributions from advisory committee members from local government public works and planning officials, representatives from other state agencies, and other affected parties including industry and tribes. This update was prepared in much the same manner. There were five separate advisory committees, with over 70 members representing a broad range of expertise and interests. Their insights and practical knowledge gained from years of experience in the field have been particularly valuable.

What is Driving the Revisions to the Manual?

There are several drivers behind the revisions to the manual. First, the manual was written in 1990-1991, drawing from research done in the 1980's and from existing manuals prepared by King County and by communities in other states. Even as the manual was published, deficiencies and shortcomings were evident. In addition, lessons learned from applying the manual and information from current research all point out additional deficiencies and errors in the manual. Second, funding has been provided under the Puget Sound Plan for the past two biennia to update the manual. Third, actual and proposed listing under the Endangered Species Act (ESA) call for significant changes in the way we manage urban runoff. Updating the technical manual to include new information and standards that are more protective will likely be an essential element in managing urban runoff under the ESA.

With this update of the manual, Ecology is seeking to broaden the applicability of the manual to the entire state. In that effort, we have found that the concepts developed originally for the Puget Sound Basin are applicable throughout western Washington. In addition, most of the minimum requirements and the BMPs are equally applicable in eastern Washington. It will probably be necessary to make adjustments in the minimum requirements for flow control and treatment, in some BMP design criteria, and in specifying which BMPs are applicable in some eastern Washington environments.

Organization of This Manual

The manual is organized into five volumes. The volumes will be published as separate documents to make it easier for the user to find needed information and to make it easier to publish future revisions. However, most users will find it necessary to have a complete set of all five volumes. We have tried to strike a balance between bouncing the user back and forth between volumes and unnecessary replication of material.

Unfinished Business (The Text Boxes – a Call for Action)

Although we are inviting comments and recommendations on the manual as a whole, there are some specific issues or questions where we want public comment, information or assistance. We have elected to use "Text Boxes" to highlight these issues. To comment, contact technical leads listed earlier.

The Process and Schedule for Completing the Revisions

Ecology will conduct public workshops, from early October to about mid-November, at both eastside and westside locations. We anticipate separate workshops on Volume I (Minimum Requirements and overall policy issues), Volume II (Construction Stormwater Pollution Prevention), and Volumes III – IV (Hydrologic Analysis, Source Control BMPs, and Runoff Treatment BMPs).

The comment period on the Public Review Draft will end December 15, 1999 and we anticipate publishing a Final Draft by mid-February 2000. We will conduct public meetings on the Final Draft during March and expect to publish a revised manual by the end of April 2000.

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FIGURES

Acknowledgments

The individuals listed below volunteered their time and knowledge to aid in the update of this volume of the Department of Ecology's Stormwater Manual. The department thanks the members of the Volume 1 committee for their efforts and advice.

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CHAPTER 1 - Introduction

1.1 Effects of Urbanization

1.1.1 Background Conditions

Prior to the Euro-American settlement, western Washington primarily was forested in alder, maple, fir, hemlock and cedar. The area's bountiful rainfall supported the forest and the many creeks, springs, ponds, lakes and wetlands. The forest system provided protection by intercepting rainfall in the canopy, reducing the possibility of erosion and the deposition of sediment in waterways. The trees and other vegetative cover evapotranspirated at least 40% of the rainfall. The forest duff layer absorbed large amounts of runoff releasing it slowly to the streams through shallow ground water flow. Forest ecosystems in eastern Washington provided similar hydrologic functions though not always to the same extent. The shrub-steppe and grasslands of eastern Washington also had their own natural hydrologic rhythms.

1.1.2 Hydrologic Changes

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

- Increased peak surface runoff volumetric flow rates;
- Increased volume of surface runoff;
- Decreased time for runoff to reach a natural receiving water;
- Reduced ground water recharge;
- Increased frequency and duration of high stream flows and reduced stream flows during dry weather;
- Greater stream velocities; and
- Increased frequency and duration of wetlands inundation and reduced water elevations during the dry season.

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As a consequence of these hydrology changes, stream channels are eroded by high flows and can lose summertime base flows. Increased flooding occurs. Habitat is degraded and receiving water species composition is altered as explained below.

Figure 1.1 (Booth and Jackson, 1997)[1] illustrates the relationship between the level of development in a basin, the changes in the recurrence of high stream flows, and the resultant streambank instability and channel erosion.

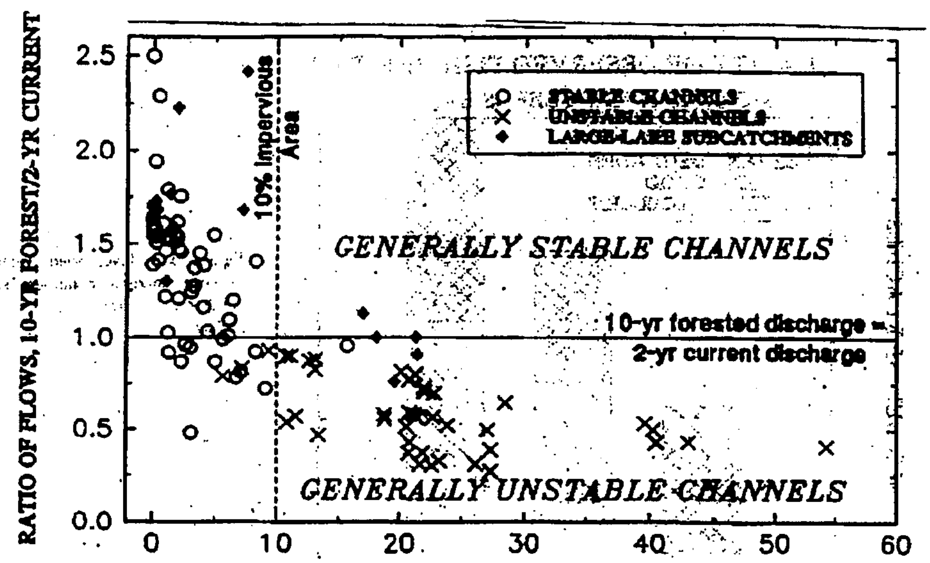

Figure 1.1: Channel Stability and Land Use: Hylebos, East Lake Sammamish, Issaquah Basins

1.1.3 Water Quality Changes

Urbanization also causes an increase in the types and quantities of pollutants in surface and ground waters. Runoff from urban areas has been shown to contain many different types of pollutants, depending on the nature of the activities in those areas. Table 1.1 from an Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected From 1990 to 1996 (1997)[2] shows mean concentrations for a limited number of pollutants from different land uses.

The runoff from roads and highways is contaminated with pollutants from our vehicles. Oil and grease, polynuclear aromatic hydrocarbons (PAH's), lead, zinc, copper, cadmium, as well as sediments (soil particles) and road salts are typical pollutants in road runoff. Runoff from industrial areas typically contains even more types of heavy metals, sediments, and a broad range of man-made organic pollutants, including phthalates, PAH's, and other petroleum hydrocarbons. Residential areas contribute the same road-based pollutants as well as herbicides, pesticides, nutrients (from

fertilizers), bacteria and viruses (from animal waste) to runoff. All of these contaminants can seriously impair beneficial uses of receiving waters.

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

The pollutants added by urbanization can be dissolved in the water column or can be attached to particulates that settle in streambeds, lakes, wetlands, or marine estuaries. A number of urban bays in Puget Sound have contaminated sediments due to pollutants associated with particulates in stormwater runoff.

Urbanization also tends to cause an increase in water temperature. Heated stormwater from impervious surfaces and exposed treatment and detention ponds discharges to streams with less riparian vegetation for shade.

Table 1.1: Land Uses Mean Concentrations for Selected Pollutants[2]

Land Use	TSS mg/l	Total Cu mg/l	Total Zn mg/l	Dissolved Cu mg/l	Total P mg/l
In-pipe Indus.	194	0.053	0.629	0.009	0.633
Instream Indus.	102	0.024	0.274	0.007	0.509
Transportation	169	0.035	0.236	0.008	0.376
Commercial	92	0.032	0.168	0.009	0.391
Residential	64	0.014	0.108	0.006	0.365
Open	58	0.004	0.025	0.004	0.166

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1.1.4 Biological Changes

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

Significant and detectable changes in the biological community of Puget Sound lowland streams begins early in the urbanization process. May et al (1997)[3] reported changes in the 5-10% total impervious area range of a watershed. Figure 1.2 from May et al (1997) shows the relationship observed between the Benthic Index of Biotic Integrity (B-IBI) developed by Kleindl (1995)[4] and Karr (1991)[5], and the extent of watershed urbanization as estimated by the percentage of total impervious area (% TIA). Also shown in the figure is the correlation between the abundance ratio of juvenile coho salmon to cutthroat trout (Lucchetti and Fuerstenberg 1993)[6] and the extent of urbanization.

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

If the hydrological changes don't knock out a species, the toxic pollutants in the water column such as pesticides, soaps, and metals can have immediate and long-term lethal impacts. Toxic pollutants in sediments can yield similar impacts with the lesions and cancers in bottom fish of urban bays serving as a prime example.

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

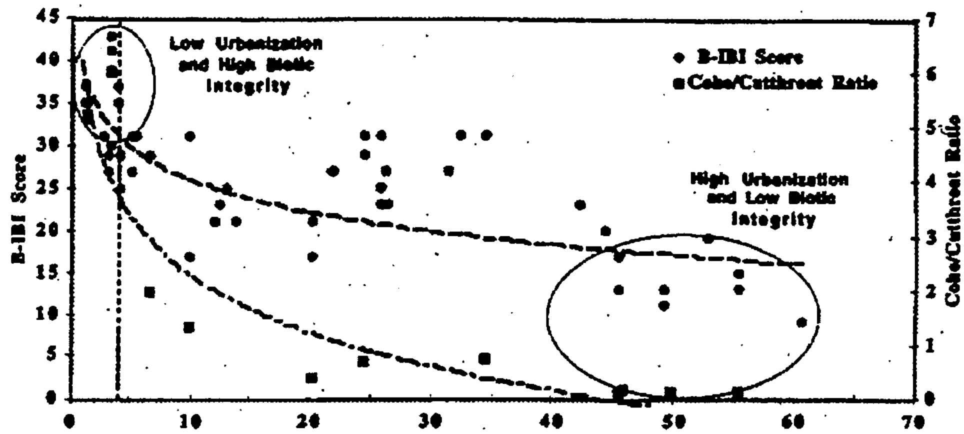

Figure 1.2: Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams

1.1.5 The Role of Land Use and Our Lifestyles

The engineered stormwater conveyance, treatment, and detention systems advocated by this and other stormwater manuals can reduce the impacts of development to water quality and hydrology. But they cannot replicate the natural hydrologic functions of the natural watershed that existed before development, nor can they remove sufficient pollutants to replicate the water quality of pre-development conditions. Ecology understands that despite the application of appropriate Best Management Practices identified in this manual, we will continue to degrade our urban and suburban receiving waters and continue to lose some beneficial uses due to development. This is because land development, as we practice it today, is incompatible with the achievement of sustainable ecosystems. Unless we adopt development methods that cause significantly less disruption of the hydrologic cycle, we will inevitably degrade and lose more beneficial uses of our waters as we develop more areas.

In recent years, researchers (May et al, 1997)[3] and regulators (e.g., Issaquah Creek Basin and Nonpoint Action Plan, 1996)[7] have speculated on the amount of natural land cover and soils that would have to be maintained in a watershed in order to retain sufficient hydrologic conditions to prevent stream channel degradation and maintain base flows. There is some agreement that preserving a high percentage (50%? 65%?) of the land cover

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and soils in an undisturbed state is necessary to preserve hydrology.

It is not clear what other combinations of measures are also necessary to preserve beneficial uses. Clearly, we must improve our stormwater detention, treatment, and source control technologies. This manual is the Department of Ecology's latest effort to apply updated knowledge in these areas. We must also improve the operation and maintenance of our engineered systems so that they function as well as possible. Changing public attitudes toward chemicals use, preferred housing, and transportation modes are also necessary.

A dramatic reduction is necessary in the amount of impervious surfaces and artificially landscaped areas we create to accommodate our preferred housing, play, and work environments, and most significantly, our transportation choices. It is estimated that 65% of the impervious surfaces are created to provide "car habitat." Therefore to make appreciable progress in reducing impervious surfaces in a watershed, we must reduce the density of our road systems, alter our road construction standards, reduce surface parking, and rely more on transportation systems that do not require such extensive impervious surfaces (rail, bicycles, walking).

In short, we must implement drastic changes in where and how we develop land and how we live and move across the land if we are to achieve the goals we set for ourselves in the federal Clean Water Act - to preserve, maintain, and restore the beneficial uses of our nation's waters.

1.2 Objective

The objective of this manual is to control the quantity and quality of stormwater produced by new development and redevelopment such that they comply with water quality standards and protect beneficial uses of the receiving waters. Application of appropriate minimum requirements and BMP's identified in this manual are necessary but sometimes insufficient measures to achieve those goals.

To accomplish the objective, the manual establishes minimum requirements for projects of all sizes and provides guidance concerning how to prepare and implement stormwater site plans. These plans are required for new development and redevelopment on both large and small parcels, and must meet the applicable minimum requirements contained in Chapter 2. These requirements are, in turn, satisfied by the application of

BMPs from Volumes II through V. Projects that follow this approach will apply reasonable, technology-based BMPs to reduce the adverse impacts of stormwater.

It is important to understand that compliance with this manual does not ensure compliance with water quality standards. State and local permitting authorities with jurisdiction can require more stringent measures that are deemed necessary to meet locally established goals, state water quality standards, or other established natural resource or drainage objectives.

The manual can also be helpful in identifying options for retrofitting BMPs to existing development. Retrofitting stormwater BMPs into existing developed areas will be necessary in many cases to meet federal Clean Water Act and state Water Pollution Control Act (Chapter 90.48 RCW) requirements.

Ecology does not have guidance specifically for retrofit situations (not including redevelopment situations). We encourage application of BMPs from this manual when it is feasible to do so. However, there are typically site constraints that make the application infeasible.

Application to Retrofit Situations

Ecology is inviting comment on how and under what circumstances to modify these BMPs for retrofit situations.

Ecology is also inviting comment on the use of BMPs not included in the manual for retrofit situations.

1.3 Development and Geographic Scope of This Manual

The Ecology stormwater manual was originally developed in response to a directive of the Puget Sound Water Quality Management Plan (Plan).[8] The Puget Sound Water Quality Authority (since replaced by the Puget Sound Water Quality Action Team, PSWQAT) recognized the need for overall guidance for stormwater quality improvement. It incorporated requirements in its Plan to implement a cohesive, integrated stormwater management approach through the development and implementation of programs by local jurisdictions, and the development of rules, permits, and guidance by Ecology.

One of the plan's stormwater elements (SW-3.1) requires Ecology to develop a stormwater technical manual for use by local jurisdictions. The Plan specifies aspects that the manual is to include.

With this update of the manual, Ecology is seeking to broaden the applicability of the manual to the entire state. In that effort, we have found that the concepts developed originally for the Puget Sound Basin are applicable throughout western Washington. In addition, most of the concepts, minimum requirements and BMPs are equally applicable in eastern Washington. Adjustment in the minimum requirements for flow control and treatment, adjustment of some BMP design criteria, and specification of the types of BMPs applicable in some eastern Washington environments seem appropriate.

1.4 Development of Best Management Practices to Improve Water Quality

1.4.1 Best Management Practices (BMPs)

The primary method by which the manual controls the adverse impacts of development and redevelopment is through the application of Best Management Practices

Best Management Practices are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants to waters of Washington State. The types of BMPs are source control, runoff treatment, and flow control.

The primary purpose of using BMPs is to protect beneficial uses of water resources through the reduction of pollutant loads and concentrations, and through reduction of discharges (volumetric flow rates) causing stream channel erosion. If it is found that, after the implementation of BMPs advocated in this manual, beneficial uses are still threatened or impaired, then additional controls may be required.

1.4.2 Source Control BMPs

Stormwater management programs should keep in mind that it is generally more cost effective to **prevent** impacts using source control than using runoff treatment to remove pollutants. However, since source controls cannot prevent all impacts, some combination of measures will always be needed.

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

1.4.3 Treatment BMPs

Runoff treatment BMPs include facilities that remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, and soil adsorption. Runoff treatment BMPs can accomplish significant levels of pollutant load reductions if properly designed and maintained.

1.4.4 Flow Control BMPs

Flow control BMPs typically control the rate, frequency, and flow duration of stormwater surface runoff releases. The need to provide flow control BMPs depends on whether a development site discharges to a stream system or wetland, either directly or indirectly. Stream channel erosion control can be accomplished by BMPs that detain runoff flows and also by those which physically stabilize eroding streambanks. Both types of measures may be necessary in urban watersheds. Only the former is covered in this manual.

Construction of a detention pond is the most common means of meeting flow control requirements. The concept of detention is to collect runoff from a developed area and release it at a slower rate than it enters the collection system. The reduced release rate requires temporary storage of the excess amounts in a pond with release occurring over a few hours or days. The volume of storage needed is dependent on 1) the size of the drainage area; 2) the extent of disturbance of the natural vegetation, topography, and soils and creation of effective impervious surfaces (surfaces that drain to a stormwater collection system); and 3) how rapidly the water is allowed to leave the detention pond, i.e., the target release rates.

The 1992 Ecology manual focused primarily on controlling the peak flow release rates for recurrence intervals of concern – the 2, 10, and 100-year rates. This level of control did not adequately address the increased duration at which those high flows occur because of the increased volume of water from the developed condition as compared to the pre-developed conditions. To protect stream channels from increased erosion, it is necessary to control the durations over which a stream channel experiences geomorphically significant flows such that the energy imparted to the stream channel does not increase significantly. Geomorphically significant flows are those that are capable of moving sediments. This target will translate into lower release rates and significantly larger detention ponds than the previous Ecology standard. The size of such a facility can be reduced by changing the extent to which a site is disturbed.

In regard to wetlands, it is necessary to not alter the natural hydroperiod . This means control of flows from a development such that the wetland is within certain elevations at different times of the year. If the amount of surface water runoff draining to a wetland is increased because of land conversion from forested to impervious areas, it may be necessary to bypass some water around the wetland in the wet season. If however, the wetland was fed by local ground water elevations during the dry season, the impervious surface additions and the bypassing practice may cause variations from the dry season elevations. Estimations of what should be done to maintain the natural hydroperiod requires the use of a continuous runoff model. It remains to be seen whether the continuous runoff models we have available are sufficiently accurate to determine successful flow management strategies. And even if the modeling approaches are sufficient, it will be a challenge to simulate pre-development hydrology once you have significant development around and draining to or through a wetland.

1.5 Organization of This Manual

The manual is organized into five volumes

Volume I provides an introduction and overview, establishes thresholds for determining whether to apply small or large parcel minimum requirements, establishes the minimum requirements for large and small parcels, and provides guidance on preparation of a stormwater site plan. A glossary is included at the back of Volume I.

Volume II covers stormwater pollution prevention at construction sites with a primary focus on erosion and sediment control. The volume provides an overview of erosion and sedimentation, summarizes various regulatory requirements, describes how to prepare a Construction Stormwater Pollution Prevention Plan, and details the standards and specifications for BMPs.

Volume III covers hydrologic analysis methods for estimating pre- and post-developed runoff quantities and flow rates, and details of detention facility design, construction, and maintenance. It provides general information in regard to infiltration and constructed wetlands with references to Volume V for further details. It provides reference to the use of natural wetlands for stormwater. We have deleted the chapter on conveyance design, and encourage the use of other references.

Volume IV addresses control of runoff pollution produced by urban land uses with a primary emphasis on source control BMPs. Source control BMPs for specific types of activities are described in detail. Extensive appendices provide guidance on BMPs applicable to business types and helpful information concerning other related regulatory requirements and recycling, disposal, and treatment options for waste materials.

Volume V provides the details of treatment BMP design, construction, and maintenance. It is organized by treatment BMP types and details how to select BMPs according to the requirements and the needs of the site.

1.6 Users of This Manual

The users of this manual will be engineers, planners, environmental scientists, plan reviewers, and inspectors from local government and private industry. Local government officials may adopt and apply the requirements of this manual directly or adopt and apply the requirements of an equivalent manual. Local government staff will use this manual, or their own manual, as a reference for reviewing stormwater site plans, checking BMP designs, and for providing technical advice in general. Private industry will use the manual for information on how to develop and implement stormwater site plans, and as a reference for technical specifications of BMPS.

Where permits, such as the Baseline General Permit for Industrial Activities, references BMPs in this manual, affected industries shall use the manual for specifics concerning how to comply with their permits.

1.7 How to Use This Manual

Development project proponents will want to take the following steps:

- Read Chapter 2 in Volume I to determine the minimum requirements that apply to the project;
- Use Chapter 4 of Volume I to help select permanent BMPs for the project;
- Reference Volumes III through V for BMP design criteria;
- Use Chapter 3 of Volume I to help develop your stormwater site plan; and
- Use Volume II to plan your construction activities, including:
  - check your regulatory responsibilities in chapter 2;
  - use chapter 3 to develop your Construction Stormwater Pollution Prevention Plan; and
  - use chapter 4 to select and specify BMPs.

Businesses which need to comply with their industrial stormwater permit or a local requirement to apply source control BMPs should reference Volume IV.

1.8 Regulatory Status of the Manual

This manual has been developed by Ecology to represent the latest developments in technology-based management of urban stormwater. The manual itself has no independent regulatory authority. Its requirements and BMPs only become required through:

- ordinances and rules established by local governments; and,
- permits and other authorizations issued by local, state, and federal authorities.

1.9 Relationship of this Manual to Federal, State, and Local Regulatory Requirements

The Ecology manual is one cog in the efforts to manage and reduce the impacts of urban stormwater discharges. This section will explain the relationship of the manual to each of the various programs, permits, and planning efforts described below.

1.9.1 The Puget Sound Water Quality Management Plan

The Puget Sound Water Quality Management Plan (The Plan) requires all cities and counties in the Puget Sound Basin to implement stormwater management programs. Element SW-1.1 states that those programs are to include:

Ordinances for all new development and redevelopment which address control of off-site water quality and quantity effects; the use of source control BMPs; the effective treatment of the water quality design storm; the use of infiltration where appropriate; the protection of stream channels, fish and shellfish habitat, and wetlands; erosion and sediment control at construction project, and local enforcement of these stormwater controls.

Element SW-1.3 states that:

> "In conjunction with the runoff control ordinances for new development and redevelopment, each jurisdiction shall adopt a stormwater management manual containing best management practices. A local government may adopt the manual prepared by Ecology under element SW-3 or prepare its own manual as long as it has substantially equivalent technical standards to those in Ecology's manual. Ecology shall review alternative manuals of local governments for substantial consistency with the Plan and Ecology's manual and guidance."

Element SW-2.4 of the Plan requires that:

> "Each urban stormwater program shall seek to control the quality and quantity of runoff from public facilities and industrial, commercial and residential areas, including streets and roads, consistent with manuals and guidance provided by Ecology…"

Element SW-3.1 requires Ecology to:

> "…maintain a technical manual that implements the requirements in elements SW-1 and SW-2 for use by local jurisdictions in stormwater planning."

Ecology publishes this manual to fulfill its responsibilities under the Plan. Cities and counties are to adopt ordinances and manuals that are substantially equivalent. Ecology published guidance ("Guidance for Local Governments When Submitting Manuals and Associated Ordinances for Equivalency Review," 3/94, Publication #94-45) that listed the following criteria that Ecology uses to determine equivalency:

1. The Minimum Requirements *(in Chapter 2 of Volume I)* for new development and redevelopment now in the model ordinance *(also published by Ecology)* and the technical manual or their equivalents must be included in the ordinance adopted by the local government. More stringent requirements may be used, and/or the Minimum Requirements may be tailored to local circumstances through the use of basin plans.
2. The thresholds for and definitions of new development, redevelopment, land disturbing activities, and existing conditions should provide equivalent protection of receiving waters or equivalent levels of pollution treatment as those provided by Ecology's criteria.
3. The substantially equivalent manual must include BMP selection and site planning processes that have outcomes that provide equivalent or greater protection to those in Ecology's technical manual.
4. BMPs equivalent to those contained in Volumes II through IV *(corresponding to proposed Volumes II through V of this update)* of Ecology's manual must be included in the local government's version of the manual.
5. An exceptions or variance process similar in content to Section I-2.16 *(Section 2.8 of Volume I in this update)*, Exceptions, must be included.

Manual Equivalency Criteria

As part of this manual update, Ecology will update the equivalency criteria. Ecology invites comments on this section.

The text in Chapter 2 of Volume 1 that is in **bold print** are those concepts that Ecology will require local governments to incorporate or to have equivalent concepts that provide an equal or greater level of protection or treatment.

1.9.2 Phase I NPDES and State Waste Discharge Stormwater Permits for Municipalities

Ecology has issued joint NPDES and State Waste Discharge permits to regulate the discharges of stormwater from the municipal separate storm sewer systems operated by the following cities and counties:

> Clark County, King County, Pierce County,
>
> Snohomish County, Seattle, and Tacoma.

The Washington Department of Transportation is also a Phase I municipal stormwater permittee for its stormwater discharges within the jurisdictions of the above cities and counties.

As a condition (Special Condition S7.b.8.a.) of the permits issued in July, 1995, these entities are required to implement stormwater programs that must include:

> "… ordinances (except WSDOT's program), minimum requirements and best management practices (BMPs) equivalent to those found in Volumes I-IV of Ecology's *Stormwater Management Manual for the Puget Sound Basin* (1992 edition, and as amended by its replacement)…."

These entities have until the end of the permit terms, July, 2000 to comply with this requirement.

Ecology will reissue the Phase I permits in July, 2000. At that time we will add whatever additional municipalities are required by federal law to have an NPDES Phase I municipal stormwater permit. We also intend to continue to retain the above special condition with a reference to the year 2000 edition of the Ecology stormwater manual. Ecology may also add a deadline or deadlines within the term of the permit for compliance with the condition.

1.9.3 Phase II NPDES and State Waste Discharge Stormwater Permits for Municipalities

The U.S. Environmental Protection Agency (EPA) intends to promulgate its Phase II stormwater regulations in October, 1999. Those rules will identify additional municipalities as subject to NPDES municipal stormwater permitting requirements. An initial estimate is that 76 municipalities will be subject to the requirements, and 13 additional municipalities may be subject to the requirements depending upon an analysis that Ecology must perform. Unless the dates change in the final rule, the Phase II permits must be issued by November 2002. The Phase II communities must submit their stormwater programs to comply with permit requirements by January 2003.

The proposed regulations specify minimum requirements for the stormwater programs developed to comply the Phase II permits.

One of those requirements is the adoption of a program for "post-construction stormwater management in new development and redevelopment." Another is a program for "construction site stormwater runoff control."

To at least partially fulfill these requirements, Ecology intends to require the Phase II municipalities to adopt ordinances, minimum requirements, and BMPs equivalent to those in this updated manual. Essentially, this would be the same permit condition as required of the Phase I municipalities. However, a different schedule for compliance may be necessary for some municipalities. Municipalities within the Puget Sound Basin should have already completed these tasks as required by the Puget Sound Water Quality Management Plan, and as encouraged by the State's strategy for salmon recovery.

1.9.4 Municipalities Not Subject to the Puget Sound Water Quality Management Plan nor NPDES Stormwater Permits for Municipalities

Municipalities not subject to the Puget Sound Plan nor NPDES stormwater permits for municipalities are encouraged to adopt stormwater programs at least equivalent to the Puget Sound Basic Stormwater Program. This would include adoption of ordinances, minimum requirements, and BMPs equivalent to those in Ecology's manual. Any municipalities in areas where urban stormwater has been identified as a limiting factor to salmon recovery are expected to have an equivalent stormwater manual as part of a Comprehensive Stormwater Program as defined by the Puget Sound Water Quality Management Plan.

1.9.5 The NPDES and State Waste Discharge Baseline General Permit for Stormwater Discharges Associated With Industrial Activities (a.k.a., industrial stormwater permit)

Businesses subject to the Baseline General Permit for Stormwater Discharges Associated With Industrial Activities have to prepare and implement a Stormwater Pollution Prevention Plan in accordance with the terms of that permit. The permit issued in November 1995 requires a description and implementation of generic "operational BMPs" (the same category of BMPs referred to as operational source control BMPs in this manual), and "source control BMPs" (the same category of BMPs referred to as "structural source control" BMPs in this manual) from Volume IV of the 1992 Puget Sound Stormwater Manual. Additionally, application of erosion and sediment control BMPs, flow control BMPs and treatment BMPs from the 1992 manual and other published guidance is required if necessary to address an erosion, flow, or pollution problem.

The existing industrial stormwater permit expires in November 2000. Ecology intends to redraft the permit conditions and reissue the permit by that date. As a condition of the reissued permit, Ecology anticipates that it will require industrial stormwater permittees to implement the BMPs in this updated stormwater manual. Ecology will consider retaining the statement in the existing permit that allows businesses to implement alternative BMPs as long as they can demonstrate that it will result in equal or better quality of stormwater discharge.

1.9.6 The NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated With Construction Activity (a.k.a., construction stormwater permit)

Projects covered by the construction stormwater permit must select BMPs from Volume II of this manual if the date of the BMP selection process for the project is 120 days or more after the issue date of the manual.

Construction sites that will disturb five acres or more and will have a discharge of stormwater from the project site to a surface water must apply for Ecology's construction stormwater permit. The permit requires application of stabilization and structural practices to reduce the potential for erosion and the discharge of sediments from the site. The stabilization and structural practices cited in the permit are very similar to the 15 minimum requirements for sedimentation and erosion control in Volume I of the 1992 Puget Sound stormwater manual. The permit also requires construction sites within the Puget Sound basin to select BMPs from Volume II of **the most recent version of the Ecology stormwater manual that has been available at least 120 days prior to the BMP selection.** Sites outside the basin are required to select BMPs from the manual, from the Erosion and Sediment Control Handbook, by Goldman et al, or to select other appropriate BMPs. The permit also states that where Ecology has determined the local government requirements for construction sites to be at least as stringent as Ecology's, Ecology will accept compliance with the local requirements.

The construction stormwater permit issued in November 1995 expires in November 2000. Ecology intends to reissue a new permit by the latter date. We anticipate that the reissued permit will require compliance with the construction stormwater pollution prevention elements cited in Large Parcel Minimum Requirement #1, and listed in Chapter 3 of Volume II. We also anticipate that the permit will require selection of BMPs from Volume II of this manual, and that it will allow use of BMPs from local government manuals where they have been determined to be equivalent.

The proposed EPA Phase II stormwater regulations would require construction sites of 1 acre and larger to apply for an NPDES stormwater permit. If that regulation is adopted as proposed, Ecology will likely require all such sites to apply for coverage under its reissued construction stormwater permit.

1.9.7 The Endangered Species Act: Section 4(d) Rules, Section 7 Consultations, Section 10 Habitat Conservation Plans

With the listing of multiple species of salmon as threatened or endangered across much of Washington State, and the probability of more listings in the future, implementation of the requirements of the Endangered Species Act will have a dramatic effect on urban stormwater management. The manner in which that will occur is still evolving.

Under Section 4(d) of the statute, the federal government issues regulations to provide for the conservation of the species. A 4(d) rule may require new development and redevelopment to comply with specific requirements. It remains to be seen whether the federal government will cite the requirements of this manual in a 4(d) rule.

Under Section 7 of the statute, all federal agencies must insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species (or a species proposed for listing), nor result in the destruction or adverse modification of designated critical habitat. The responsibility for determining whether jeopardy is likely to occur rests with the "action" agency. If an action "may affect" a listed species, the "action" agency must consult with the National Marine Fisheries Service (NMFS), or the U.S. Fish and Wildlife Service (F&WS) depending on the species involved, to determine whether jeopardy is likely to occur. Where NMFS or F&WS believes that jeopardy would result, it must specify reasonable and prudent alternatives to the action that would avoid jeopardy if any such alternatives are available. If the "action" agency rejects these, the action cannot proceed. This manual may play a role in these jeopardy decisions and the alternatives cited to avoid jeopardy.

Under Section 10 of the ESA, through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit an "incidental take" of individuals of that species as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). This new provision of the ESA is designed to resolve conflicts between development pressures and endangered species protection. A "Habitat Conservation Plan" (HCP) is an example of this type of agreement. Under an HCP, the applicant's plan must:

- outline the impact that will likely result from the taking;
- list steps the applicant will take to minimize and mitigate such impacts, and funding available to implement such steps; and
- include alternative actions the applicant considered and reasons alternative acts are not being used.

The federal government may grant a permit if it finds that the taking will be incidental; the applicant will minimize and mitigate impacts of taking; and the applicant will ensure that adequate funding for the conservation plan will be provided. This manual may play a key role in any proposed Habitat Conservation Plans.

1.9.8 Section 401 Water Quality Certifications

For projects that require a fill or dredge permit under Section 404 of the Clean Water Act, Ecology must certify to the permitting agency, the U.S. Army Corps of Engineers, that the proposed project will not violate water quality standards. In order to make such a determination, Ecology may do a more specific review of the potential impacts of a stormwater discharge from the construction phase of the project and from the completed project. As a result of that review, Ecology may condition its certification to require:

- application of the minimum requirements and BMPs in this manual; or
- application of more stringent requirements.

1.9.9 Hydraulic Project Applications (HPAs)

Under Chapter 75.20 RCW, the Hydraulics Act, the Washington State Department of Fish and Wildlife has the authority to require actions of projects whose stormwater discharges would change the natural flow or bed of state waters. The implementing mechanism is

the issuance of an Hydraulics Project Approval (HPA) permit. In exercising this authority, Fish and Wildlife may require:

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

1.9.10 Aquatic Lands Use Authorizations

The Department of Natural Resources (DNR), as the steward of public aquatic lands, may require a stormwater outfall to have a valid use authorization, and to avoid or mitigate resource impacts. Through its use authorizations, which are issued under authority of Chapter 79.90 through 96, and in accordance with Chapter 332-30 WAC, DNR may require:

- compliance with the provisions of this manual; or
- application of more stringent requirements that they determine are necessary to meet their statutory obligations to protect the quality of the state's aquatic lands.

1.9.11 Requirements Identified through Watershed/Basin Planning or Total Maximum Daily Loads (TMDL's, a.k.a., Water Clean-up Plans)

A number of the requirements of this manual can be superseded by the adoption of ordinances and rules to implement the recommendations of watershed plans or basin plans. Local governments may initiate their own watershed or basin planning processes to identify more stringent or alternative requirements. They may also choose to develop a watershed plan in accordance with the Watershed Management Act (ESHB 2514) that includes the optional elements of water quality and habitat. They may also choose to develop a basin plan in accordance with Chapter 400-12 WAC. As long as the actions or requirements identified in those plans and implemented through local or state ordinances or rules comply with the intent of applicable state and federal statutes (e.g., The federal Clean Water Act and the Endangered Species Act), they can supersede the requirements in this manual. The decisions concerning whether such locally derived requirements comply with the intent of federal and state statutes rest with the regulatory agencies responsible for implementing those statutes.

The requirements of this manual can also be superseded through the adoption of actions and requirements identified in a Total Maximum Daily Load that is approved by the EPA.

1.9.12 Other Local Government Requirements

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

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CHAPTER 2 - Minimum Requirements For All New Development and Re-Development

2.1 Introduction

This manual, now expanded to be applicable on a statewide basis, was originally developed to comply the 1991 Puget Sound Water Quality Management Plan. That plan (as amended) requires all counties and cities within the Puget Sound drainage basin to adopt stormwater programs which include minimum requirements for new development and redevelopment set by the Plan and in guidance developed by Ecology. The programs are to include ordinances that address:

> *"... at a minimum: (1) the control of off-site water quality and quantity effects; (2) the use of best management practices for source control and treatment; (3) the effective treatment, using best management practices, of the storm size and frequency (design storm) as specified in the manual for proposed development; (4) the use of infiltration, with appropriate precautions, as the first consideration in stormwater management; (5) the protection of stream channels, fish, shellfish habitat, other aquatic habitat, and wetlands; (6) erosion and sedimentation control for new construction and redevelopment projects; and (7) local enforcement of these stormwater controls."*

Ecology considers the above description to be generic to proper stormwater management in any region within the State of Washington. There are judgements that must be made concerning appropriate technical standards for each region of the state based on differences in hydrology, soils, and underlying geology. For this edition of the manual, Ecology has identified flow control standards and water quality treatment design storms as the only requirements that justify different standards for eastern and western Washington. Ecology has also identified different Best Management Practices (BMPs) that will aid eastern Washington development sites to achieve the intent of the minimum requirements.

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There are several sets of requirements for proposed new development and redevelopment that are applied depending on the type and size of the proposed development. In general, small sites are required to control erosion and sedimentation from construction activities and to apply simpler approaches to treatment and flow control of stormwater runoff from the developed site. Controlling flows from small sites is important because the cumulative effect of uncontrolled flows from many small sites can be as damaging as those from a single large site.

Large sites must provide erosion and sedimentation control during construction, permanent control of stormwater runoff from the developed site through selection of appropriate BMPs, and other measures to reduce and control the onsite and offsite impacts of the project. Sites being redeveloped must generally meet the same minimum requirements as new development for the portion of the site being redeveloped. In addition, if the redevelopment meets certain cost thresholds, updated stormwater management for the entire site must be provided. There may also be situations in which additional controls are required for sites, regardless of type or size, as a result of basin plans or special water quality concerns.

Development sites are to demonstrate compliance with these requirements through the preparation of Stormwater Site Plans (SSP). The plans are described in detail in Chapter I-3. Two major components of these plans are a Construction Stormwater Pollution Prevention Plan (SWPPP) and a Permanent Stormwater Quality Control (PSQC) Plan. The Construction SWPPP shall identify how the project intends to control pollution generated during the construction phase only, primarily erosion and sediment. The PSQC shall identify how the project intends to provide permanent BMPs for the control of pollution from stormwater runoff after construction has been completed. Small sites must submit these plans for review by the local government only if they add or replace 5,000 square feet or more of impervious surface.

A flow chart demonstrating how to determine which set of requirements applies to a particular project is shown in Figure 2.2.

Throughout this Chapter, guidance to meet the requirements of the Puget Sound Water Quality Management Plan is written in bold and supplemental guidelines that serve as advice and other materials are <u>not</u> in bold.

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2.2 Definitions

A full listing and definition of stormwater-related words and phrases that are used in this manual is given in the glossary. A few of the key definitions are listed here for ease in understanding the requirements that follow.

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 demolition, construction, clearing, grading, filling and excavation.

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 impervious surfaces; subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. All other forest practices and commercial agriculture are not considered new development.

Impervious surface A hard surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A hard 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.

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. 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, 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 treated to prevent leaching.

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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 firelanes, diesel equipment storage yards, and airport runways.

The following are not considered regularly-used surfaces: road shoulders primarily used for emergency parking, paved bicycle pathways, bicycle lanes adjacent to unpaved or paved road shoulders primarily used for emergency parking, fenced firelanes, and infrequently used maintenance access roads.

Pollution-generating pervious surfaces (PGPS) — Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil.

Project site — That portion of a property or properties subject to proposed project improvements including those required by this manual.

Redevelopment — On an already developed site, the creation or addition of impervious surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including an increase in gross floor area and/or exterior construction or remodeling; replacement of impervious surface that is not part of a routine maintenance activity; land disturbing activities associated with structural or impervious redevelopment; and any change in use that has the potential to release new pollutants from the site. New pollutants means a pollutant that was not discharged at that location immediately prior to the change in use, as well as a pollutant that was discharged in less quantities immediately prior to the change in use.

Replaced impervious surface — For structures, the removal and replacement of any exterior surfaces or foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement, excluding impervious surfaces removed for the sole purpose of installing underground utilities.

Site — The legal boundaries of a parcel or parcels of land that is (are) subject to new or redevelopment.

Small Parcel — A site with less than one acre of land disturbing activity, AND

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- is a single family residential site, or a small subdivision project, that adds or replaces less than 10,000 square feet of impervious surface; or
- is another type of development project that adds less than 5,000 square feet of impervious surface.

Source control BMP — A BMP that is intended to prevent pollutants from entering stormwater. This manual separates source control BMPs into two types. *Structural Source Control BMPs* are physical, structural, or mechanical devices that are intended to prevent pollutants from entering stormwater. *Operational BMPs* are schedules of activities, prohibition of practices, and other managerial practices to prevent or reduce pollutants from entering stormwater. See Volume IV for details.

Threshold Discharge Area — An onsite 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). The examples in Figure 2.1 below illustrate this definition.

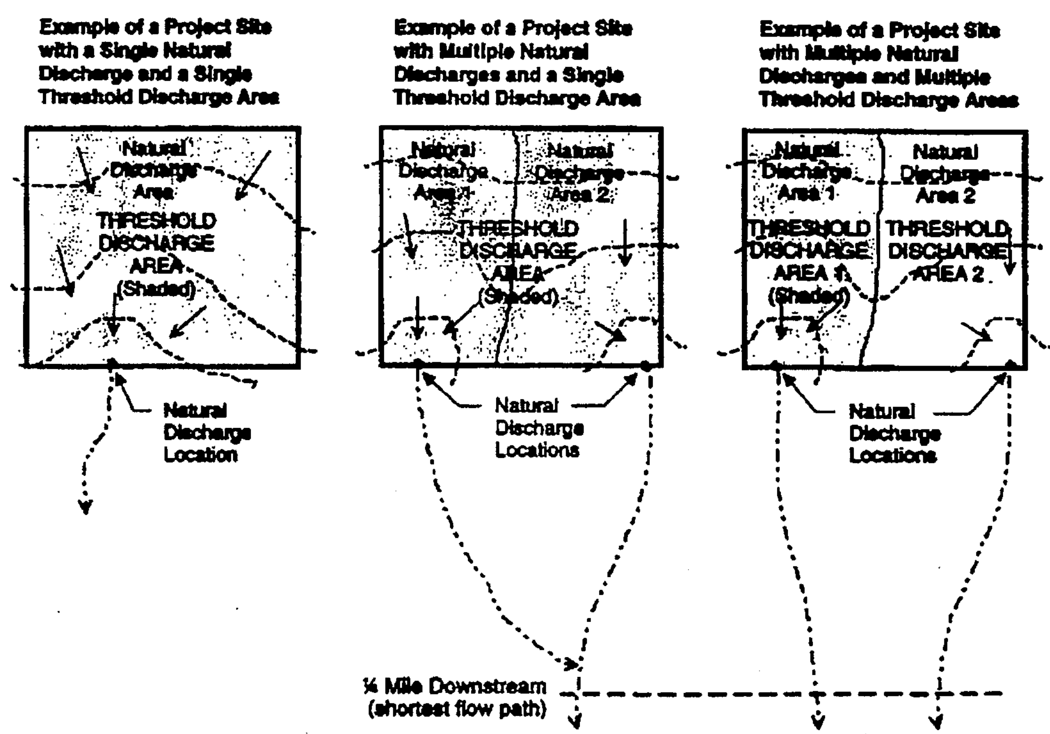

Figure 2.1. Threshold Discharge Areas

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2.3 Exemptions

Commercial agriculture, and forest practices regulated under Title 222 WAC, except for Class IV General forest practices that are conversions from timber land to other uses, are exempt from the provisions of the minimum requirements. All other new development is subject to the minimum requirements.

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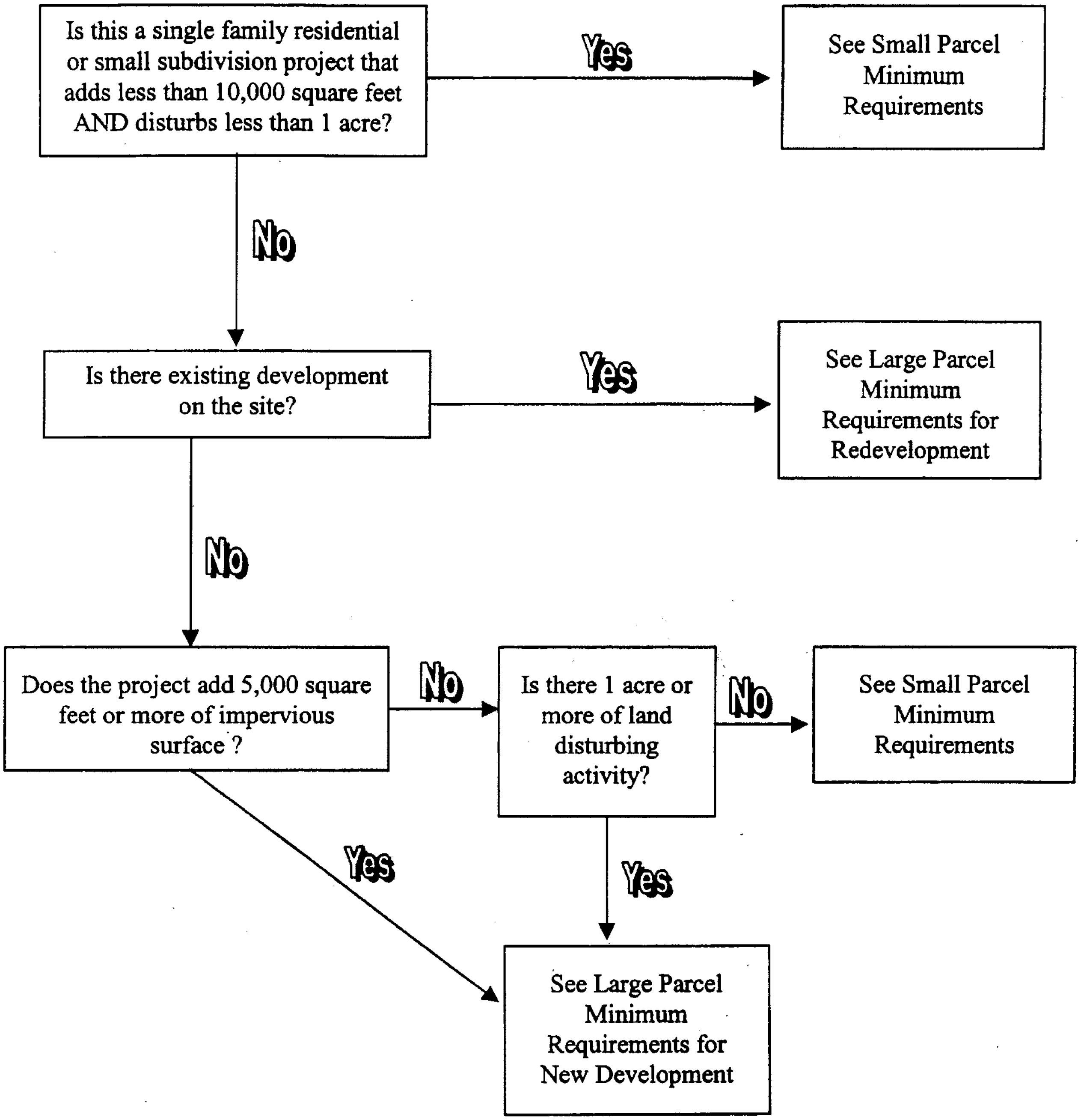

Figure 2.2: Flow Chart for Determining Applicable Requirements

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2.4 Small Parcel Requirements

A project site of a single family residence, or a small subdivision, that meets the small parcel definition is required to comply with the applicable provisions of Large Parcel Minimum Requirement #1 – Construction Stormwater Pollution Prevention (Construction SWPP) and to apply Small Site Requirements for water quality treatment and flow control. Other types of development projects that meet the definition must comply with the applicable provisions of Large Parcel Minimum Requirement #1 – Construction SWPP, Large Parcel Minimum Requirement #3 – Source Control, and apply Small Site Requirements for water quality treatment and flow control.

Small Parcels that add or replace 5,000 square feet or more of impervious surface must prepare a stormwater site plan for local government review.

Small Site Flow Control and Treatment

Ecology intends to propose small site flow control and treatment BMPs for addition to the appropriate Volumes III and V of this manual.

2.5 Large Parcel Thresholds

2.5.1 New Development

All new development, other than small parcels, that includes the creation or addition of 5,000 square feet, or greater, of new impervious surface area, and/or land disturbing activity of one acre or greater, shall comply with Large Parcel Minimum Requirements #1 through #9 and prepare a Stormwater Site Plan.

Supplemental Guidelines:

Basin planning is encouraged and may be used to tailor certain of the Large Parcel Minimum Requirements to a specific basin (see Large Parcel Minimum Requirement #8).

2.5.2 Redevelopment

All redevelopment projects in which the total of *new plus replaced* impervious surfaces is 5,000 square feet or more must comply with Large Parcel Minimum Requirements #1 and #3 for the project site.

Redevelopment projects that add 5,000 square feet or more of *new* impervious surface must comply with all the Large

Parcel Minimum Requirements for the new impervious surfaces. If the runoff quantity from the new surfaces is not separated from runoff from other surfaces prior to treatment or flow control, the stormwater facilities must be sized for the entire flow. Alternatively, the local government may allow the Large Parcel Minimum Requirements to be met for an equivalent (flow and pollution characteristics) area within the same site.

All redevelopment projects in which the total of new plus replaced impervious surfaces is 5,000 square feet or more, and whose valuation of proposed improvements – including interior improvements - exceeds 50% of the assessed value of the existing site improvements shall comply with all the Large Parcel Minimum Requirements for the entire site.

Local governments may exempt redevelopment projects from compliance with Large Parcel Minimum Requirements #4, #5, and/or #6 if they have adopted a plan that fulfills those requirements in regional facilities that will discharge to the same receiving water, AND if they have an implementation plan and a schedule for construction of those facilities. Redevelopment projects for public roads may be exempted from meeting Large Parcel Minimum Requirements #4, #5, and/or #6 for the entire site (i.e., the exemption does not extend to new surfaces that add impervious area) if there is an adopted Capital Improvement Program for retrofitting existing road surfaces.

Application of the Exemptions

Ecology is interested in advice on the application of the exemptions listed above. Should exemptions be granted for redevelopment projects if the local government has a plan and a schedule for future construction of regional facilities, or should the exemption only apply if the regional facilities have been constructed?

Also, who determines the adequacy of plans and schedules for regional facilities or of Capital Improvement Programs? Currently, there isn't a review entity identified to ensure the quality and legal adequacy of those plans, nor if they are properly implemented and on schedule.

***Supplemental Guidelines*:** Local governments can establish criteria for allowing redevelopment projects to pay a fee in lieu of constructing water quality or flow control facilities on a redeveloped site. At a minimum, the fee should be the equivalent of an engineering estimate of the cost of meeting all applicable stormwater requirements for the project. For purposes of cost estimation, the local government may allow the applicant to presume the site does not have unusual physical constraints that would escalate stormwater costs. The local government must use such funds for the implementation of stormwater control projects that would have similar benefits to the same receiving water as if the project had constructed its required improvements. Expenditure of such funds is subject to other state statutory requirements.

Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics should not be subject to redevelopment requirements.

Local governments are also encouraged to review all road projects for changes in elevations or drainage flowpath that could cause flooding, upland or stream erosion, or changes to discharges to wetlands.

2.6 Large Parcel Minimum Requirements

2.6.1 Minimum Requirement #1: Construction Stormwater Pollution Prevention (SWPP)

All new development and redevelopment shall comply with Construction SWPP Elements #1 through #12 below, and shall develop and implement a Construction Stormwater Pollution Prevention Plan (SWPPP). Each of the following twelve required elements must be included in the Construction SWPPP unless exemptions are justified in the narrative.

The following Construction Stormwater Pollution Prevention (SWPP) elements shall be met:

Element #1: Mark Clearing Limits

- **Prior to beginning earth disturbing activities, including clearing and grading, all clearing limits, easements, setbacks, sensitive areas and their buffers, trees, and drainage courses should be clearly marked to prevent damage and offsite impacts.**

Element #2: Establish Construction Access

- **Construction vehicle access and exit shall be limited to one route if possible.**
- **Access points shall be stabilized with quarry spall or crushed rock to minimize the tracking of sediment onto public roads.**
- **Wheel wash or tire baths should be located on-site.**

- If sediment is transported onto a road surface, the roads shall be cleaned thoroughly at the end of each day. Sediment shall be removed from roads by shoveling or sweeping and be transported to a controlled sediment disposal area. Street washing will be allowed only after sediment is removed in this manner.
- Street wash wastewater shall be controlled by pumping back on-site, or otherwise be prevented from discharging into systems tributary to state surface waters without prior and adequate treatment.

Element #3: Detain Flows

- Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site, as required by local plan approval authority.
- Downstream analysis is necessary if changes in offsite flows could impair or alter conveyance systems, streambanks, bed sediment or aquatic habitat. See Volume 1, Minimum Requirement #8, for downstream analysis requirements.
- Stormwater detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional before other land disturbing activities take place.

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Flow Control for Sediment Ponds

We would like to receive comment on whether the flow control achieved (as estimated by the analysis below) by the flow control release structure specified for sediment ponds in Chapter 4 is adequate for construction sites which are by their nature, temporary. Also, should flow control release structures be required for sediment traps?

The flow release structure detailed in Volume II, Chapter 4 for sediment ponds and traps will not achieve the same level of flow control as required by Minimum Requirement # 5 of Volume I. The flow control specified by Minimum Requirement # 5 is intended to protect stream channels from accelerated erosion due to increases in the duration and frequency of high stream flows.

Using a continuous runoff simulation model (King County Runoff Time Series) King County staff did a brief evaluation of the level of control achieved by the release structure specified in Chapter 4. The analysis assumed a typical sediment retention facility sized using the 2-year developed flow for a 10-acre urban residential subdivision (4 acres effective impervious area and 6 acres of grass on till soils). The performance of the facility was evaluated assuming the construction site was fully disturbed, but with no improvements (modeled as 10 acres of grass on till soils). The analysis concluded that pre-developed peak flows were at least matched up to a 5-year event. Flow durations were controlled to pre-developed rates for peak flows ranging between 70% of the 2-year and roughly a 15-year event.

Element #4: Install Sediment Controls

- **Prior to leaving a construction site, stormwater runoff shall pass through a sediment pond, sediment trap, or other appropriate sediment removal BMP.**
- **Sediment ponds and traps, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment on-site shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.**
- **Earthen structures such as dams, dikes, and diversions shall be seeded and mulched according to the timing indicated in Element #5.**

Element #5: Stabilize Soils

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

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- From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days. This condition applies to all soils on site, whether at final grade or not.
- Applicable practices include, but are not limited to, sod and other established vegetative cover, mulching, plastic covering, and the early application of gravel base on areas to be paved.
- Soil stabilization measures selected should be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization agents may have on downstream waters.
- Soil stockpiles must be stabilized and protected with sediment trapping measures.
- Work on linear construction sites and activities, including right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall not exceed the capability of the individual contractor for his portion of the project to install the bedding materials, roadbeds, structures, pipelines, and/or utilities, and to re-stabilize the disturbed soils, meeting the timing conditions specified above in Element #5.

Element #6: Protect Slopes

- Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion.
- Consider soil type and its potential for erosion.
- Reduce slope runoff velocities by reducing continuous length of slope with terracing and diversions, reduce slope steepness, and roughen slope surface.
- Divert upslope drainage and run-on waters from off-site with interceptors at top of slope. Off-site stormwater should be handled separately from stormwater generated on the site. Diversion of off-site stormwater around the site may be a viable option.
- Contain downslope collected flows in pipes, slope drains, or protected channels.

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- Provide drainage to remove ground water intersecting the slope surface.
- Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.
- Flow retention barriers shall be placed at regular intervals within trenches, which are cut down a slope.
- Stabilize soils on slopes, as specified in Element #5.

Element #7: Protect Drain Inlets

- All storm drain inlets made operable during construction shall be protected so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment.
- All approach roads shall be kept clean, and all sediment and street wash water shall not be allowed to enter storm drains without prior and adequate treatment.
- Suggested BMPs

  BMP 220: Storm Drain Inlet Protection

Element #8: Stabilize Channels and Outlets

- All temporary on-site conveyance channels shall be designed, constructed and stabilized to prevent erosion from the expected velocity of flow from a 2 year, 24-hour frequency storm for the developed condition.
- Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes and downstream reaches shall be provided at the outlets of all conveyance systems.

Element #9: Control Pollutants

- All pollutants, including waste materials and demolition debris, that occur on-site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater.
- Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and wastes present on the site.

- **Maintenance and repair of heavy equipment and vehicles involving oil changes, hydraulic system drain down, solvent and de-greasing cleaning operations, fuel tank drain down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted under cover and on impervious surfaces. These surfaces shall be cleaned immediately following any discharge or spill incident.**
- **Wheel wash, or tire bath wastewater, shall not be discharged to the storm drain, or the on-site stormwater treatment system.**
- **Application of agricultural chemicals, including fertilizers and pesticides, shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations shall be followed for application rates and procedures.**
- **Management of pH-modifying sources shall prevent contamination of runoff and stormwater collected on the site. These sources include, but are not limited to, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, and concrete pumping and mixer washout waters.**

Element #10: Control De-Watering

- **All foundation, vault, and trench de-watering water, which has similar characteristics to stormwater runoff at the site, shall be discharged into a controlled conveyance system, prior to discharge to a sediment trap or sediment pond. Channels must be stabilized, as specified in Element #8.**
- **Clean, non-turbid de-watering water, such as well-point ground water, can be discharged to systems tributary to state surface waters, as specified in Element #8, provided the de-watering flow is less than 20 percent of the receiving water flow. These clean waters should not be routed through sediment traps or sediment ponds with stormwater.**
- **Highly turbid or otherwise contaminated dewatering water, such as from construction equipment**

operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, shall be handled separately from stormwater at the site.

- **Other disposal options, depending on site constraints, may include: 1) sanitary sewer discharge with local sewer district approval, 2) overland infiltration, 3) transport off-site in vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.**

Element #11: Maintain BMPs

- **All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with BMPs.**
- **All temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal of BMPs or vegetation shall be permanently stabilized.**

Element #12: Manage The Project

- **Phasing of construction**
- **Seasonal work**
- **Employee training**
- **Pre-construction conference**
- **Coordination with utilities and other contractors**
- **Sub-contractor oversight**
- **Linear site special considerations**
- **Monitoring / reporting**
- **Keeping Construction SWPPP up to date**

Managing the Project

Ecology intends to add more detail to Element #12. We encourage comments concerning the completeness of the above list of sub-elements, and concerning the appropriate text for each of the sub-elements.

Objective: To control erosion and prevent sediment and other pollutants from leaving the site during the construction phase of a project.

Supplemental Guidelines: If a Construction SWPPP is found to be inadequate (with respect to erosion and sediment control requirements), then the Plan Approval Authority[1] within the Local Government should require that other BMPs be implemented, as appropriate.

2.6.2 Minimum Requirement #2: Preservation of Natural Drainage Systems

Natural drainage patterns shall be maintained, and discharges from the 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 downgradient receiving waters.

Objective: To preserve and utilize natural drainage systems to the fullest extent because of the multiple stormwater benefits these systems provide.

Supplemental Guidelines: Creating new discharge points can create significant stream channel erosion problems as the receiving water body typically must adjust to the new flows. Diversions can cause greater impacts than would otherwise occur by discharging runoff at the natural location. Where no conveyance system exists at the adjacent downstream property line and the discharge was previously unconcentrated flow or significantly lower concentrated flow, then measures must be taken to prevent downstream impacts. Local governments are encouraged to broaden this requirement to include protection against adverse impacts to downgradient properties and drainage systems. Drainage easements from downstream property owners may be needed and should be obtained prior to approval of engineering plans.

2.6.3 Minimum Requirement #3: Source Control Of Pollution

All known, available and reasonable source control BMPs shall be applied to all projects. Source control BMPs shall be selected, designed, and maintained according to this manual.

An adopted and implemented basin plan (Minimum Requirement #8) or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) may be used to develop more stringent source control requirements that are tailored to a specific basin.

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[1]The Plan Approval Authority is defined as that department within a local government that has been delegated authority to approve erosion and sediment control plans.

Objective:

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

Supplemental Guidelines:

A list of many source control BMPs is provided in the BMP selection chapter of this volume. Source Control BMPs include Operational BMPs and Structural Source Control BMPs. See Volume IV for design details of these BMPs. For construction sites, see Volume II, Chapter 4.

2.6.4 Minimum Requirement #4: Runoff Treatment

Thresholds

The following require construction of stormwater treatment BMPs that are sized to treat runoff from the water quality design storm:

- **Single family or multi-family residential or subdivision projects in which the total of new plus replaced pollution-generating impervious surfaces (PGIS) is 10,000 square feet or more in a threshold discharge area of the project, or**
- **Other development projects in which the total of new plus replaced PGIS is 5,000 square feet or more in a threshold discharge area of the project, or**
- **Projects in which the total of new plus modified pollution-generating pervious surfaces (PGPS) is one acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site. Modified PGPS means any existing PGPS that is re-graded or re-contoured by the proposed project.**

Standard Requirement

Treatment BMPs shall be sized to treat runoff from the water quality design storm, defined as the 24-hour rainfall amount with a 6-month return frequency. Approved single event hydrograph methods identified in Volume III shall be used to identify runoff volumes and peak flow rates for design purposes. Alternative methods can be used if they identify volumes and flow rates that are at least equivalent.

That portion of any development project in which the above PGIS or PGPS thresholds are not exceeded in a threshold discharge area shall apply Small Site Requirements for water quality treatment.

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Table 2.1. Treatment Requirements for PGIS by Threshold Discharge Area

	SFR or MFR < 10,000 sf PGIS	SFR or MFR, ≥ 10,000 sf PGIS	Other type of development <5,000 sf PGIS	Other type of development, ≥ 5,000 sf
Large Site Treatment BMPs		✔		✔
Small Site Treatment BMPs	✔		✔	

PGIS = pollution-generating impervious surfaces
SFR = single family residence
MFR = multiple family residence
sf = square feet

Performance Criteria

A discussion on performance criteria will be included in Volume V.

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Water Quality Design Storm Event

Ecology encourages discussion of options for establishing a water quality design storm event. The options currently under consideration include the following. These are discussed in more detail in Appendix B:

1) An estimation of a 6-month, 24-hour rainfall amount.

2) Selected percentages of the 2-year, 24-hour rainfall amount, as an estimate of the 6-month, 24-hour rainfall amount.

3) Using 24-hour rainfall data, selection of a precipitation amount for which the cumulative sum of rainfall amounts of that size and smaller account for a certain percentage (e.g., 90%) of the total rainfall inches.

4) Using 24-hour rainfall data, establish a rainfall amount for the knee of the curve for a graph of increasing 24-hour rainfall amounts (y-axis) versus cumulative number of rainfall events (x-axis).

5) Use a multiple of the mean annual storm.

6) Use of continuous runoff modeling to establish: a) a runoff flow rate that is exceeded only X % of the time using the appropriate time increment for a BMP sized based on a peak flow rate, and b) a 24-hour runoff amount that is exceeded only X% of the time for BMP's based on runoff volume.

A more detailed description of each of these options and the rainfall amounts they represent for various locations around the state are found in Appendix 2 to this chapter.

<u>**Additional Requirements**</u>

Direct discharge of untreated stormwater from pollution-generating impervious surfaces to ground water is prohibited, except for that achieved by infiltration or dispersion of runoff as allowed under the Small Site Requirements. All treatment BMPs shall be selected, designed, and maintained according to a local government manual deemed equivalent to this manual.

An adopted and implemented basin plan (Minimum Requirement #8), or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) may be used to develop more stringent runoff treatment requirements that are tailored to a specific basin.

Treatment BMPs applied consistent with this manual are presumed to meet the requirement of state law to provide all

known available and reasonable methods of treatment (RCW 90.52.040, RCW 90.48.010). This technology-based treatment requirement does not excuse any discharge from the obligation to apply whatever technology is necessary to comply with state water quality standards, Chapter 173-201A WAC, state ground water quality standards, Chapter 173-200 WAC, and state sediment management standards, Chapter 173-204 WAC. Additional treatment to meet those standards may be required by federal, state, or local governments.

Objective:

The purpose of runoff treatment is to reduce pollutant loads and concentrations in stormwater runoff using physical, biological, and chemical removal mechanisms. When site conditions are appropriate infiltration can potentially be the most effective BMP for runoff treatment.

***Supplemental Guidelines*:**

See Volume V. The water quality design storm is intended to capture and effectively treat about 90-93% of the annual runoff in western and eastern Washington, and about 80-85% of the annual runoff in Central Washington (an area east of the Cascade crest and west of the Columbia River).

Infiltration can provide both treatment of stormwater, through the ability of certain soils to remove pollutants, and volume control of stormwater, by decreasing the amount of water that runs off to surface water. Infiltration can be very effective at treating stormwater runoff but soil conditions must be appropriate to achieve effective treatment while not impacting ground water resources. Methods currently in use such as direct discharge into dry wells do not achieve adequate water quality treatment and are therefore not permitted.

2.6.5 Minimum Requirement #5: Flow Control for Discharges to Streams

<u>Applicability</u>

The requirement below applies only to situations where stormwater runoff is discharged directly or indirectly to a stream, and must be met <u>in addition</u> to meeting the requirements in Minimum Requirement #4, Runoff Treatment BMPs.

<u>Thresholds</u>

The following require construction of detention ponds with discharge orifices that are sized to meet the applicable standard requirement for western or eastern Washington:

- **Any projects in which the total of new plus replaced impervious surfaces is 10,000 square feet or more in a threshold discharge area of the project, or**

- Projects in which the total of land disturbing activity is one acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.

That portion of any development project in which the above thresholds are not exceeded in a threshold discharge area shall apply Small Site Requirements for flow control.

Western Washington Standard Requirement:
Applies to the geographic areas designated as regions 3 and 4 in NOAA Atlas #2 (Miller et al, 1973)[9].

Stormwater discharges to streams shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. In addition, the developed peak discharge rates shall not exceed the pre-developed peak discharge rates for 2- and 10-year return periods. The applicant shall use best available information to determine whether to assume that the pre-developed condition was forested or pasture.

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

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

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

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

Additional Requirement
As the first priority, flow control BMPs shall utilize infiltration to the fullest extent practicable if site conditions

are appropriate and ground water quality is protected. Flow Control BMPs shall be selected, designed, and maintained according to a local government manual deemed equivalent to this manual.

Flow Control Exemption

Ecology is considering an exemption from the flow control requirement for projects that discharge directly to major receiving waters and that are within a certain flowpath distance of those receiving waters. We encourage suggestions for a definition for major receiving waters and of a flowpath distance as well as other conditions for applying such an exemption.

Submerged and Intertidal Bedlands

Ecology has received comments concerning the physical impacts of stormwater discharges to lakes and marine intertidal and subtidal areas. The comments are primarily in regard to the erosive effects of the discharges. Ecology is interested in hearing suggestions regarding the wording of a generic minimum requirement to discharge flows in a manner that does not cause significant impacts to submerged and intertidal bedlands.

***Objective*:** To prevent increases in stream channel erosion rates or stream channel instability by maintaining existing erosion rates. The standard intends to maintain the total amount of time that a receiving stream exceeds an erosion-causing threshold. That threshold is assumed to be 50% of the 2-year peak flow. Maintaining existing erosion rates within streams is vital to protect fish habitat and production.

***Supplemental Guidelines*:** Reduction of flows through infiltration decreases stream channel erosion and helps to maintain base flow throughout the summer months. However, infiltration should only be used where ground water quality is not threatened by such discharges

Interim Guideline: Local governments have a choice to make concerning a flow control standard to use until a flow duration standard is adopted and a continuous rainfall/runoff model is available for use. They can continue to use the peak flow standard of the 1992 Puget Sound manual, or use a peak flow standard that approximates the results that the proposed flow duration standard would achieve. By adjusting the target peak flow standard, restricting use of variables in the SBUH hydrologic analysis, and applying a volume correction factor, you can estimate the orifice sizes and detention volumes that the proposed flow duration standard would indicate. The following example is a result of adjusting the SBUH approach to obtain similar results as the output from the King County Runoff Time Series (An application of the Hydrologic Simulation Program – Fortran) with the proposed flow duration standard as the target.

Adjusted target peak flow standard:
Limit the peak rate of runoff from individual development sites to 50 percent of the pre-developed condition 2-year, 24-hour design storm. Limit the peak rate from the 10-year, 24-hour design storm to the pre-developed condition peak rate from the 2-year, 24-hour design storm. Limit the peak rate from the 100-year, 24-hour design storm to the pre-developed condition peak rate from the 10-year, 24 hour design storm.

Restricted variable assumptions:
The flow path length assumed for sheet flow runoff in the pre-developed condition calculations must not be less than 300 feet.

The Manning's effective roughness coefficient for pre-developed forested conditions should be 0.80. For pasture conditions, the coefficient should be 0.15.

In the table of curve numbers in Volume III, Chapter 1 of the 1999 manual, the curve numbers for pre-developed forest and pasture conditions must be selected from the "fair" category.

Volume correction factor:
In addition to the above, the pond volume correction factor identified in Volume III, Chapter I should be used where the pre-developed condition is modeled as pasture.

<u>Eastern Washington Standard Requirement</u>:
Applies to geographic areas designated as regions 1 and 2 in NOAA Atlas 2 (Miller et al, 1973)[10].

Stormwater discharges to streams shall control streambank erosion by limiting the peak rate of runoff from individual development sites to 50 percent of the pre-developed condition 2-year, 24-hour design storm while maintaining the pre-developed condition peak runoff rate for the 10-year, 24-hour and 100-year, 24-hour design storms. As the first priority, flow control BMP's shall utilize infiltration to the fullest extent practicable, if site condtions are appropriate and ground water quality is protected. Flow control BMP's shall be selected, designed, and maintained according to a

local government manual that is deemed equivalent to this manual.

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

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

2) **Zoning and Land Clearing Ordinance restrictions that, in combination with an alternative flow control standard, maintain or reduce the naturally occurring erosive forces on the stream channel; or**

3) **A duration control standard is necessary for protection, maintenance, or restoration of designated beneficial uses or Clean Water Act compliance.**

Objective: To prevent increases in stream channel erosion rates or stream channel instability by maintaining existing erosion rates. The standard intends to maintain the total amount of time that a receiving stream exceeds an erosion-causing threshold. That threshold is assumed to be 50% of the 2-year peak flow. Maintaining existing erosion rates within streams is vital to protect fish habitat and production. Because of the different precipitation patterns prevalent in eastern Washington, use of a continuous runoff model to support a flow duration standard may not be necessary. Ecology has insufficient information to propose a flow duration standard for most of eastern Washington

Rainfall Regions

Figure 2.3 Rainfall Regions for Washington State from NOAA Atlas #2 to be added

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2.6.6 Minimum Requirement #6: Wetlands Protection

The requirements below apply only to situations where stormwater discharges directly or indirectly through a conveyance system into a wetland, and must be met <u>in addition</u> to meeting the requirements in Minimum Standard #4, Runoff Treatment BMPs.

<u>Thresholds</u>
The thresholds identified in Minimum Requirement #4 – Runoff Treatment, and Minimum Requirement #5 – Flow Control for Discharges to Streams shall also be applied for discharges to wetlands.

<u>Standard Requirement</u>
Discharges to wetlands shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

The publication, "Wetlands and Urbanization, Implications for the Future", the final report of the Puget Sound Wetland and Stormwater Management Research Program, 1997, shall be used as guidance for discharges to natural and constructed wetlands.

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

An adopted and implemented basin plan (Minimum Requirement #8), or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) may be used to develop requirements for wetlands that are tailored to a specific basin.

Objective:

To ensure that wetlands receive the same level of protection as any other waters of the state. Wetlands are extremely important natural resources which provide multiple stormwater benefits, including ground water recharge, flood control, and stream channel erosion protection. They are easily impacted by development unless careful planning and management are conducted. Wetlands can be severely degraded by stormwater discharges from urban development due to pollutants in the runoff and also due to disruption of natural hydrologic functioning of the wetland system. Changes in water levels and the frequency and duration of inundations are of particular concern.

***Supplemental Guidelines*:**

See Volume V for a summary of the "Wetlands and Stormwater Management Guidelines: Managing Wetland Hydroperiod While Managing Stormwater" (draft, 1999). These management guidelines are considered the best available science to assist in meeting the state water quality standards. The guidelines were developed in part, and include, the findings of the Puget Sound Wetlands and Stormwater Management Research Program.[10]

While it is always necessary to pre-treat stormwater prior to discharge to a wetland, there are limited circumstances where wetlands may be used for additional treatment and detention of stormwater. These situations are considered in the guidelines as well.

2.6.7 Minimum Requirement #7: Off Site Analysis and Mitigation

All development projects shall submit an offsite analysis report that assesses the potential off-site water quality, erosion, and drainage impacts associated with the project and that proposes appropriate mitigation of those impacts. An initial qualitative analysis shall extend downstream for the entire flow path from the project site to the receiving water or up to 1 mile, whichever is less. If a receiving water is within one-quarter mile, the analysis shall extend within the receiving water to one-quarter mile from the project site. The analysis shall extend one-quarter mile beyond any improvements proposed as mitigation. The analysis must extend upstream to a point where any backwater effects created by the project cease. Upon review of the qualitative analysis, the local administrator may require that a quantitative analysis be performed.

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

- **Upland erosion impacts**
- **stream channel erosion**
- **loss of stream channel base flow**
- **Violations of surface water quality standards as identified in a Basin Plan or a TMDL (Water Clean-up Plan); or violations of ground water standards in a wellhead protection area.**

Local governments are encouraged to expand the offsite analysis to include an assessment of the existing and potential impacts due to flooding and conveyance capacity.

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

Supplemental Guidelines:

Guidance for performing an initial qualitative analysis, a subsequent quantitative analysis, and for developing mitigation options is being developed. Ecology intends to include those in the next draft of the manual.

2.6.8 Minimum Requirement #8: Basin/Watershed Planning

Adopted and implemented watershed-based basin plans may be used to require equivalent or more stringent minimum requirements for source control, treatment, and wetlands protection, and alternative requirements for flow control. Basin/Watershed plans shall evaluate and include, as necessary, retrofitting of urban stormwater BMPs for existing development and/or redevelopment in order to achieve watershed-wide pollutant reduction and flow control goals that are consistent with requirements of the federal Clean Water Act. Standards developed from basin plans shall not modify any of the above minimum requirements until the basin plan is formally adopted and implemented by the local governments within the basin, and approved or concurred with by the Department of Ecology.

Objective: To promote watershed-based planning as a means to develop and implement comprehensive water quality protection measures. Primary objectives of basin planning are to reduce pollutant loads and hydrologic impacts to surface and ground waters in order to protect beneficial uses.

Supplemental Guidelines: While Minimum Requirements #3 through #6 establish general standards for individual sites, they do not evaluate the overall pollution impacts and protection opportunities which could exist at the watershed level. In order for a basin plan to serve as a means of modifying the minimum requirements it must be formally adopted by all jurisdictions that have responsibilities under the basin plan, and ordinances or regulations called for by the plan must be in effect. This is what is meant by an adopted and implemented basin plan.

Basin planning provides a mechanism by which the on-site standards can be evaluated and refined based on an analysis of an entire watershed. Basin plans are especially well-suited to develop control strategies to address impacts from future development and to correct specific problems whose sources are known or suspected. Basin plans can be effective at addressing both long-term cumulative impacts of pollutant loads and short-term acute impacts of pollutant concentrations, as well as hydrologic impacts to streams, wetlands, and ground water resources.

Examples of how Basin Planning can alter the minimum requirements of this manual is given in Appendix A.

2.6.9 Minimum Requirement #9: Operation and Maintenance

An operation and maintenance schedule that is consistent with the local government standards shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified.

Objective:

To ensure that stormwater control facilities are adequately maintained and operated properly.

Supplemental Guidelines:

Inadequate maintenance is likely the leading cause of failure for stormwater control facilities. The description of each BMP in Volumes II, III, and V includes a section on maintenance. The Guidance Manual also includes a section on developing an operation and maintenance program and a model operation and maintenance ordinance.

2.7 Optional Guidance #1: Financial Liability

Performance bonding or other appropriate financial guarantees shall be required for all projects to ensure construction of drainage facilities in compliance with these standards. In addition, a project applicant shall post a two year financial guarantee of the satisfactory performance and maintenance of any drainage facilities that are scheduled to be assumed by the local government for operation and maintenance.

Objective:

To ensure that development projects have adequate financial resources to fully implement stormwater management plan requirements and that liability is not unduly incurred upon local governments.

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

2.8 Exceptions

Exceptions to the Small Parcel Requirements and Large Parcel Minimum Requirements #1 through #9 may be granted prior to permit approval and construction. An exception may be granted following a public hearing, provided that a written finding of fact is prepared, that addresses the following:

- **The exception provides equivalent environmental protection and is in the overriding public interest; and that the objectives of safety, function, environmental protection and facility maintenance, based upon sound engineering, are fully met; AND**
- **There are special physical circumstances or conditions affecting the property such that the strict application of these provisions would deprive the applicant of all reasonable use of the parcel of land in question, and every effort to find creative ways to meet the intent of the Minimum Requirements has been made; AND**
- **That the granting of the exception will not be detrimental to the public health and welfare, nor 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.**

Public Hearing Alternatives

The above exception provision includes a requirement to hold a public hearing on the proposed exception. Ecology is interested in suggestions of an alternative to a public hearing which would give local governments more flexibility and less onerous administrative procedures in granting an exception while still protecting the interests of, and alerting interested and potentially impacted parties to the exception under consideration.

Supplemental Guidelines:

Ecology encourages the Plan Approval Authority to impose additional or more stringent criteria as appropriate for their area. Additionally, criteria which may be inappropriate or too restrictive for an area may be modified through basin planning (Minimum Requirement #8). Modification of any of the minimum requirements which are deemed inappropriate for the site may be done by granting an exception.

The exception procedure is an important element of the plan review and enforcement programs. It is intended to maintain a necessary flexible working relationship between local officials and applicants. Plan Approval Authorities should consider these requests judiciously, keeping in mind both the need of the applicant to maximize cost-effectiveness and the need to protect off-site properties and resources from damage.

CHAPTER 3 - Preparation of Stormwater Site Plans

3.1 Introduction

The purpose of this chapter is to provide summarized guidelines on how Construction Stormwater Pollution Prevention Plan Plan (Construction SWPPP) and Permanent Stormwater Quality Control (PSQC) Plans, the plans that make up a Stormwater Site Plan (SSP) can be prepared. The thresholds and Minimum Requirements for these plans are described in detail in Chapter 2

The goal of this chapter is to provide a framework for uniformity in plan preparation. Such uniformity will promote predictability throughout the region and help secure prompt governmental review and approval. Properly drafted engineering plans and supporting documents will also facilitate the operation and maintenance of the proposed system long after its review and approval.

Please note that this chapter describes <u>how</u> to prepare a Stormwater Site Plan - the specific BMPs and design methods and standards to be used are contained in Volumes II-V. Construction SWPPPs are covered in detail in Chapter 3 of Volume II. Guidelines for selecting BMPs are given in Chapter 3 of this Volume. Note also that all plans, except small parcel plans, shall be stamped a professional engineer licensed in the State of Washington. All land boundary surveys used, and any legal descriptions prepared, except those for small parcels, must be stamped by a professional land surveyor licensed in the State of Washington.

Chapter 3 of Volume I

The text for this chapter was not completed in time for this preliminary draft of the manual. Ecology will discuss its intent for this chapter in public meetings to discuss this preliminary draft. Public comments and criticisms of this chapter in the existing manual would be helpful.

After receiving public comment, Ecology will develop this chapter with the assistance of an advisory committee for Volume 1. A draft will be included in the second draft of the manual that is scheduled for release early in 2000.

CHAPTER 4 - BMP Selection Process For Permanent Stormwater Quality Control Plans

Chapter 4 of Volume I

We are considering combining Chapter III and IV of Volume I of the 1992 manual and moving the details of the BMP selection process to the appropriate volume in the current manual.

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APPENDIX A - Guidance for Altering the Minimum Requirements Through Basin Planning

Basin Planning Applied to Source Control

(Minimum Requirement #3)

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

1. Detection and correction of illicit discharges to storm sewer systems, including the use of dry weather sampling and dye-tracing techniques;

2. Identification of existing businesses, industries, utilities, and other activities which may store materials susceptible to spillage or leakage of pollutants into the storm sewer system;

3. Elimination or control of pollutant sources identified in (2);

4. Identification and control of future businesses, industries, utilities, and other activities which may store materials susceptible to spillage or leakage of pollutants into the storm sewer system; and

5. Training and public education

Basin Planning Applied to Runoff Treatment

(Minimum Requirement #4)

Basin plans can develop more stringent runoff treatment requirements and performance standards to reduce pollutant concentrations or loads based on an evaluation of the beneficial uses to be protected within or downstream of a watershed. Consideration must be given to the antidegradation provisions of the Clean Water Act and implementing state water quality standards. The evaluation should include an analysis of existing and future conditions. Additional levels of control beyond Minimum Requirement #4 may be justified in order to control the impacts of future development. Requirements/performance standards can be developed based on an evaluation of pollutant loads and modeling of receiving water conditions.

Runoff treatment requirements/performance standards developed from a basin plan should apply to individual development sites. Regional treatment BMPs can be considered an acceptable substitute for on-site treatment BMPs if they can meet the identified treatment requirements/performance standards. A limitation to the use of regional treatment systems is that the conveyances used to transport the stormwater to the BMP must not include waters of the state that have (or had as of November, 1975) beneficial uses other than drainage.

Basin plans shall evaluate retrofitting opportunities, such as installation of extended detention outlets for existing stormwater detention facilities.

Basin Planning Applied to Flow Control

(Minimum Requirement #5)

Basin planning is well-suited to control stream channel erosion for both existing and future conditions. Flow control standards developed from a basin plan may include a combination of on-site, regional, and stream protection/rehabilitation measures. On-site standards shall be the primary mechanism to protect streams from the impacts of future conditions. Regional flow control BMPs are to used primarily to correct existing stream erosion problems. Stream protection/rehabilitation measures may be applied where stream channel erosion problems currently exist which will not be corrected by on-site or regional BMPs. However, caution is urged in the application of such measures. If the causes of the stream channel erosion problems still exist, repairs to the physical expression of those problems will be short-lived.

Basin Planning Applied to Wetlands and other Sensitive Areas

(Minimum Requirement #6)

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

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APPENDIX B - Water Quality Treatment Design Storm Options

Ecology encourages discussion of options for establishing a water quality design storm event. The options currently under consideration include:

1. **An estimation of a 6-month, 24-hour rainfall amount.**

   This is the current water quality design storm in the Stormwater Management Manual for the Puget Sound Basin. It was originally chosen when developing the Puget Sound manual based upon a judgement of when the incremental costs of additional treatment capacity exceed the incremental benefits. In particular, the cost of providing the increased detention volume for a wet pond was not seen as cost-effective when compared with the incremental amount of annual stormwater volume that would be effectively treated. Rainfall data from Sea-Tac was used in the original analysis.

   There are at least two ways to estimate the rainfall amount of a 6-month, 24-hour storm. One way is to analyze the 24-hour rainfall records for each rainfall station. The more extensive your record, the more confidence you may have in your estimate. The rainfall amount which has a probability of being equaled or exceeded twice a year is the 6-month, 24-hour storm. The 6-month, 24-hour rainfall amounts shown for 58 stations in Table B.1 have been estimated by analyzing the daily rain gauge data obtained from CD-ROM Hydrodata, USGS Daily and Peak Values, published by Hydrosphere Data Products, Inc.[11]

   The way in which the 6-month, 24-hour estimates in table 2 are calculated is as follows. A data set containing the annual maxima series for 24-hour durations for rainfall stations throughout the state was used.to determine the 2-year, 24-hour return frequency in the first column of Table B.2. The data set was collected by Dr. Schaefer of the Washington Dept. of Ecology and is more fully described in "Regional Analyses of Precipitation Annual Maxima in Washington State,"[12] Then an algorithm was applied to convert the series to a partial duration series. Dr. Schaefer describes the conversion as follows: "A return period of 1.16 years (annual exceedance probability of 0.862) in the annual maxima data series is equivalent to a 6-month return period in the partial duration data series. The 6-month values were computed using at-site 24-hour station mean values, regional coefficients of variation (Cv) and L-skewness (tau3), and a frequency factor (K) of –0.94 which corresponds to a return period of 1.16 years. This K value of –0.94 yields 6-month estimates that are correct within 3% +/- for various Kappa distribution parameter sets for climates from arid to rainforest in Washington State." (The reader is referred to references #13 and #14.) Note that the 2-year storm values in Table B.2 differ slightly from those in Table B.1 because they are a different data set and have undergone additional statistical analysis.

A disadavantage to using a 6-month, 24-hour storm as the design storm is that we do not have isopluvials identifying 6-month, 24-hour storms statewide. We would have to produce such a map, or develop a method to estimate the volume for projects at sites not listed in a reference table of 6-month, 24-hour storms. One method to do that is listed as the second option below.

2. **72% of the 2-year, 24-hour rainfall amount for areas in western Washington and in Ferry, Stevens, Pend Oreille, Spokane, Whitman, Garfield, Walla, Walla, Columbia, and Asotin Counties of eastern Washington. Other areas of eastern Washington shall use 65% of the 2-year, 24-hour rainfall amount.**

   Based upon an analysis of the rainfall record of 58 stations across the state, the 6-month, and 2-year, 24-hour rainfall amounts were calculated and compared. Those results are shown in Table B.1. Based on those results, there seemed to be a justification for establishing two different percentages for ease in estimating 6-month, 24-hour rainfall amounts across the state.

   The arithmetic average of the ratio of the 6-month to the 2-year totals for 35 stations in western Washington (expressed as a percentage) was 71%. With the exception of a few stations, the percentages vary within a range of 67% to 76%. Using only four stations for the mountainous northeastern area and the far eastern areas of the state , the computed ratios were 71% to 73% with an average of 72%. A ratio of 72% is suggested for both of these areas.

   Using 16 stations for an area generally described as eastern Cascades and the Columbia Basin, the ratios varied from 61.6% to 68.4% with an average of 65%.

   An advantage of this approach is that updated statewide isopluvial maps for the 2-year, 24-hour design storm are expected to be available soon. By interpolation, the 2-year rainfall amount for a project site can be easily identified. Application of the percentage assigned to that area yields the estimate of the 6-month, 24-hour rainfall amount. Citing a particular percentage of the 2-year, 24-hour rainfall amount (or a 6-month, 24-hour event) means that different areas of the state will be effectively sizing treatment facilities for the runoff from storms of vastly different sizes. However, those size differences are based upon actual differences in rainfall among the sites.

Also, as mentioned above in Option 1, the original basis for 6-month, 24-hour rainfall amount was a comparison of costs to benefits based upon how much annual runoff would be effectively treated. (The assumption in these comparisons is that storm sizes crudely track relative runoff quantities). The 6-month, 24-hour storm and smaller storms constituted about 91% of the total rainfall of record at SEA-TAC. Because the % of the 24-hour rainfall volumes that the 6-month, 24-hour storm and smaller 24-hour rainfall amounts represent changes across the state (See Table B.1, column entitled, "6 month, % Rainfall Volume") the cost analysis isn't exactly the same for other areas. However, for the 58 stations computed, the 6-month storm and smaller storms represent from 93% to 82% of the total rainfall volume. Therefore, for most areas of the state, the relative cost to % of runoff effectively treated is lower than was assumed in the original analysis.

3) **Using 24-hour rainfall data, identification of a precipitation amount for which the cumulative sum of rainfall amounts of that size and smaller account for a certain percentage of the total rainfall inches.**

   For example, we could choose to size a treatment BMP to effectively treat the runoff from all the 24-hour precipitation amounts that made up 90% of the total rainfall. To do that, you order all the recorded 24-hour precipitation amounts by increasing size, and sum the total precipitation as you move up the list from smaller to larger 24-hour amounts. The last 24-hour total that you have to include to bring your cumulative total to approximately 90% of the total historical rainfall amount is your water quality design storm. The rainfall amount from this storm would be used as input to your runoff calculations to estimate total runoff volume for sizing volume-sensitive BMP's, and as input to your hyetograph/hydrograph analysis to determine the estimated peak flow rates for sizing water quality treatment BMPs. Note that for BMP's designed based on runoff volumes, we can estimate that 24-hour rainfall amounts of lesser amount will meet the detention time design criteria. However, for treatment BMP's whose design is based on volumetric runoff rates or velocity, i.e., cubic feet per second or feet per second, we do not know how frequently, nor how much of the actual runoff occurs at flow rates below the design flow rate. This is because the design flow rate is based upon an idealized hyetograph.

The relative sizes of water quality design storms defiined in this manner are shown in Table B.1 for 90% and 95% of the total rainfall inches for 58 rainfall stations. Note that a different set of rainfall data was used in this table than in Table B.2. Also the data was managed differently. However, based upon a close correlation of computed 2-year, 24-hour return frequency storms, we would expect insignificant differences in the percentages if computed for the other data set.

The water quality design storm identified in this approach would vary across the state. Assuming a 90% goal, rainfall amounts vary from 0.54 inches at Moses Lake to 3.18 inches at Cushman Dam. Runoff amounts from these storms will also vary depending upon natural soil conditions, vegetative cover, and the % effective imperviousness of a site. Maryland has recently adopted a statewide standard of capturing and treating 90% of the annual runoff volume. Rainfall in Maryland does not vary to the extent it does in Washington.

To implement this approach, Ecology would have to publish the water quality design storm for as many rainfall stations as possible. Then we would have to identify an adjustment factor to use for the project site. The factor could be based on a ratio of 2-year, 24-hour rain amounts between the nearest or most appropriate rainfall station and the project site, or upon a ratio of mean annual precipitation for the same two sites. The 2-year, 24-hour amount or the mean annual precipitation for the project site would have to be based upon interpolation of isopluvials.

An example estimation would be as follows: 1) calculate the 2-year, 24-hour or the mean annual precipitation for a site by interpolating between the two nearest isopluvials. 2) calculate ratios of the mean annual rainfall amounts or 2-year, 24-hour amounts for the site to the nearest or most appropriate gauge for which a 90% value is published; 2) multiply the 90% rainfall amount for the gauge by the ratio.

4. **Using 24-hour rainfall data, establish the knee of the curve for a graph of increasing 24-hour rainfall amounts (y-axis) versus cumulative rainfall depth (x-axis).**

Please refer to Figures B.1 and B.2. Figure B.1 shows examples of graphing the record of 24-hour rainfall amounts versus the cumulative percent of rainfall depth for the record. So each point on the curve shows the percent of rainfall depth that is represented by the corresponding 24-hour amount and lesser amounts. Figure B.2 depicts how the knee of the curve was determined for four rain gauge sites. Note that the graphs in Figures B.1 and B.2 have the same units for the x- and y-axes, but the scales are different. The curves start out fairly straight with a gentle rise, and then begin to rise sharply for the largest rainfall amounts. In order to perform the knee of the curve analysis, two tangent lines, or asymptotes were drawn, one through the horizontal portion of the curve and the other through the rising part of the curve. The two tangent lines were then bisected and the point where the bisect line intersected the curve was considered to be the knee of the curve. The rainfall depth and percent of total rainfall represented by the knee of the curve can then be determined.

The tangent lines were drawn by choosing points that included as much of the flat horizontal portion of the curve as possible and as many points as possible to represent the sharply rising portion of the curve. Then a best-fit approach on the points was used to generate the tangent lines. Only a portion of the curves are shown in Figure B.2.

The intent of this analysis is to relate the size of the storm (and by direct relationship, treatment cost) to the percent of total runoff (by assuming runoff tracks approximately with rainfall amount) that would receive treatment within the design parameters for the selected BMP (benefit).

The results of using this approach for a number of rainfall stations are shown in Table B.2. For most stations, the rainfall amounts are substantially greater than the amounts identified in options #1 or #2 above, or the amount identified in option #3 assuming a 90% total rainfall criterion.

5. **Use a multiple of the mean annual storm.**

   The mean annual storm is defined as the total annual average precipitation amount divided by the average annual number of precipitation events. Mean annual storm values for various sites were computed based on data in The National Precipitation Databook, 1992[15], and are displayed in Table B.2.

   Other areas of the country have identified multiples of the mean annual storm as the basis for sizing water quality treatment BMPs. King Co. recently adopted a multiplier of 3x the runoff of the mean annual storm as the design basis for the volume of their "basic wetpond." The factor of three was arrived at as an estimate of the volume needed to achieve the County's design goal of 80% removal of total suspended solids.

   For BMPs sized based on volumetric flow rate or velocity, a characteristic hyetograph would be used in combination with the selected multiple of the mean annual storm to compute the peak flow rate for the time increment of interest.

6. **Use continuous runoff modeling to establish: a runoff flow rate that is exceeded only X % of the time using the appropriate time increment for a BMP sized based on a peak flow rate, and a runoff amount that is exceeded only X% of the time for BMP's based on runoff volume.**

   Using continuous runoff models allows you to obtain estimates of the probability of exceedence for flow rates and runoff volumes for the available rainfall record. This approach has probably the best statistical basis for deciding upon what your goal should be for technology-based water quality treatment volumes and flow rates. In weighing the cost reasonableness of selecting any particular percentage, we could compare the flow rates and volumes to those for which we have conducted cost analyses in the past, i.e., the current standards. The only method by which we could pursue this approach within the alloted timeframe for reissuance of this manual is to use results from King Co.'s application of HSPF, i.e., KCRTS .

Table B.1. Rainfall Amounts and Comparisons for Selected USGS Stations as Published by Hydrosphere Data Products, Inc.

Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip.Inches
1 Aberdeen	2.47	92.58%	3.43	72.0%	2.25	2.81	83.12
2 Anacortes	0.93	90.45%	1.37	67.9%	0.91	1.22	25.92
3 Appleton	1.39	89.04%	1.96	70.9%	1.45	1.80	32.71
4 Arlington	1.28	93.42%	1.74	73.6%	1.11	1.40	46.46
5 Bellingham	1.27	90.78%	1.79	70.9%	1.23	1.63	35.82
6 Bremerton	1.87	90.75%	2.61	71.6%	1.83	2.22	49.97
7 Cathlamet	2.13	92.52%	3.47	61.4%	1.89	2.59	78.97
8 Centralia	1.49	91.81%	2.09	71.3%	1.40	1.78	45.94
9 Chelan	0.62	84.50%	0.96	64.6%	0.76	1.00	10.44
10 Chimacum	1.20	89.63%	1.73	69.4%	1.22	1.52	29.45
11 Clearwater	3.46	92.88%	4.75	72.8%	3.04	3.94	125.25
12 CleElum	1.06	86.85%	1.66	63.9%	1.20	1.64	22.17
13 Colfax	0.80	90.52%	1.07	74.8%	0.80	0.99	19.78
14 Colville	0.71	90.46%	0.97	73.2%	0.69	0.86	18.31
15 Cushman Dam	3.31	91.26%	5.29	62.6%	3.18	4.25	100.82
16 Cushman PwrH	3.17	90.81%	4.42	71.7%	3.08	4.00	85.71
17 Darrington	2.90	91.19%	4.01	72.3%	2.73	3.42	82.90
18 Ellensburg	0.50	84.63%	0.79	63.3%	0.62	0.81	8.75
19 Elwha RS	2.14	90.49%	2.80	76.4%	2.11	2.53	55.87
20 Everett	1.10	93.14%	1.46	75.3%	1.00	1.22	36.80
21 Forks	3.47	92.50%	5.07	68.4%	3.13	4.00	117.83
22 Goldendale	0.84	86.92%	1.29	65.1%	0.98	1.25	17.57
23 Hartline	0.61	84.85%	0.96	63.5%	0.77	0.97	10.67
24 Kennewick	0.46	84.10%	0.71	64.8%	0.55	0.72	7.57
25 Lk. Wenatchee	2.20	85.87%	3.16	69.6%	2.58	3.16	42.72
26 Long Beach	2.32	93.09%	3.08	75.3%	2.04	2.55	80.89
27 Longview	1.41	92.02%	1.97	71.6%	1.29	1.67	45.62
28 Mc Millin	1.31	92.24%	1.82	72.0%	1.21	1.49	40.66
29 Monroe	1.38	92.90%	1.86	74.2%	1.26	1.53	48.16
30 Moses Lake	0.47	85.32%	0.70	67.1%	0.54	0.68	7.89
31 Oakville	1.81	92.86%	2.28	79.4%	1.62	1.98	57.35
32 Odessa	0.52	87.23%	0.76	68.4%	0.56	0.72	10.09
33 Olga	1.02	90.82%	1.52	67.1%	0.99	1.30	28.96
34 Olympia	1.74	91.13%	2.51	69.3%	1.65	2.19	50.68
35 Omak	0.66	85.89%	0.98	67.3%	0.79	0.98	11.97
36 Packwood	2.41	88.70%	3.52	68.5%	2.51	3.20	55.20

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Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip.Inches
37 Pomeroy	0.75	89.29%	1.02	73.5%	0.78	0.98	16.04
38 Port Angeles	1.12	88.39%	1.66	67.5%	1.19	1.56	25.46
39 Port Townsend	0.77	90.56%	1.14	67.5%	0.76	0.95	19.13
40 Prosser	0.48	83.82%	0.74	64.9%	0.61	0.78	7.90
41 Quilcene	2.53	88.81%	3.40	74.4%	2.61	3.15	54.88
42 Quincy	0.53	82.12%	0.81	65.4%	0.68	0.90	8.07
43 Sea-Tac	1.32	91.13%	1.83	72.1%	1.27	1.63	38.10
44 Seattle JP	1.30	92.05%	1.74	74.7%	1.20	1.49	38.60
45 Sedro Woolley	1.50	92.07%	2.01	74.6%	1.41	1.80	46.97
46 Shelton	2.15	91.49%	3.13	68.7%	2.05	2.55	64.63
47 Smyrna	0.52	83.16%	0.76	68.4%	0.63	0.75	7.96
48 Spokane	0.68	89.54%	0.96	70.8%	0.70	0.88	16.04
49 Sunnyside	0.45	82.22%	0.73	61.6%	0.63	0.76	6.80
50 Tacoma	1.21	92.18%	1.61	75.2%	1.12	1.37	36.92
51 Toledo	1.36	92.73%	2.10	64.8%	1.25	1.68	50.18
52 Vancouver	1.35	91.32%	1.93	69.9%	1.28	1.62	38.87
53 Walla Walla	0.90	88.60%	1.23	73.2%	0.94	1.18	19.50
54 Waterville	0.67	84.43%	1.04	64.4%	0.81	1.05	11.47
55 Wauna	1.82	91.37%	2.50	72.8%	1.72	2.18	51.61
56 Wenatchee	0.58	81.97%	0.92	63.0%	0.80	1.04	8.93
57 Winthrop	0.75	85.36%	1.13	66.4%	0.94	1.13	14.28
58 Yakima	0.53	81.44%	0.85	62.4%	0.72	1.03	8.16

Table B.2. Rainfall Amounts and Statistics Using Data from References #12 and #15

	Return Freq		Knee-of-curve	Mean Annual Storm	Mean Annual Precip
Station Name	2-yr.	6-month	24 hr. (in)	(in)	(in)
ABERDEEN	3.32	2.53	2.81		83.1
ANACORTES	1.33	0.99	1.20		25.9
APPLETON	1.97	1.47	1.80		32.7
ARLINGTON	1.79	1.35	1.40		46.5
AUBURN	2.00	1.51		0.54	44.9
BATTLE GROUND	2.12	1.60			52.0
BELLINGHAM 3SSW -- F	1.70	1.27			35.0
BELLINGHAM CAA AP	1.56	1.17	1.63		35.8
BENTON CITY 2NW	0.79	0.53			8.0
BLAINE 1ENE	1.89	1.42		0.46	39.9
BREMERTON	2.31	1.74	2.22		50.0
BUCKLEY 1NE	2.09	1.58			49.0
BURLINGTON	1.75	1.31		0.40	35.0
CARNATION 4NW	1.91	1.44		0.49	47.5
CATHLAMET 6NE	3.84	2.93	2.59		79.0
CENTRALIA 1W	2.10	1.59	1.78	0.44	47.6
CHELAN	0.94	0.65	1.00		10.4
COLFAX 1NW	1.18	0.86	0.99		19.8
COLVILLE	1.02	0.74	0.86		18.3
COLVILLE WB AP	1.01	0.73		0.35	17.4
COUPVILLE 1S	1.08	0.79			21.0
CUSHMAN DAM	4.61	3.52	4.25	1.23	99.7
DARRINGTON RS	3.32	2.53	3.42	0.84	79.8
DUVALL 3NE	1.99	1.50			50.0
ELLENSBURG	0.70	0.48	0.80	0.25	9.2
ELLENSBURG WB AP	0.72	0.51			12.0
ELWHA RS	2.74	2.07	2.53		55.9
EVERETT JR. COL.	1.48	1.11	1.22	0.41	34.4
FORKS 1E	4.90	3.76	3.99		117.8
GOLDENDALE	1.12	0.81	1.25		17.6
GOLDENDALE 2E	1.31	0.95			18.0
HARTLINE	0.89	0.62	0.98		10.7
HOQUIAM AP	2.85	2.17			71.0
KENNEWICK	0.71	0.48	0.71		7.6
KENT	1.87	1.40			36.0

	Return Freq		Knee-of-curve	Mean Annual Storm	Mean Annual Precip
Station Name	**2-yr.**	**6-month**	**24 hr. (in)**	**(in)**	**(in)**
LEAVENWORTH	1.64	1.21			26.0
LONG BEACH EXP	2.99	2.28	2.54		80.0
LONGVIEW	2.20	1.66	1.67	0.48	48.1
MAZAMA 2W	1.59	1.17		0.41	22.7
MC MILLIN RESERVOIR	1.81	1.36	1.49	0.46	40.0
MILL CREEK	2.04	1.53			35.0
MONROE	1.91	1.44	1.52		48.2
MONTESANO 3NW	3.30	2.52		0.81	81.5
MOSES LAKE DEVIL FAR	0.74	0.50	0.68		7.9
MOUNT VERNON 3WNW	1.60	1.20			32.0
NEWPORT	1.41	1.05			29.0
OAKVILLE	2.46	1.86	1.99		57.4
ODESSA	0.80	0.55	0.72		10.1
OKANOGAN	0.90	0.63			12.0
OLGA 2SE	1.52	1.13	1.29		29.0
OLYMPIA WB AP	2.62	1.98	2.18	0.62	51.1
OMAK 2NW	0.99	0.70	0.98		12.0
OTHELLO 5E	0.70	0.47			8.0
PACKWOOD	2.92	2.21	3.16		55.2
POMEROY	1.10	0.79	0.97		16.0
PORT ANGELES	1.69	1.26	1.56	0.42	24.2
PORT TOWNSEND	1.11	0.81	0.95	0.35	17.6
PROSSER	0.74	0.49	0.78		7.9
PROSSER 4NE	0.72	0.48			8.0
PULLMAN 2NW	1.17	0.86		0.41	22.3
PUYALLUP 2W EXP STN	1.85	1.40			41.0
QUILCENE 2SW	3.42	2.59	3.14		54.9
QUILCENE DAM 5SW	3.84	2.92		0.77	69.4
QUINCY 1S	0.77	0.52	0.90		8.1
REPUBLIC	1.04	0.76			17.0
SEATTLE JACKSON PARK	1.49	1.12	1.49		38.6
SEATTLE TAC WB AP	1.90	1.42	1.62	0.49	37.4
SEATTLE U. OF W.	1.72	1.29			36.0
SEDRO WOLLEY 1E	2.05	1.55	1.80		47.0
SEQUIM	1.11	0.80			16.0
SHELTON	3.15	2.39	2.54		64.6
SMYRNA	0.79	0.53	0.75		8.0

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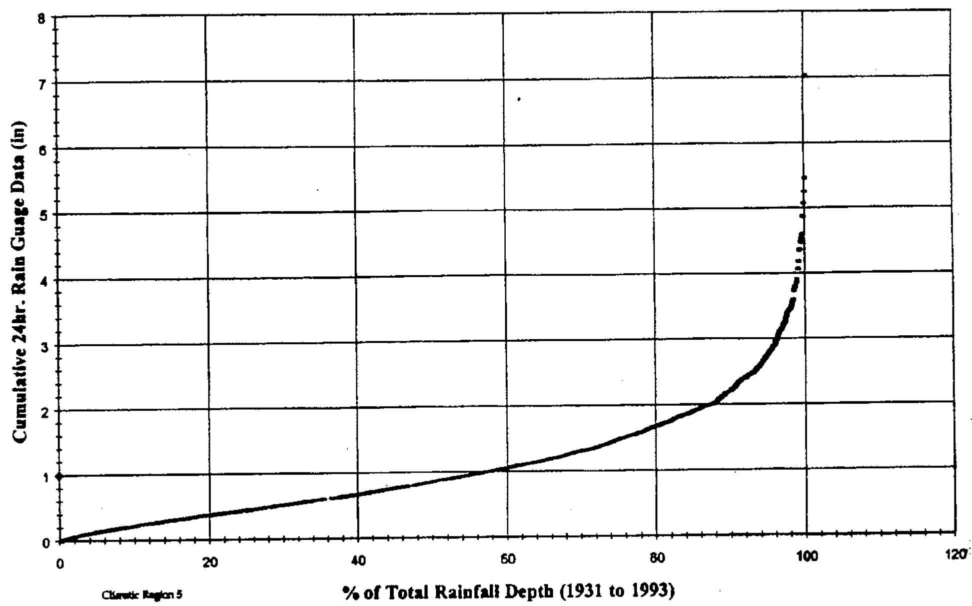
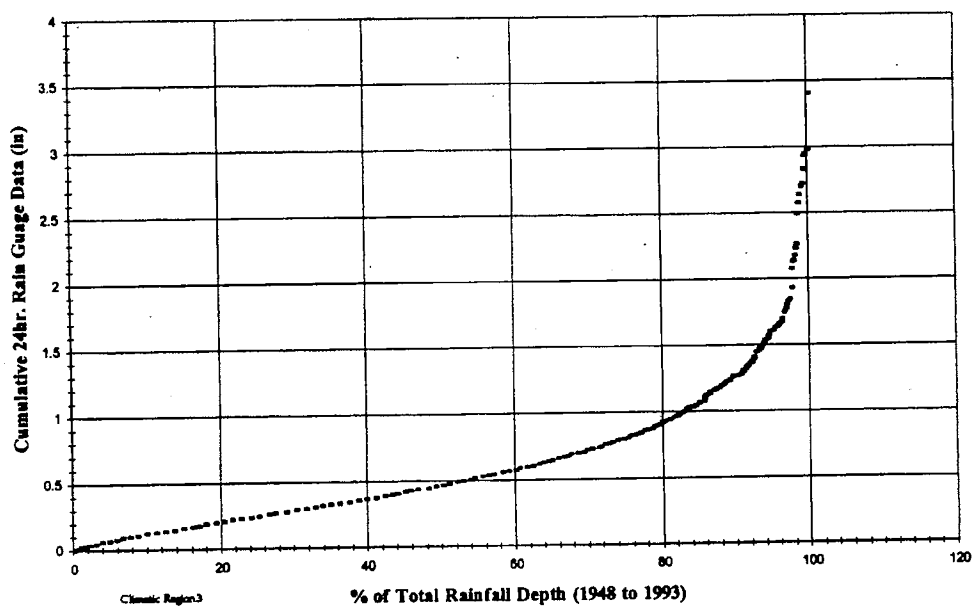
	Return Freq		Knee-of-curve	Mean Annual Storm	Mean Annual Precip
Station Name	**2-yr.**	**6-month**	**24 hr. (in)**	**(in)**	**(in)**
SPOKANE	1.11	0.80	0.88		16.0
SPOKANE WB AP	0.97	0.70		0.35	17.0
SUNNYSIDE	0.76	0.50	0.76	0.30	7.4
TACOMA CITY HALL	1.70	1.28	1.37		36.9
TOLEDO	1.99	1.51	1.68		50.2
VANCOUVER 4NNE	2.01	1.51	1.62		38.9
WALLA WALLA CAA AP	1.19	0.87	1.17		19.5
WATERVILLE	1.00	0.70	1.05		11.5
WAUNA	2.15	1.63	2.18		51.6
WENATCHEE	0.95	0.65	1.04		8.9
WINTHROP 1WSW	1.19	0.85	1.13		14.3
YAKIMA WB AP	0.81	0.54	1.03	0.33	8.2

Aberdeen Stormwater Quality Design Storm

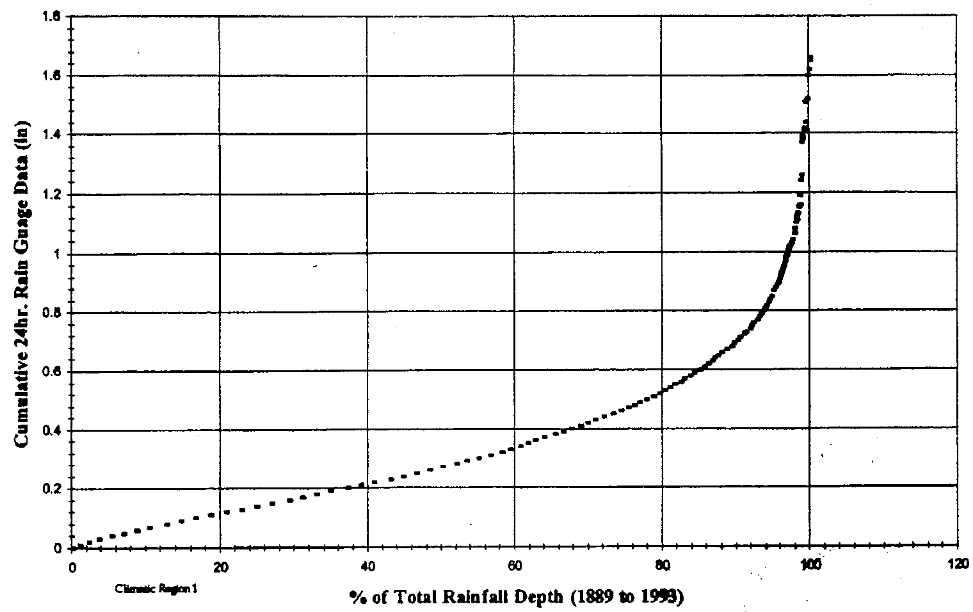


Sea-Tac Stormwater Quality Design Storm

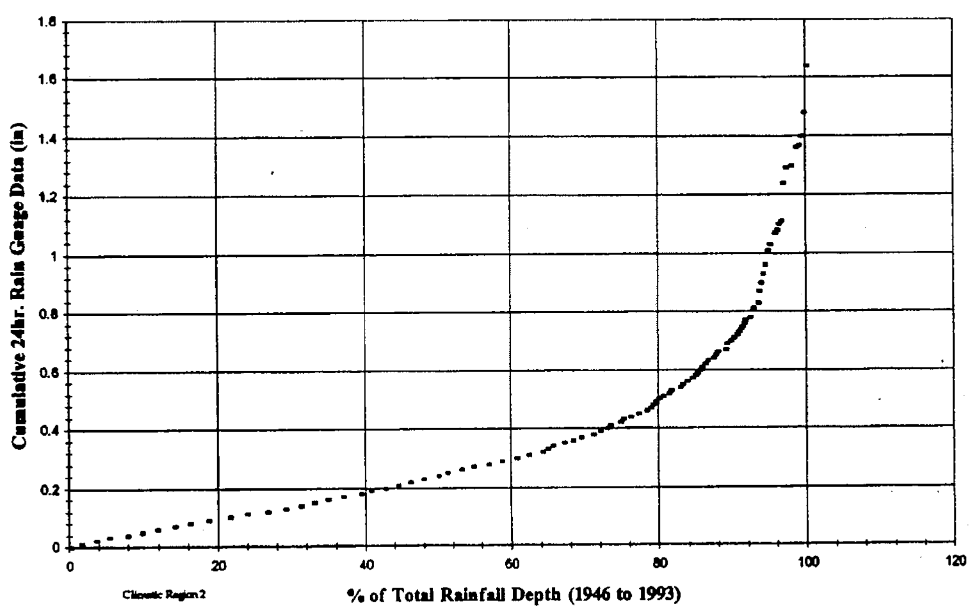


Figures B.1 and B.2: 24-hour Rainfall Amounts vs. Total Rainfall Depth

Spokane Stormwater Quality Design Storm

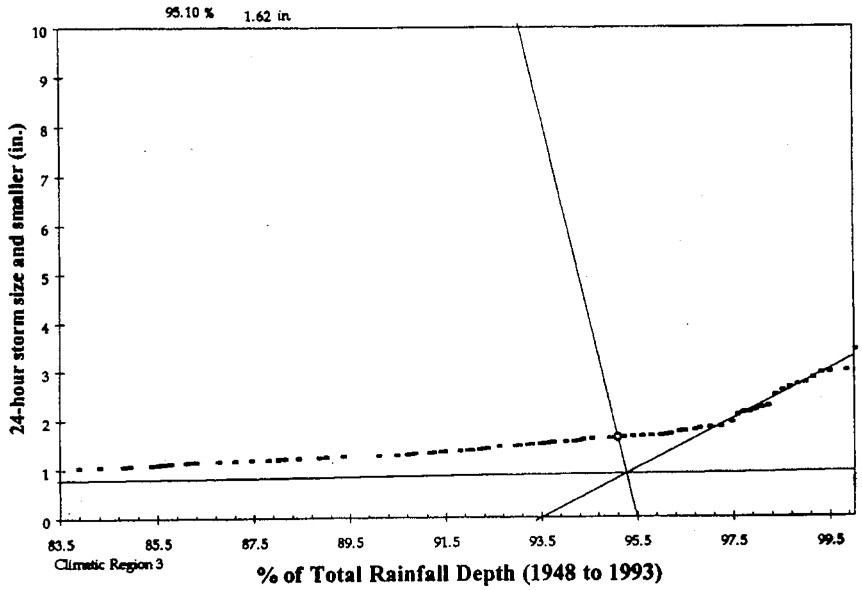


Yakima Stormwater Quality Design Storm



Figures B.3 and B.4: 24-hour Rainfall Amounts vs. Total Rainfall Depth

Sea-Tac Stormwater Quality Design Storm



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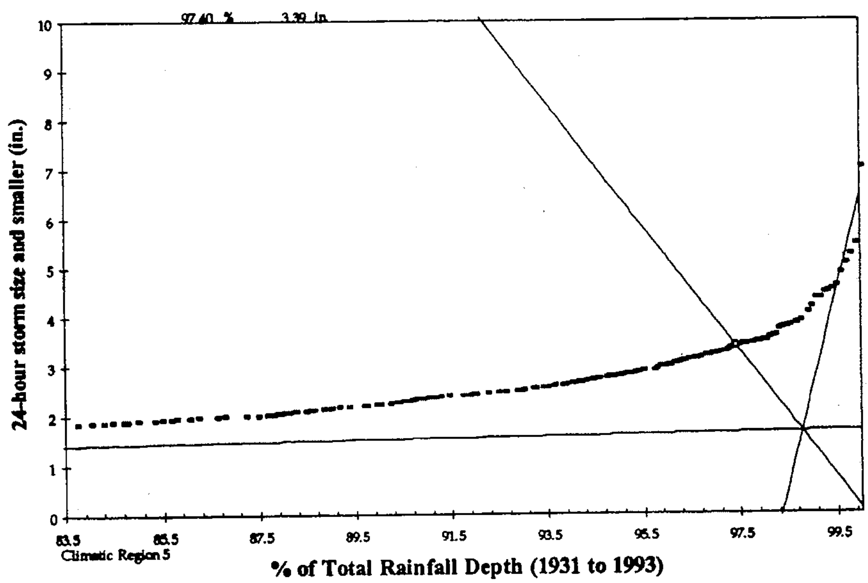

Figures B.5 and B.6: Knee of Curve Estimates

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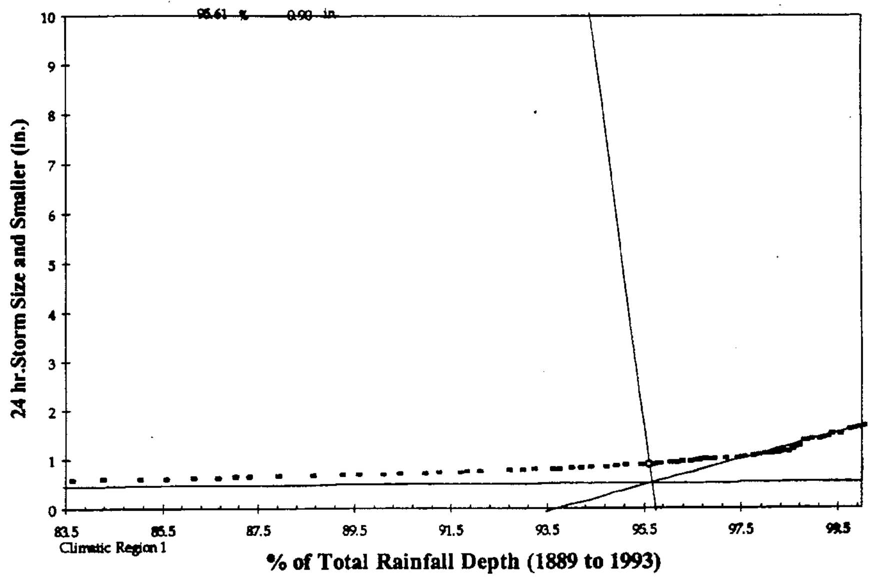
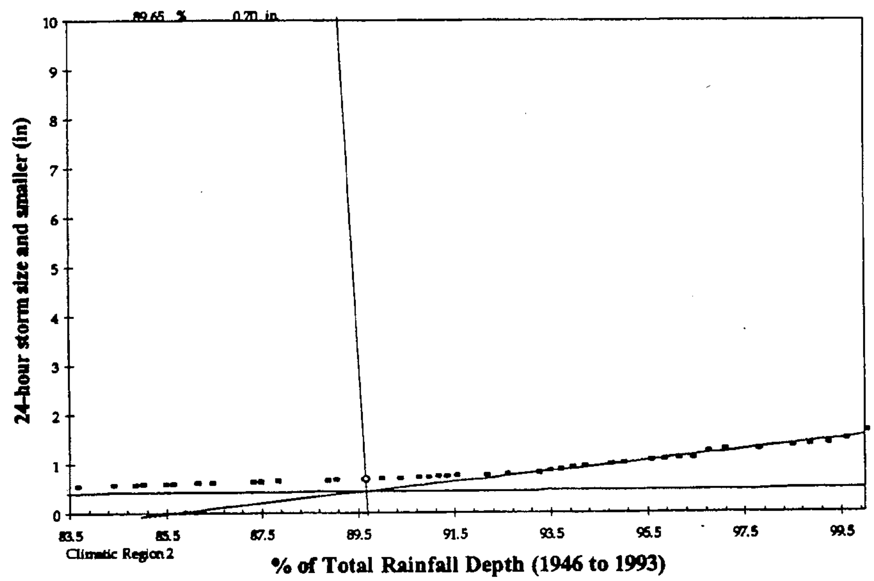
Spokane Stormwater Quality Design Storm



Yakima Stormwater Quality Design Storm



Figures B.7 and B.8: Knee of Curve Estimates

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GLOSSARY AND NOTATIONS

The following terms are provided for reference and use with this manual. They shall be superseded by any other definitions for these terms adopted by ordinance unless they are defined in a Washington State WAC or RCW or are used and defined as part of the Minimum Requirements for all new development and redevelopment.

AASHTO classification — The official classification of soil materials and soil aggregate mixtures for highway construction, used by the American Association of State Highway and Transportation Officials.

Absorption — The penetration of a substance into or through another, such as the dissolving of a soluble gas in a liquid.

Adjacent steep slope — A slope with a gradient of 15 percent or steeper within five hundred feet of the site.

Adsorption — The adhesion of a substance to the surface of a solid or liquid; often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to extract oil from waterways when oil spills occur. Heavy metals such as zinc and lead often adsorb onto sediment particles.

Aeration — The process of being supplied or impregnated with air. In waste treatment, the process used to foster biological and chemical purification. In soils, the process by which air in the soil is replenished by air from the atmosphere. In a well aerated soil, the soil air is similar in composition to the atmosphere above the soil. Poorly aerated soils usually contain a much higher percentage of carbon dioxide and a correspondingly lower percentage of oxygen.

Aerobic — Living or active only in the presence of free (dissolved or molecular) oxygen.

Aerobic bacteria — Bacteria that require the presence of free oxygen for their metabolic processes.

Aggressive plant species — Opportunistic species of inferior biological value that tend to out-compete more desirable forms and become dominant; applied to native species in this manual.

Algae — Primitive plants, many microscopic, containing chlorophyll and forming the base of the food chain in aquatic environments. Some species may create a nuisance when environmental conditions are suitable for prolific growth.

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Algal bloom	Proliferation of living algae on the surface of lakes, streams or ponds; often stimulated by phosphate over-enrichment. Algal blooms reduce the oxygen available to other aquatic organisms.
American Public Works Association or APWA	The adopted edition of the Washington State Chapter of the American Public Works Association.
Anadromous	Fishes ascending rivers from the sea for breeding.
Anaerobic	Living or active in the absence of oxygen.
Anaerobic bacteria	Bacteria that do not require the presence of free or dissolved oxygen for metabolism.
Annual flood	The highest peak discharge on average which can be expected in any given year.
Antecedent moisture conditions	The degree of wetness of a watershed or within the soil at the beginning of a storm.
Anti-seep collar	A device constructed around a pipe or other conduit and placed through a dam, levee, or dike for the purpose of reducing seepage losses and piping failures.
Anti-vortex device	A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.
Applicant	The person who has applied for a development permit or approval.
Approved manual	Means a stormwater management manual approved by Ecology.
Appurtenances	Machinery, appliances, or auxiliary structures attached to a main structure, but not considered an integral part thereof, for the purpose of enabling it to function.
Aquifer	A geologic stratum containing ground water that can be withdrawn and used for human purposes.
As-built drawings	Engineering plans which have been revised to reflect all changes to the plans which occurred during construction.
As-graded	The extent of surface conditions on completion of grading.
BSBL	See Building set back line.
Background	A description of pollutant levels arising from natural sources, and not because of man's immediate activities.
Backwater	Water upstream from an obstruction which is deeper than it would normally be without the obstruction.

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Bankfull discharge — A flow condition where streamflow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, the discharge conditions occurs on average every 1.5 to 2 years and controls the shape and form of natural channels.

Base flood — A flood having a one percent chance of being equaled or exceeded in any given year. This is also referred to as the 100-year flood.

Base flood elevation — The water surface elevation of the base flood. It shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD).

Baseline sample — A sample collected during dry-weather flow (i.e., it does not consist of runoff from a specific precipitation event).

Basin plan — A plan and all implementing regulations and procedures including but not limited to land use management adopted by ordinance for managing surface and stormwater quality and quantity management facilities and features within individual subbasins.

Bearing capacity — The maximum load that a material can support before failing.

Bedrock — The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.

Bench — A relatively level step excavated into earth material on which fill is to be placed.

Berm — A constructed barrier of compacted earth, rock or gravel.

Best management practice (BMP) — The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants to waters of Washington State.

Biochemical oxygen demand (BOD) — An indirect measure of the concentration of biologically degradable materials present in organic wastes. The amount of free oxygen utilized by aerobic organisms when allowed to attack the organic material in an aerobically maintained environment at a specified temperature (20θC) for a specific time period (5 days), and thus stated as BOD_5. It is expressed in milligrams of oxygen utilized per liter of liquid waste volume (mg/l) or in milligrams of oxygen per kilogram of waste solution (mg/kg = ppm = parts per million parts). Also called biological oxygen demand.

Biodegradable — Capable of being readily broken down by biological means, especially by bacterial action. Degradation can be rapid or may take many years depending upon such factors as available oxygen and moisture.

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Bioengineering — Restoration or reinforcement of slopes and stream banks with living plant materials.

Biofilter — A designed, vegetated treatment facility where the more or less simultaneous processes of filtration, infiltration, adsorption and biological uptake of pollutants in stormwater takes place when runoff flows over and through . Vegetation growing in these facilities acts as both a physical filter which causes gravity settling of particulates by regulating velocity of flow, and also as a biological sink when direct uptake of dissolved pollutants occurs. The former mechanism is probably the most important in western Washington where the period of major runoff coincides with the period of lowest biological activity.

Biofiltration — The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.

Biological control — A method of controlling pest organisms by means of introduced or naturally occurring predatory organisms, sterilization, the use of inhibiting hormones, or other means, rather than by mechanical or chemical means.

Biological magnification — The increasing concentration of a substance along succeeding steps in a food chain. Also called biomagnification.

Bollard — A post (may or may not be removable) used to prevent vehicular access.

Bond — A surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all local government requirements.

Borrow area — A source of earth fill material used in the construction of embankments or other earth fill structures.

Buffer — The zone contiguous with a sensitive area that is required for the continued maintenance, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from stormwater runoff and precipitation, and erosion control.

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Building setback line (BSBL) — A line measured parallel to a property, easement, drainage facility or buffer boundary, that delineates the area (defined by the distance of separation) where buildings, or other obstructions are prohibited (including decks, patios, outbuildings, or overhangs beyond 18 inches). Wooden or chain link fences and landscaping are allowable within a building setback line. In this manual the minimum building setback line shall be 5 feet.

CIP — See Capital Improvement Project.

Capital Improvement Project or Program (CIP) — A project prioritized and scheduled as a part of an overall construction program or, the actual construction program.

Catchbasin — A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Catchline — The point where a severe slope intercepts a different, more gentle slope.

Catchment — Surface drainage area.

Channel — A feature that conveys surface water and is open to the air.

Channel, constructed — Channels or ditches constructed (or reconstructed natural channels) to convey surface water.

Channel, natural — Streams, creeks, or swales that convey surface/ground water and have existed long enough to establish a stable route and/or biological community.

Channel stabilization — Erosion prevention and stabilization of velocity distribution in a channel using vegetation, jetties, drops, revetments, and/or other measures.

Channel storage — Water temporarily stored in channels while enroute to an outlet.

Channelization — Alteration of a stream channel by widening, deepening, straightening, cleaning, or paving certain areas to change flow characteristics.

Check dam — Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

Chemical oxygen demand (COD) — A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water. The COD test, like the BOD test, is used to determine the degree of pollution in water.

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Civil engineer — A professional engineer licensed in the State of Washington in Civil Engineering who is experienced and knowledgeable in the practice of soils engineering.

Civil engineering — The application of the knowledge of the forces of nature, principles of mechanics and the properties of materials to the evaluation, design and construction of civil works for the beneficial uses of mankind.

Clay lens — A naturally occurring, localized area of clay which acts as an impermeable layer to runoff infiltration.

Clearing — The destruction and removal of vegetation by manual, mechanical, or chemical methods.

Closed depression — An area which is lowlying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin.

Cohesion — The capacity of a soil to resist shearing stress, exclusive of functional resistance.

Coliform bacteria — Microorganisms common in the intestinal tracts of man and other warm-blooded animals; all the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35θC. Used as an indicator of bacterial pollution.

Commercial agriculture — Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for wholesale trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

Compaction — Densification of a fill by mechanical means.

Compensatory storage — New excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe. Equivalent shall mean that the storage removed shall be replaced by equal volume between corresponding one foot contour intervals that are hydraulically connected to the floodway through their entire depth.

Compost — Organic residue or a mixture of organic residues and soil, that has undergone biological decomposition until it has become relatively stable humus.

Composting — A controlled process of degrading organic matter by microorganisms. Present day composting is the aerobic, thermophilic decomposing of organic waste to relatively stable humus. Humus with no more than 25 percent dead or living organisms is stable enough not to reheat or cause odor or fly problems. It can undergo further, slower decay.

Comprehensive planning — Planning that takes into account all aspects of water, air, and land resources and their uses and limits.

Conservation district — A public organization created under state enabling law as a special-purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body and always with limited authority. Often called a soil conservation district or a soil and water conservation district.

Constructed wetland — Those wetlands intentionally created on sites that are not wetlands for the primary purpose of wastewater or stormwater treatment and managed as such. Constructed wetlands are normally considered as part of the stormwater collection and treatment system.

Contour — An imaginary line on the surface of the earth connecting points of the same elevation.

Conveyance — A mechanism for transporting water from one point to another, including pipes, ditches, and channels.

Conveyance system — The drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.

Cover crop — A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of permanent vegetation.

Created wetland — Means those wetlands intentionally created from nonwetland sites to produce or replace natural wetland habitat (e.g., compensatory mitigation projects).

Critical Areas — At a minimum, areas which include wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, including unstable slopes, and associated areas and ecosystems.

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Critical depth The depth which minimizes the specific energy of flow (E).

Critical Drainage Area An area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in an ordinance.

Critical flow Flow at the critical depth and velocity.

Critical reach The point in a receiving stream below a discharge point at which the lowest dissolved oxygen level is reached and stream recovery begins.

Culvert Pipe or concrete box structure which drains open channels, swales or ditches under a roadway or embankment. Typically with no catchbasins or manholes along its length.

Cut Portion of land surface or area from which earth has been removed or will be removed by excavating; the depth below original ground surface to excavated surface.

Cut-and-fill Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

DNS See Determination of nonsignificance.

Dead storage The volume available in a depression in the ground below any conveyance system, or surface drainage pathway, or outlet invert elevation that could allow the discharge of surface and stormwater runoff.

Dedication of land Refers to setting aside a portion of a property for a specific use or function.

Degradation (Biological or chemical) The breakdown of complex organic or other chemical compounds into simpler substances, usually less harmful than the original compound, as with the degradation of a persistent pesticide. (Geological) Wearing down by erosion. (Water) The lowering of the water quality of a watercourse by an increase in the pollutant loading.

Degraded (disturbed) wetland (community) A wetland (community) in which the vegetation, soils, and/or hydrology have been adversely altered, resulting in lost or reduced functions and values; generally, implies topographic isolation; hydrologic alterations such as hydroperiod alteration (increased or decreased quantity of water), diking, channelization, and/or outlet modification; soils alterations such as presence of fill, soil removal, and/or compaction; accumulation of toxicants in the biotic or abiotic components of the wetland; and/or low plant species richness with dominance by invasive weedy species.

Denitrification The biochemical reduction of nitrates or nitrites in the soil or organic deposits to ammonia or free nitrogen.

Depression storage — The amount of precipitation that is trapped in depressions on the surface of the ground.

Design engineer — The professional civil engineer licensed in the State of Washington who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.

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

Detention — The release of stormwater runoff from the site at a slower rate than it is collected by the stormwater facility system, the difference being held in temporary storage.

Detention facility — An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.

Detention time — The theoretical time required to displace the contents of a stormwater treatment facility at a given rate of discharge (volume divided by rate of discharge).

Determination of Nonsignificance (DNS) — The written decision by the responsible official of the lead agency that a proposal is not likely to have a significant adverse environmental impact, and therefore an EIS is not required.

Development — Means new development, redevelopment, or both. See definitions for each.

Discharge — Outflow; the flow of a stream, canal, or aquifer. One may also speak of the discharge of a canal or stream into a lake, river, or ocean. (Hydraulics) Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.

Dispersed discharge — Release of surface and stormwater runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils.

Ditch — A long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.

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Divide, Drainage The boundary between one drainage basin and another.

Drain A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or ground water.

(To) Drain To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow. To lose water (from the soil) by percolation.

Drainage Refers to the collection, conveyance, containment, and/or discharge of surface and stormwater runoff.

Drainage basin A geographic and hydrologic subunit of a watershed.

Drainage channel A drainage pathway with a well-defined bed and banks indicating frequent conveyance of surface and stormwater runoff.

Drainage course A pathway for watershed drainage characterized by wet soil vegetation; often intermittent in flow.

Drainage easement A legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.

Drainage pathway The route that surface and stormwater runoff, leaving any part of the site, follows downslope.

Drainage review An evaluation by Plan Approving Authority staff of a proposed project's compliance with the drainage requirements in this manual or its technical equivalent.

Drainage, Soil As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation; for example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get enough oxygen; in excessively drained soils the water is removed so completely that most crop plants suffer from lack of water. Strictly speaking, excessively drained soils are a result of excessive runoff due to steep slopes or low available water-holding capacity due to small amounts of silt and clay in the soil material. The following classes are used to express soil drainage:

- Well drained - Excess water drains away rapidly and no mottling occurs within 36 inches of the surface.
- Moderately well drained - Water is removed from the soil somewhat slowly, resulting in small but significant periods of wetness. Mottling occurs between 18 and 36 inches.

Drainage, Soil (continued)

- Somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Mottling occurs between 8 and 18 inches.

- Poorly drained - Water is removed so slowly that the soil is wet for a large part of the time. Mottling occurs between 0 and 8 inches.
- Very poorly drained - Water is removed so slowly that the water table remains at or near the surface for the greater part of the time. There may also be periods of surface ponding. The soil has a black to gray surface layer with mottles up to the surface.

Drawdown Lowering of the water surface (in open channel flow), water table or piezometric surface (in ground water flow) resulting from a withdrawal of water.

Drop-inlet spillway Overall structure in which the water drops through a vertical riser connected to a discharge conduit.

Drop spillway Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Drop structure A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

Dry weather flow The combination of sanitary sewage, and industrial and commercial wastes normally found in sanitary or storm sewers during the dry weather season of the year. Also that flow in streams during the dry season.

EIS See Environmental Impact Statement.

ESC Erosion and Sediment Control (Plan).

Earth material any rock, natural soil or fill and/or any combination thereof.

Easement The legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owners use of the land.

Embankment A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.

Emergent plants Aquatic plants that are rooted in the sediment but whose leaves are at or above the water surface. These wetland plants often have high habitat value for wildlife and waterfowl, and can aid in pollutant uptake.

Emergency spillway A vegetated earth channel used to safely convey flood discharges in excess of the capacity of the principal spillway.

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Energy dissipator
Any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.

Energy gradient
The slope of the specific energy line (i.e., the sum of the potential and velocity heads.)

Engineering geologist
A geologist experienced and knowledgeable in engineering geology.

Engineering geology
The application of geologic knowledge and principles in the investigation and evaluation of naturally occurring rock and soil for use in the design of civil works.

Engineering plan
A plan prepared and stamped by a professional civil engineer. An engineering plan contains a Technical Information Report and Site Improvement Plans which are described in detail in Chapter I-3.

Enhancement
To raise value, desirability, or attractiveness of an environment associated with surface water.

Environmental Impact Statement (EIS)
A document that discusses the likely significant adverse impacts of a proposal, ways to lessen the impacts, and alternatives to the proposal. They are required by the national and state environmental policy acts when projects are determined to have significant environmental impact.

Erodible granular soils
Soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

Erosion
The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Also, detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

- Accelerated erosion - Erosion much more rapid than normal or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of the animals or natural catastrophes that expose bare surfaces (e.g., fires).
- Geological erosion - The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. Synonymous with natural erosion.

Erosion (continued)

- Gully erosion - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
- Natural erosion - Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. Synonymous with geological erosion.
- Normal erosion - The gradual erosion of land used by man which does not greatly exceed natural erosion. See Natural erosion.
- Rill erosion - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See Rill.
- Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by runoff.
- Splash erosion - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

Erosion classes (soil survey)
A grouping of erosion conditions based on the degree of erosion or on characteristic patterns. Applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

Erosion/sedimentation control
Any temporary or permanent measures taken to reduce erosion; control siltation and sedimentation; and ensure that sediment-laden water does not leave the site.

Erosion and sediment control facility
A type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and stormwater runoff directed to the facility to settle out so as to improve the quality of the runoff.

Escarpment
A steep face or a ridge of high land.

Estuarine wetland
Generally, an eelgrass bed; salt marsh; or rocky, sandflat, or mudflat intertidal area where fresh and salt water mix. (Specifically, a tidal wetland with salinity greater than 0.5 parts per thousand, usually semi-enclosed by land but with partially obstructed or sporadic access to the open ocean).

Estuary
An area where fresh water meets salt water, or where the tide meets the river current (e.g., bays, mouths of rivers, salt marshes and lagoons). Estuaries serve as nurseries and spawning and feeding grounds for large groups of marine life and provide shelter and food for birds and wildlife.

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Eutrophication — Refers to the process where nutrient over-enrichment of water leads to excessive growth of aquatic plants, especially algae.

Evapotranspiration — The collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.

Excavation — The mechanical removal of earth material.

Exfiltration — The downward movement of runoff through the bottom of an infiltration BMP into the soil layer or the downward movement of water through soil.

Existing site conditions means

(a) For developed sites with stormwater facilities that have been constructed to meet the standards in the Minimum Requirements of this manual, existing site conditions shall mean the existing conditions on the site.

(b) For developed sites that do not have stormwater facilities that meet the Minimum Requirements, existing site conditions shall mean the conditions that existed prior to the development of the project site. If in question, the existing site conditions shall be documented by aerial photograph records, or other appropriate means.

(c) (c) For undeveloped sites existing site conditions shall mean the existing conditions on the site.

Experimental best management practice (BMP) — A BMP that has not been tested and evaluated by the Department of Ecology in collaboration with local governments and technical experts.

FIRM — See Flood Insurance Rate Map.

Fertilizer — Any material or mixture used to supply one or more of the essential plant nutrient elements.

Fill — A deposit of earth material placed by artificial means.

Filter fabric — A woven or nonwoven, water-permeable material generally made of synthetic products such as polypropylene and used in stormwater management and erosion and sediment control applications to trap sediment or prevent the clogging of aggregates by fine soil particles.

Filter fabric fence — A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. The filter fence is constructed of stakes and synthetic filter fabric with a rigid wire fence backing where necessary for support.

Filter strip — A strip of vegetation used to retard or collect sediment for the protection of diversions, drainage basins, or other structures. Often used in conjunction with a level spreader to keep flow from becoming channelized in the filter strip.

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Flocculation	The process by which suspended colloidal or very fine particles are assembled into larger masses or floccules which eventually settle out of suspension. This process occurs naturally but can also be caused through the use of such chemicals as alum.
Flood	An overflow or inundation that comes from a river or any other source, including (but no limited to) streams, tides, wave action, storm drains or excess rainfall. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.
Flood control	Methods or facilities for reducing flood flows and the extent of flooding.
Flood control project	A structural system installed to protect land and improvements from floods by the construction of dikes, river embankments, channels, or dams.
Flood frequency	The frequency with which the flood of interest may be expected to occur at a site in any average interval of years. Frequency analysis defines the "n-year flood" as being the flood that will, over a long period of time, be equaled or exceeded on the average once every "n" years.
Flood fringe	That portion of the floodplain outside of the floodway which is covered by floodwaters during the base flood; it is generally associated with standing water rather than rapidly flowing water.
Flood Hazard Areas	Those areas subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions.
Flood Insurance Rate Map (FIRM)	The official map on which the Federal Insurance Administration has delineated many areas of flood hazard, floodway, and the risk premium zones.
Flood Insurance Study	The official report provided by the Federal Insurance Administration that includes flood profiles and the FIRM.
Flood peak	The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge.
Floodplain	The total area subject to inundation by the base flood including the flood fringe and floodway.
Flood-proofing	Adaptations that ensure a structure is substantially impermeable to the passage of water below the flood protection elevation that resists hydrostatic and hydrodynamic loads and effects of buoyancy.
Flood protection elevation	The base flood elevation or higher as defined by the local government.

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Flood protection facility	Any levee, berm, wall, enclosure, raise bank, revetment, constructed bank stabilization or armoring, that is commonly recognized by the community as providing significant protection to a property from inundation by flood waters.
Flood routing	An analytical technique used to compute the effects of system storage dynamics on the shape and movement of flow represented by a hydrograph.
Flood stage	The stage at which overflow of the natural banks of a stream begins.
Floodway	The channel of the river or stream and those portions of the adjoining floodplains which are reasonably required to carry and discharge the base flood flow. The portions of the adjoining floodplains which are considered to be "reasonably required" is defined by flood hazard regulations.
Forebay	An easily maintained, extra storage area provided near an inlet of a BMP to trap incoming sediments before they accumulate in a pond or wetland BMP.
Forest practice	Any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber, including but not limited to: a. Road and trail construction. b. Harvesting, final and intermediate. c. Precommercial thinning. d. Reforestation. e. Fertilization. f. Prevention and suppression of diseases and insects. g. Salvage of trees. h. Brush control.
Forested communities (wetlands)	In general terms, communities (wetlands) characterized by woody vegetation that is greater than or equal to 6 meters in height; in this manual the term applies to such communities (wetlands) that represent a significant amount of tree cover consisting of species that offer wildlife habitat and other values and advance the performance of wetland functions overall.
Freeboard	The vertical distance between the design water surface elevation and the elevation of the barrier which contains the water.
Frequently flooded areas	the 100-year floodplain designations of the Federal Emergency Management Agency and the National Flood Insurance Program or as defined by the local government.

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Frost-heave
The upward movement of soil surface due to the expansion of water stored between particles in the first few feet of the soil profile as it freezes. May cause surface fracturing of asphalt or concrete.

Frequency of storm (design storm frequency)
The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur; thus a 10-year storm can be expected to occur on the average once every 10 years. Sewers designed to handle flows which occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.

Functions
The ecological (physical, chemical, and biological) processes or attributes of a wetland without regard for their importance to society (see also values). Wetland functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, floodflow alteration, ground water recharge and discharge, water quality improvement, and soil stabilization.

Gabion
A rectangular or cylindrical wire mesh cage (a chicken wire basket) filled with rock and used as a protecting agent, revetment, etc., against erosion. Soft gabions, often used in streambank stabilization, are made of geotextiles filled with dirt, in between which cuttings are placed.

Gage or gauge
Device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc. Also, a measure of the thickness of metal; e.g., diameter of wire, wall thickness of steel pipe.

Gaging station
A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

Geologist
A person who has earned a degree in geology from an accredited college or university or who has equivalent educational training and has at least five years of experience as a practicing geologist or four years of experience and at least two years post-graduate study, research or teaching. The practical experience shall include at least three years work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers.

Geologically hazardous areas
Areas that because of their susceptibility to erosion, sliding, earthquake or other geological events, are not suited to the siting of commercial, residential or industrial development consistent with public health or safety concerns.

Geometrics
The mathematical relationships between points, lines, angles and surfaces used to measure and identify areas of land.

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Geotechnical professional civil engineer — A practicing, geotechnical/civil engineer licensed as a professional Civil Engineer with the State of Washington who has at least four years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.

Grade — The slope of a road, channel, or natural ground. The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction such as paving or the laying of a conduit.

(To) Grade — To finish the surface of a canal bed, roadbed, top of embankment or bottom of excavation.

Gradient terrace — An earth embankment or a ridge-and-channel constructed with suitable spacing and an acceptable grade to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a stable nonerosive velocity.

Grassed waterway — A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from an area at a reduced flow rate. See also **biofilter.**

Ground water — Water in a saturated zone or stratum beneath the land surface or a surface water body.

Ground water recharge — Inflow to a ground water reservoir.

Ground water table — The free surface of the ground water, that surface subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of restoration, and other conditions. It is seldom static.

(the) Guidance Manual — "The Stormwater Program Guidance Manual for the Puget Sound Basin," a companion manual to this technical manual which contains program implementation guidance for local governments. Examples of the guidance contained are model ordinances, public education information, and guidance on setting up a stormwater utility.

Gully — A channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.

Habitat — The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful contaminants.

Hardpan — A cemented or compacted and often clay-like layer of soil that is impenetrable by roots.

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Harmful pollutant	A substance that has adverse effects to an organism including immediate death, chronic poisoning, impaired reproduction, cancer or other effects.
Head (Hydraulics)	The height of water above any plain of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head, velocity head, and head loss.
Head loss	Energy loss due to friction, eddies, changes in velocity, or direction of flow.
Heavy metals	Metals of high specific gravity, present in municipal and industrial wastes, that pose long-term environmental hazards. Such metals include cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc.
Humus	Organic matter in or on a soil, composed of partly or fully decomposed bits of plant tissue or from animal manure.
Hydraulic gradient	Slope of the potential head relative to a fixed datum.
Hydrodynamics	Means the dynamic energy, force, or motion of fluids as affected by the physical forces acting upon those fluids.
Hydrograph	A graph of runoff rate, inflow rate or discharge rate, past a specific point over time.
Hydrologic cycle	The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.
Hydrologic Soil Groups	A soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties.
Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.
Hydroperiod	A seasonal occurrence of flooding and/or soil saturation; it encompasses depth, frequency, duration, and seasonal pattern of inundation.
Hyetograph	A graph of percentages of total precipitation for a series of time steps representing the total time in which precipitation occurs.

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Illicit discharge
All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or ground water quality standards, including but not limited to sanitary sewer connections, industrial process water, interior floor drains, car washing and greywater systems.

Impact basin
A device used to dissipate the energy of flowing water. Generally constructed of concrete in the form of a partially depressed or partially submerged vessel, it may utilize baffles to dissipate velocities.

Impervious
A surface which cannot be easily penetrated. For instance, rain does not readily penetrate paved surfaces.

Impervious surface
A hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A hard 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.

Impoundment
A natural or man-made containment for surface water.

Improvement
Streets (with or without curbs or gutters), sidewalks, crosswalks, parking lots, water mains, sanitary and storm sewers, drainage facilities, street trees and other appropriate items.

Industrial activities
Material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance material handling equipment sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.

Infiltration
Means the downward movement of water from the surface to the subsoil.

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Infiltration facility (or system)	A drainage facility designed to use the hydrologic process of surface and stormwater runoff soaking into the ground, commonly referred to as a percolation, to dispose of surface and stormwater runoff.
Ingress/egress	The points of access to and from a property.
Inlet	A form of connection between surface of the ground and a drain or sewer for the admission of surface and stormwater runoff.
Insecticide	A substance, usually chemical, that is used to kill insects.
Interception (Hydraulics)	The process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs, and other vegetation. Often used for "interception loss" or the amount of water evaporated from the precipitation intercepted.
Interflow	That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface for example, in a wetland, spring or seep.
Intermittent stream	A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than three months.
Invasive weedy plant species	Opportunistic species of inferior biological value that tend to out-compete more desirable forms and become dominant; applied to non-native species in this manual.
Invert	The lowest point on the inside of a sewer or other conduit.
Invert elevation	The vertical elevation of a pipe or orifice in a pond which defines the water level.
Isopluvial map	A map with lines representing constant depth of total precipitation for a given return frequency.
Lag time	The interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff.
Lake	An area permanently inundated by water in excess of two meters deep and greater than 20 acres in size as measured at the ordinary high water marks.
Land disturbing activity	Any activity that results in a change in the existing soil cover (both vegetative and nonvegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to demolition, construction, clearing, grading, filling and excavation.

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Landslide	Episodic downslope movement of a mass of soil or rock that includes but is not limited to rockfalls, slumps, mudflows, and earthflows. For the purpose of these rules, snow avalanches are considered to be a special case of landsliding.
Landslide Hazard Areas	Those areas subject to a severe risk of landslide.
Large Parcel Erosion and Sediment Control Plan" or "LPESC Plan"	A plan to implement BMPs to control pollution generated during land disturbing activity. Guidance for preparing a Large Parcel ESC Plan is contained in Chapter II-4. *[Note: Ecology will be adding a sample Large Parcel ESC Plan to the Guidance Manual.]*
Leachate	Liquid that has percolated through soil and contains substances in solution or suspension.
Leaching	Removal of the more soluble materials from the soil by percolating waters.
Legume	A member of the legume or pulse family, Leguminosae, one of the most important and widely distributed plant families. The fruit is a "legume" or pod. Includes many valuable food and forage species, such as peas, beans, clovers, alfalfas, sweet clovers, and vetches. Practically all legumes are nitrogen-fixing plants.
Level spreader	A temporary ESC device used to spread out stormwater runoff uniformly over the ground surface as sheet flow (i.e., not through channels). The purpose of level spreaders are to prevent concentrated, erosive flows from occurring, and to enhance infiltration.
Local government	Any county, city, or town having its own incorporated government for local affairs.
Low flow channel	An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and/or baseflow, directly to the outlet without detention.
Lowest floor	The lowest enclosed area (including basement) of a structure. An area used solely for parking of vehicles, building access, or storage, in an area other than a basement area, is not considered a building's lowest floor, provided that the enclosed area meets all of the structural requirements of the flood hazard standards.
MDNS	A Mitigated Determination of Nonsignificance (See DNS and Mitigation).

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Manning's equation (Hydraulics) An equation used to predict the velocity of water flow in an open channel or pipelines:

$$V = \frac{1.486R^{2/3}S^{1/2}}{n}$$

where:

V is the mean velocity of flow in feet per second

R is the hydraulic radius in feet

S is the slope of the energy gradient or, for assumed uniform flow, the slope of the channel in feet per foot; and

n is Manning's roughness coefficient or retardance factor of the channel lining.

Mass wasting The movement of large volumes of earth material downslope.

Master Drainage Plan A comprehensive drainage control plan intended to prevent significant adverse impacts to the natural and manmade drainage system, both on and off-site.

Mean annual water level fluctuation Derived as follows--

(1) Measure the maximum water level (e.g., with a crest stage gage, Reinelt and Horner 1990) and the existing water level at the time of the site visit (e.g., with a staff gage) on at least eight occasions spread through a year.

(2) Take the difference of the maximum and existing water level on each occasion and divide by the number of occasions.

Mean depth (Hydraulics) Average depth; cross-sectional area of a stream or channel divided by its surface or top width.

Mean velocity The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach.

Measuring weir A shaped notch through which water flows are measured. Common shapes are rectangular, trapezoidal, and triangular.

Mechanical analysis The analytical procedure by which soil particles are separated to determine the particle size distribution.

Mechanical practices Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion.

Metals Elements, such as mercury, lead, nickel, zinc and cadmium, that are of environmental concern because they do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations. They are also referred to as heavy metals.

Mitigation Means, in the following order of preference:

(a) Avoiding the impact altogether by not taking a certain action or part of an action;

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;

(c) Rectifying the impact by repairing, rehabilitating or restoring the affected environment;

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

(e) Compensation for the impact by replacing, enhancing, or providing substitute resources or environments.

Modification, Modified (wetland) A wetland whose physical, hydrological, or water quality characteristics have been purposefully altered for a management purpose, such as by dredging, filling, forebay construction, and inlet or outlet control.

Monitor To systematically and repeatedly measure something in order to track changes.

Monitoring The collection of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures imposed as conditions of development.

NGPE See Native Growth Protection Easement.

NGVD National Geodetic Vertical Datum (see Base flood elevation).

NPDES The National Pollutant Discharge Elimination System as established by the Federal Clean Water Act.

National Pollutant Discharge Elimination System (NPDES) The part of the federal Clean Water Act, which requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.

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Native Growth Protection Easement (NGPE)	An easement granted for the protection of native vegetation within a sensitive area or its associated buffer. The NGPE shall be recorded on the appropriate documents of title and filed with the County Records Division.
Natural location	Means the location of those channels, swales, and other non-manmade conveyance systems as defined by the first documented topographic contours existing for the subject property, either from maps or photographs, or such other means as appropriate.
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 impervious surfaces; subdivision, short subdivision and binding site plans, as defined and applied in Chapter58.17 RCW. All other forest practices and commercial agriculture are not considered new development.
Nitrate (NO_3)	A form of nitrogen which is an essential nutrient to plants. It can cause algal blooms in water if all other nutrients are present in sufficient quantities. It is a product of bacterial oxidation of other forms of nitrogen, from the atmosphere during electrical storms and from fertilizer manufacturing.
Nitrification	The biochemical oxidation process by which ammonia is changed first to nitrites and then to nitrates by bacterial action, consuming oxygen in the water.
Nitrogen, Available	Usually ammonium, nitrite, and nitrate ions, and certain simple amines available for plant growth. A small fraction of organic or total nitrogen in the soil is available at any time.
Nonpoint source pollution	Pollution that enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.
Normal depth	The depth of uniform flow. This is a unique depth of flow for any combination of channel characteristics and flow conditions. Normal depth is calculated using Manning's Equation.
Nutrients	Essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and algal blooms. Some nutrients can be toxic at high concentrations.
Off-site	Any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.

Off-system storage Facilities for holding or retaining excess flows over and above the carrying capacity of the stormwater conveyance system, in chambers, tanks, lagoons, ponds, or other basins that are not a part of the subsurface sewer system.

On-site The entire property that includes the proposed development.

OperationalBMPs Schedules of activities, prohibition of practices, and other managerial practices to prevent or reduce pollutants from entering stormwater. Operational BMPs are a type of Source Control BMP.

Ordinary High Water Mark The term ordinary high water mark means the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil destruction on terrestrial vegetation, or the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding area.

The ordinary high water mark will be found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water shall substitute. In any area where neither can be found, the channel bank shall be substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute shall be measured so as to include the entire stream feature.

Orifice An opening with closed perimeter, usually sharp-edged, and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of water.

Outlet Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Outlet channel A waterway constructed or altered primarily to carry water from man-made structures, such as terraces, tile lines, and diversions.

Overflow A pipeline or conduit device, together with an outlet pipe, that provides for the discharge of portions of combined sewer flows into receiving waters or other points of disposal, after a regular device has allowed the portion of the flow which can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.

Overflow rate Detention basin release rate divided by the surface area of the basin. It can be thought of as an average flow rate through the basin.

Overtopping To flow over the limits of a containment or conveyance element.

Peak discharge — The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Peak-shaving — Controlling post-development peak discharge rates to pre-development levels by providing temporary detention in a BMP.

Percolation — The movement of water through soil.

Percolation rate — The rate, usually expressed as a velocity, at which water moves through saturated granular material.

Permanent Stormwater Quality Control (PSQC) Plan — A plan which includes permanent BMPs for the control of pollution from stormwater runoff after construction and/or land disturbing activity has been completed. For small sites, this requirement is met by implementing a Small Parcel Erosion and Sediment Control Plan. Guidance on preparing a PSQC Plan is contained in Chapter I-3 and Chapter I-4. *[Note: Ecology will add a sample Large Parcel ESC Plan to the Guidance Manual.]*

Permeability rate — The rate at which water will move through a saturated soil. Permeability rates are classified as follows:

a. Very slow - Less than 0.06 inches per hour.
b. Slow - 0.06 to 0.20 inches per hour.
c. Moderately slow - 0.20 to 0.63 inches per hour.
d. Moderate - 0.63 to 2.0 inches per hour.
e. Moderately rapid - 2.0 to 6.3 inches per hour.
f. Rapid - 6.3 to 20.0 inches per hour.
g. Very rapid - More than 20.0 inches per hour.

Permeable soils — Soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as SCS hydrologic soil types A and B.

Person — Any individual, partnership, corporation, association, organization, cooperative, public or municipal corporation, agency of the state, or local government unit, however designated.

Perviousness — Related to the size and continuity of void spaces in soils; related to a soil's infiltration rate.

Pesticide — A general term used to describe any substance - usually chemical - used to destroy or control organisms; includes herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins which are extracted from plants and animals.

pH	A measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acid.
Physiographic	Characteristics of the natural physical environment (including hills).
Planned unit development (PUD)	A special classification authorized in some zoning ordinances, where a unit of land under control of a single developer may be used for a variety of uses and densities, subject to review and approval by the local governing body. The locations of the zones are usually decided on a case-by-case basis.
Plat	A map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.
Plunge pool	A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.
Point discharge	The release of collected and/or concentrated surface and stormwater runoff from a pipe, culvert, or channel.
Pollution	Contamination or other alteration of the physical, chemical, or biological properties, of waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.
Pollution-generating 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 are also considered to be PGIS unless they are treated to prevent leaching. 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 firelanes, diesel equipment storage yards, and airport runways.

Pollution-generating impervious surface(PGIS) (continued)
The following are not considered regularly-used surfaces: road shoulders primarily used for emergency parking, paved bicycle pathways, bicycle lanes adjacent to unpaved or paved road shoulders primarily used for emergency parking, fenced firelanes, and infrequently used maintenance access roads.

Pollution-generating pervious surface
Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil. Modified PGPS means any existing PGPS that is re-graded or re-contoured by the proposed project.

Prediction
For the purposes of this document an expected outcome based on the results of hydrologic modelling and/or the judgment of a trained professional civil engineer or geologist.

Pretreatment
The removal of material such as gross solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, stormwater, and oil separators.

Priority peat systems
Unique, irreplaceable fens that can exhibit water pH in a wide range from highly acidic to alkaline, including fens typified by Sphagnum species, Ledum groenlandicum (Labrador tea), Drosera rotundifolia (sundew), and Vaccinium oxycoccos (bog cranberry); marl fens; estuarine peat deposits; and other moss peat systems with relatively diverse, undisturbed flora and fauna. Bog is the common name for peat systems having the Sphagnum association described, but this term applies strictly only to systems that receive water income from precipitation exclusively.

Professional civil engineer
A person registered with the state of Washington as a professional engineer in civil engineering.

Project
The proposed action of a permit application or an approval which requires a drainage review.

Project site
That portion of a property or properties subject to proposed project improvements including those required by this manual.

Puget Sound basin
Puget Sound south of Admiralty Inlet (including Hood Canal and Saratoga Passage); the waters north to the Canadian border, including portions of the Strait of Georgia; the Strait of Juan de Fuca south of the Canadian border; and all the lands draining into these waters as mapped in Water Resources Inventory Areas numbers 1 through 19, set forth in WAC 173-500-040.

R/D
See Retention/detention facility.

Rare, threatened, or endangered species
Plant or animal species that are regional relatively uncommon, are nearing endangered status, or whose existence is in immediate jeopardy and is usually restricted to highly specific habitats. Threatened and endangered species are officially listed by federal and state authorities, whereas rare species are unofficial species of concern that fit the above definitions.

Rational method
A means of computing storm drainage flow rates (Q) by use of the formula Q = CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area. This method is no longer used in the technical manual.

Reach
A length of channel with uniform characteristics.

Receiving waters
Bodies of water or surface water systems receiving water from upstream manmade (or natural) streams.

Recharge
The flow to ground water from the infiltration of surface and stormwater runoff.

Redevelopment
On an already developed site, the creation or addition of impervious surfaces, structural development including construction, installation or expansion of a building or other structure, and/or replacement of impervious surface that is not part of a routine maintenance activity; and land disturbing activities associated with structural or impervious redevelopment.

Regional
An action (here, for stormwater management purposes) that involves more than one discrete property.

Regional detention facility
A stormwater quantity control structure designed to correct existing excess surface water runoff problems of a basin or subbasin. The area downstream has been previously identified as having existing or predicted significant and regional flooding and/or erosion problems.

This term is also used when a detention facility is used to detain stormwater runoff from a number of different businesses, developments or areas within a catchment. The use of regional detention facilities may be more efficient than on-site stormwater treatment although the preferred option is to include some on-site stormwater treatment through the use of grassy swales etc. even when regional detention facilities are used.

Release rate
The computed peak rate of surface and stormwater runoff for a particular design storm event and drainage area conditions.

Replaced impervious surface
For structures, the removal and replacement of any exterior surfaces or foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement, excluding impervious surfaces removed for the sole purpose of installing underground utilities.

Residential density — The number of persons per unit of residential land area. Net density includes only occupied land. Gross density includes unoccupied portions of residential areas, such as roads and open space.

Restoration — Actions performed to reestablish wetland functional characteristics and processes that have been lost by alterations, activities, or catastrophic events in an area that no longer meets the definition of a wetland.

Retention — The process of collecting and holding surface and stormwater runoff with no surface outflow.

Retention/detention facility (R/D) — A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.

Retrofitting — The renovation of an existing structure or facility to meet changed conditions or to improve performance.

Return interval — A statistical term for the average time of expected interval that an event of some kind will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).

Rhizome — A modified plant stem that grows horizontally underground.

Riffles — Fast sections of a stream where shallow water races over stones and gravel. Riffles usually support a wider variety of bottom organisms than other stream sections.

Rill — A small intermittent watercourse with steep sides, usually only a few inches deep. Often rills are caused by an increase in surface water flow when soil is cleared of vegetation.

Riprap — A facing layer or protective mound of stones placed to prevent erosion or sloughing of a structure or embankment due to flow of surface and stormwater runoff.

Riparian — Pertaining to the banks of streams, wetlands, lakes or tidewater.

Riser — A vertical pipe extending from the bottom of a pond BMP that is used to control the discharge rate from a BMP for a specified design storm.

Rodenticide — A substance used to destroy rodents.

Runoff — Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

SCS — Soil Conservation Service, U.S. Department of Agriculture.

SCS Method — A hydrologic analysis based on the Curve Number method (National Engineering Handbook - Section 4: Hydrology, August 2971).

SEPA — See State Environmental Policy Act.

Salmonid — A member of the fish family Salmonidae. Chinook, coho, chum, sockeye and pink salmon; cutthroat, brook, brown, rainbow and steelhead trout; Dolly Varden, kokanee and char are examples of salmonid species.

Saturation point — In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Scour — Erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.

Sediment — Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.

Sedimentation — The depositing or formation of sediment.

Sensitive emergent vegetation communities — Assemblages of erect, rooted, herbaceous vegetation, excluding mosses and lichens, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as sundew and, as well as a number of species of Carex (sedges).

Sensitive life stages — Stages during which organisms have limited mobility or alternatives in securing the necessities of life, especially including reproduction, rearing, and migration periods.

Sensitive scrub-shrub vegetation communities — Assemblages of woody vegetation less than 6 meters in height, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as Labrador tea, bog laurel, and cranberry.

Settleable solids — Those suspended solids in stormwater that separate by settling when the stormwater is held in a quiescent condition for a specified time.

Sheet erosion — The relatively uniform removal of soil from an area without the development of conspicuous water channels.

Sheetflow — Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

Shoreline development — The proposed project as regulated by the Shoreline Management Act. Usually the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

Short circuiting — The passage of runoff through a BMP in less than the design treatment time.

Siltation — The process by which a river, lake, or other water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.

Site — A property which is subject to development.

Slope — Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane, with a 90° slope being vertical (maximum) and 45° being a 1:1 or 100 percent slope.

Sloughing — The sliding of overlying material. It is the same effect as caving, but it usually occurs when the bank or an underlying stratum is saturated or scoured.

Small Parcel — Single family residential and small subdivision projects that add less than 10,000 ft2 of impervious surface and disturb less than 1 acre. Other types of development projects that add less than 5,000 ft2 of impervious surface and disturb less than 1 acre.

Soil — The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil group, hydrologic — A classification of soils by the Soil Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little or no runoff, to D soils, which are not very permeable and produce much more runoff.

Soil horizon — A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming factors.

Soil profile — A vertical section of the soil from the surface through all horizons, including C horizons.

Soil structure — The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.

Soil permeability — The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.

Soil stabilization — The use of measures such as rock lining, vegetation or other engineering structures to prevent the movement of soil when loads are applied to the soil.

Sorption — The physical or chemical binding of pollutants to sediment or organic particles.

Source control BMP — A BMP that is intended to prevent pollutants from entering stormwater. A few examples of source control BMPs are erosion control practices, maintenance of stormwater facilities, constructing roofs over storage and working areas, and directing wash water and similar discharges to the sanitary sewer or a dead end sump.

Specific energy — The total energy within any system with respect to the channel bottom, equal to the potential head plus velocity and pressure heads.

Spillway — A passage such as a paved apron or channel for surplus water over or around a dam or similar obstruction. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

State Environmental Policy Act (SEPA) — The Washington State law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size and comprehensive plans. As part of this process, environmental documents are prepared and opportunities for public comment are provided.

Steep slope — Slopes of 40 percent gradient or steeper.

Storm drains — The enclosed conduits that transport surface and stormwater runoff toward points of discharge (sometimes called storm sewers).

Storm drain system — Refers to the system of gutters, pipes, streams, or ditches used to carry surface and stormwater from surrounding lands to streams, lakes, or Puget Sound.

Storm frequency — The time interval between major storms of predetermined intensity and volumes of runoff for which storm sewers and other structures are designed and constructed to handle hydraulically without surcharging and backflooding, e.g., a 2-year, 10-year or 100-year storm.

Storm sewer — A sewer that carries stormwater and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes. Also called a storm drain.

Stormwater — That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, channels or pipes into a defined surface water channel, or a constructed infiltration facility.

Stormwater drainage system — constructed and natural features which function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat or filter stormwater.

Stormwater facility — A constructed component of a stormwater drainage system, designed or constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to, pipes, swales, ditches, culverts, street gutters, detention basins, retention basins, constructed wetlands, infiltration devices, catchbasins, oil/water separators, sediment basins and modular pavement.

Stormwater Management Manual for the Puget Sound Basin or "Manual" — this manual as prepared by Ecology that contains BMPs to prevent, control or treat pollution in stormwater [or a technically equivalent Manual approved by Ecology].

Stormwater Program — Either the Basic Stormwater Program or the Comprehensive Stormwater Program as appropriate to the context of the reference. See the "Stormwater Program Guidance Manual for the Puget Sound Basin" for a complete description of the requirements of each program.

Stormwater Site Plan — a plan which includes an Erosion and Sediment Control (ESC) Plan and/or a Permanent Stormwater Quality Control Plan (PSQC). For small sites, this plan is the equivalent of a Small Parcel Erosion and Sediment Control Plan. Guidance on preparing a Stormwater Site Plan is contained in Chapter I-3.

Stream gaging — The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See Gaging station.

Streambanks — The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Stream classification — The following stream classification which applies to all streams.

1. Type 1 streams are all streams inventoried as Shorelines of the State under Chapter 90.58 RCW.
2. Type 2 streams are all streams smaller than Type 1 streams that flow year around during years of normal rainfall, or are used by salmonids.
3. Type 3 streams are streams that are intermittent or ephemeral during years of normal rainfall and are not used by salmonids.

Streams — Those areas where surface waters flow sufficiently to produce a defined channel or bed. A defined channel or bed is indicated by hydraulically sorted sediments or the removal of vegetative litter or loosely rooted vegetation by the action of moving water. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, stormwater runoff devices or other entirely artificial watercourses unless they are used to convey Type 1 and 2 streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (i.e. swales) shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.

Structure — A catchbasin or manhole in reference to a storm drainage system.

Structural Source Control BMPs — Physical, structural, or mechanical devices that are intended to prevent pollutants from entering stormwater.

Stub-out — A short length of pipe provided for future connection to a storm drainage system.

Subbasin — A drainage area which drains to a water course or waterbody named and noted on common maps and which is contained within a basin.

Subcatchment — A subdivision of a drainage basin (generally determined by topography and pipe network configuration).

Subcritical flow — Flow at depths greater than the critical depth.

Sub-division retention/detention facility — A retention/detention facility which is both (1) located within or associated with a short or formal plat sub-division containing only single family or duplex residential structures located on individual lots; and 2) which is required to handle excess runoff generated by development of an area of which two-thirds or more is designated for single family or duplex residential structures located on individual lots.

Subdrain — A pervious backfilled trench containing stone or a pipe for intercepting ground water or seepage.

Subgrade — A layer of stone or soil used as the underlying base for a BMP.

Subsoil — The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that under it as the "subsoil."

Substrate — The natural soil base underlying a BMP.

Supercritical flow — Flow at depths less than the critical depth.

Surcharge — The flow condition occurring in closed conduits when the hydraulic grade line is above the crown of the sewer.

Surface and stormwater — Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow ground water.

Surface and stormwater management system — Drainage facilities and any other natural features which collect, store, control, treat and/or convey surface and stormwater.

Suspended solids — Organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles (and associated pollutants) as well as solids in stormwater.

Swale — A shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.

Terrace — An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.

Threshold Discharge Area — An onsite 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). The examples below illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.

Drawings of three different situations depicting the relationship of project sites, natural discharge locations, and threshold discharge areas.

Tile, Drain	Pipe made of burned clay, concrete, or similar material, in short lengths, usually laid with open joints to collect and carry excess water from the soil.
Tile drainage	Land drainage by means of a series of tile lines laid at a specified depth and grade.
Time of concentration	The time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the tributary drainage area.
Toe of slope	A point or line of slope in an excavation or cut where the lower surface changes to horizontal or meets the exiting ground slope.
Top of slope	A point or line on the upper surface of a slope where it changes to horizontal or meets the original surface.
Topography	General term to include characteristics of the ground surface such as plains, hills, mountains; degree of relief, steepness of slopes, and other physiographic features.
Total dissolved solids	The dissolved salt loading in surface and subsurface waters.
Total solids	The solids in water, sewage, or other liquids, including the dissolved, filterable, and nonfilterable solids. The residue left when the moisture is evaporated and the remainder is dried at a specified temperature, usually 130°C.
Toxic	Poisonous, carcinogenic, or otherwise directly harmful to life.
Tract	A legally created parcel of property designated for special nonresidential and noncommercial uses.
Trash rack	A structural device used to prevent debris from entering a spillway or other hydraulic structure.
Travel time	The estimated time for surface water to flow between two points of interest.
Treatment BMP	A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are detention ponds, oil/water separators, biofiltration swales and constructed wetlands.
Turbidity	Dispersion or scattering of light in a liquid, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.
Underdrain	Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration BMP which are used to collect and remove excess runoff.

Undisturbed buffer	A zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and stormwater facilities.
Undisturbed low gradient uplands	Forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.
Unstable slopes	Those sloping areas of land which have in the past exhibited, are currently exhibiting, or will likely in the future exhibit, mass movement of earth.
Unusual biological community types	Assemblages of interacting organisms that are relatively uncommon regionally.
Urbanized area	Areas designated and identified by the U.S. Bureau of Census according to the following criteria: an incorporated place and densely settled surrounding area that together have a maximum population of 50,000.
USEPA	The United States Environmental Protection Agency.
Values	Wetland processes or attributes that are valuable or beneficial to society (also see Functions). Wetland values include support of commercial and sport fish and wildlife species, protection of life and property from flooding, recreation, education, and aesthetic enhancement of human communities.
Vegetation	All organic plant life growing on the surface of the earth.
Water body	Surface waters including rivers, streams, lakes, marine waters, estuaries, and wetlands.
Water quality	A term used to describe the chemical, physical, and biological characteristics off water, usually in respect to its suitability for a particular purpose.
Water quality BMP	A BMP specifically designed for pollutant removal.
Water quality design storm	The 6-month 24-hour design storm.
Water quality standards	Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonate, pH, total dissolved salts, etc. In Washington, the Department of Ecology sets water quality standards.
Water quality swale	An open vegetated drainage channel intended to optimize water quality treatment of surface and stormwater runoff by following the specific design criteria described in the manual.

Watershed — A geographic region within which water drains into a particular river, stream, or body of water as identified and numbered by the State of Washington Water Resource Inventory Areas (WRIAs) as defined in Chapter 173-500 WAC.

Water table — The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of ground water.

Weir — Device for measuring or regulating the flow of water.

Weir notch — The opening in a weir for the passage of water.

Wetlands — Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. This includes wetlands created, restored or enhanced as part of a mitigation procedure. This does not include constructed wetlands or the following surface waters of the state intentionally constructed from sites that are not wetlands: Irrigation and drainage ditches, grass-lined swales, canals, agricultural detention facilities, farm ponds, and landscape amenities.

Wetland edge — Delineation of the wetland edge shall be based on the U.S. Army Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1, U.S. Army Engineers Waterways Experiment Station, Vicksburg, Miss. (1987)

Wetponds and wetvaults — Drainage facilities for water quality treatment that contain permanent pools of water that are filled during the initial runoff from a storm event. They are designed to optimize water quality by providing retention time in order to settle out particles of fine sediment to which pollutants such as heavy metals absorb, and to allow biologic activity to occur that metabolizes nutrients and organic pollutants.

Zoning ordinance — An ordinance based on the police power of government to protect the public health, safety, and general welfare. It may regulate the type of use and intensity of development of land and structures to the extent necessary for a public purpose. Requirements may vary among various geographically defined areas called zones. Regulations generally cover such items as height and bulk of buildings, density of dwelling units, off-street parking, control of signs, and use of land for residential, commercial, industrial, or agricultural purposes. A zoning ordinance is one of the major methods for implementation of a comprehensive plan.

Notations

This list of notations is provided only as a guide to some of the notations used in this report. The exact definition and units are listed when the symbol is used. Since the same symbol can be used for different design methods, the exact definition should be obtained directly from the appropriate section of the report.

A	=	drainage area (mi^2), also full cross-sectional area of culvert barrel (ft^2)
A_b	=	top surface area of basin (ft^2), also area of pond bottom (ft^2)
A_d	=	drainage area
A_p	=	surface area of porous asphalt pavement (ft^2)
A_s	=	surface area of swale (ft^2), also average surface area for detention BMP
A_t	=	total area (acres)
C	=	estimated runoff coefficient
CN	=	SCS runoff curve number
ΔCN	=	change in curve number
D	=	interior height of culvert barrel (ft)
D_{50}	=	median stone diameter (riprap)
d	=	average permanent pool depth of a detention BMP
d_b	=	basin depth (ft)
d_c	=	critical depth (ft)
d_p	=	depth of porous asphalt paving stone subbase (ft)
d_s	=	depth of swale check dam (ft)
dt	=	time interval in minutes
d_x	=	a mixture of riprap sizes where the percent of stone by weight is $<x$ (the specified diameter)
E	=	designated fraction of particulates to be removed by a BMP
f	=	final infiltration rate of soil (in/hr)

f_d	=	infiltration rate including a safety factor of two
g	=	acceleration due to gravity, 32.2 ft/sec^2
H	=	stage height (ft) or water depth above pond bottom, also $H = H_f + H_e + H_{ex}$; head on orifice
H_c	=	specific head at critical depth ($d_c + V_c^2/2g$) (ft)
H_d	=	design depth of pond
H_e	=	entrance head loss (ft) = $K_e(V^2/2g)$
H_{ex}	=	exit head loss (ft) = $V^2/2g$
H_f	=	Friction loss (ft) = $V^2n^2L/2.22R^{1.35}$ Note: if $(H_f + TW - LS) < D$, adjust H_f such that $(H_f + TW - LS) = D$. This will keep the analysis simple and still yield reasonable results (erring on the conservative side)
HW	=	headwater depth above inlet invert (ft)
h_b	=	distance from the hydraulic grade line at the 2-year flow on the outflow pipe to the overflow elevation
I	=	inflow at time 1 and time 2
I(t)	=	instantaneous hydrograph, in cfs (SBUH hydrograph method)
i	=	hydraulic gradient (ft/ft)
K_e	=	entrance loss coefficient
k	=	time of concentration velocity factor (feet/second)
k_c	=	time of concentration velocity factor; channel flow
k_s	=	time of concentration velocity factor; shallow flow
L	=	distance of flow across a given segment, also length of culvert (ft), also width of emergency overflow weir
MB_{el}	=	mean tributary basin elevation above sea level (ft)
M_s	=	potential average snowmelt during storms (in)
m	=	number of flow segments
N_s	=	number of check dams along total length of swale

n	=	Manning's "n"
n_s	=	sheet flow; Manning's effective roughness coefficient
O	=	outflow at time 1 and time 2
P	=	rainfall depth (inches)
P_R	=	the total precipitation at a site for the 24-hour design storm event for the given return frequency (R)
Q	=	flow or discharge (cfs), also runoff depth from overlying area of dry well (ft), also orifice area
Q_a	=	after development depth of runoff (inches)
Q_b	=	before development depth of runoff (inches)
Q_c	=	depth of runoff from contributing area (ft)
Q_d	=	runoff depth in inches over a given area
Q_o	=	average release rate from detention BMP
Q_s	=	depth of runoff controlled by vegetated swale (inches)
Q_t	=	release rate for orifice
Q_{total}	=	total flow at maximum head
$Q(t)$	=	the routed flow of the runoff hydrograph (SBUH method)
$Q_{10\%}$	=	the flow that is not exceeded more than 10% of the time during the months of adult (salmonid) migration
ΔQ	=	change in runoff depth (inches)
Δq	=	change in peak discharge (cfs)
R	=	hydraulic radius (ft) in Manning's equation
$R(t)$	=	the total runoff depth at time increment dt, in inches; also known as precipitation excess
S	=	storage at time 1 and time 2, also culvert barrel slope (ft/ft)
$S(H)$	=	storage (ft^3) at stage height (H)
S_d	=	the largest volume from an initial pond sizing

s_f = friction slope = $n^2V^2/2.21R^{4/3}$

s_o = slope of flow path (ft/ft), also bottom slope

T = width of swale or vegetated filter strip

T_c = time of concentration (hrs)

T_t = travel time of overland flow across separate flow path segments

$T_{1,2,n}$ = the consecutive flow paths of different land cover categories having significant differences in flow path slope

TW = tailwater depth above invert of culvert outlet (ft) Note: if $TW < (D + d_c)/2$, set $TW = (D + d_c)/2$.

t_d = design detention time of a BMP

Δt = time interval; time 2 - time 1

V = average velocity across the land cover (ft/sec), also barrel velocity (fps), also mean velocity

V_c = flow velocity at critical depth (fps)

V_{max} = maximum allowed velocity of runoff in a biofilter

V_{pp} = permanent pool volume

V_r = void ratio

V_{sed} = settling velocity of the deign soil particle

W_{50} = the median stone size (riprap)

w = settling velocity of target particle

y = depth of flow

y_n = normal flow depth

Z = basin side slope ratio (h:v)

Z^1,Z^2 = side slope ratio of swale cross section (h:v)

α = energy coefficient which corrects for the non-uniform distribution of velocity over the channel cross-section