**State of Oregon Department of Environmental Quality**
**Clean Water State Revolving Fund**

# Guide 3: Stormwater Management Standards

Contact: Chris Bayham
541-687-7356

The Clean Water State Revolving Fund offers below-market loans for all phases of stormwater management, from planning to construction. This guide provides resources for Clean Water State Revolving Fund applicants and borrowers.

The resources below are intended to assist planners, public works staff and consultants to identify barriers in existing land use development standards and provides several examples of how to integrate nonstructural controls into local codes. The loan program offers a comprehensive guide to stormwater water management on the program website.

## Site performance standards

Site performance standards are critical for a municipality's effort to manage stormwater volume and minimize pollutant discharge. These standards define requirements such as the size of the design storm, the volume of stormwater to be retained on-site, the level of treatment for stormwater discharged off-site and the allowable discharge rate of runoff from a development. Site characteristics will greatly influence the most effective means to meet site performance standards.

### Retention requirement

Site performance standards typically include a retention requirement for retaining a portion of the stormwater on the development site and a treatment requirement for removing pollutants in stormwater discharged from the development. Numeric retention (water quantity) and treatment (water quality) requirements may be developed, for example, using one or more of the following methods:

- Volume-based method, for example retain the first one inch of storm event
- Storm event percentile-based method, for example treat the 95$^{th}$ percentile storm event
- Annual average runoff-based method, such as treating 80 percent of annual average runoff

Additionally, a narrative performance standard to match predevelopment hydrology could be implemented using a flow duration curve matching method. This standard not only strives to conserve the predevelopment hydrology but also provides a reliable pollutant reduction measure by reducing stormwater volume.

**Example Site Performance Standards in stormwater manuals and as required when Endangered Species Act-listed salmonids are present**

| Source | Design storm | Retention requirement | Discharge rates |
|---|---|---|---|
| Portland Stormwater Management Manual<br>The Portland Stormwater Manual uses the 10-year, 24-hour storm as the design storm for managing runoff volume, recognizing that few sites will be able to retain this volume of stormwater without discharge. The water quality treatment standard is a volume treatment goal of 90 percent of the average annual runoff. | Water quantity – 10-year, 24-hour storm (3.4 inches) | Stormwater must be infiltrated onsite to the maximum extent feasible before any flows are discharged offsite | The base standard must be sufficient to maintain peak flow rates at their predevelopment levels for the two-year, five-year, and 10-year, 24-hour runoff events |
| Central Oregon Stormwater Manual<br>The version of Central Oregon Stormwater Manual cited in this guide uses the Natural Resources Conservation Service (NRCS) Type I storm for its design storm requirements. However, the NRCS published an update in January 2016 indicating rainfall distributions of Types IA and II represent climate in Oregon. | Water quality – six-month NRCS Type I 24-hour storm; size varies with community; 0.7 – 1.2 inches (see Table 5-5) | Infiltration encouraged, no site performance standard for retention | The post development discharge rate must be kept equal to or less than the pre-development discharge rate for the two-year and 25-year precipitation events |
| Eugene Stormwater Management Manual | 1.4-inch, 24-hour storm; selected based on 80 percent capture of average annual runoff.<br><br>Flow through treatment control (target 80 percent capture):<br>• Off-line, flow-through type facilities: treat the peak flow rate resulting from a design storm with a rainfall intensity of 0.13 inches per hour<br>• On-line flow-through type facilities: treat the peak flow rate resulting from a design storm with a rainfall intensity of 0.22 in/hour | None | The design storm for flood control requirements vary by size of drainage area. The City requires that stormwater runoff does not:<br>• Exceed the capacity of the receiving conveyance facility<br>• Increase the potential for stream bank and channel erosion<br>• Create or increase any flooding problems |
| National Marine Fisheries Service Standard Local Operating Procedures for Endangered Species V | Flows between 50 percent of the two-year event and the 10-year flow event (annual series) | Retention or detention facilities must limit discharge to match pre-development discharge rates (for example. discharge rate of the site based on its natural groundcover and grade before development occurred). | |

## Treatment requirement

A treatment requirement ensures that a significant percentage of the annual volume of stormwater generated from impervious surfaces is captured and treated by structural stormwater controls before discharging to surface waters. Treatment criteria allow a municipality to evaluate the performance of a structural control. There are minimum required standards that a municipality must meet. After optimizing the retention of stormwater at a development site, NPDES Municipal Phase I Permit holders are required to treat the remaining portion of 80 percent of the average annual stormwater volume that cannot be retained onsite. The Eugene Stormwater Management Manual describes the precipitation analysis as follows:

> Detention Type Water Quality Facilities Long-term hourly precipitation data at the Eugene airport were analyzed to select the water quality design storm parameters for designing detention type stormwater quality facilities. The Surface Synoptic Observations (SYNOP) analysis was conducted using an inter-event time of 6 hours and a minimum storm depth of 0.01 inches. Based on the results presented in Figure 1, a design storm rainfall depth of 1.4 inches is required to capture approximately 80% of the average annual runoff from a site. A design storm rainfall depth of 0.95 inches is required to capture approximately 70% of the average annual runoff from a site. A design storm rainfall depth of 2.4 inches is required to capture 90% of the average annual runoff from a site.

**Example treatment standards in Oregon stormwater manuals**

| Stormwater manual | Percent capture for water quality | Treatment performance | Other pollutants |
|---|---|---|---|
| Portland Stormwater Management Manual | Stormwater must be infiltrated onsite to the maximum extent feasible before any flows are discharged offsite | 70 percent removal of total suspended solids from 90 percent of the average annual runoff | In watersheds that have established Total Maximum Daily Loads (TMDLs) or that are on DEQ's Clean Water Act section 303(d) list of impaired waters, stormwater management facilities must be capable of reducing the pollutant(s) of concern as approved by Bureau of Environmental Services |
| Central Oregon Stormwater Manual | The goal is to treat the runoff to the maximum extent practicable by treating approximately 80 percent of total runoff volume generated at a project site on an annual basis. This can be achieved by designing facilities to treat the full six-month NRCS Type I 24-hour storm event | 80 percent removal of suspended solids for typical influent concentrations ranging from 30 mg/L to 100 mg/L | Oil control facilities are intended to achieve the goal of non-visible sheen, and to have a 24-hour average total petroleum hydrocarbons concentration below 15 mg/L.<br><br>Structural controls for metals are intended to achieve a goal of 50 percent removal of total metals on an annual basis. |
| Eugene Stormwater Management Manual | 80 percent capture of average annual runoff; 1.4-inch, 24-hour design storm | Treatment performance standard not specified, structural controls must meet manual design specifications | |

### Off-site stormwater mitigation

Off-site stormwater mitigation is needed when the numeric retention and treatment requirement cannot be fully met at a site. Municipalities can develop criteria for determining which site constraints would warrant off-site mitigation, such as shallow bedrock, high groundwater, groundwater contamination, and soil instability as documented by a geotechnical analysis or land use that is inconsistent with capture or infiltration of stormwater.

Once approved, municipalities allow the developer to capture and treat the unmet portion of numeric retention standard at another location in the same subwatershed by undertaking the off-site project directly, contributing to a stormwater payment-in-lieu program or purchasing credits from a locally established stormwater mitigation bank. Off-site stormwater mitigation may also include groundwater replenishment projects or a treatment equivalent that attains the water quality benefits of on-site retention.

A payment-in-lieu program involves establishing a currency-based rate, such as a dollar amount per volume of runoff mitigated, as well as trading ratios and the scale of trading. The trading ratios establish the runoff reduction volume that a stormwater control must be designed to infiltrate or evapotranspire, while the scale of trading defines the geographic boundary linking the development site to eligible alternative locations for compliance. The payment-in-lieu option provides more flexibility to minimize compliance costs while leveraging limited resources to strategically locate stormwater controls.

The development of a stormwater mitigation bank requires an analysis of the supply and demand for off-site mitigation credits to determine if there is viable market to support the program. It also involves the establishment of a trade currency based on the unmet stormwater retention at the development site. Given this, municipalities with a greater administrative capacity and pool of potential mitigation sites are more likely to pursue this option. Institutional standards and management systems are needed to value, estimate and track how retention volume credits are used to ensure compliance.

Key references for off-site stormwater mitigation include the following:

- Guidance for Developing an Off-Site Stormwater Compliance Program in West Virginia
- Creating Clean Water Cash Flow – Developing Private Markets for Green Stormwater Infrastructure in Philadelphia
- Managed Aquifer Recharge:  A Water Supply Management Tool

## Example design criteria for structural controls

Some structural stormwater controls can act as both treatment and volume controls. These include retention ponds, infiltration basins and constructed wetlands. Their effectiveness depends on the specific design.

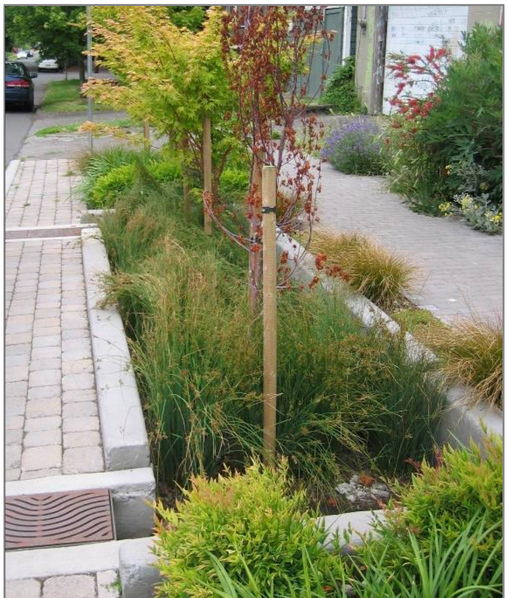
### Sizing structural controls

Sizing criteria can include sizing for the water quality treatment volume, on-site retention such as infiltration and re-use, channel protection and flood control. Each municipality must develop sizing criteria based on documented local or regional rainfall frequency and intensity. Western Oregon's Low Impact Development Guidance Manual provides a spreadsheet model for simplified NRCS Type IA storm distribution sizing criteria that can be adapted to the other storm type distribution in Eastern Oregon. Examples for sizing structural controls include the following:

- Minnesota developed an issue paper that provides a review of various approaches to size stormwater structural controls for groundwater recharge, water quality, channel protection, overbank flood control and extreme flood control, and this sizing approach is summarized on a Unified Sizing Criteria webpage.
- The Denver Metropolitan Area Urban Drainage and Flood Control District has a series of manuals with criteria for urban storm drainage. Chapter 3 of Volume 3 describes a water quality capture volume appropriate for the Denver area as well as information on quantifying the volume reduction achieved with low impact development approaches.
- Chapter 2 of the Maryland Stormwater Design Manual provides an example of specific sizing criteria for water quality treatment volume, recharge volume, channel protection and overbank flood protection.
- The City of Eugene Stormwater Management Manual, noted above in Table 2, includes a worksheet titled Simplified Approach for Stormwater Management for sizing stormwater facilities based on the effective impervious area in the facility's drainage.

### Design considerations and criteria

Stormwater manuals for the cities of Portland and Eugene, the Oregon Environmental Council and the Central Oregon Intergovernmental Council provide design criteria for several types of structural controls. Many of these provide some volume control as well as treatment. There are many other stormwater manuals, fact sheets and references with design criteria for structural controls available online. The following are a few examples to consider:



**Bio-swales collect stormwater runoff from roadways and then slowly filter it through layers of soil, sand and stone.**

- The California Stormwater Quality Association's Best Management Practices Handbooks contain fact sheets on structural best management practices with design considerations and guidelines as well as recommendations for inspection and maintenance of the best management practices.
- Clean Water Services' Design and Construction Standards includes administrative and technical requirements for the design and construction of residential or commercially developed surface water management systems as well as sanitary systems, erosion control methods, and vegetated corridors.
- EPA's Post-Construction Stormwater Management in New Development & Redevelopment Website has links to best management practices facts sheets with design considerations and links to several resources on post-construction stormwater management.
- The Urban Drainage and Flood Control District cited above, which serves the Denver metropolitan area, has a website with technical papers on the stormwater quality best management practices.
- The Washington Department of Ecology has a Stormwater and Design Manuals Website dedicated to stormwater management and design manuals.
- The structural stormwater controls in other manuals referenced in the Oregon DEQ's Stormwater Management Plan Submission Guidelines.

### Percent removal versus effluent concentration in treatment

Percent removal is commonly used as a measure of structural control performance and is an easy way to understand the effectiveness of pollutant removal. However, there are some shortcomings with this method for quantifying the performance of best management practices. The percent removal performance of a BMP is related to the quality of its influent. The higher the concentration of pollutants coming in, the higher the reported removals. Very clean influent will result in low percent removal, even though effluent quality may be good. Very dirty influent could result in a high percent removal performance, but the effluent quality might still be low. Finally, a BMP might perform well for particulate pollutants such as total suspended solids, but it might not remove other priority pollutants, such as nutrients or bacteria, at the same rate.

To address the concern that percent removal is a function of influent quality, an upper and lower threshold influent pollutant concentration can be set for a percent removal treatment requirement, for example, 80 percent removal of total suspended solids for typical influent concentration of 30 mg/L to 100 mg/L. This would better reflect the practical limits of a structural stormwater control.

Volume reduction must also be considered to assess the overall performance of a structural control's effectiveness at removing pollutants from stormwater discharges. A good example of volume reduction is presented in the EPA website Three Keys to BMP performance. EPA explains that the overall reduction in pollutant load discharge from a structural control is a function of the reduction in pollutant concentration and the reduction in the volume of stormwater discharged. The goal should be to estimate the total pollutant load that may be removed by a structural stormwater control when evaluating and demonstrating compliance with TMDL wasteload or load allocations for municipal stormwater discharges.

### Targeted pollutant removal

Stormwater is considered a source of bacteria, sediment/turbidity and nutrients that can adversely affect the beneficial uses of surface water. DEQ generally does not consider stormwater to contribute to in-stream temperature impairments, because rainfall typically occurs during the cooler seasons when in-stream flows are high and ambient stream and runoff temperature are low. Municipalities that discharge to impaired waters may want to specifically target the pollutants causing the impairments so that beneficial uses of the waterbody can be restored.

The specific design criteria of a structural control will affect its performance. Water quality benefits of stormwater treatment will occur through specific unit processes such as sedimentation, filtration, adsorption, biotransformation and plant uptake. Applying fundamental principles of flow and water quality processes in structural stormwater controls will allow for the design of quantitative pollutant load reduction and more predictable performance. The unit processes typically associated with green infrastructure, with its focus on bioretention (sedimentation, adsorption, filtration and plant uptake) are effective for reducing the loading of a variety of stormwater pollutants.

For example, a vegetated swale that is designed with well-drained, porous soil to allow more stormwater to flow through the mulch layer and soil mix provides more effective bioretention and bacteria control than a swale without this. Similarly, a longer flow path improves the performance of a vegetated buffer strip in controlling bacteria. Therefore, the space available for the best management practice and the unit processes incorporated are likely to influence the extent of pollutant removal.

**Table 4: Relative Removal Efficiency for Stormwater Treatment BMPs. Data Reproduced From the City of San Diego Treatment Control Selection Matrix**

| BMP | Sediment | Nutrients | Metals | Bacteria | Oil and Grease |
|---|---|---|---|---|---|
| Infiltration Basin | H | H | H | H | H |
| Bioretention Basin | H | M | H | H | H |
| Constructed Wetland | H | M | H | H | H |
| Extended Detention Basin | M | L | M | M | M |
| Vegetated Swale | M | L | M | L | M |
| Vegetated Buffer Strip | H | L | H | L | H |
| Flow Through Planter Boxes | H | M | H | H | H |
| Vortex Separator | M | L | L | L | L |
| Media Filter | H | L | H | M | M |

H = High, M = Medium, and L = Low Removal efficiency

To better understand the range of performance for structural stormwater controls, the International Stormwater BMP Database contains over 500 best management practice studies with performance analysis results and other tools and information. The intent is to provide scientifically sound information to improve the design, selection and performance of best management practices. A study of the database titled Statistical Addendum: TSS, Bacteria, Nutrients, and Metals analyzed the performance data to develop influent and effluent event mean concentration statistics for classes of structural BMPs and pollutant categories. Other publications on design and performance are available, as well.

For additional information, contact Chris Bayham from DEQ's Clean Water State Revolving Fund at 541-687-7356.

## Alternative Formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us