CHAPTER 14

WATER QUALITY

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14.1 Introduction

This chapter provides minimum requirements and technical guidance for the planning and design of permanent stormwater control facilities that provide water quality treatment. The methodology is intended for those with an understanding of basic hydrologic and hydraulic methods and some experience in the design of stormwater structures. Projects that follow the stormwater best management practices contained in this chapter should achieve compliance with federal and state water quality regulations. While federal and state water quality requirements are subject to change, this chapter is based on the best practicable engineering approaches to stormwater management currently available for ODOT facilities.

Figure 14-1 Extended detention dry pond

A water quality facility, also called a stormwater treatment facility or BMP (for Best Management Practice), is that portion of the highway drainage system whose function is to remove or reduce pollutants in roadway runoff prior to discharging to receiving waters. The facility receives surface water by way of sheet flow or through a conveyance system of inlets, pipes, and ditches. They range from unmodified or enhanced side slopes within the right-of-way to intensely engineered facilities.

Planning and designing the treatment of highway runoff needs to be done early in project development. Delay only limits options and leads to less effective and more expensive facilities, and can cause project deadlines to slip. Proposed treatment facility types, locations and area requirements should be determined before DAP so design, right-of-way acquisition and environmental permitting can proceed on schedule. Choosing the best BMPs for a project is a collaborative effort; the water quality designer will need to coordinate with Roadway, Environmental, and Right-of-Way staff. Guidance on the selection and siting of stormwater Best Management Practices is provided in Section 14.9.

The stormwater BMPs described in this chapter, its appendices and current technical bulletins are approved for use on ODOT projects. Projects are not limited to these BMPs. If new, innovative BMPs or substantially modified approved BMPs provide the best option for a project, their use may be approved through the Hydraulic Design Deviation process. See **Chapter 3** for guidance on the Hydraulic Design Deviation process.

14.2 Organization of this Chapter

The intent of the main body of this chapter is to provide an overview of:

- Goals and objectives of water quality treatment,
- Project elements that trigger the requirement for treatment of highway runoff,
- Pollutants of concern from stormwater runoff (oil and grease, sediment, nitrogen, phosphorus, metals, and debris),
- Recommended water quality treatment approaches,
- Minimum requirements for design of water quality facilities, and
- Generalized procedures for treatment facility design.

The intent of the chapter appendices is to provide:

- Detailed design criteria for each permanent water quality treatment approach,
- Step-by-step procedures to aid the designer in understanding the analysis process, and
- Detailed design criteria for facility components such as pretreatment, inlet structures, piping conveyance, outlet control structures, and outfalls.

14.3 How to use this Chapter

Completing a water quality design requires the use of many other manual chapters.

The design of a stormwater treatment facility is generally a process that evolves as a project develops. The components of this process are listed below in a general order with references to their respective chapters.

- Collect data– **Chapter 6**
- Receive approval for new, innovative BMPs or substantial modifications to approved BMPs through the Hydraulic Design Deviation process –**Chapter 3**

- Prepare Preliminary Stormwater Recommendation – **Chapter 4**
- Evaluate hydrology – **Chapter 7**
- Analyze storm drainage – **Chapter 13**
- Design treatment facility – Chapter 14, Section 12
- Design and analyze stormwater treatment features:
  - Selection and Siting – Chapter 14, Section 9
  - Requirements and Design Elements – Chapter 14, Section 10
  - Treatment Facility Design – Chapter 14, Appendix A through D
    - **Appendix A** - Low Impact Development Approach
    - **Appendix B** - Biofiltration Facilities
    - **Appendix C** – Media Filtration Facilities
    - **Appendix D** – Density Separation Facilities
  - Facility Components Design – Chapter 14, **Appendix E**
    - Inlet Structures (Flow Splitter, weir type or orifice type)
    - Pretreatment Facilities or Structures
    - Flow Spreading Options
    - Outlet Control Structures
    - Auxiliary Outlets
    - Conveyance Piping (also see **Chapter 13**)
    - Outfalls (also see Chapters **8** and **11**)
  - Oil Control Structures - **Appendix F**
- Prepare Stormwater Design Report – **Chapter 4**
- Prepare Operation and Maintenance Manual – **Chapter 4**
- Prepare contract plans – ODOT Contract Plans Development Guide
- Prepare specifications and/or special provisions – ODOT Specifications Manual
- Stormwater Control Facilities Special Provisions – **ODOT Specification Website**

14.4 Definitions

Definitions and terms important to understanding water quality features and their design are listed in this section. Additional definitions are located in the manual glossary.

1. Basic Treatment – Intended to achieve a goal of 80% removal of total suspended solids as well as targeting petroleum hydrocarbon concentrations.

2. Best Management Practice (BMP) – a physical, structural, and/or managerial practice that when used individually or in combination prevents or reduces pollution of water.

3. Biochemical Oxygen Demand (BOD) - a measure of the amount of oxygen needed by aquatic organisms to break down solids and other readily degradable organic matter present in water.

4. Chemical Oxygen Demand (COD) - amount of oxygen required for the chemical oxidation or decomposition of compounds in water.

5. Complexing - bonding between a dissolved metal species and another chemical (ligand).

6. Contributing Impervious Area (CIA) – consists of all impervious surfaces within the strict project limits plus impervious surfaces outside the project limits which drain to the project via direct flow or discrete conveyance.

7. Dissolved Metals – the fraction of metals in stormwater that pass through a 0.45 micron filter. A portion of dissolved metals will be in ionic form, but most will be complexed or otherwise attached to very fine organic or inorganic particles.

8. Dissolved Oxygen - the amount of oxygen dissolved in water. This term also refers to a measure of the amount of oxygen available for biochemical activity in a waterbody, an indicator of the quality of that water.

9. Drainage Facility Identification (DFI) - a unique identifier assigned to each stormwater treatment and storage facility. It is used to associate or link the stormwater facility to an Operation and Maintenance Manual. The number is assigned by contacting the Geo-Environmental Section's Senior Hydraulics Engineer to obtain a unique "DFI". The Geo-Environmental Section will maintain a database of assigned Drainage Facility IDs.

10. Enhanced Treatment – Intended to achieve a higher level of treatment than basic treatment. Enhanced treatment is targeted at the removal of dissolved metals.

11. Hydraulic Conductivity – a measure of the rate of flow through soils. Also known as the coefficient of permeability. It depends on the inherent permeability of the material and on the degree of saturation.

12. Infiltration – the flow of a fluid into a substance through pores or small openings or the process by which water on the ground surface flows into the soil.

13. Infiltration Rate – the rate at which water enters the soil under a given condition. The rate is usually expressed in inches per hour

14. Low Impact Development (LID) - a stormwater management approach intended to mimic natural hydrology using vegetation and soil conditions that reduce the rate and quantity of runoff, filter out pollutants, and facilitate infiltration, detention, and evapotranspiration of stormwater.

15. Media Filtration – the flow of stormwater through compost, amended soil or other porous material to remove pollutants. Media filtration is differentiated from infiltration because the stormwater is discharged to surface water instead of into groundwater.

16. Natural Resources Conservation Service (NRCS) Hydrologic Soil Groups:

    - Type A – soils having high infiltration rates, even when thoroughly wetted. These soils consist of deep, well-drained to excessively-drained sands or gravels and have a high rate of transmission (rate at which water moves within the soil).

    - Type B – soils having moderate infiltration rates when thoroughly wetted. These soils consist of moderately-fine to moderately-coarse textures and have a moderate rate of water transmission.

    - Type C – soils having slow infiltration rates when thoroughly wetted. These soils consist of a layer that impedes downward movement of water or soils with moderately fine to fine textures. These soils have a slow rate of water transmission.

    - Type D – soils having very slow infiltration rates when thoroughly wetted. These soils consist of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over bedrock or other nearly impervious material and have a very slow rate of water transmission.

17. Operation and Maintenance (O&M) Manual - provides information about a facility's maintenance and operation. It is prepared by the project hydraulics designer to assist personnel who maintain the facility. All engineered stormwater treatment and storage facilities are required to have an Operation and Maintenance Manual.

18. Phosphorous Treatment – Intended to achieve a goal of 50% total phosphorous removal from the influent.

19. Plug Flow - a flow regime where water flows as if in a full pipe, the unit that enters first, exits first and there is no mixing between different units of water, designing for this type of flow prevents "short circuiting".

20. Pretreatment – the initial component of a stormwater treatment facility component that is designed to extend the life and efficiency of the primary stormwater treatment facility by removing coarse sediment and debris. Effective pretreatment allows the primary facility to function as designed between inspection/maintenance cycles and minimizes damages associated with sediment loading, and clogging of orifices.

21. Short Circuiting - the passage of runoff through a BMP in less than the design treatment time.

22. Stormwater Control Facilities (Treatment and/or Storage) - A treatment or storage facility that requires engineering analysis to determine the hydrology, hydraulics, and design of the structure. Treatment facilities include dry and wet detention basins, swales, filter strips, treatment wetlands, bioslopes and proprietary systems. Storage facilities used for stormwater management include dry detention basins, vaults, and tanks. Design guidance for storage facilities is discussed in Chapter 12.

23. Stormwater Facility Field Marker - used to identify and locate ODOT stormwater facilities or alert maintenance crews of stormwater facility maintenance areas. Three types of markers are recommended for identifying, locating, or alerting.

    - Field Marker Type S1 – Marker for identifying the beginning and end of a stormwater control facility maintenance area using a non-reflective flexible plastic post.

    - Field Marker Type S2 – Marker for displaying the DFI for a stormwater control facility using a white background non-reflective aluminum paddle mounted onto one (1) steel post.

    - Field Marker Type S3 - Marker created by stamping the drainage facility ID onto the top of manhole, vault, and/or tank access covers.

24. Stormwater Facility Maintenance Area - the stormwater facility footprint which includes the area needed to accommodate the pretreatment structure, storm drain piping, treatment zone (basin or pond, swale, filter strip, etc.), primary and auxiliary outlets, outfalls, maintenance access road, and maintenance operational area. These maintenance areas are applicable to all above ground stormwater treatment and storage facilities. Markers are placed at the start and end of each facility's maintenance area to alert maintenance crews of special maintenance requirements as outlined in the applicable Operation and Maintenance Manual.

25. Total Dissolved Solids - the dissolved matter found in water, comprised of mineral salts and small amounts of other inorganic and organic substances.

26. Total Maximum Daily Load (TMDL) - the maximum amount of a pollutant that can be discharged into a water body from all sources (point and non-point) and still maintain water quality standards. Under Clean Water Act section 303(d), TMDLs must be developed for all water bodies that do not meet water quality standards.

27. Total Nitrogen - a measure of all forms of nitrogen (e.g., nitrate, nitrite, ammonia-N, and organic forms) that are found in a water sample.

28. Total Kjeldahl Nitrogen - the sum of organic nitrogen and ammonia in a water body, measured in milligrams per liter (mg/L). High measurements typically result from sewage and manure discharges to water bodies.

29. Total Phosphorous - the total concentration of phosphorus found in the water. Phosphorus is a nutrient and acts as a fertilizer, increasing the growth of plant life such as algae.

30. Total Suspended Solids (TSS) - solids suspended in water including a wide variety of material such as silt, decaying plant matter, industrial wastes and sewage.

31. Treatment Train or System - the combination of several treatment facilities with unique unit processes applied in a linear progression (also called "in series").

32. Underground Injection Control (UIC) - any system, structure, or activity created to place fluid below the ground or sub-surface. Common stormwater UICs or activities include, but are not limited to sumps, infiltration galleries, drywells, trench drains, and drill holes. Infiltration basins are generally not considered UICs.

33. Unit Process - the specific mechanism of pollutant removal (i.e., sedimentation or vegetative uptake).

34. Unit Operations - the treatment facilities in which the unit process occurs (i.e., wet pond or swale).

35. Vegetative (or Biological) Uptake - absorption or utilization of nutrients and other dissolved chemicals by plants or algae.

14.5 Stormwater Quality Design Objectives

The selection and design of stormwater treatment facilities can be a complex, time consuming, and costly process. It is important that overall management objectives be clearly defined early in the design process. These objectives must ensure compliance with water quality goals and support permitting of ODOT projects by regulatory agencies.

14.5.1 Stormwater Quality Treatment Goals and Triggers

ODOT's water quality goal is to design and implement highway projects in a manner that manages project runoff to protect the beneficial uses of the receiving surface and ground waters, and to manage project runoff quantities and flows to protect the receiving water's stream form, function, and stability**.** This chapter is concerned with water quality. Flow control is covered in **Chapter 12**.

Managing highway runoff for water quality is defined as, "Directing highway runoff through natural and artificial features that remove pollutants and reduce the volume and flow rate of the stormwater." The requirement to treat stormwater therefore does not automatically mean that consolidated, engineered facilities must be designed and built.

The water quality goal is considered to be met if the following design criterion is met:

- Treatment is provided for all of the runoff generated by the Water Quality Design Storm from the Contributing Impervious Area using Best Management Practices that utilize infiltration, media filtration or vegetative filtration.

It is not always possible to meet this criterion. The goal can still be met by taking alternative actions, including off-site mitigation, that provide a similar water quality benefit.
Projects that include the following "trigger" elements are required to provide treatment of highway runoff:

- Producing new impervious surface area. Does not include:
    - Minor actions such as constructing sign or signal post pads, etc., or
    - Non-pollutant generating areas such as detached bike paths and detached sidewalks
- Changing the total Contributing Impervious Area. In situations where the CIA is decreased, there may be a possibility for "banking" of treatment provided.
- Re-constructing a roadway from the subgrade. Does not include pavement overlays or inlays, nor spot reconstruction.
- Changing the type, location, direction, length or endpoint of the pre-project stormwater conveyance system.
- Replacing or widen a stream crossing structure including adding new bridge decks or retrofitting bridge deck drainage.
- Requiring a Clean Water Act Section 404 permit and actively involving modification of impervious surfaces.

Figure 14-2 Combined Biofiltration Swale/Detention Pond

14.5.2 Facility Maintenance Objectives

Maintenance is necessary to ensure:

- Long term capacity and treatment capability are not diminished,
- Removal of pollutants as designed,
- Prevention of damage to the adjacent highway, and
- Protection of adjacent property from damage.

Therefore, all designs must include recommendations for appropriate preventive maintenance that would ensure that stormwater treatment facilities operate properly. **Water quality facilities that require extensive or specialized maintenance activities or equipment are discouraged.**

Project designs should include features that will minimize maintenance tasks. It is possible to minimize maintenance requirements while still achieving removal goals. A few ways to minimize and make maintenance easier or efficient include:

- Facility Selection
  - Use above ground facilities whenever possible and appropriate. Above ground facilities are easier to access and maintain than underground facilities.
- Site Selection
  - Site access must be adequate to allow for necessary maintenance vehicles and equipment to get to the facility. Avoid restrictive access conditions.
  - Do not place underground facilities in a location that would require closing a traffic lane to access.
- Sediment control
  - Provide appropriate pretreatment as discussed in Section 14.10.3.
  - Provide adequate dead or sediment storage to allow for sediment accumulation between maintenance cycles as discussed in Appendix E.
- Inlet and Outlet structures
  - Screens or debris risers should be applied to orifices smaller than 6 inches because small diameter orifices can be susceptible to clogging from debris.
  - Inlet and outlet structure configuration and size should be selected to provide adequate access for maintenance or inspection.
  - Minimize depth of inlet and outlet structures to prevent the need for specialized equipment for maintenance or inspection.

14.5.3 Cost Effectiveness

The construction and maintenance costs for different stormwater treatment options vary substantially. The goal is to select a treatment facility that minimizes lifecycle costs while achieving treatment goals, overcoming site constraints, and ensuring public safety. In most cases there will be more than one BMP to choose from and this may make the selection process more difficult. When more than one type of facility can meet treatment goals, select the one with the lowest overall costs, including maintenance, construction costs, and right-of-way costs for the life of the facility.

14.6 Pollutants

The purpose of water quality treatment facilities is to remove pollutant loads contained in stormwater runoff. Pollutants of concern could include:

- Petroleum hydrocarbons, including oil and grease, and combustion by-products
- Sediment, including sand, silt and suspended solids
- Nutrients such as nitrogen and phosphorus,
- Oxygen demanding substances (Chemical oxygen demand and Biological oxygen demand)
- Metals, both total and dissolved, such as copper, zinc and lead
- Certain bacteria,

- Herbicides and pesticides, and
- Debris, litter, and other pollutants

The source of these pollutants may be highway related, or may be external to the highway and deposited by air fall or run on. Highway related sources include:

- Vehicle tires
- Brake linings
- Fluid leaks from engines or other vehicle parts
- Fuel combustion
- Wear of the pavement
- Litter
- Organic debris and other materials

External sources include:

- Industrial emissions
- Drift from agricultural or landscape spraying
- Run on from adjacent land uses, such as agriculture, landscaped areas and industrial land

Identifying these constituents, aids in determining which water quality treatment facilities can be effective in meeting receiving water quality goals. The following subsections provide a brief review of the pollutants that may be present in highway runoff.

14.6.1 Petroleum Hydrocarbons

Petroleum hydrocarbons include a wide range of organic compounds such as oil and grease and combustion byproducts such as polycyclic aromatic hydrocarbons (PAHs). Common sources of hydrocarbons in highway runoff are gas tank leaks, oil leaks, car wash-off during rain events, and heavy equipment activity near and on the roadway. PAHs result from the burning of gasoline and diesel fuels. Petroleum hydrocarbons are generally toxic. Hydrocarbons are not highly soluble in water, although some slight dissolution does occur. Oil and grease are lighter than water, and runoff transporting these compounds may produce sheen on the surface of receiving waters. Hydrocarbons have a strong tendency to attach to particulate matter; thus, oil and grease, as well as PAHs may attach to particles that ultimately settle and accumulate in bottom sediments of an aquatic environment, creating the potential for adverse impacts to aquatic life.

14.6.2 Sediment

Sediment is typically one of the principle pollutants in highway runoff. Sediment may include natural material such as sand, soil particles, and vegetative matter, as well as synthetic material such as bits of plastic and metal. Typically, suspended sediment concentration is measured as total suspended solids (TSS). This test measures the weight of dry solids retained after filtering a known volume of water containing the suspended matter. TSS measurements are not generally used to determine the level of gross solids such as litter and gravel. Since TSS measurement detects both inorganic and organic suspended matter, TSS values can include particulate matter that originates from many possible sources, including soils, vegetation, vehicles, and atmospheric deposition. TSS measurements are given as concentrations, generally grams of TSS per liter of tested water.

Often sediments carry other pollutants with them, due to chemical bonding between the pollutant and the sediment particle. Effectively removing sediment from runoff is an excellent means of improving water quality.

Turbidity is another measure of suspended matter in water. Unlike the TSS test, however, it is not a weight measurement. Rather, turbidity is a measure of the light-scattering tendency of particulates dispersed in water and is a useful measure of the light penetrating properties of the dispersion. Unfortunately there is no simple correlation between TSS and turbidity. Turbidity measurements are given in Nephelometric Turbidity Units or NTU.

Suspended material can cause a variety of adverse impacts to aquatic habitat. Particulates can clog fish gills, interfere with filters of invertebrates, smother bottom-dwelling organisms, and impact spawning areas. Increased turbidity can interfere with light penetration, reducing prey capture for sight feeding predators, or conversely by increasing prey capture by allowing predator to sneak up on prey.

14.6.3 Nitrogen and Phosphorus

Nitrogen and phosphorus play a role in the aquatic habitat as valuable nutrients for plant and algal growth. The principle undesirable environmental effect associated with these nutrients is the stimulation of excess algae and plant growth, which subsequently increases oxygen demand, particularly in lakes and other water impoundments. Both nitrogen and phosphorus may be present as dissolved species or in particulate form. The distinction is important because treatment methods that reduce particulate forms differ from those that reduce dissolved forms.
Dissolved forms of nitrogen are typically inorganic and include ammonia, nitrite, and nitrate. Organic nitrogen (e.g., originating from vegetation) is frequently particulate. Often, nitrate and nitrite measurements are reported as the sum of both forms, since nitrite converts very rapidly to nitrate in the environment. Total nitrogen is the sum of all dissolved and particulate forms, inorganic and organic. The amount of organic nitrogen and ammonia nitrogen combined is given as Total Kjehldahl Nitrogen or TKN as a concentration, generally milligrams per liter.

Total phosphorus is the sum of both particulate and dissolved phosphorus. Phosphorus can exist in several chemical forms in the aquatic environment and is generally reported as a concentration in milligrams per liter.

14.6.4 Oxygen-Demanding Pollutants

Some organic compounds in highway runoff can be decomposed by aerobic microbes present in the aquatic environment. These aerobic microbes use oxygen during the decomposition process, and when this occurs dissolved oxygen in the water may be reduced. The Biochemical Oxygen Demand (BOD) test provides a rough measure of the concentration of organic material that can be readily oxidized. The Chemical Oxygen Demand (COD) test provides a means of measuring the organic "strength" of a waste stream or water body. The result is the total quantity of oxygen required to oxidize all the waste's carbon into carbon dioxide and water. These tests are generally used for wastewater treatment where the concentration of organics present is much higher than in typical stormwater. Some sources of organics in stormwater include grass clippings, fallen leaves, hydrocarbons, and human and animal waste from septic systems, yard runoff, or feedlots. BOD and COD are both given as concentrations, generally milligrams per liter of runoff.

Increases in water temperature and salinity both reduce the amount of oxygen that can be dissolved in water. Healthy streams can contain up to 7 milligrams per liter at 95 degrees Fahrenheit and nearly 15 milligrams per liter at 32 degrees Fahrenheit assuming standard atmospheric conditions (1 atmosphere and dry air containing 20.9 percent oxygen). The amount of oxygen that can be dissolved into a water body is dependent on the partial pressures and a relation called Henry's Law.

It is possible to deplete dissolved oxygen levels to nearly 0 milligrams per liter; this is often a result of high algal or plant growth and very warm, standing water. To help raise dissolved oxygen levels, adding shading, controlling plant and algae growth, and adding riffles or highly turbulent areas in the stream or facility (when appropriate) can increase entrained dissolved oxygen concentrations.

14.6.5 Metals

Metals found in highway runoff include copper, lead, zinc, iron, cadmium, chromium, nickel, and manganese. They may occur as particulate metals or as dissolved metals. Particulate metals behave like sediment, as a physical contaminant. Dissolved metals (often metal salts) can be much more difficult to remove. Biological uptake and complexing (chemical bonding) are the two major removal mechanisms for dissolved metals. Potential toxicity to aquatic life is the principle concern with the discharge of both particulate and dissolved metals. However, potential contamination of drinking water supplies can also be a concern.

14.6.6 Bacteria

Bacteria levels in highway runoff are typically measured using procedures that test for a specific group of bacteria — the coliform group. These bacteria are used as indicators of potential public health hazards. Measurements may be reported as either total coliform values or as fecal coliform values, depending on the specific procedure used and the intent of the measurement.

The intent of the fecal coliform test is to determine whether stormwater runoff has been exposed to fecal contamination and, therefore, has the potential to spread disease.

The major sources of bacterial contamination are failing septic systems and animal feedlots, and therefore is generally not a priority for treatment of highway runoff. If bacterial contamination is found to be an issue in highway runoff, then preventative measures are generally the most beneficial way to prevent bacterial from entering the system. These measures can include dog ordinances requiring owners to collect waste, buffers between livestock and septic system facilities, and other site-specific measures.

14.6.7 Herbicides and Pesticides

The most common sources of herbicides and pesticides in highway runoff are roadside herbicide spraying to kill encroaching vegetation and domestic pesticide use on private property discharging into public stormwater collection systems. Herbicides and pesticides (or "biocides") may be inorganic or organic and, if present, are generally found in very low concentrations. However, some biocides can accumulate to high levels in certain aquatic species, causing chronic effects. If present in high concentrations, (e.g., from a spill) acute effects to aquatic life could occur.

14.6.8 Debris, Litter, and Other Pollutants

Debris, litter, and a variety of chemicals such as household wastes, plasticizers, and wood preservatives may occasionally be present in highway runoff as a result of spills, illegal disposal, or other activities. The occurrence of these pollutants is generally sporadic and detected concentrations are typically very low. These pollutants can be a primary contributor to the clogging of drainage features and may interfere with the effectiveness of treatment when present in highway runoff.

14.7 Treatment Mechanisms

There are six primary treatment mechanisms considered most appropriate for stormwater. The following subsections provide a brief review of these six treatment mechanisms.

14.7.1 Hydrologic Attenuation

Hydrologic attenuation achieves pollutant reduction through runoff volume reduction. Infiltration is the primary means of hydrologic attenuation in the types of BMPs used in stormwater management. Evapotranspiration is also used by some BMPs. Attenuation reduces the pollutant load discharged to surface waters, but does not necessarily reduce pollutant concentrations. Infiltration allows for several different treatment mechanisms. Processes such as sorption, filtration, and microbial degradation occur as runoff infiltrates through the soil matrix.

14.7.2 Sedimentation/Density Separation

Density separation refers to the unit processes of sedimentation and flotation that are dependent on the density differences between the pollutant and the water to effect removal. Sedimentation is the gravitational settling of particles having a density greater than water. Flotation is used for pollutants that are lighter than water, and therefore float. Typically, floatable materials such as trash, debris, and hydrocarbons are removed through treatment processes that collect or skim these pollutants from the water surface.

14.7.3 Sorption

Sorption refers to the individual unit processes of both absorption and adsorption. Absorption is a physical process whereby a substance of one state is incorporated into another substance of a different state (e.g., liquids being absorbed by a solid or gases being absorbed by water). Adsorption is the physiochemical adherence or bonding of ions and molecules (ion exchange) onto the surface of another molecule. In stormwater treatment applications, the primary pollutant types targeted with absorption unit processes are petroleum hydrocarbons, while adsorption processes typically target dissolved metals, nutrients, and organic toxicants such as pesticides and polycyclic aromatic hydrocarbons (PAHs). Different types of filter media, including natural or amended soils, may provide either or both of these unit processes.

14.7.4 Filtration

Filtration can encompass a wide range of physical and chemical mechanisms, depending on the filtering media. Typical media filter materials include sand, natural soil, grassy vegetation, or mixes of chemically active ingredients such as perlite, zeolite, and granular activated carbon. Filtration is an important component of infiltration, media filtration and vegetative filtration treatment facilities. Filtration removes particulate matter either on the surface of the filter or within the pore space of the filter by physically trapping or capturing the particles in miniature hydraulic dead zones. Filtration such as a sand filter can provide the added benefit of removing stormwater constituents that may be attached to solids such as metals and bacteria. Filtration can also provide opportunities for sorption processes to occur, reducing dissolved and fine suspended constituents. Filtration can often be an effective preliminary treatment for stormwater, by increasing the longevity of downstream BMPs and reducing maintenance frequency.

14.7.5 Uptake/Storage

Uptake and storage refer to the removal of organic and inorganic constituents by plants and microbes through nutrient uptake and bioaccumulation. Nutrient uptake converts required micro- and macro-nutrients into living tissue. In addition to nutrients, various algae and wetland and terrestrial plants accumulate organic and inorganic constituents in excess of their immediate needs (bioaccumulation). The ability of plants to accumulate and store metals varies greatly. Significant metals uptake by plants will not occur unless the appropriate species are selected.

14.7.6 Microbially Mediated Transformation

Microbial activity promotes or catalyzes redox reactions and transformations including degradation of organic and inorganic pollutants and immobilization of metals. Bacteria, algae, and fungi present in the soil or water column are primarily responsible for the transformations. Stormwater treatment that incorporates vegetation or permanent water pools usually has a diverse microbial population. These transformations can remove dissolved nitrogen species, metals, and simple and complex organic compounds. Soils may be inoculated with desirable microbes to promote specific reactions.

14.7.7 Effectiveness of Treatment Mechanisms

The treatment effectiveness of a BMP is essentially related to which processes are actually utilized by the BMP and the ability of the BMP to maximize the process(es). Table 14-1 summarizes the stormwater related pollutants of concern considered to be effectively removed by each treatment mechanism.

Table 14-1 Treatment Mechanism – Target Pollutant

Treatment Mechanism - Target Pollutant Matrix		Mechanism					
		Hydrologic Attenuation (1)	Density Separation	Sorption (chemical activity)	Filtration	Uptake/Storage(2)	Microbial Transformation(3)
Target Pollutant	Sediment/Particulate (suspended solids)	■	■		■		
Target Pollutant	Nutrients(4)	■		■		■	■
Target Pollutant	Oil and Grease	■	■	■	■		■
Target Pollutant	Polycyclic Aromatic Hydrocarbons (PAH)	■	□	■	□	■	■
Target Pollutant	Metals (particulate)	■	■		■		
Target Pollutant	Metals (dissolved)	■		■	□	□	□

■ *= Treatment mechanism effective for target pollutant removal*

□ *= Depending on chemical activity of filter media*

(1) *Refers to infiltration which is credited for overall pollutant mass load reduction of all target pollutants primarily through volume reduction; pollutant removal is also achived through filtering, sorption, and microbial transformation in the soil column.*

(2) *Dependent on plant species*

(3) *Dependent on types of microbes present (in soil or water column)*

(4) *May not be considered a highway target pollutant, but included for completeness*

14.8 Treatment Facilities

The following sub-sections provide an overview of the acceptable runoff treatment facilities used on ODOT projects. Specific design criteria for each BMP are provided in the chapter appendices.

14.8.1 Low Impact Development (LID) Techniques

Low Impact Development (LID) is an innovative stormwater approach that mimicks natural hydrology and utilizes vegetation and infiltration to reduce the rate and quantity of runoff, remove pollutants, and facilitate detention and evapotranspiration of stormwater. LID was pioneered in Prince Georges County, Maryland and has been applied successfully across the country. When effectively and broadly implemented, LID helps improve the quality of receiving waters and stabilize the hydrology of nearby streams.

LIDs are intended to:

- Be effective at treating stormwater runoff,
- Facilitate detention and infiltration opportunities,
- Promote groundwater recharge,
- Preserve existing flow paths,
- Minimize disturbance,
- Be less expensive to construct and maintain than traditional facilities,
- Eliminate or reduce the need for storm drain systems such as pipes, inlets, curbs, and large consolidated facilities such as ponds and swales, and
- Be applied to roadway re-construction, widening, and new alignment projects.

LID is not a significant departure from the current rural road design practices in which curb and gutter systems are not typically used. The major difference is that LID techniques are specifically designed not to concentrate flows while still providing effective means of water quality treatment close to the source of pollution. This reduces the need for long or complex pipe routing configurations. The LID approach utilizes the hydrologic characteristics of the existing roadside area, modifications of the roadside area, and distributed, small, hydraulically engineered BMPs that incorporate vegetation, infiltration and media filtration. For the latter techniques the difference between LID and non-LID is more a matter of scale and location than any qualitative distinction.

The use of LIDs should be evaluated for *feasibility* on all transportation projects. The feasibility depends on the physical characteristics of the site (including slope, soil infiltration, existing drainages, etc.), the adjacent development, the availability and cost of additional right-of-way if necessary, safety, maintenance, highway structural integrity, and local groundwater contamination. Note that LID methods will not always be feasible.
The recommendations and requirements for planning and designing LIDs are outlined in **Appendix A**.

14.8.2 Biofiltration Facilities

14.8.2.1 Biofiltration Swales

Biofiltration swales are above ground open channels engineered to treat stormwater runoff by sedimentation and filtration as runoff is conveyed through the vegetated surface (usually grass) and upper soil layer. Grassed swales are popular because of their low construction and maintenance costs and minimal design limitations. Biofiltration swales incorporate amended soils or compost to enhance infiltration and maximize the contact of stormwater with pollutant removing media.

Good locations for grassed swales include median strips, roadways shoulders, and parking lots.

Additional information regarding biofiltration swales can be found in **Appendix B**.

Pollutant Removal Mechanisms

- Filtration
- Sorption
- Density Separation
- Uptake/Storage
- Microbial Transformation
- Hydrologic attenuation

Primary Targeted Pollutants

- Sediments
- Metals (particulate)
- Metals (dissolved) (using amended soil)

Secondary Targeted Pollutants

- Nutrients
- Oil and Grease
- Polycyclic Aromatic Hydrocarbons (PAH)

Facility Treatment Types

The two application techniques for swales are:

- Basic biofiltration swale – designed to provide water quality treatment only.
- Combination biofiltration swale – designed to provide water quality treatment and convey high flows.

14.8.2.2 Filter Strips

Filter strips consist of the right-of-way parallel to the road, with a relatively flat cross slope to maintain sheet flow of stormwater runoff over the entire width of the strip and are designed to treat sheet flow from an adjacent impervious area. Treatment occurs as the stormwater runoff flows through the grass and soil surface. Filter strips are good for highway application because of their low maintenance requirements.

Additional information regarding filter strips can be found in **Appendix B**.

Pollutant Removal Mechanisms

- Filtration
- Sorption
- Hydrologic attenuation
- Density Separation
- Uptake/Storage
- Microbial Transformation

Primary Targeted Pollutants

- Sediment/Particulates
- Metals (particulate)
- Metals (dissolved) - may require using amended soil depending on the native soil type

Secondary Targeted Pollutants

- Nutrients
- Oil and Grease
- Polycyclic Aromatic Hydrocarbons (PAH)

14.8.3 Media Filtration Facilities

14.8.3.1 Bioretention Facilities

A bioretention facility is an above ground basin or cell that is designed to capture stormwater runoff and infiltrate it through a water quality mix to remove pollutants through a variety of physical, biological and chemical treatment processes. They are good for highway applications because of their moderate construction and maintenance cost.

Opportunities for siting bioretention facilities include medians, interchanges, adjacent to ramps, parking lot islands, and along right-of-way adjacent to roads.

Additional information regarding bioretention facilities can be found in **Appendix C**.

Pollutant Removal Mechanisms

- Hydrologic Attenuation
- Sorption
- Filtration
- Density Separation
- Uptake/Storage
- Microbial Transformation

Primary Targeted Pollutants

- Sediment/Particulate
- Nutrients
- Polycyclic Aromatic Hydrocarbons (PAH)

- Metals (particulate and dissolved)

Secondary Targeted Pollutants
- Oil and Grease

14.8.3.2 Bioslopes

Bioslopes are flow-through BMPs incorporated into roadside embankments and placed between pavement and a downstream conveyance system that use a variety of physical, biological and chemical treatment processes to provide stormwater treatment. Bioslopes are good for highway applications because of their minimal right-of-way requirements and maintenance schedule.

Additional information regarding bioslopes can be found in **Appendix C**.

Pollutant Removal Mechanisms
- Hydrologic Attenuation
- Sorption
- Filtration
- Density Separation
- Uptake/Storage
- Microbial Transformation

Primary Targeted Pollutants
- Sediment/Particulates
- Nutrients
- Polycyclic Aromatic Hydrocarbons (PAH)
- Metals (particulate and dissolved)

Secondary Targeted Pollutant
- Oil and Grease

14.8.4 Density Separation Facilities

14.8.4.1 Extended Detention Dry Pond

An extended detention dry pond is an above ground basin that is designed to detain stormwater runoff for some minimum time to allow particles and attached pollutants to settle, thus providing water quality treatment. Extended dry ponds do not have a large permanent pool of water; instead, water that enters the pond is released over a period of time, longer than standard detention ponds. They typically have the following facility components:
- An extended detention outlet control structure, and
- An emergency spillway if the primary outlet control structure cannot safely pass the projected high flows.

Extended detention dry ponds are good for highway applications because of their moderate construction and maintenance cost.

Opportunities for siting extended detention dry ponds include medians, interchanges, adjacent to ramps and along right-of-way adjacent to roads.

Additional information regarding extended detention dry ponds can be found in **Appendix D**.

Pollutant Removal Mechanisms

- Density separation
- Sorption (secondary mechanism)
- Filtration (secondary mechanism)
- Uptake/Storage (secondary mechanism)
- Microbial transformation (secondary mechanism)

Primary Targeted Pollutants

- Sediments
- Particulate bound pollutants

Secondary Targeted Pollutants

- Nutrients
- Oil and Grease
- Polycyclic Aromatic Hydrocarbons (PAH)
- Particulate metals (not effective for dissolved metals)

14.8.5 Proprietary Structures

There is a wide range of proprietary structures that can be used for stormwater treatment but only a few have been approved for use on ODOT projects. (See the ODOT QPL) ODOT relies on the Washington Department of Ecology's Emerging Stormwater Treatment Technologies Evaluation Program Technology Assessment Protocol - Ecology (TAPE) to determine which products are added to the QPL. Structures obtaining General Use Level Designation (GULD) through the TAPE Program are placed on the QPL and are considered to be "highly" capable of removing the category or target pollutant.

Most proprietary products are more compact than other treatment systems and are installed underground. These features often make them a preferred method for treatment in space limited settings. Information should be obtained from the various manufacturers for more detailed discussion of the product types discussed below.

The general types of proprietary products include:

Separation structures

Separation structures utilize underground vaults and manholes to remove coarse sediment, pollutants absorbed to sediment, oil, and floatables from stormwater runoff. These units use separation inserts and either gravity, vortex, or centrifugal separation to provide treatment.

These units do not meet treatment standards as a stand-a-lone product and require additional facilities to meet current water quality standards.

Pollutant Removal Mechanism

- Density Separation

Primary Targeted Pollutants

- Sediment/Particulate
- Metals (particulate)
- Oil/Grease (separation)

Filtration structures

Filtration structures (or media filters) utilize special media mix in underground vaults, manholes, or catch basins to remove sediment, metals, and oil/grease from stormwater runoff. These structures will need to have GULD approval as providing "Enhanced Treatment" prior to be used as a stand-a-lone water quality facility.

Pollutant Removal Mechanisms

- Sorption
- Filtration

Primary Targeted Pollutants

- Sediment/Particulate
- Metals (particulate)

Secondary Targeted Pollutants

- Oil and Grease
- Metals (dissolved)

The following is a list of guidelines for the use of proprietary water quality structures.

- All water quality structures shall comply with applicable general requirements outlined in Section 14.10.
- There are several types of media used in filtration structures. Select a media that will remove the target pollutant.
- Select a structure that is on the Qualified Products List (QPL) in the "Stormwater Control Facilities" Category. There are five treatment categories established and structures can be placed under one or more treatment categories. The treatment categories include:
    - Sediment pretreatment,
    - Oil treatment,
    - Suspended solids treatment,

  - Dissolved metals treatment, and
  - Phosphorous treatment.

- Utilize Special Provision SP1010 for projects using proprietary structures. Include the following information in the project's special provision SP1010:
  - Requirement that the facility be selected from the QPL.
  - Drainage facility identification number
  - Hydraulic performance requirements such as the water quality design flow and peak conveyance flow rate
  - Specification of on-line or off-line application
  - Water quality structure definition – An underground self-activating structure with no moving mechanical parts or external power sources which removes pollutants from stormwater runoff and retains the pollutants in the structure. Pollutants to be removed and retained as specified include, but are not limited to, suspended solids, floatables, petroleum products, particulate and dissolved metals, and phosphorous.

14.8.6 Other Non-Proprietary BMPs

Other non-proprietary methods of treating stormwater runoff may be proposed but must be evaluated on a project-by-project basis to determine if the proposed treatment method is adequate. A hydraulic design deviation request must be submitted to the region hydraulics engineer for consideration. Concurrence from the region hydraulics engineer is required and is then submitted to the Geo-Environmental Senior Hydraulics Engineer for approval.

The hydraulic design deviation request form and additional discussion of the review process is discussed in Chapter 3. The design deviation request should include an explanation of the issues, a brief description of the project, a justification for the deviation, and adequate supporting documentation.

After a non-proprietary BMP is approved for use on a specific ODOT project it is placed on an evaluation list. This list is available at Geo-Environmental's website. The performance of the BMPs placed on the evaluation list will be monitored and approved stormwater management approaches will be added to future revisions to this chapter.

14.8.7 Emerging Proprietary Technology

An emerging proprietary technology must be approved prior to use on an ODOT project. The following steps outline the emerging proprietary technology evaluation process:

Step 1: Manufacturer submits required documentation to Washington State's Department of Ecology Emerging Stormwater Treatment Technologies Evaluation Program. Go to step 2 if proprietary technology obtains General Use Level, Conditional Use Level, or Pilot Use Level designation through Department of Ecology's evaluation program.

Step 2: Manufacturer submits required documentation to ODOT's Structure Service Unit's Product Evaluation Coordinator. Contact information and submittal requirements can be obtained at the following website:

http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/QPL/QPIndex.shtml

14.9 Selection and Siting

The selection of a BMP is based on many factors including treatment capability, site characteristics, maintenance requirements, and lifecycle costs. BMP site requirements, pollutant removal effectiveness, and basic lifecycle cost considerations are covered in this section.

The expectation is that a project will fully meet the stormwater treatment criteria (Section 14.5.1) unless site constraints make it impractical to do so. When site constraints prevent the criteria from being met, the project will provide as much on-site treatment as is practical, and will also arrange for off-project mitigation.

14.9.1 BMP Selection Prioritization

ODOT has established a hierarchy of stormwater treatment approaches and techniques that supports regulatory requirements and the agency's water quality goals and objectives. The preference for stormwater treatment approaches is to disperse treatment along the length of the project, using the characteristics of the right of way to provide treatment, using consolidated facilities only when that is not possible. The preferred treatment techniques are those that have high effectiveness at treating the broad range of highway pollutants, and use infiltration, media filtration, or vegetative filtration as a primary treatment mechanism (see Table 14-2).

A requirement to manage highway runoff for water quality does not necessarily mean that a treatment facility needs to be constructed. Often the properties of the right-of-way provide excellent stormwater treatment, or can do so with minimal enhancement.

The stormwater designer should evaluate treatment approaches and techniques in the following order:

1. Use of the adjacent unaltered right-of-way as a treatment filter strip
2. Modification of the right-of-way (slopes, soils and/or vegetation) to provide treatment
3. Use of small, distributed treatment facilities along the length of the project
4. Use of large, consolidated treatment facilities.

The first choice for a BMP should be one of those that are highly rated for multiple pollutants. If none of those are suitable, the next step is to try to assemble a treatment train that is, in aggregate, as effective overall as one of the preferred BMPs. Failing that, use a single BMP that targets the pollutant of greatest concern in the receiving water, and anticipate compensatory actions. Off-site project mitigation may be necessary if treatment is not feasible at all.

More detail about the stormwater design process is found in Section 14.12.

14.9.2 Pollutant Removal Capabilities

The treatment capability of a BMP is usually quantified as either percentage removal of a pollutant, or by average effluent concentration. Both have limitations. Percentage removal is often affected by the influent concentration – the more polluted the stormwater is going in, the greater the percentage removal achieved. Effluent concentration varies greatly between storms, and is affected by design, local conditions, and maintenance, and can be hard to quantify. Instead of using either of these measures, this manual uses a qualitative rating based on unit processes and demonstrated ability to substantially reduce pollutant concentrations between inflow and outflow.

The mechanisms of pollutant removal are discussed in detail in Section 14.7. Detailed discussions of the different classes of BMPs and their unit processes are provided in Section 14.8.

Table 14-2 summarizes key pollutant removal capabilities of the water quality facilities described in this chapter (references 2, 3, 5, 6-10). Ranges shown are based on the following criteria:

-=Low capability to remove target pollutant
◦=Moderate capability to remove target pollutant
●=High capability to remove target pollutant

These ranges assume a properly designed, operated, and maintained treatment facility. Note also that in many cases removal is dependent on whether the pollutant is in the particulate or dissolved form.
Limited information exists on the capability of treatment facilities to remove pollutants other than those identified in Table 14-2. One source reports the following, based on limited information:

- Bacteria – can potentially be reduced by grassed swales, wet ponds, and treatment wetlands, but these treatment techniques may have no effect or could even increase bacterial concentration.
- Herbicides/Pesticides – can potentially be reduced by grassed swales, wet ponds, treatment wetlands, and media filters.

Additional guidance on pollutant removal capabilities for bacteria, herbicides/pesticides, etc. will be provided as it becomes available.

Table 14-2 Key Pollutant Removal Capabilities for Water Quality Facilities

Treatment Mechanism - BMP Matrix		Best Management Practice																
		Pre-treatment		Infiltration				Filtration				Pool-Ponds			Space-constrained or Urban Application			
		Oil Control Structures * or ***	Sediment Control * or ***	Infiltration facility **	Bioretention facility *	Bioslope *	Porous Pavement (not stand-alone) **	Biofiltration Swale (soil amended) *	Filter Strip (soil amended) *	Biofiltration Swale (no soil amendment) *	Filter Strip (no soil amendment) *	Constructed Wetlands **	Extended Detention Dry Pond *	Wet Ponds **	Wet Vaults **	Media Filters (non-proprietary) **	Proprietary Separation ***	Proprietary Filtration ***
Treatment Mechanism	Hydrologic Attenuation			■	■	■	■	□	□	□	□	□	■	□				
	Density Separation (Sedimentation or Flotation)	■	■	□	□	□		□	□	□	□	■	■	■	■		■	
	Sorption	□		□	■	■		■	■	□	□	■	□	□		□	□	■
	Filtration	□	□	■	■	■		■	■	■	■	□	□	□		■	□	■
	Uptake/Storage(1)			□	■	□		□	□	□	□	■	□	□				
	Microbial Transformation(1)			□	■	□		□	□	□	□	■	□	□		□		□
Target Pollutant	Sediment/Particulate (suspended solids)	○	●	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Nutrients			●	●	●	○	○	○	○	○	●	○	○		-		
	Oil and Grease	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○
	Polycyclic Aromatic Hydrocarbons (PAH)			●	●	●	○	○	○	○	○	●	○	○		○		
	Metals (particulate)	○	○	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●
	Metals (dissolved)			●	●	●	-	●	●	○	○	●	○	○		○		●

■ = *Primary treatment mechanism for BMP*

□ = *Secondary treatment mechanism for BMP; dependent on plant species/microbes present*

● = *High capability to remove target pollutant*

○ = *Moderate capability to remove target pollutant*

\- = *Low capability to remove target pollutant*

(1) *Dependent on types of plant species or microbes (in soil or water column) present*

* = *acceptable bmp with design guidance provided in the chapter appendices*

** = *acceptable bmp and design guidance under development or submit a Hydraulic Design Deviation with supporting documentation*

*** = *acceptable bmp is added to Qualified Product List (QPL). BMP added to conditional product list requires construction project manager approval. Target pollutant rating above applicable for proprietary structures added to the QPL list for "Stormwater Control Facilities". Assume "low" capability to remove target pollutant for proprietary structures added to the Conditional list for "Stormwater Control Facilities".*

14.9.3 Maintenance Requirements

Maintenance requirements must be taken into account when selecting BMPs. All other factors being equal, the BMP with the lowest maintenance costs should be selected. Aspects of maintenance that need to be considered include:

- Accessibility (see below)
- Frequency of maintenance
- Complexity of maintenance
  - Tasks required
  - Equipment required
- Materials required (such as proprietary filters, or replacement compost), with availability and cost
- District equipment resources

Every BMP installed must be accessible for the equipment required for maintenance. Both physical access and safety of the Maintenance crews must be addressed in the BMP design. Access roads must be wide enough for equipment to get in, maneuver and get out. No BMP should be installed in a location where it would be necessary to close a lane of traffic to perform routine maintenance.

Always coordinate with Maintenance before making a final selection of BMPs.

14.9.4 Right of Way and the Facility Footprint

The facility footprint includes the area needed to accommodate any pretreatment structure, storm drain piping, treatment zone (basin, swale, filter strip, etc.), primary and auxiliary outlets, outfalls, maintenance access road, and maintenance operational areas. Facility footprints will vary from spanning the entire length of the project to being localized to a small area to accommodate a facility.

The facility footprint should be evaluated for right-of-way requirements. If existing right-of-way is not adequate for the facility, additional property or easement will have to be acquired. The designer will need to coordinate with the Right-of-Way specialist, as well as the Project Leader and, at times, the Roadway Designer.

It is important to determine placement and sizing of BMPs early in project development, because right-of-way acquisition of real property and various types of easements is a lengthy process. The process begins around the design acceptance phase of project design and ends when all of the necessary right-of-way has been acquired and it is certified for the project bid letting. Note that it takes the same amount of time to process and negotiate easements as it does to acquire real property. **While minimization of right-of-way requirements is a factor in selecting a BMP, lack of time to acquire necessary right-of-way is not an acceptable reason for not choosing the most effective BMP.**

Note that design changes that require additional right-of-way after the right-of-way acquisition has started will likely delay a project. Design changes with minor right-of-way impacts could delay the acquisition process up to four months. Design changes with major right-of-way impacts could delay the acquisition process for seven months or more.

The ODOT Highway Design Manual provides additional discussion on time allowances for the acquisition process, and the different property rights such as fee title, permanent easements and temporary easements.

14.9.5 Site Requirements for BMPs

Each type of BMP has minimum requirements for size and slope, and the infiltration-based BMPs have soil characteristics criteria. Additional information regarding specific criteria is provided in the appendix for the individual BMPs.

Table 14-3 Potential Restrictions for Applying Treatment Approaches

Treatment Facility	No Slope	Steep Site Slope	High Groundwater Table	Bedrock Close to Surface	Soils	Proximity to Structures/ Wells
Extended Detention Dry Facility	+	+++	+++	++	+	++
Bioretention/ Infiltration Facility	+	+++	+++	+++	++/ +++	+++
Biofiltration Swale	+++	+++	++	++	++	++
Filter Strip	++	++	++	++	++	++
Bioslopes	++	++	+++	+++	+	++
Proprietary Structures	**See mfg's literature**	**See mfg's literature**	**See mfg's literature**	**See mfg's literature**	**n/a**	**See mfg's literature**

+++ Will or may preclude the application of this type of facility
++ Can generally be overcome with appropriate site design
+ Generally not a restriction

14.9.6 Site Characteristics

14.9.6.1 Topography

Topography controls the size, shape, and type of BMP that can be placed in a given location. Some BMPs, such as detention and retention basins, require fairly level ground, while flow-through facilities need a minimum slope. Modification of the topography is sometimes feasible, but will likely increase construction costs. Topography can also affect Maintenance access, so the designer must look at the entire facility footprint (as described above) when selecting a BMP. Table 14-3 includes slope restrictions for the categories of BMPs.

14.9.6.2 Soils

Site soils determine whether infiltration based BMPs are feasible or not. Hydrologic class A and B soils support infiltration BMPs, C soils will allow for minor infiltration as a component of a BMP, while D soils are not suitable for infiltration (see Definitions for descriptions of the soil classes).

The character of the soil also determines its ability to remove pollutants from stormwater. Organic material and fine particles support the removal of many dissolved pollutants. Hydrologic Class A soils, which are generally coarse grained, may have relatively low pollutant removal capability. Removal of the upper soil horizons can also reduce the soil's pollutant removal capability.

Keep in mind that the Hydrologic soil classes are based on the NRCS soil survey and may not accurately reflect the properties of the soils at the site. It is preferable to obtain site-specific soil information whenever possible.

Soil amendments (see **Appendix E**) can improve the pollutant removal characteristics of soils while maintaining acceptable permeability. They can also improve permeability in tight soils, but only in the layer with the amendment, so the amendment will support media filtration but not infiltration.

14.9.6.3 Climate

Consider climate when selecting and designing water quality facilities. Arid conditions and temperature extremes can reduce the density and survivability of vegetation and lengthen the establishment period. Poor vegetation cover can reduce the effectiveness of pollutant removal. Biofiltration swales, wet ponds, and treatment wetlands are examples of facilities that need to be placed in the proper climatic environment to achieve projected performance expectations. In some cases, design modifications that account for climatic conditions can still allow for effective BMP performance.

14.9.6.4 Groundwater

A high groundwater table precludes the use of most BMPs that require deep excavation. The aquifer may be vulnerable to contamination if there is not a sufficient and good soil between the bed of a BMP and the groundwater. Table 14-3 includes a column showing the sensitivity of BMPs to high groundwater.

Groundwater contamination is a risk anywhere surface runoff from developed areas is infiltrated into the soil. BMP practices that allow for infiltration of polluted runoff can be of concern if sited incorrectly. BMP infiltration systems should not be implemented if there is a high potential for spills that may be conveyed directly to the facility. Best Management Practices designed to infiltrate stormwater are typically very effective at removing normal concentrations of pollutants and numerous studies have shown that they present only a minor risk of contaminating either groundwater or soil if sited in areas where there is a low potential for spills. These studies indicate that natural and amended surface soils are very effective at removing pollutants from urban runoff because concentrations are typically low and surface soils utilize a number of natural processes such as physical filtering, ion exchange, adsorption, biological processing, conversion, and uptake by plants.

Drywells, infiltration galleries and subsurface drainfields that release stormwater or other fluids directly below the land surface are considered Class V injection wells (often called underground injection control systems, or UICs) and are subject to regulation by DEQ and the U.S. EPA. A Class V injection well is defined as any bored, drilled, or driven shaft, or dug hole, that is deeper than its widest surface dimension. These types of facilities are considered stormwater disposal systems, not treatment systems, and have impacted groundwater quality in a number of communities across the nation. See Section 14.10.14 for detailed design criteria for these types of facilities.

14.9.6.5 Competing Resources

Water quality facilities should not be placed so they impinge on protected resources or other sensitive areas. Examples include wetlands, habitat for threatened and endangered species, riparian zones, archaeological sites, historic sites, and parks and public recreation areas. When there is a potential conflict between protected resources and the ability to implement water quality treatment, early coordination with Environmental staff is imperative.

In some circumstances it may be appropriate to impact a protected resource in order to provide stormwater treatment, but those circumstances will be rare and will require extensive coordination and mitigation for the impacted resource. Both the REC and the appropriate resource specialist must be included in the conversation.

If it is necessary to expand the right-of-way to install a BMP, the adjacent land uses will affect the cost of doing so, and may preclude the use of particular BMPs.

14.9.6.6 Hazards

Hazards that may affect the selection and placement of BMPs include geotechnical constraints, floodplains, hazardous material contamination, safety and health issues. Coordination between the designer and geotechnical and hazmat staff is important. Following are some examples of potential hazards and BMPs:

- Infiltration BMPs are not acceptable on unstable slopes.
- Excavation for BMPs on unstable or steep slopes may trigger geotechnical instability.
- Hazardous material sites are unsuited for infiltration, since the stormwater could cause migration of the contamination.
- BMPs that include basins with steep side slopes are a potential drowing hazard in residential areas. If such BMPs are selected, fencing may be required.
- Vector control, specifically mosquito control, may be an issue if there will be standing water for four or more days. (Mosquitoes can go from egg to biting in four days.)

14.9.7 Cost

The cost of a BMP includes construction, right-of-way, and maintenance. Construction costs must cover any access roads, fencing, and signage, pretreatment structure or basin, flow splitter manhole, excavation and grading, water quality mix placement, porous pavers, underdrain system, outlet structure, energy dissipator, and storm drain piping when applicable. Table 14-4 is provided to assist with the screening and selecting of water quality treatment alternatives. It rates the right-of-way, capital, and maintenance costs of the treatment facilities discussed in this chapter.

The goal is to select a treatment facility that minimizes lifecycle costs while achieving treatment goals, overcoming site constraints, and ensuring public safety. In most cases there will be more than one BMP to choose from and this may make the selection process more difficult. In general, when more than one type of facility is appropriate, select the BMP with the lowest construction and maintenance costs.

Table 14-4 Cost and Effective Life of BMP Options

Structural BMP	Right-of-Way Costs[1]	Capital Costs	O&M Costs	Effective Life[2]
Extended Detention Dry Facilities	Moderate to High	Moderate	Low to Moderate	20 - 50 years
Bioretention Facilities	Moderate to High	Moderate	Low to Moderate	5 – 20 years
Biofiltration Swales	Moderate	Low to Moderate	Low	5 - 20 years
Filter Strips	Low to Moderate	Low	Low	20 - 50 years
Bioslopes	Low to Moderate	Moderate	Low to Moderate	5 – 20 years
Proprietary Structures	Low	Moderate to High	Moderate to High	See manufacturer's literature

Adapted from Young et al. (1996); Claytor and Schueler (1996); USEPA (1993); and others
NA = Not Applicable or Not Available
[1] Rating could be reduced to "low" if adequate right-of-way is available with easement or acquisition.
[2] Assumes regular maintenance, occasional removal of accumulated materials, and removal of any clogged media.
Modified from Reference 10, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, FHWA

Cost is a valid factor in determining if treatment is feasible at any given location, but cannot be the sole determinant. There is no standard formula or percentage for apportioning costs between the project (construction and right-of-way) and maintenance and determining if treatment is too expensive. The decision about appropriate costs will be influenced by the sensitivity of the receiving water and the impact from the project; the more sensitive the receiving water or the bigger the impact, the greater the acceptable cost.

If on-project treatment is not practical, off-project compensatory mitigation will often be required. The designer will need to coordinate with the REC and resource specialists to develop mitigation, and additional time may be needed.

14.9.8 Siting Criteria

Location

- ODOT must have legal access to stormwater treatment facilities in order to perform inspection and maintenance. If necessary, additional right-of-way or a permanent easement must be acquired if a treatment facility footprint cannot fit within existing ODOT right-of-way
- Access for maintenance shall not require shutting travel lanes.
- Facilities treating only stormwater runoff from outside ODOT right-of-way must be placed outside the ODOT right-of-way.
- Facilities shall avoid impacts to protected environmental or cultural resources.
- Facilities must not be located on steep hillsides or other geologically unstable areas.
- If the facility includes a berm, the toe of the berm must be setback from property line by one half the berm height or 5 foot minimum.

- Maintain a minimum distance of 3 feet from the bottom or invert of a facility to bedrock or seasonally high water table.
- UIC horizontal and vertical setback requirements are given in Section 14.10.14
- Infiltration BMPs should be located at least 100 feet (in Type “B” soils) to 200 feet (in Type “A” soils) away from domestic water wells. Contact the municipal drinking water well owner to determine specific setback requirements. Groundwater protection areas and Wellhead Protection Zones may also have special requirements.
- Above-ground facilities shall be located at least 100 feet from septic tanks and drain fields.

Geotechnical and Geological

- Embankments must be adequately designed to safely impound stormwater runoff.
- The long-term permeability of the surrounding soil must be verified to be adequate when designing infiltration facilities.
- Retaining walls must be designed according to the ODOT Geotechnical Design Manual.

14.10 Requirements and Design Elements for Water Quality Facilities

This section provides the general requirements for stormwater treatment facilities

14.10.1 Contributing Impervious Area for Transportation Projects

The project’s contributing impervious area (CIA) consists of all impervious surfaces within the strict project limits plus impervious surfaces outside the project limits which drain to the project via direct flow or discrete conveyance (See Figure 14-3). For ODOT, the CIA is limited to ODOT owned or operated right-of-way or facilities, and for Local Agency projects, the CIA covers facilities owned or under the control of the local jurisdiction.

Treatment Requirements for Contributing Impervious Area for ODOT Transportation Projects:

The entire ODOT CIA must be treated for most projects with stormwater treatment triggers. There are some situations when the area that must be treated is smaller than the CIA. These include projects where the only triggering element is the replacement of a stream culvert, and long paving projects with only limited segments with widening or other triggers. Coordinate with the project Environmental staff to determine the treatment requirements for those projects.

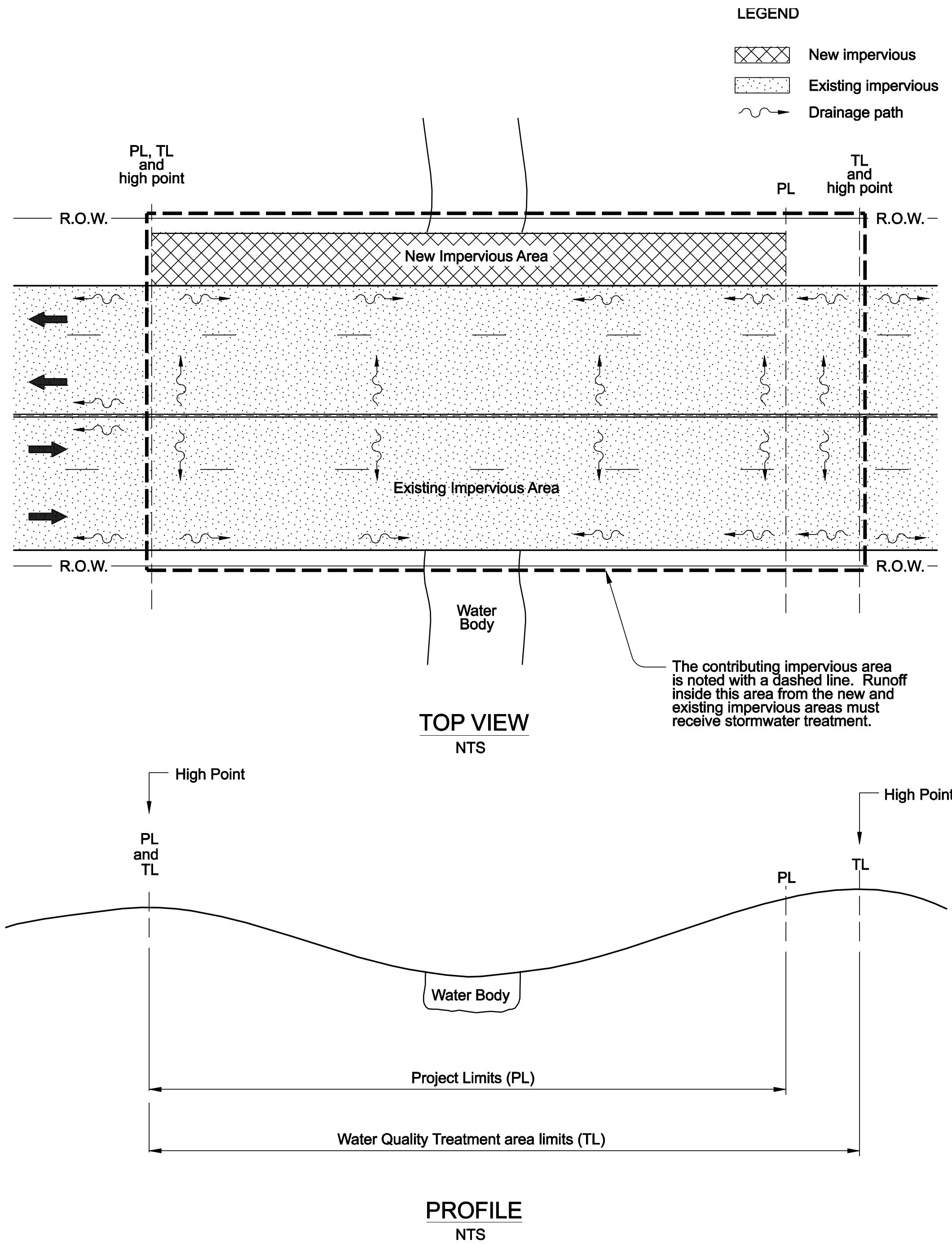

Figure 14-3 Treatment Area Limits (ODOT Transportation project example)

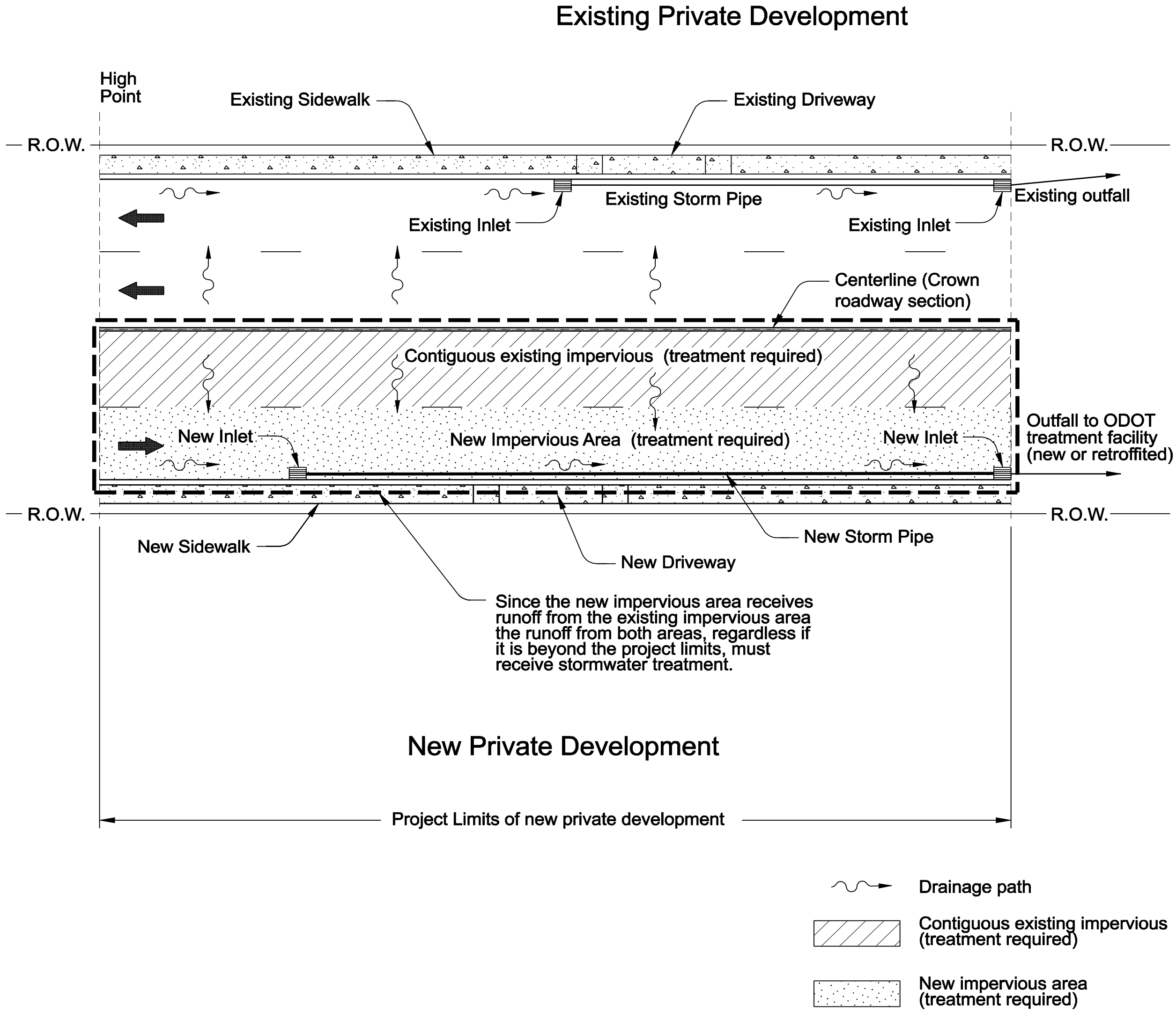

Figure 14-4 Treatment Area Limits (private development example)

Treatment Requirments for Contributing Impervious Area for ODOT Mandated Frontage Improvements for Private Development Projects:

Private development projects adjacent to ODOT right-of-way maybe required to construct frontage improvements. Frontage improvements could include constructing sidewalks, driveway aprons, travel lanes, turn lanes, bike lanes, storm drain piping, manholes, catch basins, runoff treatment and detention facilities, etc. These frontage improvements are paid for with private funds and then ownership and maintenance obligations are transferred to ODOT.

These projects must treat all new ODOT impervious area and contiguous existing ODOT impervious area whose runoff flows over the new impervious surface (See Figure 14-4).

14.10.2 Water Quality Design Storm, Flow, and Volume

A stormwater treatment facility is sized based on a water quality design flow rate or water quality design volume. The hydrologic analysis needed to determine a design flow rate or volume is discussed in **Chapter 7**. The water quality design storm is discussed below.

Water Quality Design Storm

The water quality design storm is designated as a percentage of the 2-year 24-hour storm and is used to determine the water quality design flow rate or water quality design volume. The maximum design storm depth is 2.5 inches and the minimum water quality design storm depth is 0.7 inches.

The following steps outline how to select the design storm for a project:

Step 1: Determine the 2-year, 24-hour storm for the project. Use the precipitation maps to determine the project's 2-year, 24-hour storm or the GIS project created for use to view Oregon's precipitation data. See **Chapter 7** for more information.

Step 2: Determine the water quality design storm factor. Figure 14-5 outlines the storm factor to use for each climate zone in the state.

Step 3: Determine the water quality design storm. It is determined by multiplying the project's 2-year, 24-hour storm (step 1) times the design storm factor (step 2).

Water Quality Design Flow

The water quality design flow rate is the predicted peak discharge for the proposed conditions using the water quality design storm determined from the steps noted above. The design flow rate is calculated using hydrology guidance in **Chapter 7**. Flow-through stormwater quality facilities discussed in this chapter, such as swales and filter strips, are sized using this flow rate.

Water Quality Design Volume

The water quality design volume is the predicted volume of runoff for the proposed conditions using the water quality design storm determined from the steps noted above. The design volume is calculated using hydrology guidance in **Chapter 7**. Stormwater quality facilities discussed in this chapter that temporarily store runnoff, such as stormwater treatment wetlands, wet ponds, extended dry detention ponds, bioretention facilities, and infiltration facilities are sized using this design volume.

14.10.3 Pretreatment

The purpose of a pretreatment facility component is to extend the life and efficiency of the primary stormwater treatment facility. Pretreatment facilities are designed to target coarse sediment and debris transported by stormwater runoff. Installing a pretreatment facility should allow the primary facility to function as designed between inspection/maintenance cycles and should minimize damage associated with sediment loading, clogging of orifices, and erosion.

Although most BMPs benefit from pretreatment, it is especially important for:

- Facilities whose primary treatment mechanism is infiltration or media filtration.
- Facilities with a drainage area anticipated to produce heavy sediment loads (e.g., high frequency of winter sanding or agricultural activities).
- Facilities that include orifices.

The most common pretreatment facilities are:

- Sediment basin (such as a forebay or wet pool)
- Pollution control manhole
- Proprietary separation structure, or
- A vegetated filter such as a filter strip placed prior to a bioslope or a continuous swale parallel to roadway pavement

Additional discussion and design criteria are presented in **Appendix E**.

14.10.4 On-line and Off-line Facilities

Water quality treatment facilities can be designed to be "on-line" or "off-line".

On-line

On-line BMPs are designed so that all flows pass through the facility. The goal of an on-line facility is:

- to provide treatment and storage capacity in a single facility, or
- to provide treatment and high flow conveyance in a single facility.

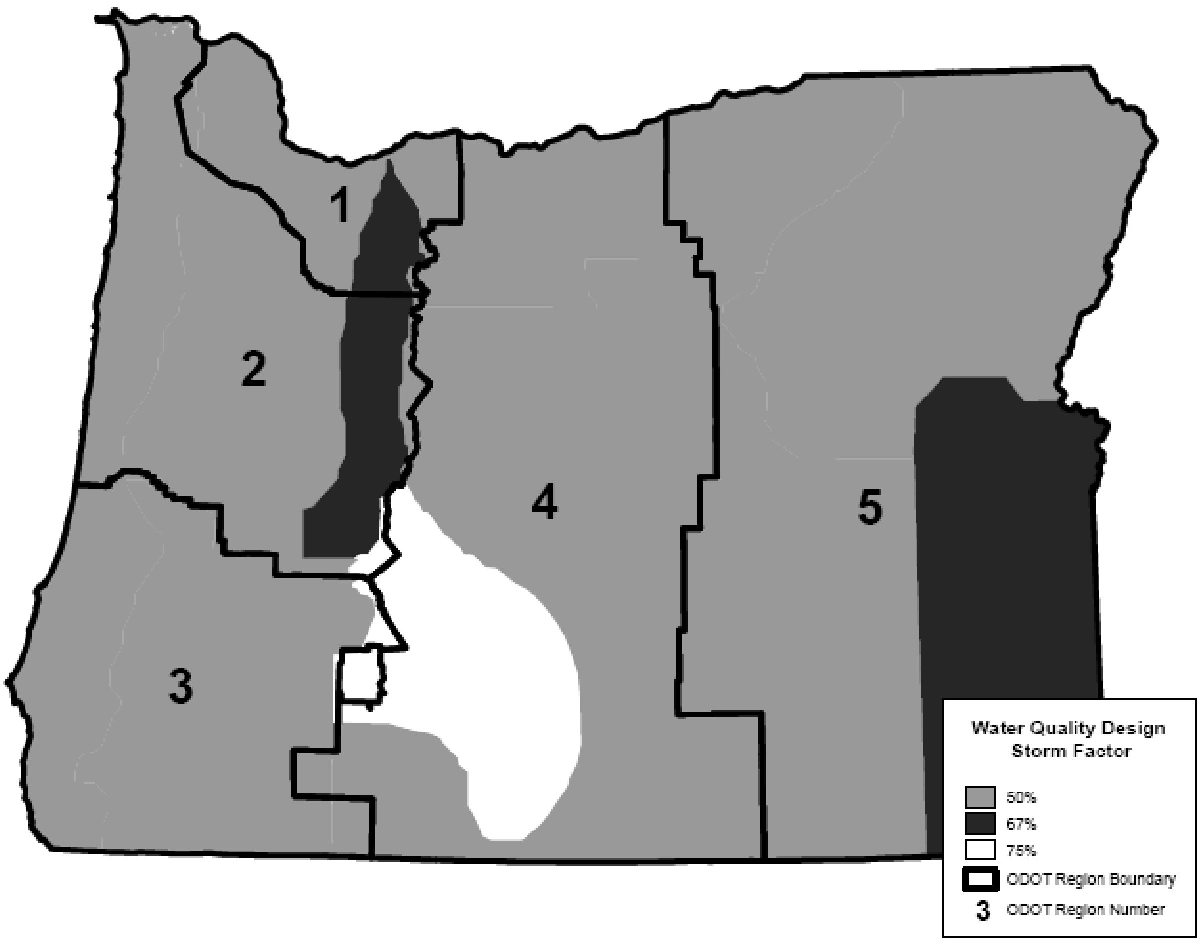

Figure 14-5 Design Storm Factors

Figure 14-6a illustrates an on-line treatment facility.

A single treatment and storage capacity facility is an option when both water quality and water quantity must be provided because of receiving water requirements. This application is considered to be an "on-line" facility and in many situations the most cost-effective stormwater management approach. Use the water quality design guidance in this chapter when designing combination facilities. Combination facilities are examples of units that can provide treatment and storage capacity in a single unit. Additional information on combination facilities is discussed in Section 14.10.7. Storage facility design guidance is discussed in **Chapter 12**.

A single treatment and high flow conveyance facility is an option when:

- Water quality must be provided because of receiving water requirements, and
- Regulating the quantity of stormwater is not required.

Swales and most proprietary facilities are examples of units that can provide treatment and convey high flows.

On-line facilities should be used when:

- Pollutants of concern can be removed and retained and
- Peak flows will not damage the facility.

Off-line

The goal of off-line facilities is to provide only water quality treatment. They are designed such that flows up to the water quality design storm flow rate are routed through the facility while higher flows bypass and continue downstream.

Figure 14-6b illustrates an off-line facility. An off-line facility must be preceded by a flow splitter manhole or other structure that allows flows only up to the water quality design storm flow rate to be conveyed into the treatment facility. Design criteria for flow splitters are discussed in Appendix L.

Off-line facilities should be used when:

- Pollutants of concern can only be removed and retained in an off-line facility, and
- Peak flows would damage an in-line facility.

Off-line water quality facilities are preferable because they prevent or minimize wash out of pollutants that have collected in the facility. All the design guidance discussed in this chapter is based on off-line facilities.

14.10.5 Sequence of Facilities

Water quality facilities should be installed upstream of detention facilities in order to prevent sediment build up in detention facilities. The build up of sediment in a detention facility would reduce storage volume over time, thereby resulting in a facility that does not function as designed. This sequencing also reduces the likelihood that a storage flow control structure will plug with sediment, litter, or debris because the water quality facility upstream controls and contains these pollutants within the water quality facility.

14.10.6 Multiple Treatment Facilities

Multiple treatment facilities in series (also known as a “treatment train” or “treatment system”) may be needed if a single treatment approach is not sufficient to meet water quality objectives.
There are many combinations of standard structural BMPs that can form effective treatment trains. The effective combination of BMPs occurs when a treatment system incorporates two or more unit operations that each use different unit processes. This type of system is recommended

when it is not practical to use a single BMP with multiple unit processes that treat all of the pollutants of concern.

Be aware of the following limitations when planning treatment trains:

- Unit operations utilizing the same unit processes should not be placed in series. This is not a treatment train.
- Removal efficiencies cannot be added together to obtain the total removal rate. For example, an extended dry pond could remove 50 percent of phosphorus. The goal is to remove 90 percent of the total phosphorus. If two extended dry ponds were proposed in series, then it would be incorrect to assume that this application would remove 100 percent of the phosphorus (50 + 50 = 100). The actual removal rate would only be slightly greater than 50 percent because the first pond should have removed almost all that could be removed using the settling technique. There would be minimal benefit to using a second extended dry pond. The recommended approach is to use a different unit process that has a high capability of removing the target pollutant before or after the extended dry pond to achieve the desired removal rate.

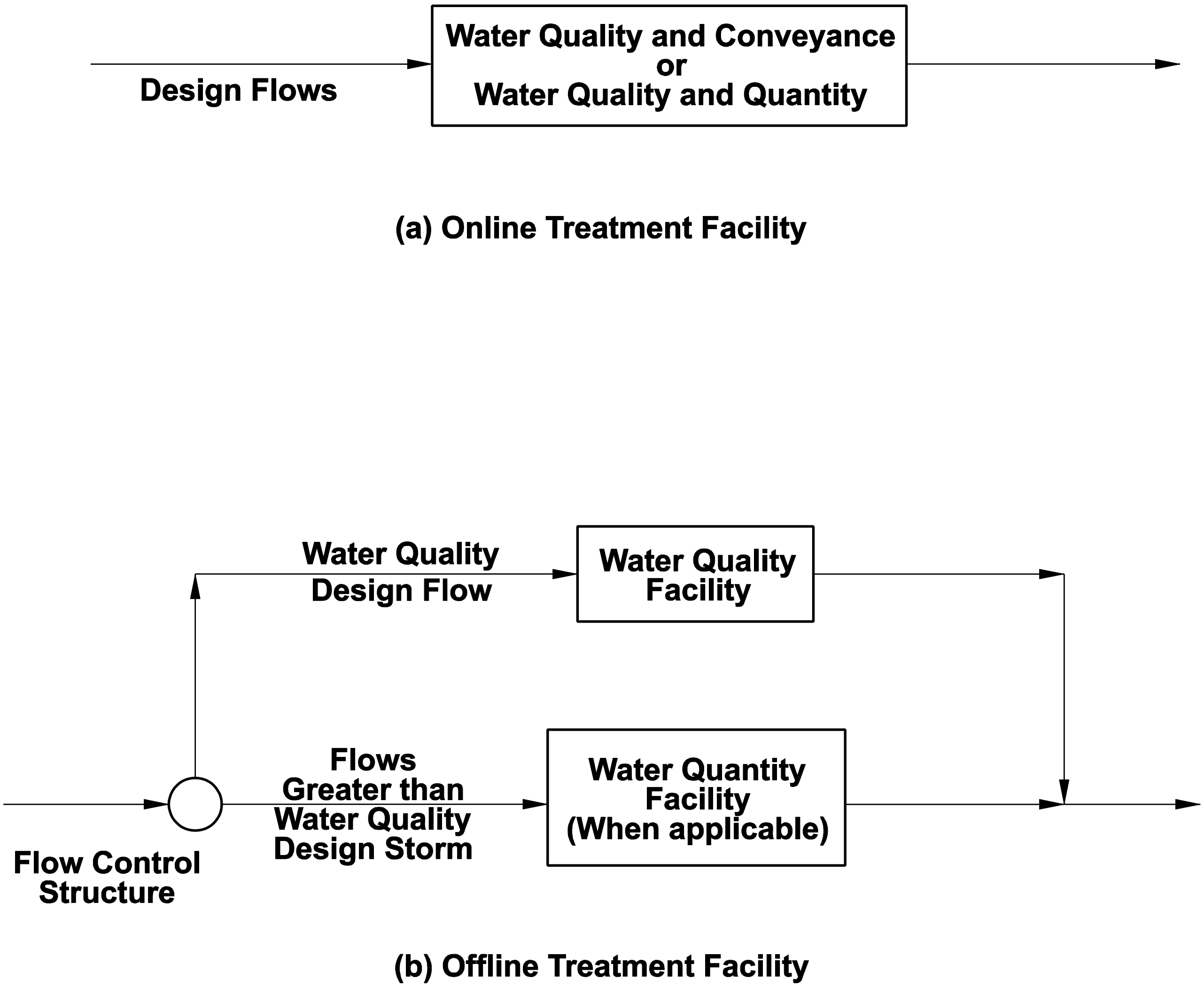

Figure 14-6 Online and Offline Treatment Configurations

14.10.7 Combined Facilities

Combination facilities are designed to treat stormwater and provide detention storage for peak flow reduction. Extended dry detention ponds, wet ponds, wet vaults, stormwater treatment wetlands, and infiltration facilities can be designed as combination facilities. The typical design technique for combined facilities is to dedicate the lower volume for water quality treatment and the upper volume is for detention storage.

A combination facility design is a two step process:

Step 1: Select a treatment method, design the stormwater quality component, and then design the stormwater facility components such as pretreatment and outlet control structure.

Water quality design guidance in this chapter should be used when designing combination facilities.

Step 2: Design the detention component, and then design the facility components such as the flow control structure, piping for conveyance, and outfall improvements when applicable. Storage facility design guidance is discussed in **Chapter 12**.

Note: The pond volume required to provide water quality treatment should be assumed to be full and unavailable for peak flow storage when designing a pond as a combination extended detention dry water quality facility and peak flow detention facility.

Figure 14-7 Combined Facility (Hwy 213)

14.10.8 Bypass Requirements

When a facility is placed off-line, stormwater flows must be directed or split in two directions. The water quality design flow is routed into the treatment facility. The higher flows are bypassed around the facility. This flow splitting is always located upstream of the treatment unit. The bypass flow is typically directed toward the downstream drainage system, or into a storage pond when necessary for flow control.

Pre-facility Bypass

General requirements include:

- High flow bypass is required for all water-quality-only (off-line) treatment facilities.

- The bypass structure and features must be designed to the same design storm as the upstream conveyance system.

Facility Bypass (Overflow)

The outlet structure releases the design peak flow rate or volume. The overflow structure must be designed to pass high flows in the event that the flow splitter fails or the flow control orifice is inadvertently removed or clogged by debris or sediment.

General requirements include:

- The outlet structure's high flow bypass feature or auxiliary outlet must be designed to convey the same design storm as the upstream conveyance system.
- Spillway weirs and storm drain pipes that outfall onto embankments and channels must be armored to prevent erosion. See Sections 14.10.12 and 14.10.13.

14.10.9 Inlet Structure (Flow Splitter)

The inlet structure, or flow splitter, is installed to control flow into the stormwater treatment facility. In most cases the inlet structure consists of a manhole, a flow splitter feature, and a high flow bypass feature. See **Appendix E** for more information.

Flow splitter feature (orifice or weir)

- Design using the water quality peak discharge.
- Orifices less than six inches in diameter require removable screening to prevent plugging.

14.10.10 Storm Drain Piping or Open Channel Conveyance

Storm drain piping and open channels are used to route stormwater into and out of a stormwater treatment facility.

General storm drain piping requirements include:

- All water quality facility storm drain piping must be designed to the same design storm as the upstream conveyance system.
- Minimum pipe size is 12-inches in diameter.
- Piping conveyance is analyzed using guidance in **Chapter 13**.

General open channel requirements are summarized in Section 14.10.12

14.10.11 Outlet Control Structure

The outlet control structure is installed to control flow out of the stormwater treatment facility. These structures are used in treatment ponds and combination facilities. In most cases the outlet structure consists of a manhole, inlets, an outflow control device such as orifices or weirs, and a high flow bypass feature.

General requirements include:

- Overflow or bypass capability must be included in case of excess inflow or plugging of the outflow control device.
- Design using the same design storm as the upstream conveyance system.
- Orifices less than six inches in diameter require removable screening to prevent plugging.

14.10.12 Outfalls

The location where a stormwater treatment facility releases runoff is known as the outfall. The outfall can be along an embankment or into a natural channel or existing storm drain system.

General requirements include:

- Outfall channels stability and hydraulic capacity must be designed to the same design criteria as the upstream conveyance system. Channel improvements are analyzed using guidance in **Chapter 8**.
- Outfall channels located in a waterway's floodplain must be designed to conform to the local floodplain regulations.
- Outfalls into a channel should be oriented to prevent outflow from causing erosion on the channels opposite bank.
- Outfalls must be armor protected to prevent erosion as discussed in Section 14.10.13.

14.10.13 Energy Dissipation

Energy dissipators are used to reduce the velocity and, consequently, the erosion potential of flowing water. Protection is usually required at the outlet of storm drain systems that discharge onto embankments or into natural or unlined channels, swales, and ponds.

Inlet dissipator

- Inlet dissipators must be designed to the same design storm as the upstream conveyance system. Dissipator design is sized using guidance in **Chapter 11**.

Outlet dissipator

- Outlet dissipators must be designed to the same design storm as the upstream conveyance system.
- Outlet dissipators located in a waterway's floodplain must be designed to conform to the local floodplain regulations.

14.10.14 Underground Injection Control (UIC) Requirements

A UIC is a system, structure, or activity that is created to place fluid below the ground or sub-surface. Common stormwater UICs or activities include, but are not limited to sumps, infiltration galleries, drywells, trench drains, and drill holes. However, not all infiltration facilities are classified as UICs. The distinction between UICs and non-UIC infiltration facilities is often subtle. If there is any doubt, DEQ should be consulted for clarification.

UICs are not stand-alone treatment BMPs. Treatment of stormwater is required before discharge to a UIC.

Before deciding to use a UIC for stormwater management:

- Consult with DEQ to verify the selected method qualifies as a UIC.
- Consider all other treatment options before selecting a method that qualifies as a UIC.
- Determine DEQ's current UIC permit requirements prior to beginning design.

General requirements include:

- Provide treatment prior to discharging stormwater into a UIC. In most cases sediment removal is sufficient; sedimentation manholes are generally acceptable in urban areas.
- Comply with DEQ requirements for setback from domestic, public or irrigation water wells. The basic requirements are:
    - 500 feet from any domestic water well, any irrigation water well, and any public water well that does not have an Oregon Department of Human Services approved 2-year time of travel, and
    - Outside the Department of Human Services approved 2-year time of travel for a public water supply well, or
    - Demonstrate that the water wells are protected from pollutants entrained in stormwater discharged into the underground injection systems within these setback areas.
- Comply with DEQ requirements for vertical separation between the bottom of a UIC and the seasonal high groundwater level. The basic requirements are:
    - Underground injection systems that are more than 5 feet deep shall have a minimum vertical separation distance of 10 feet between the bottom of the underground injection system and the seasonal high water table.
    - Underground injection systems less than or equal to 5 feet deep shall have a minimum separation distance of 5 feet between the bottom of the injection system and the seasonal high water.

14.10.15 Operation and Maintenance

The proper operation, performance, structural integrity, and aesthetics of a stormwater treatment facility are dependent on routine inspection and adequate maintenance. Inspection schedule and maintenance guidelines for each facility are summarized in an Operation and Maintenance Manual prepared to assist personnel who maintain the facility.

General requirements include:

- **Discuss proposed stormwater treatment facilities with the responsible Maintenance District before selection and design. Maintenance input can help in selecting and developing BMPs that are maintainable.**
- All stormwater treatment facilities require an Operation and Maintenance Manual. Prepare an operation and maintenance manual as outlined in **Chapter 4**.
- Distribute all prepared manuals to the appropriate district maintenance office and Geo-Environmental's Senior Hydraulics Engineer. An inventory of prepared manuals can be viewed at the following website:

  Operation & Maintenance Manuals Website

- All facilities need to be assigned a drainage facility identification number (see 14.10.17 below). Guidance on obtaining a drainage facility identification number is outlined in **Chapter 17**.
- All stormwater treatment facility structures should be accessible by foot and necessary equipment (e.g., vactor truck or mowers) for inspection and maintenance. Access road design criteria for pretreatment and primary treatment facilities are discussed in Appendices A, B, C, and D.
- Implement with Maintenance District concurreance: Manhole lids located in non-traffic areas outside or beyond the clear zone such as grassed areas or behind guardrail must be set 1 foot above finish ground so that manhole location is visible for locating and for maintenance. Lid elevations must match proposed finish grade in traffic areas.

14.10.16 Field Marking

Field markers are used to locate and identify ODOT stormwater facilities or alert maintenance crews of the location of a stormwater facility's maintenance area. There are three stormwater markers recommended for identifying, locating, or alerting. Two of these markers are used for marking above ground facilities and there is one marker applicable to underground stormwater facilities. ODOT's field marking process is outlined in **Chapter 17**.

14.10.17 Drainage Facility Identification Number

A drainage facility identification number (DFI) is a unique identifier assigned to each stormwater treatment and storage facility. It is used to associate or link the stormwater facility to an Operation and Maintenance Manual. The number is assigned by contacting the Geo-Environmental Section's Senior Hydraulics Engineer to obtain a unique "DFI". The Geo-Environmental Section will maintain a database of assigned Drainage Facility IDs. Guidance on obtaining a drainage facility identification number is outlined in **Chapter 17**.

Figure 14-8 Stormwater Facility Field Marker (Type S2)

14.11 Documentation

The following documents are required for most stormwater design projects. **Chapter 4** provides documentation guidance, outlines when the following reports are prepared, and what is to be included in each of these reports.

ODOT Projects

- Preliminary Stormwater Recommendations,
- Stormwater Design Report,

- Operation and Maintenance Manual, and
- A Stormwater Management Plan. This plan is required for Clean Water Act (CWA) Section 401 Water Quality Certification for projects needing CWA 404 permits. A template is available that provides guidance on what stormwater design information is required for a stormwater management plan. The template sections highlighted in green are to be completed by the project stormwater designer. This template can be viewed using the link below:

  Stormwater Management Plan Template

Distribute a copy of the Operations and Maintenance Manual to the appropriate district maintenance office. Distribute a copy of the Stormwater Design Report and Operation & Maintenance Manual in Adobe Acrobat portable document format (pdf) and in word format, and the operational plan Microstation file to Geo-Environmental's Senior Hydraulics Engineer by completing the project report submittal form located at the following website:

http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/hyd_data_resources.shtml

14.12 Treatment Facility Design Procedure

Water quality planning and design begins as soon as a project has been determined to include elements that trigger the requirement for stormwater treatment (see section 14.5.1). The criteria for stormwater treatment are the same for all projects where treatment is required, but the approach and complexity will depend on the specifics of the project and its location. In some situations, the right-of-way can provide adequate treatment with little or no modification, while in other situations intensively engineered facilities may be needed. The first step in design is early scoping to gather information needed to select and locate treatment facilities, including opportunities for Low Impact Development (LID) techniques. Coordination with environmental specialists is vital during scoping and through DAP. Based on information gathered during scoping and subsequent project design information, treatment options are evaluated, with final recommendations ready by DAP. The design then advances into calculating site hydrology (sub-basin delineation, land use types, runoff coefficients, time of concentration, and peak discharges or volume) and facility component design (facility sizing, pretreatment, inlet structure, piping conveyance, outlet control structure, and outfall improvements, when applicable).

A generalized procedure for the selection of a permanent stormwater treatment facility or facilities follows. Although many projects may require different tasks, many of the following steps will be applicable.

Step 1 - Determine if stormwater treatment is needed. The Prospectus Part 3 will indicate if the project elements trigger stormwater treatment requirements. This information can be supplied by the Region Environmental Coordinator or the project Water Resources Specialist. Special treatment requirements are identified by the Water Resources Specialist or other Environmental staff.

Step 2 - Attend scoping trip with project team. Collect data as needed to develop the Preliminary Stormwater Recommendation (see **Chapter 4**). An additional site visit may be needed to collect more data or to address specific concerns. See **Chapter 6** for data collection guidance. Information required for water quality purposes includes the extent of the Contributing Impervious Area, characteristics of the roadside area (topography, soils, vegetation, protected resources etc.), and identification of receiving waters and location of outfalls. Coordinate with Environmental staff to identify conflicting resources that would preclude the placement of BMPs.

Step 3 - Evaluate stormwater treatment techniques and strategies in the following priority order:

1. Utilize existing site characteristics to treat stormwater runoff by:

   - Preserving or minimizing disturbance of permeable native soils and vegetation to maintain its function of storing and infiltrating stormwater runoff

   - Using existing dispersion site conditions within existing right-of-way to provide water quality treatment and limited flow control. Dispersion conditions occur along roadway sections in which curb and gutter systems are not used to collect and convey stormwater runoff from highway pavement. See Appendix **A** and **B**.

   Coordinate with Maintenance during the evaluation process to identify potential issues.

   Consider constructability costs, maintenance requirements and costs, site constraints such as steep slopes, high groundwater table, bedrock location, and proximity to existing or proposed structures and wells when performing this determination.

2. Improve site characteristics to treat stormwater runoff by:

   - Acquiring additional right-of-way to provide sufficient dispersion area needed for treatment
   - Modifying slopes or using water quality mix (see **Appendix E**) to improve treatment opportunities

3. Treat the remaining contributing impervious area by distributing treatment facilities throughout the project or consolidating runoff and routing to a treatment facility. Select BMPs from Table 14-2 (Engineered BMPs). Consider BMP removal capabilities; constructability; costs; and maintenance, site constraints such as steep slopes, high groundwater table, bedrock location, and proximity to existing or proposed structures and wells when performing this determination.

The goal is to consider the best treatment alternatives. Consider treatment alternatives in the following order:

1. “high” capability of removing the target pollutants.
2. “moderate” capability of removing the target pollutants.
3. “low” capability of removing the target pollutants

If high capability BMPs are not appropriate for the site, assemble a treatment train of other BMPs to achieve similar pollutant removal capability.

New, innovative BMPs or substantially modified approved BMPs that provide the best option for a project may be approved through the Hydraulic Design Deviation process. See **Chapter 3** for guidance

Step 4 - Eliminate from consideration the BMPs that are obviously impractical (including due to maintenance issues) or ineffective.

Step 5 - Coordinate design with other agencies – this is a very important element to the design process for stormwater treatment facilities. Coordinating ODOT work with cities and counties would:

- Inform the designer of local drainage or water quality ordinances that ODOT projects must satisfy.
- Allow local agencies an opportunity for watershed-wide collaboration and cost sharing

Step 6 - Prepare the Preliminary Stormwater Recommendation. This recommendation does not contain facility designs. See **Chapter 4** for guidance.

Step 7 - Distribute the Preliminary Stormwater Recommendation to the project team and Maintenance prior to DAP. Review comments and concerns from project team members should be considered when designing the engineered stormwater treatment facility or facilities.

Step 8 - Verify if adequate right-of-way is available for the approved facility or facilities. No easements or additional right-of-way are necessary if adequate right-of-way is available for placement and maintenance access. If adequate right-of-way is not available, then coordinate easements or additional right-of-way with the project leader, roadway designer, and right-of-way specialist.

Step 9 - Assemble additional data required for design of the selected BMPs. See **Chapter 6** for data collection guidance.

Step 10 - Verify survey. The type, source, and complexity of data for a stormwater treatment facility design will vary depending on the location and type of construction activity. If necessary, obtain additional survey information. See **Chapter 6** for data collection guidance.

Step 11 - If additional data collection was necessary and has been conducted, verify accuracy and completeness. See **Chapter 6** for guidance.

Step 12 - Design the approved facility or facilities based on the design criteria provided in the appropriate appendix or appendices. Design tasks include:

- Determine the water quality storm.
- Determine hydrology. See **Chapter 7**.
- Size facility or facilities to convey or store the water quality design storm

Step 13 - Design the appropriate facility components such as:

- Inlet structure
- Pretreatment
- Piping conveyance
- Outlet control structure
- Outfalls, and
- Energy dissipation

The facility components should be based on the design criteria provided in **Appendix E**.

Step 14 - Evaluate and address hydraulic grade line effects through the entire system to assure proper operation under design conditions. See **Chapter 13** for guidance.

Step 15 - Obtain a drainage facility identification number for each proposed facility. See **Chapter 17** for guidance.

Step 16 - Prepare the Stormwater Design Report. See **Chapter 4** for guidance.

Step 17 - Prepare the Operation and Maintenance Manual. An O&M manual is required for every new facility. The is a Microsoft Word template document available for water quality facilities that must be used to prepare these manuals. See Chapter 4 for guidance.

Step 18 - Complete the Stormwater Management Plan sections required by the project stormwater designer when applicable. See Section 14.11.

Step 19 - Distribute the Stormwater Design Report. Forward an Adobe Acrobat portable document format (pdf) copy and word format copy to Geo-Environmental's Senior Hydraulics Engineer by completing the project report submittal form located at the following website:

http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/hyd_data_resources.shtml

File project stormwater design report and background information. See **Chapter 4** for guidance.

Step 20 - Utilize the appropriate stormwater control special provisions. Special provisions are provided for:

- SP01010 – Water Quality Structures
- SP01011 – Ponds
- SP01012 – Water Quality Biofiltration Swales
- SP01013 – Water Quality Bioslopes

- SP01014 – Water Quality Filter Strips

These provisions can be viewed and downloaded at the following website:

http://www.oregon.gov/ODOT/HWY/SPECS/2008_special_provisions.shtml

Step 21 - Coordinate installation of the field markers. Marking guidance is provided in **Chapter 17**.

Step 22 - Distribute a copy of the Operations and Maintenance Manual to the appropriate district maintenance office. Forward an Adobe Acrobat portable document format (pdf) copy and word format copy and the operational plan Microstation file to Geo-Environmental's Senior Hydraulics Engineer by completing the project report submittal form located at the following website:

http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/pages/omm.aspx

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