APPENDIX B: BMP IMPLEMENTATION CRITERIA

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APPENDIX B: BMP IMPLEMENTATION CRITERIA

Planning, design, construction, and maintenance criteria and considerations common to multiple BMPs are provided in this appendix.

PLANNING

Infiltration Testing

Perform infiltration testing per Appendix C for all infiltration BMPs. Refer to **Appendix C**, **Table C-1** for a list of BMPs requiring infiltration. Size the BMPs based on the finding of the infiltration test.

DESIGN

BMP Sizing Methods

There are two approaches to sizing facilities:

1. **Simplified Sizing Approach**
2. **Engineered Design Approach**

Simplified Sizing Approach

As outlined in **Chapter 2** and in sections throughout **Chapter 4**, sizing of BMPs may be performed using the Simplified Sizing Approach described in detail in **Chapter 5**. As long as the requirements for water quality and flow control are met (**Chapter 2**), sizing does not require a licensed engineer. A description of the Simplified Sizing Approach is in **Chapter 2**, "*Simplified Sizing Approach*".

Engineered Design Approach

BMPs that do not meet requirements for the Simplified Sizing Approach must be designed by a licensed engineer. Modeling is used to size BMPs and predict how facilities will respond to and manage stormwater, and is often performed for the entire site, which should include runoff prevention and runoff reduction BMPs.

The design criteria for hydrologic modeling is outlined in **Chapter 2**, "*Stormwater Management: Water Quality*" and "*Stormwater Management: Flow Control*". If designing only for water quality, the BMP will not count as managing the drainage area for flow control and either an additional BMP for flow control will be required (unless approved by City Engineer) or the BMP must be designed for flow control.

<u>Use the following hydrologic criteria to size facilities:</u>

- Due to the continuous nature of our storms, facilities should drain the volume of the design storm in 30 hours or less.
- Water quality: Follow design requirements in **Chapter 2** "*Stormwater Management: Water Quality*"
- Flow Control: Follow design requirements in **Chapter 2** "*Stormwater Management: Flow Control*"
- Modeled with approved methods below.

MODELING

Design Storms

The National Oceanic and Atmospheric Administration (NOAA) has published isopluvial charts showing rainfall depths for a range of recurrence intervals in certain geographic areas. Table B-1 presents the rainfall depths for the City of Grants Pass obtained from NOAA isopluvial charts.

Table B-1. 24-hour Storm Depths

Storm Event	Precipitation (in)*
2-year	3
5-year	3.7
10-year	4.1
25-year	5
50-year	5.5
100-year	5.9

*Source: NOAA Atlas 2, Volume X

Another parameter of a design storm is how the given amount of precipitation is distributed over the duration of the storm (temporal distribution). A hyetograph illustrates the typical temporal distribution of a storm. The hyetograph shape is theoretical and is based on historical data collection and extrapolation. The Natural Resource Conservation Service (NRCS) has developed region-specific hyetographs for the State of Oregon. For Grants Pass, the NRCS recommends the use of a Type 1A distribution. The 25-year storm hyetograph is illustrated in ***Figure B-1***.

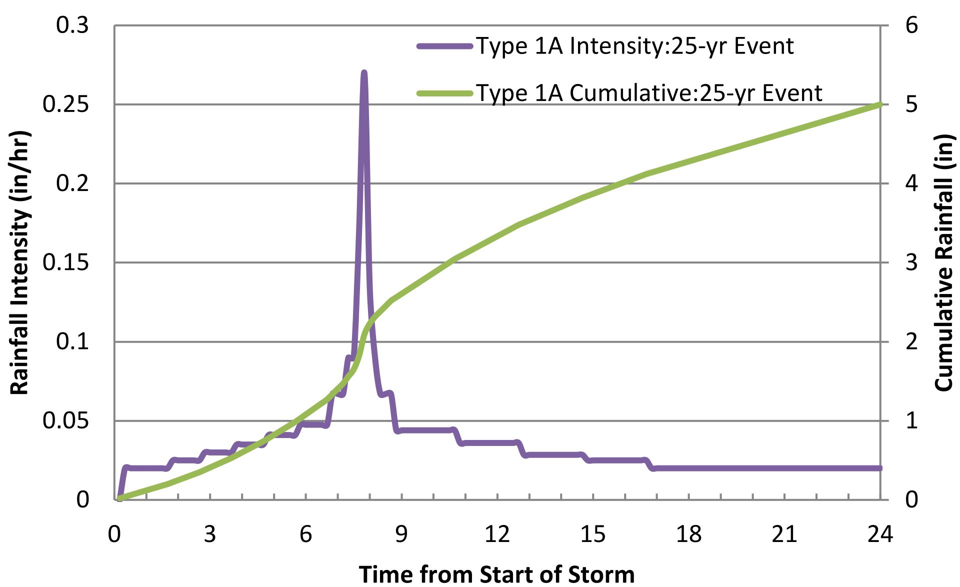

Figure B-1: Type 1A 25-year storm hyetograph.

Santa Barbara Urban Hydrograph

The Santa Barbara Urban Hydrograph (SBUH) method may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the Simplified Sizing Approach.

The Natural Resource Conservation Service "*Urban Hydrology for Small Watersheds*" (NRCS TR-55) method may be applied to small, medium, and large projects. This is also one of the recommended methods for completing hydrologic analyses necessary for designing flow control facilities when not using the Simplified Sizing Approach.

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District to determine a runoff hydrograph for an urbanized area. It is a simpler method than some other approaches, as it computes a hydrograph directly without going through intermediate steps (i.e., a unit hydrograph) to determine the runoff hydrograph.

The SBUH method is a popular method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the method approved by the City for determining runoff when doing flow control calculations.

Elements of the SBUH Method

The SBUH method depends on several variables:

- Pervious (A_p) and impervious (A_{imp}) land areas
- Time of concentration (T_c) calculations
- Runoff curve numbers (CN) applicable to the site
- Design storm

These elements shall all be presented as part of the submittal process for review by staff. In addition, maps showing the pre-development and post-development conditions shall be presented to help in the review.

Land Area

The total area, including the pervious and impervious areas within a drainage basin, shall be quantified in order to evaluate critical contributing areas and the resulting site runoff. Each area within a basin shall be analyzed separately and their hydrographs combined to determine the total basin hydrograph. Areas shall be selected to represent homogenous land use/development units.

Time of Concentration

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed. (In this case, T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration.) T_c depends on several factors, including ground slope, ground roughness, and distance of flow. The following formula for determining T_c is:

$$T_c = T_{t1} + T_{t2} \ldots + T_{tm}$$

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{60V}$$

For sheet flow of less than 300 feet, use Manning's kinematic solution to compute T_t:

$$T_t = \frac{0.42(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}}$$

Shallow concentrated flow for slopes less than 0.005 ft/ft:

$$V = 16.1345(s)^{0.5}\ [Unpaved\ surfaces]$$

$$V = 20.3282(s)^{0.5}\ [Paved\ surfaces]$$

Where,

T_t = travel time (minutes)

T_c = total time of concentration, (minutes) (minimum T_c = 5 minutes)
n = Manning's roughness coefficient[1]
L = flow length (feet)
V = average velocity (ft/s)
P_2 = 2-year, 24-hour rainfall depth (inch) (enter 3.0 inches for this variable (refer to Table B-1))
s = slope of hydraulic grade line (land slope ft/ft)

When calculating T_c, the following limitations apply:

- Overland sheet flow (flow across flat areas that does not form into channels or rivulets) shall not extend for more than 300 feet.
- For flow paths through closed conveyance facilities such as pipes and culverts, standard hydraulic formulas shall be used for establishing velocity and travel time.
- Flow paths through lakes or wetlands may be assumed to be zero (i.e. T_c = 0).

Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to reduce diverse characteristics such as soil type, land usage, and vegetation into a single variable for doing runoff calculations.

(Refer to the TR-55 "*Urban Hydrology for Small* Watersheds" Tables 2-2a through Table 2-2d for a list of Curve Numbers)

Rational Method

The Rational Method may be used for hydrologic modeling by a licensed engineer with approval from the City Engineer.

The Rational Method is[2]:

$$Q = C_f CiA$$

Where:
Q = Peak flow in cubic feet per per second (cfs)
C_f = Runoff coefficient adjustment factor to account for reduction of infiltration and other losses during high intensity storms
C = Runoff coefficient to reflect the ratio of rainfall to surface runoff
i = Rainfall intensity in inches per hour (inch/hour)
A = Drainage area in acre (acre)

Computer Modeling

Different Software can be used for performing hydrologic modeling. A list of Grants Pass approved computer models are:

1. AutoCAD Civil 3D - Hydraflow extensions
2. The US Army Corps of Engineers "Hydrologic Modeling System" (HEC-RES)
3. The Environmental Protection Agency's Storm Water Management Model (EPA-SWMM)
4. Other software approved by City Engineer

[1] Urban Hydrology for Small Watersheds. (1986). *United States Department of Agriculture Natural Resources Conservation Service Conservation Engineering Division.*
[2] APPENDIX F – RATIONAL METHOD. (2014). *ODOT Hydraulics Manual,* 7-F-1-7-F-1. Retrieved March 12, 2014, from http://www.oregon.gov/ODOT/GeoEnvironmental/Docs_Hydraulics_Manual/Hydraulics-07-F.pdf

Currently, many developers in the Grants Pass region use AutoCAD Civil 3D with Hydraflow extensions to perform hydrologic modeling of stormwater. An example of parameters entered into and calculated by the software are shown in Table B-2 and Figures B-2 through B-7. Modeling parameters are at the discretion of the engineer and may differ from what is show below.

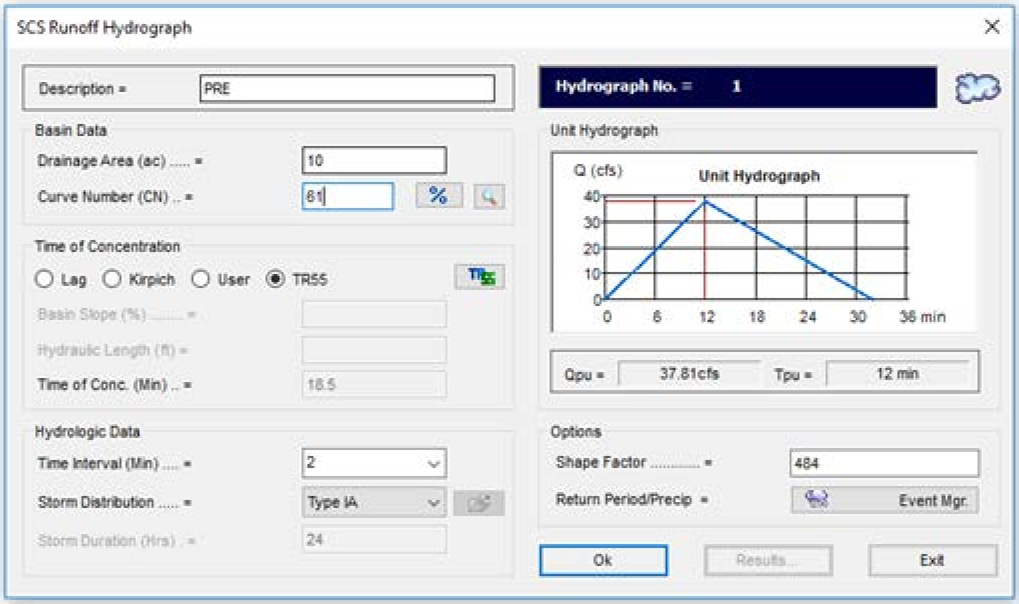

Figure B-2: Hydrograph input page.

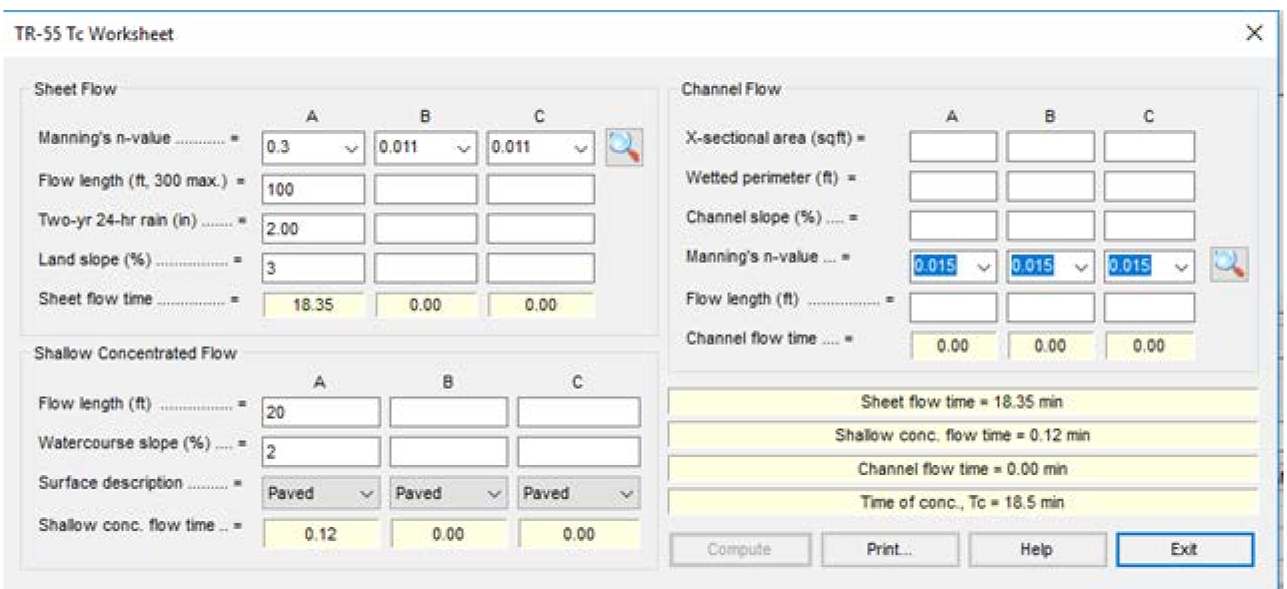

Figure B-3: Time of concentration.

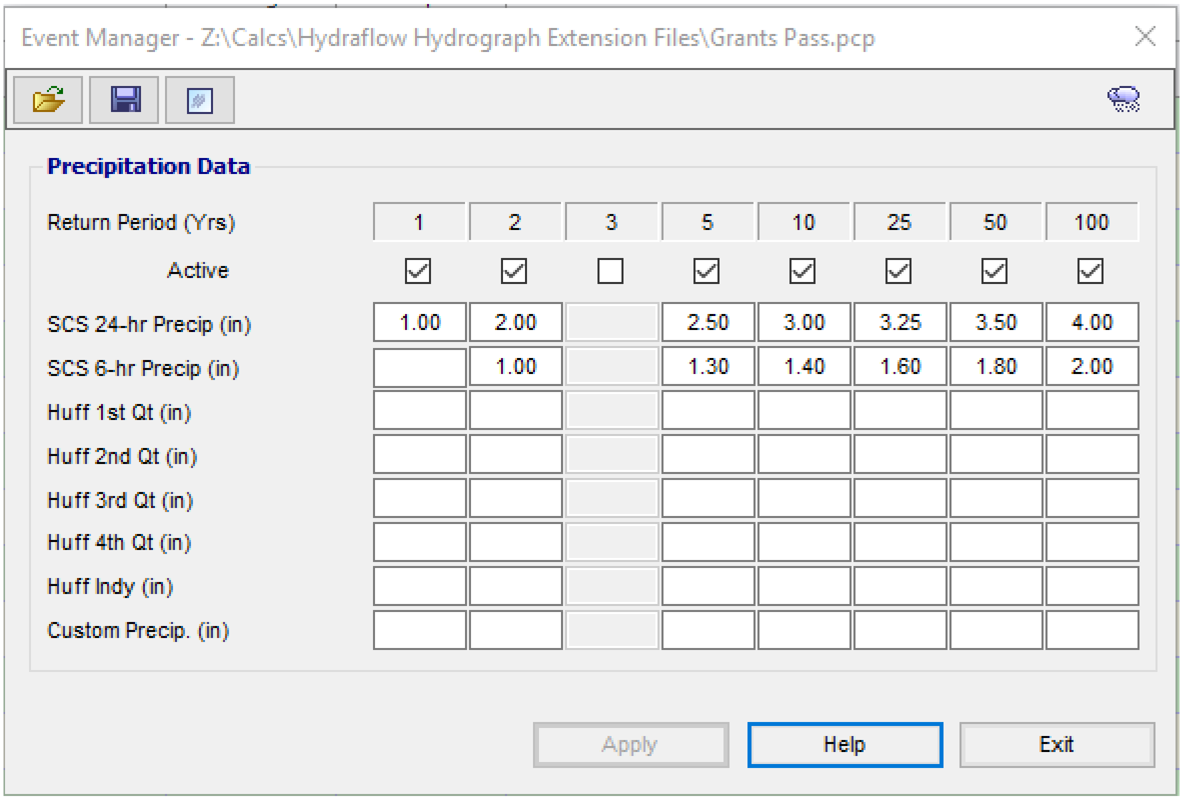

Figure B-4: IDF curves.

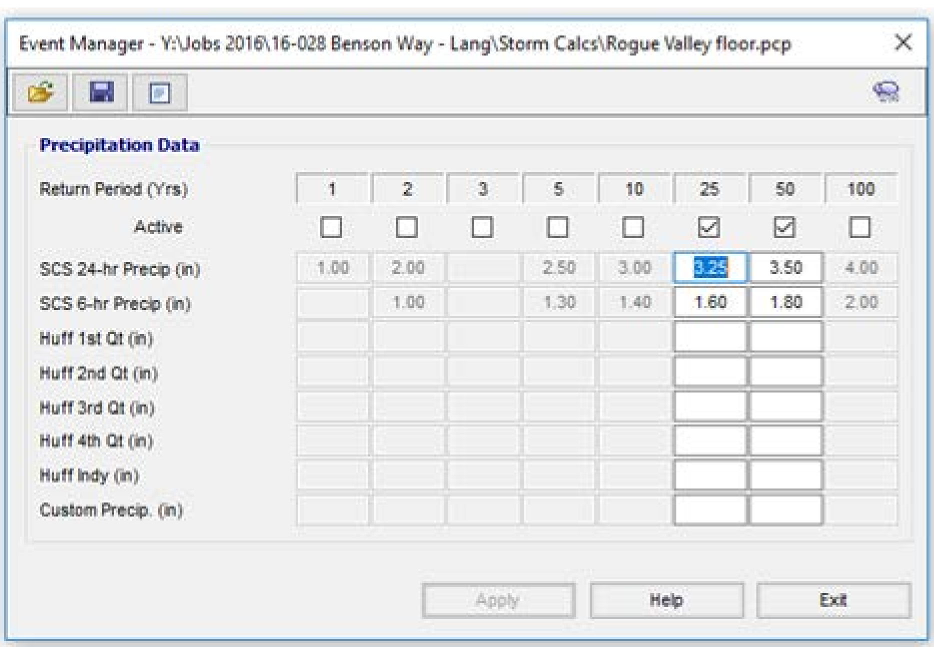

Figure B-5: Event manager tool.

Land Use Description	Hydrologic Soil Group			
Residential	A	B	C	D
Average lot size:				
1/8 acre or smaller	77	85	90	92
1/4 acre	61	75	83	87
1/3 acre	57	72	81	86
1/2 acre	54	70	80	85
1 acre	51	68	79	84
2 acre	46	65	77	82
1/8 acre or smaller	77	85	90	92
Paved parking lots and roofs	98	98	98	98
Streets and roads:				
Paved with curbs	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Commercial and business areas	89	92	94	95
Industrial districts	81	88	91	93
Open spaces, lawns, and parks:				
Good condition	39	61	74	80
Fair condition	49	69	79	84
Fallow	77	86	91	94
Row crops	72	81	88	91

*Average Runoff Condition. Ia = 0.25

Source: Soil Conservation Service TR-55

Figure B-6: table for conditions for the curve number.

Table B-2. Hydrograph Report (Displayed parameters do not reflect recommended parameters and are for demonstration purposes only)

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4 Friday, 09 / 8 / 2017

Hyd. No. 2

POST

Hydrograph type	= SCS Runoff	Peak discharge	= 2.018 cfs
Storm frequency	= 50 yrs	Time to peak	= 8.00 hrs
Time interval	= 2 min	Hyd. volume	= 38,146 cuft
Drainage area	= 10.000 ac	Curve number	= 72*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 3.50 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(3.000 x 98) + (7.000 x 61)] / 10.000

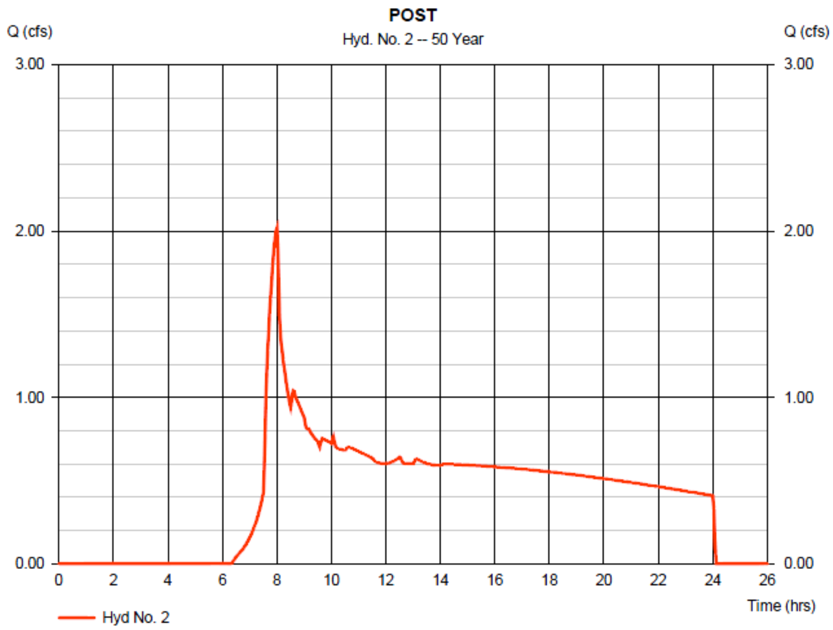

Figure B-7: Example post development hydrograph output from Civil 3D Hydraflow software.

BMP Design Criteria

Each of the design criteria in this section should be accommodated in the design of the following BMPs:

- Vegetated Roof BMP (except information in "Infiltration Facility Siting" does not apply)
- Porous Pavement BMP
- Rain Garden, Stormwater Planter, & LID Swale BMP
- Soakage Trench BMP
- Drywell BMP
- Water Quality Conveyance Swale BMP
- Dispersion BMPs

Infiltration Facility Siting. In order to protect structures and natural features from water quantity impacts such as localized flooding or landslides, infiltration facilities have a number of vertical and horizontal setbacks, defined in **Chapter 4**.

Initially, evaluate, select and apply runoff prevention BMPs. Comprehensively applying multiple runoff prevention practices to manage runoff at a site may preclude the need for design and installation of some runoff reduction BMPs. This would save considerable costs related to BMP construction and maintenance for the life of the facility.

High-Flow Bypass. Depending on site conditions and how vegetated facilities are designed, exposure to high velocity flows can cause erosion and impact long-term functioning and maintenance as well as their value for water quality protection. In these cases, employ a high-flow bypass system to allow only selected flows to enter an LID facility, while routing the rest around the facility. For instance, an opportunity to retrofit a pavement area might create a smaller than desired rain garden, just big enough to store and infiltrate the volume of the water quality storm, but a bypass structure could send the remaining storm volumes to another facility such as a drywell for infiltration; thereby protecting the water quality facility from erosive flows, reducing maintenance, and protecting downstream banks from erosion. A control structure similar to those used in detention basins is one example of how this might be achieved. If a curb and gutter is adjacent to the vegetated facility, then a passive bypass system can be achieved by careful grading that allows stormwater flows that exceed the water quality storm event to simply continue flowing along the curb and gutter when the ponding area is full.

Figure B-8. This facility is being eroded and exporting sediment off-site. A high-flow bypass or better plant placement and establishment could help.

Safe Overland Route. No stormwater facility can be designed for every size storm. There will always be a lower frequency, larger storm that cannot be accommodated regardless of how large a storm size is managed; therefore, incorporate a safe overland route for all stormwater facilities that allows water to take a route that will minimize property damage.

Clearly indicate this flow path on the plans. Final grades critical to overland conveyance should be confirmed as a "punch list item" at the end of the construction phase by the designer to ensure that runoff will actually flow where intended during the design phase.

- **Approved Discharge Point/Outlet**. Overflow structures must direct excess stormwater to an approved discharge point as approved by The City of Grants Pass. Approved discharge points may be drainage ditches, nearby streams, or existing storm drain systems. Connection to an underground perforated pipe outside the limits of a BMP, or a drywell or soakage trench (see "*Drywells BMP*" or "*Soakage Trenches BMP*" for more information on underground injection controls) will require registration through the Oregon Department of Environmental Quality.

Materials Choices. Downspouts, gutters, rain chains and other conveyance materials should not be made of copper, galvanized steel (leaches zinc), or iron, which leach harmful metals into waterways even when those metals pass through soil and plants. Art is often desired to celebrate stormwater; however, unless the material is known to be non-polluting (e.g. concrete, stainless steel, untreated wood), artwork should be located outside the facility where it will not come in extended contact with ponded or flowing stormwater.

Maintenance Considerations during Design, **Sediment Removal.** Maintenance of conventional "gray" stormwater infrastructure, such as catch basins, pipe and culverts, has focused primarily on reducing sediment loads and preventing clogging. Removal of sediment is even more critical for BMPs such as rain gardens, planters, swales and porous pavements. If sediments are in a structure like a manhole or catch basin, they are usually vacuumed out. Public facilities will require access for a large maintenance vehicle.

CONSTRUCTION

BMPs and contributing drainage areas should be constructed to protect water quality and maximize function as follows:

Protecting Permeability

For the reasons described in **Chapter 3** "*The LID Construction Process*", permeability of the soil should be carefully protected throughout the construction phase using the following techniques:

Install Protection Fencing. Areas of high permeability on the site should have been discovered through infiltration testing in the planning phase (see **Appendix C**: Infiltration Testing). It is the responsibility of the general contractors and subcontractors to install protection fencing as shown on the plans and to respect the boundaries of it.

At the beginning of construction, before clearing and grubbing, fence off all infiltration areas (*i.e*. the footprint of infiltration facilities) and the area under tree canopy to be protected (see **Chapter 4** "*Tree Protection BMP*") to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of native soils. The most effective protection fencing is something that cannot be easily moved out of the way, such as cyclone fencing at least 3 feet high, which is more expensive than the less effective plastic orange fencing, but which can often be rented on a temporary basis. Keep fencing in place until site construction is complete. Some construction traffic is possible within the footprints of infiltration facilities, which is described in more detail below in "*Protect permeability when working inside a BMP footprint*" and in the "*Construction*" sections of BMPs in **Chapter 4**.

Figure B-9. Orange protection fencing at this project is not deterring stockpiling within the tree canopy. Inadequate tree root protection often leads to health issues that turn a healthy tree into a hazard tree. Tree protection is covered in detail in Chapter 4.

Figure B-10. Avoid foot or vehicular traffic before, during, and after construction. This backhoe is excavating from outside the rain garden, as outlined by the white paint in the grass.

Don't use an infiltration LID facility location as a temporary sediment pond. If a temporary sediment pond is needed as a sediment control strategy, avoid building this measure within the footprint of any of the following BMPs:

- Porous Pavement BMP
- Infiltration Rain Garden, Stormwater Planter, or LID Swale BMPs

- Soakage Trench BMP
- Drywell BMP
- Water Quality Conveyance BMP
- Dispersion BMP

On large sites, usually over 5 acres, a sediment control facility called a “Temporary Sediment Basin” may control runoff from a construction site. On conventional projects, the footprint of the future detention basin often serves as the location of this temporary basin and runoff from the stripped site (which can be very high on large sites) is directed to it. At the end of construction, the detention basin is dredged. This is convenient and acceptable in conventional development, since detention basins are not designed to infiltrate.

Low impact development sites should infiltrate and evaporate to the greatest extent possible. Directing sediment-laden runoff to these footprints of an infiltration rain garden or a porous pavement will probably clog the facility. If soil is clogged, it will not infiltrate the volume of runoff expected or may fail entirely. In addition, dredging operations are likely to compact the subgrade, especially if the subgrade is wet and clayey. Clogged soils also make vegetation establishment and survival difficult, which eliminates this key role in treating stormwater and reducing maintenance. In addition to fencing off the area, route construction runoff around all infiltration facilities using sand bags, slope drains, or other means. The only LID BMP footprints acceptable for settling out sediment are lined facilities. Directing runoff to any LID facility on very tightly constrained sites will be reviewed on a case-by-case basis.

- Protect excavated soils from rain exposure. Until soils can be planted and mulched, cover soils with jute or other natural, breathable material or by waiting until the last moment to expose soils. In the case of vegetated stormwater facilities where soil will be imported, the exposed surface may also be covered in mulch immediately upon excavation. The mulch may be left in place as subsequent layers of rock or soil are placed.

Figure B-11. Fine clay particles exposed to rain fall have re-sorted and clogged this infiltration facility.

- If soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils creating a naturally impervious layer. In clayey soils, restoring permeability can be difficult. In the case that soils are accidentally exposed to rain, if soils don’t clump, rake the surface to loosen soil before proceeding. If soils do clump, wait until they dry before raking them or try applying the Restored Soils BMP (described in detail in **Chapter 4**) to the bottom of the facility.
- Protect permeability when working inside a BMP footprint. Take care not to compact soil within the infiltration facility footprint when installing overflow structures that may require compaction under them, such as area drains and non-perforated pipes. Compact only the soil underneath the structure or in the pipe trench. Perforated pipes located within the facility footprint of rain gardens, stormwater planters, and other vegetated BMPs are not designed to receive loading from vehicular

traffic, so compaction underneath these is not desirable.

- Use track equipment and/or work from the sides of the facility footprint (*i.e.* infiltration area) when using machinery for construction operations. For other techniques specific to certain BMPs, see the "*Construction*" sections of BMPs in **Chapter 4.**

Call Before You Dig, Locating Underground Utilities

- Call 811, a free service, to locate utilities in the public right-of-way of any project. On sites with existing utilities or infrastructure, hire a private utility locate company to mark underground private utilities.

MAINTENANCE

BMPs and contributing drainage areas should be maintained to protect water quality and maximize function as follows:

- **Integrated Pest Management.** Maintain BMPs and sites with integrated pest management using little to no herbicides, pesticides, or fertilizers. Using "cides" impacts the soil life responsible for creating long-term permeability and can actually increase long-term maintenance efforts. Avoid spraying "cides" on impervious surfaces.
- **Irrigation.** Maintain with irrigation as needed to conserve water. (See Appendix E, "*Establishment Period Maintenance*".
- **Trimming Grasses and Shrubs.** Encourage vegetation to grow and become dense. For example, unless flows into the facility are blocked, vegetation doesn't need to be thinned. Preferably, plants are allowed to grow tall since this will encourage root penetration into native soils increasing the infiltration rate of the facility over time. In addition, do not trim grasses and shrubs right before or during the rainy season (September to June), since plants will have less structure to reduce runoff through evaporation and evapotranspiration.