DESIGN GUIDE NO. 6

BIORETENTION DESIGN UNDER THE 2009 DRAINAGE DESIGN AND EROSION CONTROL MANUAL

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Purpose

The purpose of this design guide is to summarize the requirements for designing bioretention facilities using the 2009 Drainage Design and Erosion Control Manual for Thurston County (DDECM). Bioretention design requirements are found in several locations within the DDECM including:

Volume I: Minimum Technical Requirements and Site Planning

- Section 2.4.6, *Minimum Requirement #5: Onsite Stormwater Management*
- Section 3.1.2, *Site Design – Smart Design and Low Impact Development*
- Section 4.2, *Step-by-Step BMP Selection Process*
- Section 4.5, *Enhanced Treatment: Supplemental Information*
- Section 4.6, *Basic Treatment: Supplemental Information*

Volume III: Hydrologic Analysis and Stormwater Conveyance

- Section 2.3, *Site Suitability and Hydrologic Analysis for Infiltration Facilities*

Volume V: Stormwater BMPs

- Section 2.2.5, LID.08, *Bioretention Facilities*
- Table 2.4: *Continuous Modeling Assumptions for Bioretention Cells*
- Table 2.5: *Bioretention Soil Aggregate Gradation*
- Table 2.6: *Bioretention Soil Compost Gradation*
- Appendix V-B, *Facility Liners and Geotextiles*
- Appendix V-C, *Maintenance Checklist for Bioretention Facilities*
- Appendix V-E, *Site Design Elements* – Requirements for, signage, setbacks, & planting/landscaping.

Additional references providing design guidance include:

- ***Low Impact Development Technical Guidance Manual for Puget Sound***, Puget Sound Action Team, January 2005

- ***Technical Memorandum, Bioretention Soil Mix Review and Recommendations for Western Washington***, Washington State University, Pierce County Extension, January 2009.

Minimum Requirements and Site Planning

A bioretention facility is a shallow depression with a designed planting soil mix (bioretention soil mix) and planted with a variety of plants including trees, shrubs, grasses and ground cover. It can be designed for flow control (detention or infiltration) and/or runoff treatment.

Bioretention facilities are typically smaller in scale and integrated into the landscape to better mimic natural hydrologic systems. They are most appropriate for contributing areas

of 10,000 square feet or less, but may be designed for larger areas up to 1 or 2 acres of contributing area.

Bioretention is considered an "onsite" measure and should be used to the maximum extent practicable with other Low Impact Development (LID) techniques for projects to comply with Minimum Requirement #5, "Onsite Stormwater Management."

Specific methods of employing bioretention as part of a project's overall stormwater management may include:

- To manage rooftop, driveway and other on-lot impervious surfaces for individual lots.
- To provide enhanced treatment when required.
- To provide phosphorous treatment when required.
- As a vegetated curb extension along roadways. A bulb-out is created along the road right-of-way to accept roadway runoff.
- As a bioretention swale: bioretention swales are linear facilities with the same design features as bioretention cells. An example is the roadside swale required for many Thurston County rural roadways per the Road Standards. These swales could be designed for bioretention to provide flow control and treatment.
- Within parking lot landscape islands and perimeter landscaping. Modeling of bioretention systems demonstrates that for most native soil conditions the land area required to manage parking lot runoff for water quality treatment using bioretention is less than 10% of the parking lot area. Flow control can be provided with as little as 10 to 20% of the parking lot area if native soils have greater than 1 inch per hour infiltration rates. These area requirements are comparable to the area required for a conventional wet pond and infiltration/detention pond design for most sites.
- As common landscaped areas in apartment complexes or other multi-family housing designs.
- Within cul-de-sacs and loop roads serving proposed subdivisions or commercial development.

When the native soils on the project have low infiltration rates (<0.5 inches/hr) the use of bioretention (with an underdrain) is still feasible for stormwater treatment and to provide some level of flow control/infiltration. However, it is probably not feasible to use bioretention for full flow control and additional conventional facilities such as detention ponds will be required.

Bioretention is a cost effective and land area competitive method of managing stormwater on projects. However, successfully incorporating bioretention into a project requires some additional site investigation and pre-planning. The owner, architect, civil engineer and geotechnical professional should work together early in the process of developing site plans to establish appropriate locations and adequate area for proposed bioretention facilities. The following steps are recommended in preparing the project site plan:

1. **Prepare a Conceptual Site Plan**. Provide conceptual level landscape area locations for bioretention that are located downgradient of contributing areas and dispersed throughout the site. Consult with the project engineer as to approximately how much landscape/bioretention area is required as a percentage of the contributing area. This may vary from less than 5% if only runoff treatment is provided to more than 25% if runoff treatment and flow control is proposed on low

infiltration rate native soils. Advantages in site characterization can be realized by limiting contributing area to each proposed bioretention area to less than 7,500 square feet.

2. **Preliminary Soils Investigation**. Based on the conceptual site plan, conduct preliminary soils investigations to establish an estimate of native soil design and short term infiltration rates. Also determine whether certain areas of the site are more suitable for infiltration.

3. **Bioretention Soils Mix Design**. Concurrent with the site soils investigation, identify potential sources of bioretention soil mix and have testing completed to establish the design infiltration rate of the soil mix. This will be necessary to accomplish the next step.

4. **Preliminary Bioretention Sizing**. Perform preliminary bioretention facility sizing to establish a general idea of how much bioretention area will be required to manage runoff from the project. Also determine whether 100% infiltration can be accomplished or whether additional flow control or infiltration facilities might be required.

5. **Revised Site Plan**. Based on the preliminary soils work and preliminary sizing, revise the proposed site plan consistent with the results.

6. **Final Soils Investigation**. Conduct additional geotechnical site investigations to provide the minimum required number of borings within the footprint of each proposed bioretention facility. If contributing areas were kept less than 7,500 square feet then only one soil boring or test pit is required within the proposed footprint of the bioretention facility, otherwise, at least two borings or test pits will be required.

7. **Finalize Site Plan.** Confirm design assumptions from steps 2 and 4 and finalize the site plan for use in project permitting.

Hydrologic Design Criteria

Bioretention facilities can be designed to meet Minimum Requirement #6 (Runoff Treatment) and Minimum Requirement #7 (Flow Control). Bioretention facilities meet the requirements for basic, enhanced, and phosphorous treatment.

Minimum Requirement #6, *Runoff Treatment,* requires projects to construct stormwater treatment facilities to treat 91 percent of the influent runoff file using an approved continuous runoff model (WWHM). This can be accomplished by designing to either infiltrate 91 percent of the runoff influent file or ensuring that 91 percent of the runoff influent file passes through the bioretention soil mix if an under-drain is provided. If flow control (Minimum Requirement #7) is required, an overflow and/or discharge from the under-drain shall be routed to an appropriately sized flow control facility (infiltration or detention).

Where appropriate native soils are available, a bioretention facility can be sized to provide flow control by either infiltrating 100% of the runoff influent file or providing additional ponding volume and a control structure sized to meet the flow control standard as demonstrated by an approved continuous runoff model.

The continuous simulation hydrologic model used for designing bioretention facilities is generally the Western Washington Hydrologic Model, Version 3 (WWHM3) as developed for the Department of Ecology by Clear Creek Solutions, Inc.. WWHM3 has also been modified with Thurston County specific data and the modified version shall be used for design of bioretention facilities in Thurston County.

A runoff treatment facility (bioretention is one type of runoff treatment facility) is required for projects that:

1. Create 5,000 square feet or more of pollution generating impervious surfaces (PGIS) in a threshold discharge area.

2. Have ¾ of an acre or more of pollution generating pervious surface in a threshold discharge area, and from which there is a surface water discharge to a natural or man-made conveyance system from the site.

A threshold discharge area is defined as an onsite area draining to a single natural discharge location or multiple discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath).

Pollution generating impervious surfaces (PGIS) are those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those subject to: vehicular use; industrial activities, or storage of erodible or leachable materials and which receive direct rainfall or the run-on or blow-in of rainfall. Metal roofs are also considered PGIS unless they are coated with an inert, non-leachable material.

A surface, whether paved or not, is considered subject to vehicular use if it is regularly used by motor vehicles. This includes roads, un-vegetated road shoulders, driveways, parking lots, unfenced fire lanes, and vehicular storage yards. Not considered PGIS are bicycle and pedestrian pathways separate from and not subject to drainage from roads, fenced fire lanes, and infrequently used maintenance access roads.

Pollution generating pervious surface (PGPS) is any non-impervious surface subject to the use of pesticides and fertilizers or loss of soil and includes lawns, landscaped areas, golf courses, parks, cemeteries and sports fields.

If runoff from new and replaced PGIS or PGPS cannot be separated from existing PGIS or PGPS runoff then treatment facilities shall be sized to treat all of the runoff.

Treatment Processes

Bioretention facilities treat stormwater by filtering stormwater as it passes through the bioretention soil as well as by sorption, sedimentation, and biological uptake of dissolved pollutants. Sorption removes dissolved constituents by chemical attachment to media at the molecular level. There are three types of sorption: adsorption, absorption, and ion exchange.

Special Requirements

Bioretention is a type of infiltration Best Management Practice. Characterization of soils and determination of design infiltration rates in accordance with requirements of Volume III of the DDECM is required. This section summarizes those requirements as they relate to bioretention facilities.

Depth to Seasonal High Groundwater

The base of the bioretention facility shall be a minimum of 3 feet above seasonal high groundwater levels, bedrock, hardpan or any other low permeability layer. The base of the bioretention facility is considered the bottom of the bioretention soil, which will typically be 18 to 24 inches below the surface of the facility.

A reduced vertical separation of 1-foot to seasonal high groundwater is allowed for linear bioretention facilities (roadside swales) with continuous sheet flow in-flow or for other bioretention facilities with contributing areas meeting all of the following criteria:

- <10,000 square feet of impervious area
- <5,000 square feet of pollution generating impervious area
- <3/4 acre of landscape contributing area.

Infiltration Receptor Characterization and Mounding Analysis

Characterizing the soil and groundwater conditions beneath a proposed infiltration facility (infiltration receptor characterization) is generally required if the separation between the base of the facility and the seasonal high groundwater is less than 50-feet and any of the following conditions apply:

- Tributary area to the facility is more than 3/4 acre total or more than 15,000 square feet of impervious surface.
- Soils may not have adequate infiltration capacity (Hydrologic Soil Group C or D).
- There is less than 2 times the minimum setback to a critical area, drainfield, or steep slope (>15%).

If infiltration receptor characterization is required, groundwater wells will need to be installed and monitored over one wet season (December – April).

If it is determined that there is less than 15 feet to seasonal high groundwater, a mounding analysis may be required if the tributary area to the facility is greater than ¾ acre or there is greater than 15,000 square feet of impervious area contributing to the facility.

Note the advantages of keeping the size of the bioretention facility small (<10,000 to 15,000 SF of contributing impervious area). Under the appropriate circumstances this can eliminate the requirement to do a winter water study or mounding analysis.

Required Soils Testing at Bioretention Facility Location

Once a site plan has identified the location and approximate size of bioretention facilities, additional soil borings/test pits are required within the footprint of each proposed facility. Typically, the preliminary soils investigation does not provide sufficient test pits in the appropriate location to meet testing requirements of Table 2.3 of Volume III of the DDECM. These requirements are:

1 Test Pit/Boring per BMP if contributing area is <7,500 sq ft and project is either a single family residential project or commercial project.

OTHERWISE

1 Test Pit/Boring per 5,000 square feet of infiltration area per BMP (2 minimum) or 1 per 100 linear feet for linear configurations (2 minimum)

Test pits/borings must be dug mid to late in the wet season (December through April) and should be dug to a depth of at least 6-feet below the proposed bottom of the facility, or deeper if layers which may impede infiltration may exist or as recommended by the geotechnical professional.

Bioretention Soil Mix Requirements

As the use of bioretention expands in the Puget Sound area additional suppliers of bioretention soil mix should become available. Consult with local landscape soil suppliers to

determine if a bioretention soil mix is available that meets required specifications. The specifications for an acceptable bioretention soil mix are as follows:

Cation Exchange Capacity (CEC)
Cation exchange capacity is a measure of the soils ability to remove dissolved metals. Cation exchange capacity shall be tested using EPA laboratory method 9081 and shall be equal to or greater than 5 meq/100 grams of dry soil.

Organic Matter Content
Final organic matter content of the bioretention soil mix shall be 8 to 10 percent by dry weight as determined by ASTM D 2974.

Soils
Bioretention soils should be a well mixed blend of approximately 60 percent aggregate and 40 percent compost, by volume. Using "topsoil" in the bioretention mix is not recommended since typical topsoil may contain silts and clays that reduce infiltration capacity.

Aggregate
Aggregate shall be a well-graded utility or screened sand meeting the following criteria:

1. Gradation

Sieve Size/No.	Percent Passing
3/8 inch	100
US No. 4	95 – 100
US No. 10	75 – 90
US No. 40	25 – 40
US No. 100	4 – 10
US No. 200	2 - 5

2. Coefficient of Uniformity: $C_u = d_{60}/d_{10} \geq 6$

   Coefficient of uniformity is a measure of whether a soil is uniformly graded or well graded. A well graded soil has a C_u of greater than 5.

3. Coefficient of Curvature: $C_c = (d_{30})^2 / (d_{60} \times d_{10}) \rightarrow 1 < C_c < 3$

   Coefficient of curvature, also known as coefficient of gradation is a measure of the shape of the particle distribution curve. A value of less than 0.1 indicates a potentially gap-graded soil.

Compost
Compost shall be the result of the biological degradation and transformation of Type I, II, or III feedstock per WAC 173-350-220. Compost shall be stable with regard to oxygen consumption and carbon dioxide generation. Additional specifications for acceptable compost are:

1. Gradation

Sieve Size/No.	Percent Passing
2 inch	100
1 inch	99 – 100
5/8 inch	90 – 100
US No. 4	40 – 90

2. pH: 5.5 to 8.0

3. Carbon to Nitrogen Ratio:
    - 20:1 to 25:1 for most landscapes
    - 30:1 to 35:1 preferred for native woody plantings.

4. Organic matter content: 45 to 65 percent by test method TMECC 05.07A "Loss-on Ignition Organic Matter Method" or equivalent.

5. Electrical conductivity (measures soluble salt content): < 6 mmhos/cm tested in accordance with TMECC 04.10-A

6. Moisture content: 35 – 50 percent

7. No viable weed seeds.

Note: TMECC (Test Methods for the Examination of Composting and Compost) is an on-going Composting Council Research and Education Foundation project, funded in part by the USDA.

Attached to this design guide is a detailed bioretention soil specification issued by the City of Seattle. Use of the most current version of this specification complies with the requirements of the Thurston County DDECM. Check the City of Seattle web site to ensure you are using the most current version.

Determine Design Infiltration Rate for Bioretention Facility

The design infiltration rate for the bioretention facility shall be the lower of the long-term infiltration rate of the bioretention soil mix and the short term infiltration rate of the underlying native soil.

The short term infiltration rate for the underlying native soils shall be determined using the methods outlined in Volume III, Chapter 2 of the DDECM without applying corrections for clogging, maintenance, etc. Calculating the native soils infiltration rate is not addressed in this design guide.

The long term infiltration rate of the bioretention soil mix shall be determined by laboratory testing using ASTM 2434, "Standard Test Method for Permeability of Granular Soils (Constant Head)." The sample should be compacted to 80 percent of maximum density using ASTM 1557 Test Method (Modified Proctor). The resulting infiltration rate should be reduced by a reduction factor of 2 or 4 as follows:

- Use a reduction factor of 2 if the contributing area meets all of the following:
    - <5,000 square feet of pollution generating impervious surface
    - <10,000 square feet of impervious area, and
    - <3/4 Acre of landscape area.

- Use a reduction factor of 4 if the above conditions cannot be met.

The minimum design infiltration rate for the bioretention soil mix should be 1 inch per hour.

The Department of Ecology now accepts a short term infiltration rate of 12 inches per hour for bioretention soil mixes. If the proposed bioretention soil mix testing results in a design (long term) infiltration rate of less than 1 inch per hour or a short term infiltration rate of greater than 12 inches per hour, the mix will have to be adjusted to obtain an infiltration rate between these limits.

Design Elements

Bioretention facilities should be located to maximize their function and made an attractive feature of the urban environment. Design requirements include:

- Pre-Treatment: If landscape or other pervious surfaces contribute flow to the bioretention facility a pre-treatment facility such as a filter strip, pre-settling basin or vault is required. However, dispersed flows should not be concentrated for purposes of presettling.

- Steep Slopes: For slopes greater than 10% consider using sloped biodetention and weep garden designs. Details for these designs can be found in the LID Manual (PSAT, 2005).

- Flow Entrance: Four types of flow entrances can be used for a bioretention facility, in priority order:
    - Dispersed, low velocity (sheet) flow across grass or landscape areas.
    - Dispersed flow across pavement or gravel and past wheel stops for parking.
    - Curb cuts with concrete chute.
    - Pipe flow entrance.

- Sheet Flow Inlet: Ideally flow into the bioretention facility should be by sheet flow. A minimum 1-inch drop to a minimum 1-ft width of crushed rock or grass strip should be provided to uniformly distribute flow into the facility and prevent flow blockage along the edge of the pavement.

- Curb Cuts: If curb cuts are used for road side or parking lot bioretention facility entrances, the curb cuts should include a concrete chute below the gutter grade. Install rock or other erosion protection material in the channel outlet to dissipate energy.

- Energy Dissipation: For inlet concentrated flows, dissipate energy at the inlet to reduced velocities less than 1 foot per second.

- Ponding Depth: Maximum ponding depth is 12 inches. A maximum of 30 inches of ponding depth can be provided if the facility will provide optional detention storage by including an orifice control system.

- Bottom Width: The minimum bottom width is 2 feet.

- Side Slopes: Maximum side slope is 3H:1V. Steeper side slopes may be allowed for bioretention swales in roadway projects. Vertical walls are not permitted. For side slopes of 3H:1V or shallower, sidewall infiltration is allowed (see modeling guidance).

- Freeboard: Freeboard is the depth available above the overflow elevation for the bioretention facility. For small facilities (<1,000 square feet contributing area) and linear (i.e. swale) facilities the minimum freeboard is two inches. For larger facilities the minimum freeboard is six inches.

- Overflow: Unless the facility is designed for 100% infiltration an overflow must be provided. A typical overflow is a yard drain or catch basin with a grate inlet elevation set to the maximum ponding elevation. Overflow structures shall be designed to convey the 100-year recurrence interval flow and provide a controlled discharge directly into the downstream conveyance system or another acceptable discharge point. For facilities designed for 100% infiltration, a safe overflow path should also be identified that prevents property damage or downstream impacts.

- Drawdown Time: The surface pool drawdown time shall be a maximum of 24 hours. This can be estimated by dividing the maximum ponded depth by the design infiltration rate for the facility. For a ponded depth of 12 inches, the drawdown time will be met for design infiltration rates of 0.5 inches per hour or greater.

- Underdrain Pipe: An underdrain may be appropriate where infiltration is not permitted and a liner is used to protect groundwater; or where native soil infiltration rates are not adequate to meet maximum pool drawdown time (generally <0.5 inches/hour).

  Design alternatives for underdrain pipes include the following:
  - Underdrain pipe shall be per WSDOT standard specification Section 9-05.2 for:
    1. Perforated PVC Under Drain Pipe.
    2. Perforated Corrugated Polyethylene Drainage Tubing Under Drain Pipe (≤ 10 inch).
    3. Perforated Polyethylene Under Drain Pipe (12" to 36").
  - Provide a 6 inch granular fill filter around the under drain. Geotextile wrapping is discouraged as it has a history of clogging.
  - Gravel Filter Materials should meet the following gradation:

Sieve Size/No.	Percent Passing
1 inch	100
3/4 inch	80 – 100
3/8 inch	10 – 40
US No. 4	0 – 4
US No. 200	0 – 2

  - Slope underdrain at 0.5% minimum slope.
  - Install 6-inch diameter rigid non-perforated observation pipes connected to the underdrain every 250 to 300 feet for cleanout/observation.

  Alternative under drain designs, as described in the Low Impact Development Manual (PSAT, 2005) are also allowed. Design requirements for these alternatives include the following:

  1. Slotted Under Drain
     - Use slotted 4-inch to 8-inch, thick-walled plastic pipe (PVC per ASTM D1785 SCH 40).
     - Slot openings should be smaller than the smallest aggregate gradation for the gravel blanket to prevent migration of material.
     - An example specification for slots and filter materials is:
       - Slots should be cut perpendicular to the long axis of the pipe and be 0.04 to 0.069 inches by 1 inch long and spaced 0.25 inches apart (spaced longitudinally).
       - Slots should be arranged in four rows spaced on 45 degree centers and cover ½ of the circumference of the pipe.
       - For this slot size, use the following filter material specification:

Sieve Size/No.	Percent Passing
3/4 inch	100
1/4 inch	30 – 60
US No. 8	20 – 50
US No. 50	3 – 12
US No. 200	0 – 1

- Place under drain on a 3-foot wide bed of aggregate with a minimum thickness of 6-inches and cover to a depth of 1-foot.

2. Perforated Pipe Under Drain: If proper gradation and/or slotted pipe are not available and perforated PVC or flexible HDPE pipe is used:

   i. Under drain pipe should be placed on a 3-foot wide bed of 1/2 to 1-½" drain rock (ASTM No. 57 Aggregate or equivalent) at a minimum thickness of 3-inches, and covered with 6-inches of No. 57 aggregate. Doubled washed stoned is preferred to reduce suspended solids and potential for clogging.

   ii. If filter fabric is used, use a non-woven material placed over the drain rock and extending 2-feet on either side of the under-drain. Wraping the gravel blanket in filter fabric can cause premature failure due to clogging and is not recommended.

   iii. A pea gravel diaphragm (with or without a filter fabric) reduces the likelihood of clogging when used with drain rock. Use ¼ to ½ inch diameter double-washed gravel (ASTM D448 or equivalent) placed over the drain rock to a thickness of 3 to 8 inches. If filter fabric is used, place between the drain rock and pea gravel extending 2 feet on either side of the under-drain. The strip of filter fabric placed above the under-drain acts as an impediment to direct gravitational flow and causes the water to move laterally and then down toward the under drain.

- Control Structure: For bioretention facilities designed to provide detention a control structure can be provided. Control structures can be combinations of weirs and orifices. For smaller facilities the use of an orifice structure is limited by the minimum allowable orifice diameter of 0.5-inches.

- Plantings: Plantings should be designed by a landscape architect or landscaper. Appendix V-E of the DDECM (copy attached) includes a detailed plant list. Bioretention facilities generally feature three planting zones, reflecting the different soil moisture and frequency of inundation. A minimum of 3 tree, 3 shrub and 3 herbaceous groundcover species should be included in the planting plan. Native plants are preferred, but not required. Use smaller plant materials. Trees and shrubs should generally be 3 gallon size or less. Optimum planting time is fall (beginning in early October). Summer planting is least desirable, and requires temporary irrigation.

- Bioretention Soil Depth: Bioretention soil depth shall be a minimum of 18-inches if providing runoff treatment, otherwise 12-inches.

- Mulch: Place mulch with a maximum thickness of 2 to 3 inches around plantings. Use compost in the bottom area of the bioretention facility to avoid floating debris. Shredded or chipped wood (no beauty bark) can be used along the side slopes.

- Signage & Fencing: Bioretention facilities are stormwater facilities, and shall be identified as such with signage and fencing. Signs shall be installed identifying the facility and it purpose and not to disturb. Fencing should be considered to reduce public access through the facility, especially if located within a parking area or other area easily accessible to the public. Fence may be post and cable, or other suitable types. Signage and fencing should be proposed as part of the application and requires Thurston County acceptance.

Setbacks

Setbacks for bioretention facilities are the same as for infiltration ponds. Setbacks from the maximum water surface include:

- 1-foot vertical clearance to built structures within 25 feet.
- 10-feet horizontal to:
  - Building sewer lines
  - Property lines
- 20-feet horizontal setback from building foundation or basement where infiltration facilities are located downgradient from the building. (100-feet when facility is located upgradient).
- 50-feet horizontal to septic tank, holding tank, pump chamber or distribution box. (Note: this may be reduced to no less than 10-feet with County acceptance).
- 50-feet horizontal to slopes steeper than 15% and greater than 10 feet high. May be reduced with recommendations from geotechnical engineer or licensed engineering geologist.
- 100-feet horizontal to:
  - A drinking water well or spring used for drinking water supply.
  - A building foundation or basement where infiltration facilities are located upgradient from the building.
  - Septic drainfields and reserve areas. (Note: This setback may be reduced to no less than 30-ft for bioretention facilities serving a single family residence or for other bioretention facilities depending on soil conditions and with County acceptance).
- 300-feet horizontal to landslide hazard area (as defined by Thurston County Code) unless a slope stability analysis has been completed and acceptable mitigation proposed by a geotechnical professional.

  Note: A landslide hazard area under TCC Title 17.15.600 includes all slopes (at least 15-ft high) greater than 50% (2H:1V); slopes greater than 30% meeting certain conditions such as a hardpan layer and seepage; areas with landslide history in last 10,000 years; and areas with listed soils (Table 4.2 of Title 17) that are not located along Puget sound.

Design Process

The following generalized design process is suggested for bioretention facility design:

1. Evaluate project site for suitability including area available, depth to bedrock, native soil infiltration rates, depth to water table, etc. If a bioretention facility is deemed suitable to the site proceed with the design process.
2. Identify a source of supply for the bioretention soil mix and have testing conducted to confirm its suitability in accordance with the DDECM and to establish a design infiltration rate.
3. Using the test pits or borings conducted within the footprint of the proposed facility establish the short term infiltration rate for the underlying soils.

4. Modeling of Bioretention Facility in WWHM3.

   a. Calculate the impervious and pervious area tributary to each bioretention facility and input all contributing basin information and setup model to route contributing basin(s) to the point of discharge from the site (point of compliance). Include any flow control facilities and other treatment facilities as required. Be sure to include the estimated area of the bioretention facility as an impervious area.

   b. Bioretention facilities may be modeled in one of three ways using WWHM3.

      i. Infiltration pond
      ii. Infiltration trench/bed.
      iii. Bioretention Swale (WWHM3 Pro version only)

      Note: It is anticipated that future free versions of WWHM will include a bioretention element.

   c. Use the software guidance/use documentation to model the bioretention facility as applicable. The following general assumptions should be used in modeling:

      i. Use sidewall infiltration if side slopes are shallower than 3H:1V.

      ii. Use a porosity of 0.4 for the bioretention soil mix unless testing indicates a different value.

      iii. Use a flat weir/riser unless a designed control structure/overflow is proposed. Set the elevation of the riser pipe at the maximum design ponding elevation and provide a large enough diameter to avoid weir affects (i.e. 10 feet).

      iv. If the element chosen for the model does not apply precipitation and evaporation to the facility, include the facility area in the basin area (note this will underestimate the evaporation of ponded water).

      v. Verify that at least 91% of the inflow file is infiltrated to meet water quality requirements.

      vi. Either design to infiltrate 100% of the inflow file, or demonstrate that any overflow meets the duration standards for flow control, if facility will provide flow control.

      vii. If modeling the bioretention facility using the infiltration pond element in WWHM3 adjust pond dimensions to account for soil storage as follows:

         1. If the long-term infiltration rate through the bioretention soil mix is lower than the underlying native soils short term infiltration rate, the bioretention facility dimensions and slopes should be entered into the WWHM3 as the pond dimensions and slopes. The effective depth entered in the model is the distance from the surface of the bioretention soil mix to the invert of the overflow pipe.

         2. If the short term infiltration rate through the underlying soils is lower than the estimated long term infiltration rate through the bioretention soil mix, the pond dimensions entered into the WWHM should be adjusted to account for the storage volume in the void space of the bioretention soil mix. For example, if the void space is 40%, and the depth of the imported soils is 2 feet, the depth of the pond is increased by 0.8 feet. If the depth of imported soils varies with the side slopes of the swale, the theoretical side slopes of the pond can be adjusted also.

5. Layout bioretention facility design and grading on drainage plans and be sure to address all applicable design details such as berm construction, signage, inlet protection, control structures, etc.. Show design maximum water surface elevation on plan drawing.

6. Show in drainage plans and construction drawings at least one facility cross-section. Indicate design maximum water surface elevations.

7. Prepare a landscaping plan showing number, type, and special handling requirements for plants.

8. Include all design calculations, assumptions, modeling parameters, etc. in the Drainage Report for the project.

Submittal Information

Include the following in any submittal documentation for the project:

- Show on the work map included in the Drainage Report the following:
  - Limits of contributing drainage basins per threshold discharge area for pre-development and developed conditions
  - Summary of areas by type (pollution generating and non pollution generating impervious, native, lawn/landscape).
  - Location of clear path of overflow to downstream collection point.
  - Natural drainage channels.

- Include in the construction plans and specifications:
  - Max design water level and overflow level in plan view & facility cross-section.
  - Planting plan showing plant species, quantity, location and any special planting requirements.
  - Channel protection from path of overflow to downstream collection point.
  - Details of inlets and outlets.
  - Inlet and outlet pipe invert elevations, slopes and pipe lengths.
  - Details, construction notes and specifications for all structures and materials.
  - Bioretention facility cross-section.
  - Proposed design & location for the stormwater facility information sign.
  - Include construction notes in drawings to protect the native soil layer from compaction during construction and prevent putting facility into operation until site is stabilized.

- Include in the Drainage Report for the project:
  - Design calculations for overflow structures, under drains, piping and emergency spillway.
  - Testing results for proposed bioretention soil mix. Indicate source of supplier.
  - Document facility meets any setback requirements.
  - If the bioretention facility is located within 300 feet of the top of a slope designated a landslide hazard area or within the minimum setback distance of 50-feet to a slope of greater than 15% and 10-ft height a geotechnical analysis and report shall be submitted.
  - Hydrologic modeling results including a schematic of the model setup referencing model basin identifiers to basins and sub-basins shown in the work map. Demonstrate that water quality treatment and flow control requirements are met, as applicable.
  - Document design infiltration rate calculations. Infiltration rate must be determined by a geotechnical engineer or other licensed soil professional. A certified soil scientist or other soils professional may determine infiltration rates for facilities where Minimum Requirements #6 (runoff treatment) or #7 (flow control) are not applicable.
  - Include in the Soils Management Plan prepared per BMP LID.02 the bioretention soils mix for proposed bioretention facilities.

Construction

More so than other stormwater Best Management Practices, the proper functioning of a bioretention facility depends on proper construction techniques. The following considerations should be incorporated into the specifications for the project:

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

- Excavation of the bioretention facility should be by low ground pressure equipment or should be performed while the equipment is located outside the footprint of the facility. Avoiding operating equipment within the footprint of the facility to avoid native soil compaction.

- Once the bioretention facility is excavated to subgrade, the native soils should be scarified to a depth of at least 4 inches prior to placement of bioretention soil mix.

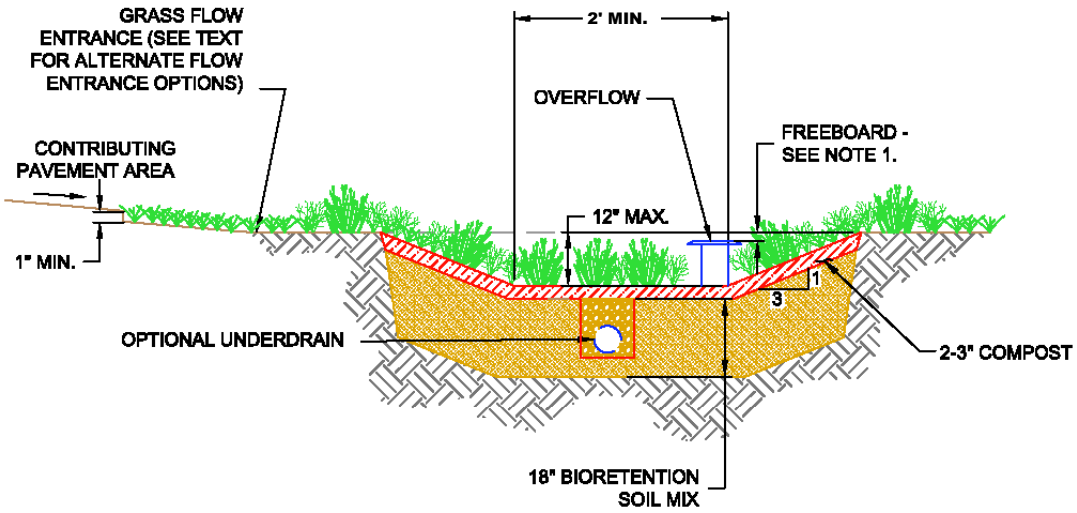
BIORETENTION FACILITY

Applicant Use	REVIEW CHECKLIST	Staff Use Only
	HYDROLOGIC DESIGN	
	Do pre-developed and developed land area assumptions in Drainage Report match input to WWHM3 & Single Event models?	
	If WWHM3 is used to size bioretention facility, verify Thurston County customized version used in design.	
	Will proposed bioretention facility provide runoff treatment, flow control, or both.	
	SPECIAL REQUIREMENTS	
	Is base of the proposed bioretention facility a minimum of 3 feet above seasonal high groundwater levels, bedrock, hardpan or any other low permeability layer?	
	Does the proposed facility meet the requirements for a reduced (1-ft minimum) vertical separation to seasonal high groundwater? 1. Linear bioretention facility (roadside swales) with continuous sheet flow in-flow? or 2. Contributing area meets all of the following criteria: a. <10,000 sf impervious area b. <5,000 sf pollution generating impervious area c. <3/4 acre of landscape contributing area	
	Is an infiltration receptor characterization, including a winter water study, required? Yes if <50-feet to groundwater and any of the following conditions apply: 1. Tributary area to facility is >3/4 acre total and >15,000 sf impervious. 2. Surface soils of hydrologic soil group C or D 3. Less than 2 times the minimum setback to a critical area, drainfield, or slope steeper than 15%.	
	Is a mounding analysis required? Yes if: 1. <15-feet to groundwater & 2. Tributary area to facility is >3/4 acre, or >15,000 sf impervious area.	
	Have the required number of test pits and/or borings been completed within the footprint of the proposed bioretention facility and to a minimum depth of at least 6-feet below the bottom of the facility?	
	Has a bioretention soil mix supplier been identified and have testing results been received demonstrating the suitability of the bioretention soil mix and its infiltration rate?	
	Does the aggregate proposed for the bioretention soil mix meet gradation specifications?	
	Does the compost proposed for the bioretention soil mix meet minimum gradation and other specifications?	
	Has the short term native soil infiltration rate been determined using appropriate methods of Volume III of the DDECM?	
	Has infiltration rate testing of the bioretention soil mix been completed and results submitted per ASTM 2434? Is the rate <12 inches per hour? If not mix redesign is required.	
	Has the appropriate reduction factor been applied to the bioretention soil mix short term infiltration rate? (i.e. 2 for <1,000 square feet of contributing areas, otherwise 4). Is the long term infiltration rate >1 inch per hour? If not mix redesign is required.	
	DESIGN ELEMENTS	
	If landscape or other pervious surfaces contribute flow to the bioretention facility is pre-treatment provided? (filter strip, pre-settling vault/basin).	
	Has sheet flow inlet been provided where feasible? If so is a 1-inch minimum drop provided to a 1-ft width crushed rock or grass strip to distribute flows evenly?	
	If curb cuts are used is a concrete chute provided with energy dissipation?	
	Is maximum design ponding depth 12-inches (30-inches if detention storage provided)?	
	Are facility dimensions within requirements (3H:1V side slopes, 2-ft minimum bottom width, 6-inch freeboard)	
	Is a safe overflow path provided? Designed to convey the 100-year recurrence interval flow?	
	Check surface pool drawdown time (divide pond depth by infiltration rate), is it less than 24-hours?	
	If providing an underdrain, do pipe and filter materials meet applicable specifications? Is pipe sized to adequately convey the 100 year recurrence interval flow?	
	Are at least 3 tree, 3 shrub, and 3 herbaceous groundcover species provided for in the planting plan? Are plants appropriate for the planting zone?	
	Is a minimum bioretention soil mix depth of 18-inches provided if facility will provide runoff treatment? (If just flow control, then 12-inches is sufficient).	

	Has 2 to 3 inches of mulch been specified? Is mulch specification appropriate (no beauty bark)?	
	Have signage and fencing been provided for. The facility shall include signage to identify it as a stormwater facility and a contact provided.	
	SETBACKS	
	Is the design maximum water surface elevation shown on the drainage plan and also shown in the bioretention facility cross-section?	
	Is there at least a 1-foot vertical clearance from the maximum water surface to any structures (buildings) within 25-feet?	
	Is there at least a 10-foot horizontal separation from the maximum water surface to on-site structures, sewer lines and property lines? (See also larger setbacks for basement and building foundations).	
	Is there at least a 20-foot horizontal separation from any building foundation or basement where the facility is located downgradient from the building?	
	Is there at least a 100-foot horizontal separation from any building foundation or basement where the facility is located upgradient from the building?	
	Is there at least a 50-foot horizontal separation from the maximum water surface to any septic tank, holding tank, pump chamber, or distribution box for a septic system? (This may be reduced to no less than 10-feet with County acceptance). The location of nearby septic systems (on-site and off-site) and drainfields should be shown on the site plan if they are in proximity to the bioretention facility.	
	Is there at least a 50-foot horizontal separation from the maximum water surface to slopes steeper than 15% and greater than 10 feet high? If not, a geotechnical engineer shall evaluate for stability and include recommendations in the geotechnical report. In no case shall setback be less than the height of the slope greater than 15%.	
	For a facility serving a single family residence is there at least a 30-foot horizontal separation to the drainfield or reserve area.	
	Is there at least a 100-foot horizontal separation from the maximum water surface to any septic drainfields or reserve areas or a drinking water well?	
	Is there at least a 300-foot horizontal separation to any landslide hazard area as defined by Thurston County Code title 17.15.600? If not, a geotechnical engineer shall evaluate for stability and include recommendations in the geotechnical report.	
	SUBMITTAL INFORMATION	
	DRAINAGE REPORT	
	Hydrologic modeling results including schematic of model setup referencing model basin identifiers to basins and sub-basins shown in the work map and hydrologic model.	
	Work map showing sub-basins and basins contributing to the bioretention facility with basin identifiers corresponding to the nomenclature used in the hydrologic model.	
	Summary table of contributing sub basins identifying soil type and areas of impervious, landscape, forest, etc. corresponding to hydrologic model inputs.	
	Document how all required facility setbacks are met.	
	Geotechnical report including analysis of bioretention soils mix, native soils infiltration rate, infiltration receptor characterization (if required), slope stability for steep slopes located within setback distances or within 300-ft of the top of a slope designated a landslide hazard area, retaining wall design, and any other analysis required by geotechnical engineer.	
	Design calculations for overflow structures, emergency spillway, outlet pipe, outfalls etc. provided.	
	Show on work map the location of natural drainage channels and show a clear path of overflow to downstream collection point for overflows.	
	CONSTRUCTION DRAWINGS & SPECIFICATIONS	
	Show existing topography based on field verified survey.	
	Show proposed topography and indicate surface flow directions. Extend proposed topography to catch points.	
	Show any tract boundaries and easements with widths and location of easement markers.	
	Planting plan showing plant species, quantity, location and any special planting requirements.	
	Include excavation and soil placement specifications to prevent compaction of subgrade in vicinity of bioretention facility.	
	Design and maximum water surface shown in pond cross-section. Show any over pavement ponding that might occur.	
	Show details of inlets, outlets, and overflow structures.	
	Proposed design and location of stormwater facility information sign and any fencing.	
	Details of any proposed control structure shown – including invert elevation of pond outlet, elevation of secondary overflow and top of structure.	

SUPPLEMENTAL INFORMATION

1. Bioretention Cell – Typical Section
2. Seattle Public Utilities – Bioretention Soil Mix Specification
3. Planting Guide



SECTION

BIORETENTION FACILITY NOTES:

1. FREEBOARD DEPTH SHALL BE 2" MIN. FOR CONTRIBUTING AREAS < 1,000 SF; FREEBOARD DEPTH SHALL BE 6" MIN. FOR CONTRIBUTING AREAS ≥ 1,000 SF.

THURSTON COUNTY BMP LID.08
DETAIL: BIORETENTION FACILITY
SCALE: NTS

1
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Figure 2.8. Bioretention Area.

Appendix A

SPU Bioretention Soil Specification

7-21 BIORETENTION SOIL

7-21.1 DESCRIPTION

Section 7-21 describes work consisting of the installation of Bioretention Soil in turf and landscape areas intended to receive surface runoff for infiltration.

7-21.2 MATERIALS

Materials for Bioretention Soil will be specified in the Contract and consist of one or more of the following:

Landscape Bioretention Soil	9-14.1(3)B
Turf Bioretention Soil	9-14.1(3)C

7-21.3 CONSTRUCTION REQUIREMENTS

7-21.3(1) GENERAL

Bioretention soil shall be protected from all sources of additional moisture at the Supplier, in covered conveyance, and at the Project Site until incorporated into the Work. Soil placement and compaction will not be allowed when the ground is frozen or excessively wet, or when the weather is too wet as determined by the Engineer.

When the Contract specifies testing by a Contractor provided testing laboratory, the laboratory must be an STA, AASHTO or ASTM or other designated recognized standards organization accredited laboratory with certification maintained current. The laboratory must be capable of performing all tests to the designated recognized standards specified, and will provide test results with an accompanying Manufacturer's Certificate of Compliance.

7-21.3(1)A SUBMITTALS

At least 10 Working Days in advance of construction, the Contractor must submit to the Engineer for approval:

1) A 10-pound minimum sample of mineral aggregate (Sections 9-03.2(2) and 9-03.2(3), as applicable);

2) A 10 pound sample of mixed Bioretention Soil (Sections 9-14.1(3)B and 9-14.1(3)C, as applicable);

3) A 10 pound minimum sample of compost (Section 9-14.4(9));

4) Grain size analysis results of mineral aggregate performed in accordance with ASTM D 422, Standard Test Method for Particle Size Analysis of Soils;

5) Quality analysis results for compost performed in accordance with Seal of Testing Assurance (STA) standards, as specified in Section 9-14.4(9);

6) Organic content test results of mixed Bioretention Soil. Organic content test shall be performed in accordance with Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, “Loss-On-Ignition Organic Matter Method”.

7) Modified Proctor compaction testing of mixed Turf Bioretention Soil, performed in accordance with ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort;

8) A description of the equipment and methods proposed to mix the mineral aggregate and compost to produce Bioretention Soil;

9) Permeability or hydraulic conductivity testing of the Bioretention Soil, performed in accordance with ASTM D 2434, Standard Test Method for Permeability of Granular Soils. For the Landscape Bioretention Soil assume a relative compaction of 85 percent of Modified maximum dry density (ASTM D 1557);

10) Provide the following information about the testing laboratory(ies):

    1. name of laboratory(ies) including contact person(s),
    2. address(es),
    3. phone contact(s),
    4. e-mail address(es);
    5. qualifications of laboratory and personnel including date of current certification by STA, ASTM, AASHTO, or approved equal.

7-21.3(2) BIORETENTION SOIL CONSTRUCTION

Contractor shall not start bioretention construction until the site draining to bioretention area has been stabilized and authorization is given by Engineer.

At the locations shown on the Drawings, excavate, grade, and shape to the contours indicated to accommodate placing of Bioretention Soil to the thicknesses required. Dispose of excavated soil or reuse elsewhere as the Contract or Engineer will allow. Scarify the subgrade soil a minimum of 2 inches deep where slopes allow, as determined by the Engineer prior to placing Bioretention Soil.

Mixing or placing Bioretention Soil will not be allowed if the area receiving bioretention soil is wet or saturated or has been subjected to more than ½-inch of precipitation within 48-hours prior to mixing or placement. Engineer shall have final authority to determine if wet or saturated conditions exist.

Place Landscape Bioretention Soil loosely. Final grade shall be measured only after the soil has been water compacted, which requires filling the cell with water, without creating any scour or erosion, to at least 1 inches of ponding. If water compaction is not an option, final grade shall be measured at X inches above the grade specified on the plans to allow for settling after the first storm. X shall be calculated by depth of soil x 0.85 and rounded up to the nearest whole number.

Place Turf Bioretention Soil in loose lifts not exceeding 8 inches. Compact Turf Bioretention Soil to a relative compaction of 85 percent of Modified maximum dry density (ASTM D 1557), where slopes allow, as determined by the Engineer. Where Turf Bioretention Soil is placed in the 2-foot road shoulder, compact to a relative compaction of 90 percent of Modified maximum dry density (ASTM D 1557).

7-21.4 MEASUREMENT

Bid items of Work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs here in this Section.

Measurement for Bioretention Soil Construction will be by the cubic yard.

7-21.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 7-21 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "Bioretention Soil Construction" per cubic yard.

The Bid item price for "Bioretention Soil Construction" shall include all costs for the work necessary to furnish, place, compact, excavate, grade, shape, mix, dispose of, and as necessary.

9-03.2 MINERAL AGGREGATES FOR BIORETENTION SOIL

9-03.2(1) GENERAL

Mineral aggregate shall be free of wood, waste, coating, or any other deleterious material. All aggregate passing the No. 200 sieve size shall be non-plastic.

9-03.2(2) MINERAL AGGREGATE FOR TURF AND LANDSCAPE BIORETENTION SOIL

Mineral aggregate for Turf and Landscape Bioretention Soils shall be analyzed by an accredited lab using #200, #100, #60, #40 and #20. #10, #4, 3/8 inch and 1 inch sieves, and meet the following gradation:

Sieve Size	Percent Passing
3/8″	100
No. 4	95 - 100
No.10	75 - 90
No. 40	25 - 40
No. 100	4 - 10
No. 200	2 - 5

Efforts should be made to have the mineral aggregate for Turf and Landscape Bioretention Soils meet the following gradation coefficients: Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) equal to or greater than 6; and Coefficient of Curve ($C_c = D_{30}^2/D_{60}D_{10}$) greater than or equa1 to 1 and less than or equal to 3.

9-14.1(3) BIORETENTION SOIL

9-14.1(3)A GENERAL

Bioretention Soil shall be a well blended mixture of mineral aggregate and compost measured on a volume basis.

9-14.1(3)B LANDSCAPE BIORETENTION SOIL

Landscape Bioretention Soil shall consist of 2 part compost by volume meeting the requirements of Section 9-14.4(9) and 3 parts mineral aggregate meeting the requirements of Section 9-03.2(3). The mixture shall be well blended to produce a homogeneous mix. Efforts should be made to attain organic matter content as close to 8 to 10 percent as possible, with the final mix to be determined by the engineer based on samples and test results submitted.

9-14.1(3)C TURF BIORETENTION SOIL

Turf Bioretention Soil shall meet the requirements of section 9-14.1(3)B.

9-14.4(9) COMPOSTED MATERIAL

Compost products shall be the result of the biological degradation and transformation of Type I or III Feedstocks under controlled conditions designed to promote aerobic decomposition, per WAC 173-350-220, which is available at http://www.ecy.wa.gov/programs/swfa/compost. Compost shall be stable with regard to oxygen consumption and carbon dioxide generation. Compost shall be mature with regard to its suitability for serving as a soil amendment or an erosion control BMP as defined below. The compost shall have a moisture content that has no visible free water or dust produced when handling the material.

Compost production and quality shall comply with Chapter 173-350 WAC, and meet the following physical criteria:

1. Compost material shall be tested in accordance with Testing Methods for the Examination of Compost and Composting (TMECC) Test Method 02.02-B, “Sample Sieving for Aggregate Size Classification”.

   Compost shall meet the following:

	Min.	Max.
Percent passing 1”	99%	100%
Percent passing 5/8”	90%	100%
Percent passing 1/4”	40%	90%

2. The pH shall be between 5.5 and 8.0 when tested in accordance with TMECC 04.11-A, “1:5 Slurry pH”.

3. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0 percent by weight as determined by TMECC 03.08-A "percent dry weight basis".

4. Organic matter content should be between 45 and 65 percent dry weight basis as determined by TMECC 05.07A, “Loss-On-Ignition Organic Matter Method”.

5. Soluble salt contents shall be less than 6.0 mmhos/cm tested in accordance with TMECC 04.10-A, “1:5 Slurry Method, Mass Basis”.

6. Maturity shall be greater than 80% in accordance with TMECC 05.05-A, “Germination and Vigor”.

7. Stability shall be 7 or below in accordance with TMECC 05.08-B, Carbon Dioxide Evolution Rate”

8. The compost product must originate a minimum of 65 percent by volume from recycled plant waste as defined in WAC 173-350-100 as “Type 1 Feedstocks.” A maximum of 35 percent by volume of other approved organic waste as defined in WAC 173-350-100 as “Type III”, including post-consumer food waste, but not including biosolids, may be substituted for recycled plant waste. The supplier shall provide written verification of feedstock sources.

9. Carbon to nitrogen ratio shall be less than 25:1 as determined using TMECC 04.01 “Total Carbon” and TMECC 04.02D “Total Kjeldhal Nitrogen”. The engineer may specify a C:N ratio up to 35:1 for projects where the plants selected are entirely Puget Sound native species.

10. The Engineer may also evaluate compost for maturity using the Solvita Compost Maturity Test at time of delivery. Compost shall score a number 6 or above on the Solvita Compost Maturity Test.

The compost supplier will test all compost products within 90 calendar days prior to application. Samples will be taken using the Seal of Testing Assurance (STA) sample collection protocol. (The sample collection protocol can be obtained from the U.S. Composting Council, 4250 Veterans

Memorial Highway, Suite 275, Holbrook, NY 11741 Phone: 631-737-4931, www.compostingcouncil.org). The sample shall be sent to an independent STA Program approved lab. The compost supplier will pay for the test. A copy of the approved independent STA Program laboratory test report shall be submitted to the Contracting Agency prior to initial application of the compost. Seven days prior to application, the Contractor shall submit a sample of each type of compost to be used on the project to the Engineer.

Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall be immediately removed from the project and replaced at no cost to the Contracting Agency.

The Contractor shall submit the following information to the Engineer for approval:

1. A copy of the Solid Waste Handling Permit issued to the supplier by the Jurisdictional Health Department as per WAC 173-350 (Minimum Functional Standards for Solid Waste Handling).

2. The supplier shall verify in writing, and provide lab analyses that the material complies with the processes, testing, and standards specified in WAC 173-350 and these specifications. An independent STA Program certified laboratory shall perform the analysis.

3. A list of the feedstock by percentage present in the final compost product.

4. A copy of the producer’s STA certification as issued by the U.S. Composting Council.

Acceptance will be based upon a satisfactory Test Report from an independent STA program certified laboratory and the sample(s) submitted to the Engineer.

THURSTON COUNTY
BIORETENTION
PLANTING GUIDE

Seed Mixes. The seed mixes listed in Tables E-2 through E-4were developed for central Puget Sound.

Seed Mixes for Specific Bioinfiltration Swales

The seed mixes listed below were developed for central Puget Sound.

Plant Recommendations for Bioretention Facilities

Bioretention facilities generally feature three planting zones, reflecting the different soil moisture and frequency of inundation. Tables E-5 through E-7 provide planting recommendations for the different planting zones. Tables E-5 through E-7 include both native and non-native plant species commonly available in the Puget Sound region and suitable for bioretention facilities. Refer to the bioretention facility design guidelines (BMP LID.08 in Chapter 2) for additional planting requirements. Consultation with a landscape architect is recommended for site-specific planting recommendations.

Table E-2. Stormwater Tract "Low Grow" Seed Mix

Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye "Barclay"*	30%
Red fescue	25%
Colonial bentgrass	5%

* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perennial rye can be reduced proportionately to the amount of wildflower seed used.

Table E-3. Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas

Mix 1		Mix 2	
75-80 percent	tall or meadow fescue	60-70 percent	tall fescue
10-15 percent	seaside/colonial bentgrass	10-15 percent	seaside/colonial bentgrass
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight.
* based on Briargreen, Inc.

Table E-4. Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington

Groundcovers	
kinnikinnick*	*Arctostaphylos uva-ursi*
Epimedium	*Epimedium grandiflorum*
creeping forget-me-not	*Omphalodes verna*
--	*Euonymus lanceolata*
yellow-root	*Xanthorhiza simplissima*
--	*Genista*
white lawn clover	*Trifolium repens*
white sweet clover*	*Melilotus alba*
--	*Rubus calycinoides*
strawberry*	*Fragaria chiloensis*
broadleaf lupine*	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
tufted fescue	*Festuca amethystine*
buffalo grass	*Buchloe dactyloides*
red fescue*	*Festuca rubra*
tall fescue grass*	*Festuca arundinacea*
blue oatgrass	*Helictotrichon sempervirens*

Table E-5. Plant Species Appropriate for Area of Periodic or Frequent Standing or Flowing Water (Zone 1)

Species	Common Name	Exposure	Mature Size/Spread	Comments
Trees				
*Alnus rubra**	Red alder	Sun/partial shade	30-120 feet/ 25 ft. spread	Prefers moist, rich soils, highly adaptable, drought tolerant; nitrogen fixer; rapid growing, relatively short-lived (60-90 years)
*Fraxinus latifolia**	Oregon ash	Sun/partial shade	30 ft. spread	Moist, saturated or ponded soils; flood tolerant; small green-white flowers
*Malus fusca**	Pacific crabapple	Sun/partial shade	To 40 feet/35 ft. spread	Tolerant of prolonged soil saturation; produces fruit (do not plant near public walkways)
*Salix lucida**	Pacific willow	Sun	40-60 feet/ 30 ft. spread	Wet soils; tolerates seasonal flooding should not be planted in areas near pavement or underground structures
Shrubs				
*Cornus sericea**	Red-osier dogwood, Red-twig dogwood	Sun/partial shade	To 15 feet	Prefers wet to moist organically rich soils, but is adaptable; tolerates seasonal flooding; small white flowers; berrylike fruits
Cornus sericea 'Kelseyi'	Dwarf dogwood	Sun	To 1.5 feet	Prefers wet to moist organically rich soils, but is adaptable; small white flowers; berrylike fruit; low growing, compact form; good ground cover.
Cornus sericea	'Flaviramea' Yellow dogwood	Sun/partial shade	6-8 feet	Prefers wet to moist organically rich soils, but is adaptable; easily transplanted and grown; small, white flowers; yellow stems and reddish, purple fall color
Cornus sericea 'Isanti'	Isanti dogwood	Sun/partial shade	4-5 feet	Prefers wet to moist organically rich soils, but is adaptable; deciduous shrub; tiny white flowers; red stems; purple fall color
*Lonicera involucrata**	Black twinberry	Partial shade/ Shade	2-8 feet	Moist soils; prefers loamy soils; tolerant of shallow flooding; yellow, tubular flowers attract hummingbirds
*Myrica californica**	Pacific wax myrtle	Sun/partial shade	To 30 feet	Evergreen shrub preferring moist soils; inconspicuous spring flowers; drought tolerant; if drought tolerance is not an issue try the smaller Washington native, *Myrica gale**
*Physocarpus capitatus**	Pacific ninebark	Sun/partial shade	6-13 feet	Moist or dry soils; drought tolerant; snowball shaped; white flowers; seeds persist into winter

Species	Common Name	Exposure	Mature Size/Spread	Comments
Shrubs (continued)				
*Rosa pisocarpa**	Clustered wild rose	Sun/partial shade	6-8 feet	Moist soils, tolerates seasonal flooding but also tolerant of dry conditions; pink clustered flowers; fruits persist
Salix purpunea 'Nana'	Dwarf Arctic willow	Sun/partial shade	3-5 feet	Grows well in poor soils; moderately drought tolerant; small yellow flowers in the fall
*Spiraea douglasii**	Douglas spirea, Steeplebush	Sun/partial shade	4-7 feet	Moist or dry, to seasonally inundated soils; spikes of small, pink flower clusters
Emergents				
*Carex obnupta**	Slough sedge	Sun/partial shade	1-5 feet	Moist to seasonally saturated soils; shiny foliage; excellent soil binder; drought tolerant
*Carex stipata**	Sawbeak sedge	Partial shade	10 inches-3 feet	Wet soils; excellent soil binder
*Juncus effusus**	Common rush	Sun/partial shade	1-2 feet	Wet soils; evergreen perennial; hardy and adaptable; drought tolerant; small, non-showy flowers
*Juncus ensifolius**	Daggerleaf rush	Sun	12-18 inches	Wet soils; shallow water; excellent soil binder
*Juncus tenuis**	Slender rush	Sun	.5–2.5 feet	Moist soils; tufted perennial
*Scirpus acutus**	Hardstem bulrush	Sun	4-8 feet	Wet soils; favors prolonged inundation; excellent soil binder
*Scirpus microcarpus**	Small-fruited bulrush	Sun/shade	2-4 feet	Wet soils; tolerates prolonged inundation; good soil binder; drought tolerant

Source: Adapted from PSAT 2005.
* Denotes native plant species.

Table E-6. Plant Species Appropriate for Bioretention Facility Areas Subject to Periodic Saturation During Large Storms (Zone 2)

Species	Common Name	Exposure	Mature Size	Comments
Trees				
Acer truncatum	Pacific sunset maple	Sun	To 25 feet/ 20 ft. spread	Prefers moist, well-drained soils, but drought tolerant; very cold hardy; deciduous tree with moderate growth rate
*Amelanchier alnifolia**	Western serviceberry	Sun/partial shade	10-20 feet/ 25 ft. spread	Moist to dry, well-drained soils; drought tolerant; large white flowers; purple to black berries; deciduous
*Corylus cornuta**	Beaked hazelnut	Sun/partial shade	20–30 feet/ 15 ft. spread	Moist, well-drained soils; edible nuts; intolerant of saturated soils; catkins throughout winter add interest; deciduous
*Crataegus douglasii**	Black hawthorn	Sun/partial shade	3-30 feet/ 25 ft. spread	Moist to dry, well drained, gravelly soils; small white flowers, black berries; 1 inch spines; forms thickets; deciduous
Fraxinus oxycarpa	Raywood ash	Sun	25-50 feet/ 25 ft. spread	Drought tolerant; grows in varying soil types; deciduous; can take extreme temperatures; does not tolerate constant wind or fog; resists pests and disease better than other non-native ashes; inconspicuous flowers
*Rhamnus purshiana**	Cascara sagrada	Sun/shade	20-40 feet/ 25 ft. spread	Moist to fairly dry soils; small greenish-yellow flowers; deciduous; sensitive to air pollution; yellow fall color
*Salix scouleriana**	Scouler willow	Sun/partial shade	6-40 feet/ 15 ft. spread	Moist to dry soils; drought tolerant; deciduous tree; do not plant near paved surfaces or underground structures
*Salix sitchensis**	Sitka willow	Sun/partial shade	3-26 feet/ 25 ft. spread	Moist soils; tolerates seasonal flooding; deciduous tree; do not plant near paved surfaces or underground structures
*Thuja plicata**	Western red cedar	Partial shade/shade	200 feet+/ 60 ft. spread	Moist to swampy soils; tolerates seasonal flooding and saturated soils; long-lived; prefers shade while young
Shrubs – Deciduous				
*Acer circinatum**	Vine maple	Filtered sun/shade	To 25 feet	Dry to moist soils; tolerant of shade and clay soils; excellent soil binder; beautiful fall color
Hamamelis intermedia	Diane witchhazel	Sun/partial shade	10-20 feet/ 10 ft. spread	Moist, fertile, acidic soil; showy fall color – yellow to yellow-orange; long-lasting, slightly fragrant, coppery-red flowers; not drought tolerant; may require watering in dry season

Species	Common Name	Exposure	Mature Size	Comments
Shrubs – Deciduous (continued)				
*Oemleria cerasiformis**	Indian plum/Osoberry	Sun/partial shade	5-16 feet	Moist to dry soils; prefers shade; tolerates fluctuating water table
Philadelphus x lemoinei	'Belle Etoile' Mock-orange	Sun/partial shade	5-6 feet	Prefers moist, well-drained soils, high in organic matter, but soil and pH adaptable; easily transplanted and established; fragrant, large white flowers, tinged red at the base; other cultivars available
*Ribes lacustre**	Black swamp gooseberry	Partial shade	1.5–3 feet	Moist soils; deciduous shrub; reddish flowers in drooping clusters; dark purple berries; *R. divaricatum** (Wild gooseberry) grows to 5 feet and is also an option; attracts butterflies, but is very thorny
*Rosa nutkana**	Nootka rose	Sun/partial shade	6-10 feet	Moist to fairly dry soils; tolerates inundation and saturated soils; aggressive spreader; fruits persist; less thorny that *R. rugosa*
Rosa rugosa	Rugosa rose	Sun	To 8 feet	Drought resistant; hardy, vigorous and aggressive; highly prickly; fragrant white to purple flowers; fruits persist
*Rubus parviflorus**	Thimbleberry	Sun/partial shade	4-10 feet	Moist to dry soils; white flowers; red berries; makes thickets and spreads easily
*Rubus spectabilis**	Salmonberry	Partial sun/shade	5-10 feet	Prefers moist, wet soils; good soil binder; magenta flowers; yellow/ orange fruit; early nectar source for hummingbirds; makes thickets
*Sambucus racemosa**	Red elderberry	Partial sun/partial shade	To 20 feet	Moist to dry soils; small white flowers; bright red berries; vase shaped; pithy stems lead to "messy" form – prune for tidiness
*Symphoricarpos albus**	Snowberry	Sun/shade	2-6 feet	Wet to dry soils, clay to sand; excellent soil binder; drought and urban air tolerant; provides good erosion control; spreads well in sun; white berries; flowers attract hummingbirds
*Vaccinium parvifolium**	Red huckleberry	Partial shade/shade	4-10 feet	Slightly moist to dry soils; prefers loamy, acid soils or rotting wood; tolerant of dry, shaded conditions; red fruit; tricky to transplant

Herbaceous				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Aquilegia formosa** / Western columbine	Sun/partial shade	1-3 feet	Spring	Moist soils of varying quality; tolerant of seasonal flooding; red and yellow flowers attract hummingbirds and butterflies
*Asarum caudatum** / Wild ginger	Partial shade/shade	To 10 inches	Mid spring	Moist organic soils; heart-shaped leaves; reddish-brown flowers
*Aster chilensis** / Common California aster	Sun	1.5 – 3 feet	June - September	Moist soils; white to purple flowers
*Aster subspicatus** / Douglas aster	Sun	.5 – 2.5 feet	June - September	Moist soils; blue to purple flowers
*Camassia quamash** / Common camas	Sun/partial shade	To 2.5 feet	May - June	Moist to dry soils; lots of watering needed to establish; loose clusters of deep blue flowers
Camassia leichtlinii / Giant camas		2–4 feet	May - June	Moist to dry soils; lots of watering to establish; large clusters of white, blue or greenish-yellow flowers
*Iris douglasiana** / Pacific coast iris	Sun/partial shade	1-2 feet	Spring	Tolerates many soils; withstands summer drought and seasonal flooding; white, yellow, blue, reddish purple flowers; fast growing; velvety purple flowers; vigorous
Iris foetidissima / Gladwin iris	Sun/partial shade	1-2 feet	May	Moist to dry, well-drained soils; pale lilac flower; also called Stinking Iris
*Juncus tenuis** / Slender rush	Sun	6 inches – 2.5 feet		Moist soils; yellow flowers
Iris sibirca / Siberian Iris	Sun	1-2.5 feet	Late spring – early summer	Moist soils; deep blue, purple to white flowers
*Tellima grandiflora** / Fringecup	Partial sun/shade	1-3 feet	March - June	Perennial preferring moist soils; yellowish-green to pink flowers
*Tiarella trifoliata** / Foamflower	Partial sun/shade	To 1 foot	Early - mid summer	Moist soils; perennial with some drought tolerance after established; can form dense colonies; white flowers
*Tolmiea menziesii** / Youth-on-age/Piggy-back plant	Partial shade/shade	1-2 feet	April - August	Moist soils; brownish-purple flowers; also makes and effective groundcover
Viola species* / Violets	Partial shade/shade	6-12 inches	Late spring – early summer	Moist soils; yellow to blue flowers

Table E-7. Plant Species Appropriate for Rarely Inundated Areas of Bioretention Facility (Zone 3)

Trees				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Arbutus unedo / Strawberry tree	Sun/partial shade	8-35 feet/ 8-20 ft. spread	November - December	Tolerant of extremes; tolerant of urban/ industrial pollution; white or greenish white flowers
*Calocedrus decurrens** / Incense cedar	Sun	75-90 feet/ 12 ft. spread		Tolerant of poor soils; drought tolerant after established; fragrant evergreen with a narrow growth habit; slow growing
Chamaecyparis obtusa / Hinoki false cypress	Sun/partial shade	40-50 feet/ 15-30 ft. spread		Moist, loamy, well-drained soils; very slow growing; prefers sun, but tolerates shade; does not transplant well or do well in alkaline soils. Note there are
				many alternative varieties of false cypress of varying sizes and forms from which to choose
Cornus spp. / Dogwood	Sun/partial shade	20-30 feet/ 30 ft. spread	May	Reliable flowering trees with attractive foliage and flowers; may need watering in dry season; try *C. florida* (Eastern dogwood), or *C. nuttallii** (Pacific dogwood) or hybrid 'Eddie's White Wonder'. Also, *C. kousa* for small tree/ shrub which is resistant to anthracnose
Pinus mugo / Swiss mountain pine	Sun/partial shade	15-20 feet/ 25-30 ft. spread		Prefers well-drained soil; slow growing, broadly spreading, bushy tree; hardy evergreen
Pinus thunbergiana / Japanese black pine	Sun	To 100 feet/ 40 ft. spread		Dry to moist soils; hardy; fast growing
*Prunus emarginata** / Bitter cherry	Sun/partial shade	20-50 feet/ 20 ft. spread	May - June	Dry or moist soils; intolerant of full shade; bright red cherries are attractive to birds; roots spread extensively
Prunus virginiana / Choke cherry		15-25 feet/ 15-20 ft. spread	Late spring – Early summer	Dry or moist soils; deep rooting; attractive white fragrant flowers; good fall color
*Pseudotsuga menziesii** / Douglas-fir	Sun	100-250 feet/ 50-60 ft. spread		Does best in deep, moist soils; evergreen conifer with medium to fast rate of growth; provides a nice canopy, but potential height will restrict placement
*Quercus garryana** / Oregon white oak	Sun	To 75 feet		Dry to moist, well-drained soils; slow growing; acorns

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Holodiscus discolor** / Oceanspray	Sun/partial shade	To 15 feet	June - July	Dry to moist soils; drought tolerant; white to cream flowers; good soil binder
*Mahonia aquifolium** / Tall Oregon grape	Sun/partial shade	6-10 feet	March - April	Dry to moist soils; drought resistant; evergreen; blue-black fruit; bright yellow flowers; 'Compacta' form averages 2 feet tall; great low screening barrier
*Philadelphus lewisii** / Mock-orange	Sun/partial shade	5-10 feet	June - July	Adapts to rich moist soils or dry rocky soils; drought tolerant; fragrant flowers

▶ ZONE 3

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pinus mugo pumilio / Mugho pine	Sun	3-5 feet/ 4-6 ft. spread		Adapts to most soils; slow growing and very hardy; newer additions with trademark names such as 'Slo-Grow' or 'Lo-Mound' are also available
Potentilla fruticosa / Shrubby cinquefoil	Sun	To 4 feet	May - September	Moist to dry soils; several cultivars available with varying foliage and flower hues; try 'Tangerine' or 'Moonlight'
*Ribes sanguineum** / Red-flowering currant	Sun/partial shade	8-12 feet	March - April	Prefers dry soils; drought tolerant; white to deep-red flowers attract hummingbirds; dark-blue to black berries; thornless
*Rosa gymnocarpa** / Baldhip rose	Partial shade	To 6 feet	May - July	Dry or moist soils; drought tolerant; small pink to rose flowers

Shrubs-Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Abelia x grandiflora / Glossy abelia	Partial Sun/Partial shade	To 8 feet/ 5 foot spread	Summer	Prefers moist, well-drained soils, but drought tolerant; white or faintly pink flowers
Arbutus unedo 'Compacta' / Compact strawberry tree	Sun/partial shade	To 10 feet	Fall	Prefers well drained soils; tolerant of poor soils; good in climate extremes; white to greenish-white flowers; striking red-orange fruit

Cistus purpureus / Orchid rockrose	Sun	To 4 feet	June - July	Moist to dry well-drained soils; drought resistant; fast growing; reddish purple flowers
Cistus salvifolius / White rockrose	Sun	2-3 feet/ 6 ft spread	Late spring	Moist to dry well-drained soils preferred, but can tolerate poor soils; tolerant of windy conditions and drought; white flowers
Escallonia x exoniensis 'fradesii' / Pink Princess	Sun/partial sun	5-6 feet	Spring - Fall	Tolerant of varying soils; drought tolerant when established; pink to rose colored flowers; good hedge or border plant; attracts butterflies
Osmanthus delavayi / Delavay Osmanthus	Sun/partial shade	4-6 feet	March - May	Tolerant of a broad range of soils; attractive foliage and clusters of white fragrant flowers; slow growing
Osmanthus x burkwoodii / Devil wood	Sun/partial shade	4-6 feet	March - April	Drought tolerant once established; masses of small, white fragrant flowers
Rhododendron / 'PJM' hybrids	Sun/partial shade	To 4 feet	Mid – late April	Moist to fairly dry soils; well drained organic soil; lavender to pink flowers
Stranvaesia davidiana	Sun	6-20 feet	June	Moist soils; white flowers in clusters; showy red berries
Stranvaesia davidiana / undulata	Sun	To 5 feet	June	Moist soils; lower growing irregularly shaped shrub; great screening plant
Vaccinium ovatum* / Evergreen huckleberry	Partial shade/ shade	3-15 feet	March	Moist to slightly dry soils; small pinkish-white flowers; berries in August

▶ ZONE 3

Groundcover – Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Arctostaphylos uva-ursi** / Kinnikinnik	Sun/partial shade		April - June	Prefers sandy/rocky, well-drained soils; flowers pinkish-white; bright red berries; slow to establish; plant closely for good results
*Gaultheria shallon** / Salal	Partial shade/ shade	3-7 feet	March - June	Dry and moist soils; white or pinkish flowers; reddish-blue to dark-purple fruit
*Fragaria chiloensis** / Wild/Coastal strawberry	Sun/partial shade	10 inches	Spring	Sandy well drained soils; flowers white; small hairy strawberries; evergreen; aggressive spreader

Helianthemum nummularium / Sunrose	Sun	To 2 feet/ 2 ft. spread	May - July	Prefers well-drained soils, but will tolerate various soils; low-growing, woody sub shrub; many varieties are available with flowers in salmon, pink, red, yellow and golden colors
Lavandula angustifolia / Lavender	Sun/partial shade	To 1.5 feet	June - August	Adaptable to various soils; blue, lavender, pink to white flowers, semi-evergreen aromatic perennial
*Mahonia nervosa** / Cascade Oregon grape/Dull Oregon grape	Partial shade/ shade	To 2 feet	April – June	Dry to moist soils; drought resistant; evergreen; yellow flowers; blue berries
Mahonia repens / Creeping mahonia	Sun/partial shade	3 feet	April - June	Dry to moist soils; drought resistant; yellow flowers; blue berries; native of Eastern Washington
*Penstemon davidsonii** / Davidson's penstemon	Sun	To 3 inches	June - August	Low growing evergreen perennial; prefers well-drained soils; drought tolerant; blue to purple flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Achillea millefolium** / Western yarrow	Sun	4 inches – 2.5 feet	June - September	Dry to moist, well-drained soils; white to pink/reddish flowers; many other yarrows are also available
Anaphalis margaritaceae / Pearly everlasting	Sun/partial shade	To 18 inches		Drought tolerant perennial; spreads quickly; attracts butterflies
*Bromus carinatus** / Native California brome	Sun/partial shade	3-5 feet		Dry to moist soils; tolerates seasonal saturation
Carex buchannii / Leather leaf sedge	Sun/partial shade	1-3 feet		Prefers well-drained soils; copper-colored foliage; perennial clumping grass; tolerant of a wide range of soils; inconspicuous flowers
Carex comans / 'Frosty curls' New Zealand hair sedge	Sun/partial shade	1-2 feet	June -August	Prefers moist soils; finely textured and light green; compact, clumping perennial grass; drought tolerant when established; inconspicuous flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Coreopsis spp. / Tick-Seed	Sun	1-3 feet		Dry to moist soils; drought tolerant; seeds attract birds; annual and perennial varieties; excellent cut flowers
Echinacea purpurea / Purple coneflower	Sun	4-5 feet		Prefers well drained soils; hardy perennial; may need occasional watering in dry months
*Elymus glaucus** / Blue wildrye	Sun/partial shade	1.5-5 feet		Dry to moist soils; shade tolerant; rapid developing, but short lived (1-3 years); not good lawn grass
*Dicentra formosa** / Pacific bleeding-heart	Sun/shade	6-20 inches	Early spring - early summer	Moist, rich soils; heart-shaped flowers
*Erigeron speciosus** / Showy fleabane	Sun/partial shade	To 2 feet	Summer	Moist to dry soils; dark violet or lavender blooms; fibrous roots
Festuca ovina 'Glauca' / Blue fescue	Sun/partial shade	To 10 inches	May - June	Prefers moist, well-drained soils; blue-green evergreen grass; drought tolerant; shearing will stimulate new growth
*Festuca idahoensis** / Idaho fescue	Sun/partial shade	To 1 foot		Bluish-green bunching perennial grass; drought tolerant
*Fragaria vesca** / Wood strawberry	Partial shade	To 10 inches	Late spring - early summer	Dry to moist soils; white flowers
Gaura lindheimeri / Gaura	Sun	2.5-4 feet		Perennial; fairly drought tolerant and adaptable to varying soil types; long blooming period
*Geum macrophyllum** / Large-leaved avens	Sun/partial shade	To 3 feet	Spring	Moist, well-drained soil; bright yellow flowers; other Geum cultivars available, some which may require supplemental watering
Geranium maculatum / Spotted geranium	Sun/shade	To 1.5 feet	July	Moist, well-drained soils; low perennial; pale pink, blue to purple flowers
Geranium sanguineum / Cranesbill	Sun/partial shade	To 1.5 feet	May - August	Moist soils; deep purple almost crimson flowers
Helichrysum italicum / Curry Plant	Sun	To 2 feet	Summer	Moist or dry soils; hardy evergreen perennial; a good companion to lavender; bright yellow flowers; fragrant

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Helictotrichon sempervirens / Blue oat grass	Sun/partial shade	1-1.5 feet	June - August	Tolerant of a variety of soil types but prefers well-drained soil; clumping bright blue evergreen grass; bluish white flowers
Hemerocallis fulva / Day lilies	Sun/partial shade	1-4 feet	Summer	Tolerant of a variety of soil types; easy to grow and tolerant of neglect; hardy perennial; entire plant is edible
Heuchera americana / Coral bells (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist to dry, well-drained soils; never wet; easily transplantable perennial; red, greenish-white flowers; may need supplemental watering in dry season
Heuchera micrantha / 'Palace purple' (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist, well-drained soils; bronze to purple foliage in shade; small, yellowish-white flowers; perennial, evergreen; a number of other species and varieties are available. Try *H. sanguinea* for bright red flowers
*Lupinus** spp. / Lupines	Sun	3-5 feet	March - September	Moist to dry soils; various native varieties; blue to purple, violet to white flowers; both native and non-native varieties
*Lupinus bicolor** / Two-color lupine	Sun	4 inches - 1.5 feet	Spring	Dry gravelly soils; small-flowered; annual
*Lupinus latifolius** / Broadleaf lupine	Sun	To 1 foot	June - August	Dry to moist soils; perennial; bushy herb; bluish flowers
*Lupinus polyphyllus** / Large-leafed lupine	Sun	To 3 feet	Spring - summer	Dry to moist, sandy to gravelly soils; perennial
*Maianthemum dilatatum** / False lily-of-the-valley	Partial shade/ shade	3-12 inches	Spring	Prefers moist soils; small, white flowers; light-green to red berries
Pennisetum alopecuroides / Fountain grass	Sun/partial shade	1-2 feet	August - September	Moist, well-drained soils; tolerant of many soil types; clump-forming grasses. A number of varieties are available in different heights and bloom times. Try *P. caudatum* (White-flowering fountain grass) and *P. alopecuroides* cultivars 'Hameln' and 'Little Bunny' (Dwarf fountain grass)

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pennisetum orientale / Oriental fountain grass	Sun/partial shade	1-3 feet	June - October	Prefers moist, well-drained soils; somewhat drought tolerant; small clumping, blooming grass, showy pink flowers; fountain grasses will benefit from annual shearing in late winter/early spring, but not required
Penstemon fruticosus / Shrubby penstemon	Sun	8–10 inches	May	Prefers well-drained soils; evergreen perennial; drought tolerant; violet-blue flowers 1 inch long attract hummingbirds
*Polystichum munitum** / Swordfern	Partial shade/ Deep shade	2-4 feet		Prefers moist, rich soil conditions, but drought tolerant; large evergreen fern
*Potentilla gracilis** / Graceful cinquefoil	Sun	1-2 feet	July	Moist to dry soils; yellow flowers
Rudbeckia hirta / Black-eyed susan	Sun/partial shade	3-4 feet	Summer	Moist to dry soils; showy flowers, hardy and easy to grow; several other varieties are available
*Smilacina racemosa** / False Solomon's seal	Partial sun/shade	1-3 feet	April - May	Moist soils; creamy white flowers; red berries