LID Technical Workshop – Puget Sound

Bioretention: Design and Construction

Presentation Overview

Bioretention Components
Design by Component
Layout, Elevation & Grade
Construction Considerations

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BIORETENTION COMPONENTS

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- Pre-Settling / Flow Entrance
- Ponding Area
- Bioretention Soil
- Mulch/Co
- Vegetation
- Underdrain (optional)
- Filter Fabric (?)
- Overflow

PRE-SETTLING

DESIGN CRITERIA / TYPES

- Pre-settling preceding facility
  - e.g., vegetated filter strip, catch basin
- To reduce potential for clogging of bioretention soil
- May be required:
  - For larger drainage areas
  - Where sediment loading is expected (e.g., high-use parking lots and roadways)

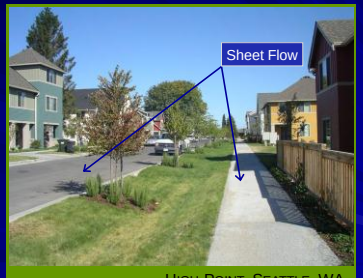
Flow Entrance

Design Criteria / Types

- Flow entering should be non-erosive
  - Velocity less than 1.0 fps
- Dispersed/low velocity flow entrance
  - e.g., vegetated buffer strip, sheet flow, between wheel stops or wide curb cuts
  - **Preferred!**
- Concentrated flow entrance
  - e.g., piped, rock channel, narrow curb cuts
  - Requires erosion protection (e.g., rock) in entrance

Flow Entrance

Field Examples



High Point, Seattle, WA

Flow Entrance

Field Examples

Pinehurst, Seattle, WA

Coupeville High School
Coupeville, WA

Flow Entrance

Field Examples

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Finish grade should be lower than inlet to allow for settling

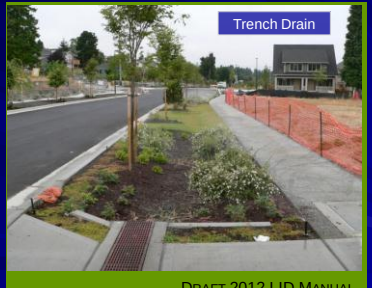
Flow Entrance

Field Examples

SW 12th Avenue Green Street, Portland, OR

Flow Entrance

Field Examples



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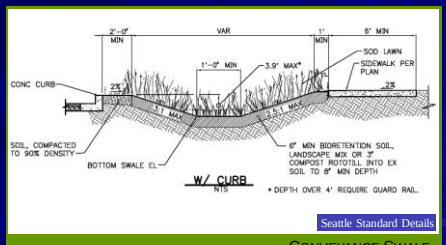
Flow Entrance

Design Resources

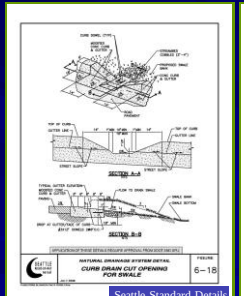


Seattle Standard Details

Conveyance Swale

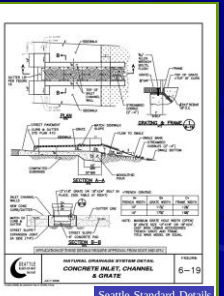
Flow Entrance

Design Resources



Seattle Standard Details

Curb Cut



Seattle Standard Details

Channel with Grate

Ponding Area

Ponding Reservoir Types

High Point, Seattle, WA

Earthen Depression

Portland, OR

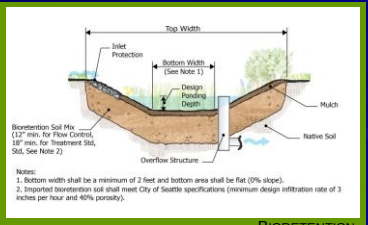
Concrete Reservoir

PONDING AREA

DESIGN/PERFORMANCE

Without Underdrain

- Earthen depression (w/o liner) or open-bottomed planter
- Relies on infiltration to native soil
- Can provide effective flow control and WQ treatment



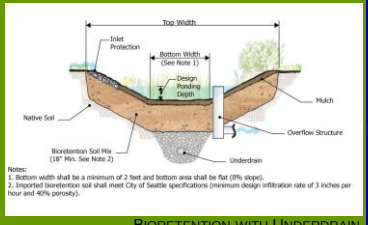
BIORETENTION

PONDING AREA

DESIGN/PERFORMANCE

With Underdrain

- Some infiltration to native soil (w/out liner)
- Cannot meet forest duration flow control (orifice improves performance)
- Can provide effective WQ treatment



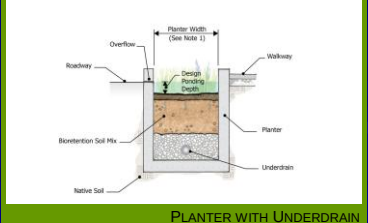
BIORETENTION WITH UNDERDRAIN

PONDING AREA

DESIGN/PERFORMANCE

With Underdrain & Liner/Impermeable Container

- No infiltration to native soil
- Typically provides minimal flow control (orifice improves performance)
- Can provide effective WQ treatment



PLANTER WITH UNDERDRAIN

Ponding Area

Sizing Criteria

- Stormwater Management Standards
  - Flow control standards (peak/duration)
  - Water quality standards (infiltrate 91% runoff volume)
- Max. surface pool drawdown time (24 hours)
  - Soil allowed to dry out periodically
  - Restore hydraulic capacity of system
  - Maintain adequate soil oxygen levels
  - Prevent conditions supportive of mosquito breeding

*Surface Pool Drawdown=
Ponding Depth ÷ Design Infiltration Rate

Ponding Area

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*Surface Pool Drawdown=
Ponding Depth ÷ Design Infiltration Rate
Ex. 6 inch ÷ 0.25 inch/hour = 24 hours

Ponding Area

Size a Function of:

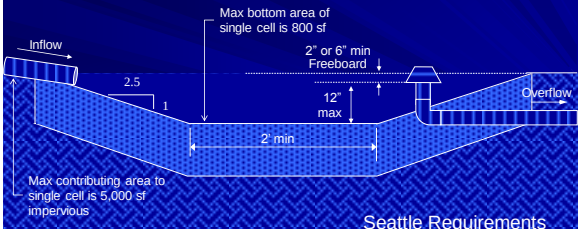
Smaller Footprint

- Contributing area → Smaller
- Site precipitation → Lower
- Native soil infiltration rate → Higher
- Ponding depth → Deeper
- BR Soil depth → Deeper

Ponding Area

Cross Section Criteria

- Max ponding depth
- Min bottom width
- Max planted side slope
- Min freeboard
- Max contributing area (or bottom area)?



Seattle Requirements

Ponding Area

Roadway Facilities

Roadway Cross Section

- 2-foot shoulder
- Grade at 3H:1V (4H:1V at intersections)

Ponding Area

Roadway Facilities

Fixed Object Hazards

- Rockery >1' high, min 10' from curb/edge of road
- Rockery <1' high min 5' from curb/edge of road

Ponding Area

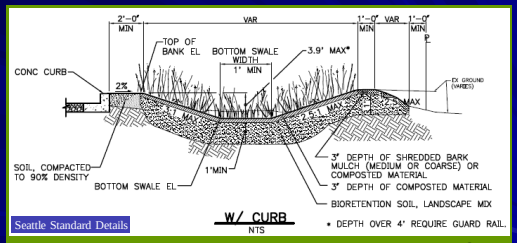
Roadway Facilities

Maximum Facility Drop

Max 4' drop from vehicular lane

Ponding Area

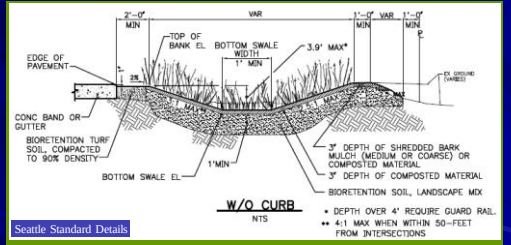
Design Resources



Bioretention with Curb

Ponding Area

Design Resources



Bioretention without Curb

BIORETENTION SOIL

OVERVIEW

- Purpose
  - Supports plants & microbes
  - Removes pollutants
- Options
  - Amend Native soils in place
  - Over excavate and place imported soil
- Minimum soil depth
  - 12 inches for flow control
  - 18/24 inches for water quality treatment

BIORETENTION SOIL

OVERVIEW

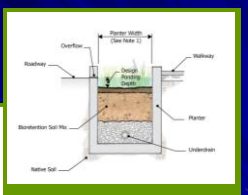
- For treatment → meet Ecology trtmnt soil rqmnts
  - Minimum CEC= 1me/mg
  - Minimum organic matter content = 1%
  - Maximum infiltration rate
- Specifications and proper installation critical
- Seattle BRS specification
  - 40% porosity
  - Short-term infiltration rate of 6 inches / hour
  - Design rate of 3 inches / hour (for contributing areas up to 5,000 sf)

MULCH/COMPOST

OVERVIEW

- Purpose
  - Reduces weed establishment
  - Regulates soil temp & moisture
  - Adds organic matter to soil
  - Attenuates heavy metals
- Composition
  - Compost in the bottom of the facilities
  - Wood chip mulch composed of shredded or chipped hardwood / softwood on cell slopes
- Depth
  - Max 3 inches compost or 4 inches wood chips

UNDERDRAINS



PLANTER WITH UNDERDRAIN

BIORETENTION WITH UNDERDRAIN

UNDERDRAINS

DO YOU NEED THEM? WHY? WHEN?

BROADVIEW GREEN GRID, SEATTLE, WA

- Infiltration not permitted
- Near sensitive infrastructure that may flood
- Soil infiltration rates not adequate to meet maximum pool and system drawdown rates

UNDERDRAINS

WHAT SEATTLE USES:

PVC Slotted Pipe with Aggregate Filter Blanket

- Slotted, thick-walled plastic pipe
  - Minimum 4" diameter Schedule 40 PVC
- Slot openings
  - Smaller than smallest aggregate gradation of filter material
  - Slots perpendicular to long axis of pipe
- Gravel Filter Material
  - City of Seattle Mineral Aggregate Type 26 (sandy gravel)
- NOT wrapped in filter fabric

Note: If using City of Seattle Mnrl Agg 26, slots shall be 0.069 inches by 1-inch long, spaced 0.125 inches apart. Slots arranged in four rows spaced on 45-degree centers.

UNDERDRAINS

WHAT SEATTLE USES:

PVC Slotted Pipe

Filter Material (Ag 26)

BR Soil

UNDERDRAINS

WHY SEATTLE USES IT:

- Increased media area provides better filtering
- Reduced potential for clogging
- Easier to clean (e.g., rotary cutter or water jet)

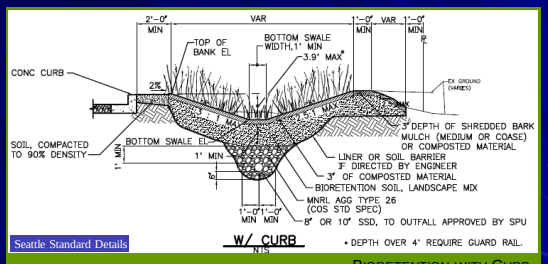
UNDERDRAINS

DESIGN CONTINGENCY

- Design with access for future modification
  - Cap drain pipe
  - Throttle flows with orifice
- Raised underdrain
  - Maximize infiltration
  - Denitrification

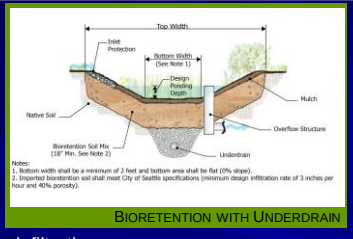
UNDERDRAINS

DESIGN RESOURCES



BIORETENTION WITH CURB

FILTER FABRIC????



BIORETENTION WITH UNDERDRAIN

- Inhibits infiltration
- Potential for clogging
- Gradation difference between bioretention soil and native soil is typ. small so no migration of fines
- Can use aggregate blanket between soil and underdrain

OVERFLOW

DESIGN CRITERIA/TYPES

- Typically required unless designed for full infiltration
- Overflow set at max. ponding depth
- Directed to downstream BMP or approved discharge pt
- Surface Overflow Types
  - Sheet flow, gravel level spreader, exit curb cut / trench drain
- Subsurface Overflow Types
  - Catch basin, stand pipe or pipe
- Sizing
  - Conveyance sized for local jurisdiction level of service
  - Consider larger overflows (e.g., grade so overflows to ROW)

OVERFLOW

FIELD EXAMPLES

TIGHTLINE

EXIT CURB CUT TRENCH DRAIN

OVERFLOW

FIELD EXAMPLES

STAND PIPE WITH BEEHIVE GRATE

OVERFLOW

FIELD EXAMPLES

SHEET FLOW OVERFLOW

*grade to direct overflow via sheet flow

Layout Options

Single Cell →
Series of Connected Cells ↓

Series

Single

Elevations and Grade

Design Considerations

- Cross Slope
  - Larger footprint area and berming or wall(s) to achieve ponding area
- Longitudinal Slope (series of flat-bottomed cells)
  - Optimum slope is 2% / Maximum slope = 8%
  - Steep slopes: control gradient with intermittent weirs or berms or standpipe overflow to provide ponding and dissipate energy
  - Flat slopes: may need weir to create ponding
- Need positive grade for gravity flow
  - Inflow from contributing area to bioretention cell
  - Overflow from bioretention cell

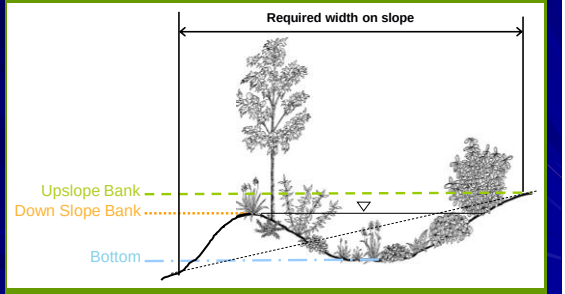
Elevations and Grade

Cross Slope

Broadview Green Grid, Seattle, WA

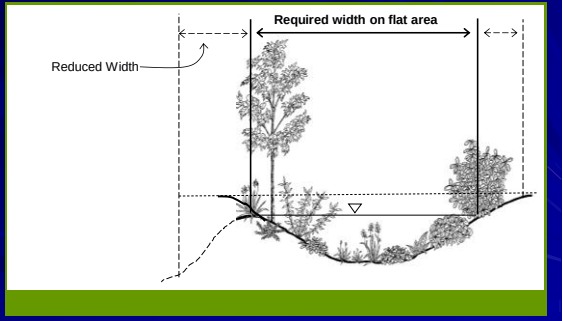
Elevations and Grade

Cross Slope



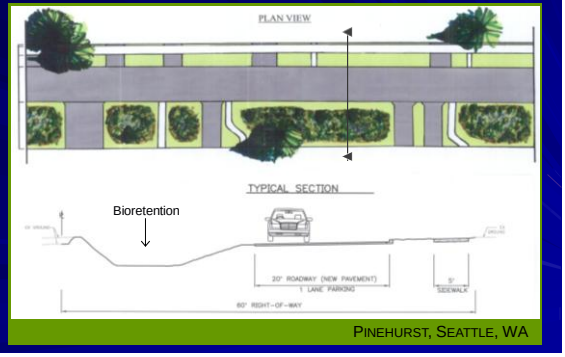
Elevations and Grade

Cross Slope



Elevations and Grade

Cross Slope



Pinehurst, Seattle, WA

Elevations and Grade

Longitudinal Slope- Series of Flat-Bottomed Cells

- Mild Slope
  - Can use earthen berms to create ponding
- Steep Slope
  - Can use weirs / standpipe overflow to create ponding
  - Control gradient
  - Dissipate energy/reduce velocities
- Flat Slopes
  - Can use weirs to create ponding on flat surface

Elevations and Grade

Mild Longitudinal Slope

Mild Longitudinal Slopes

Elevations and Grade

Steeper Longitudinal Slope

Steep Longitudinal Slopes

Elevations and Grade

Steep Longitudinal Slope

Steep Longitudinal Slopes

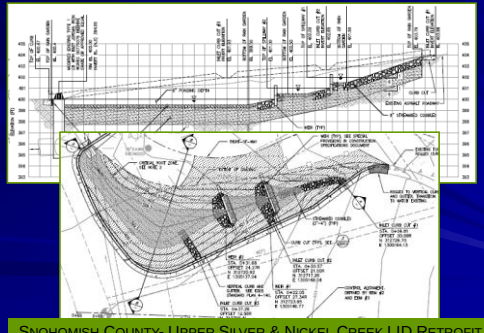
Elevations and Grade

Flat Longitudinal Slope

Flat Longitudinal Slopes

Elevations and Grade

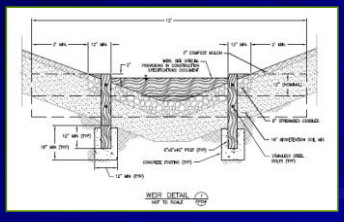
Design Example- Longitudinal Slope (Weirs)



Snohomish County- Upper Silver & Nickel Creek LID Retrofit

Elevations and Grade

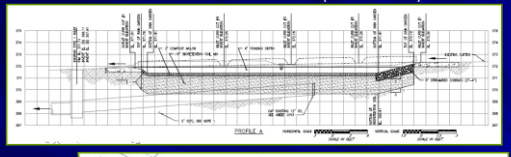
Design Example- Longitudinal Slope (Weirs)

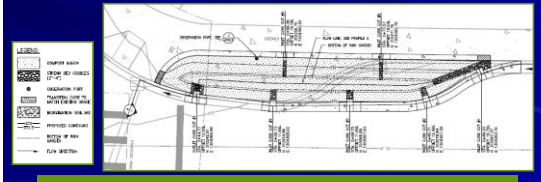


Snohomish County- Upper Silver & Nickel Creek LID Retrofit

Elevations and Grade

Design Example- Longitudinal Slope (Curb Cuts)





Snohomish County- Upper Silver & Nickel Creek LID Retrofit

Construction Considerations

- Minimize site disturbance
- Tree protection
- Preventing over compaction
- Erosion and sediment control
- Construction sequencing (covered tomorrow)

Construction Considerations

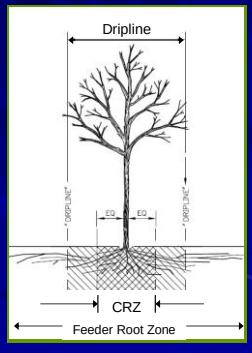
Tree Protection

- Trees are valuable!
- Arborist evaluation
- Valuation posted on each tree
- Vegetation protection in TESC

Construction Considerations

Tree Protection

- Critical Root Zone (CRZ) →
  - No disturbance
  - Arborist present for construction in CRZ
- Dripline →
  - Fence during construction
- Feeder Root Zone →
  - Limit heavy equipment/ stockpiling
  - Limit Trenching
- Utility Boring
  - Tunnel/bore under trees to avoid open cut trench through CRZ and dripline



Construction Considerations

Back-Up Plan for Native Soil Variability

- Do they look like test pit?
- If lower permeability:
  - Increase size
  - Over-ex and add more BR soil
  - Increase ponding depth (if drawdown can be maintained)
  - Add underdrain

Broadview Green Grid, Seattle, WA

Construction Considerations

Vehicular Loading Prism- Some Compaction is Necessary

For road or parking lot stability, need heavily compacted from road prism-2H:1V from edge

High Point, Seattle, WA

Construction Considerations

Preventing Over-Compaction

- Prevent over compaction CRITICAL FOR PERFOMANCE
- No excavation, soil placement, or soil amendment during wet or saturated conditions
- Operate equipment adjacent to (not in) the facility
- If machinery must operate in the facility, use light weight, low ground-contact pressure equipment

Construction Considerations

Scarify Native Soil

Cell base scarified at subgrade to refracture soil

Construction Considerations

Erosion and Sedimentation Control

- Protect adjacent properties
- Protect public waterways and storm systems
- Protect installed work
- Protect infiltration systems including swales, soils and porous pavement

High Point, Seattle, WA

Resources

- Low Impact Development Technical Guidance Manual for Puget Sound
  http://www.pierce.wsu.edu/water_quality/LID/LID_manual2005.htm
- Rain Garden Handbook for WWA Homeowners
  http://www.pierce.wsu.edu/water_quality/LID/raingarden_handbook.pdf
- Seattle Public Utilities GSI
  http://www.seattle.gov/util/greeninfrastructure
- Seattle Stormwater Manual
  http://www.seattle.gov/dclu/codes/dr/DR2009-17.pdf
- Seattle Right-of-Way Improvements Manual
  http://www.seattle.gov/transportation/rowmanual/manual/
- Portland Sustainable Stormwater
  http://www.portlandonline.com/bes/index.cfm?c=34598

Seattle Design Review

Technology Description

A bioretention cell is a shallow depression with a designed soil mix and plants, with or without an underdrain. See Figures 4.7 and 4.8 of the Manual. Bioretention cells may be connected in series, with the overflows of upstream cells directed to downstream cells.

Infiltration Feasibility Requirements (Manual Volume 3, Section 4.3.4)

	Review Item
FC	1. Facility is not within landslide-prone areas as defined by the Regulations for Environmental Critical Areas (SMC 25.09) and shown on the Critical Areas theme of GIS.
FC	2. Facility is not located in areas likely to have excessive sediment contamination (such as areas to be sanded) or high potential for concentrated pollutant spills.
FC	3. For projects located on arterial streets and/or in areas of dense underground infrastructure, the facility is limited to the sidewalk and planting strip area only and only receives sidewalk runoff, unless otherwise approved by SPU.
FC	4. Infiltration is typically not permitted within any of these specified setbacks:
	• Within the top of steep sloped areas, as defined by the Regulations for Environmental Critical Areas (SMC 25.09) and shown on the Critical Areas theme of GIS, calculated as 10 times the slope rise (to a 500 foot maximum) unless demonstrated as feasible by geotechnical analysis
	• Within 5 feet from property lines (excluding the property line abutting ROW)
	• Within 5 feet from structure without basement, 10 feet from structure with basement when runoff from < 5,000 square feet of new/replaced impervious area is infiltrated on site
	• Within a 1H:1V slope between the bottom edge of an infiltration facility and a building structure when runoff from = 5,000 square feet of new/replaced impervious area is infiltrated on site. The resulting setback is no less than 5 feet from structure without basement, 10 feet from structure with basement.
	• Within 100 feet of a contaminated site or abandoned landfill

Acknowledgments

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