Environmental Assessment

Innovative Wet Weather Program

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Prepared for

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Prepared by

City of Portland

Bureau of Environmental Services

1120 SW Fifth Avenue, Room 1000

Portland, Oregon 97204

CH2MHILL

825 NE Multnomah, Suite 1300
Portland, Oregon 97232

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CHAPTER 1

Purpose of and Need for Action

Background

Stormwater carries pollution to Portland's streams and the Willamette River, an American Heritage River, causing water quality and watershed health problems. All but one of Portland's streams have state-listed impaired water quality.

Stormwater runoff is the rain that flows off roofs, sidewalks, yards, parking lots, and streets. Stormwater runoff carries pollutants it picks up from yards or the street, including excess fertilizers and pesticides, toxic chemicals from automobiles, and bacteria from animal wastes. Following the Clean Water Act amendments of 1987, the U.S. Environmental Protection Agency (EPA) issued regulations to control urban stormwater pollution. The regulations require the City of Portland, as a Phase I community, to have a National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge Permit for its storm sewer discharges and also a comprehensive stormwater management program. Many activities are taking place to reduce pollutant loads that are discharged from stormwater.

In Portland, stormwater runoff is conveyed via ditches, separated storm sewers, and combined sewers to one of three disposal locations: the ground, water treatment plants, or local waterways. While some stormwater soaks into the ground, most goes into a stormwater inlet or catch basin, the familiar grated openings in the street. In neighborhoods where ditches and dedicated storm sewers carry stormwater, the runoff flows to the nearest water body—usually a small stream that leads to the Willamette River.

Portland's combined sewer system serves businesses, institutions, and about 523,000 residents. In combined sewer areas, stormwater mixes with sewage in pipelines during significant storm events. The combined sewage is a mixture of about 80 percent stormwater runoff and 20 percent untreated sanitary wastes. Combined sewer overflows (CSOs) result when pipelines do not have enough capacity to carry all of the combined sewage and stormwater during storm events. Rain causes overflows on more than 100 days each year, about one-third of which occur during the summer, when water is most likely to be used by boaters and other recreationists.

The City of Portland's CSO problem is severe. In 1994, EPA issued the CSO Control Policy, which stated that municipalities such as Portland are responsible for developing and implementing CSO Long Term Control Plans (LTCP) that will ultimately result in compliance with the requirements of the federal Clean Water Act. Primary objectives of Portland's LTCP are to meet applicable water quality standards in support of designated uses of water, and to reduce risks to human health and the environment by eliminating, relocating, or controlling CSOs to the affected waters.

BES is working to get as much stormwater runoff as possible out of the combined sewers. Portland first took steps toward reducing combined sewer overflows in the 1970s. Since then, Portland has eliminated 72 percent of the overflow volume, and CSOs in the Columbia Slough were virtually eliminated by 2000. By the year 2011, Portland is required to eliminate 94 percent of the overflows to the Willamette River.

The city's Bureau of Environmental Services (BES) is taking steps to bring area streams into compliance with water quality standards. BES's citywide management program focuses on reducing the impacts of pollution and stormwater runoff quantity. The Portland *Stormwater Management Manual 2.0* (BES, 2002) forms the technical foundation of the program and presents design standards for pollution control devices as well as best management practices (BMPs) designed to improve stormwater quality.

Need for Action

Underlying the City of Portland's Innovative Wet Weather Program (IWWP) is the need for prompt and proven actions that improve water quality and watershed health in Portland by reducing CSOs, stormwater runoff peaks and volumes, and associated pollutant concentrations and by monitoring the effectiveness of green solutions as alternatives to expensive wastewater transport and treatment.

Purpose of Action

The Innovative Wet Weather Program grants have the following purposes:

- Capture and detain stormwater runoff as close to the source as possible
- Reduce the volume of stormwater entering the combined sewer system
- Filter stormwater to remove pollutants before the runoff enters groundwater, streams, or wetlands
- Use and promote methods that provide multiple environmental benefits
- Mimic natural (predevelopment) hydrologic conditions
- Make all materials and pertinent information available to educate others
- Use techniques that are less costly than traditional piped solutions
- Protect human health and safety

Proposed Action

EPA is conditionally funding portions of the City of Portland's Innovative Wet Weather Program. The City of Portland proposes to use the EPA grants to implement innovative approaches to manage stormwater runoff and will be providing matching funds. Two EPA grants for specified types of projects have already been awarded, and additional federal grants for similar project types are expected. BES has lead responsibility for implementing IWWP projects. The IWWP grant projects funded from these first two EPA grants will be implemented over the period from 2003 through at least 2005, but some implementation may extend beyond this timeframe. The implementation timeframe for IWWP projects funded by additional federal grants will be determined at the time of award. The grant projects will complement ongoing CSO reduction and wet weather actions by the City of Portland and other government, business, community, and environmental groups in the Portland area.

The IWWP consists of individual projects at locations throughout the city that are designed to improve the water quality and the natural environments of Portland. The majority of the IWWP projects will be conducted in the combined sewer area of the city. The proposed projects will reduce the volume of stormwater entering the combined sewer system and will remove stormwater pollutants.

Proposed projects are in five main categories: (1) Water Quality-Friendly Streets and Parking Lots, (2) Downspout Disconnections, (3) Eco-Roofs, (4) Monitoring and Feasibility Studies, and (5) Educational Efforts. Only the first three are categories of construction projects. Also included is a sixth funding category, Grant and Project Management, which provides for program and project management. The IWWP selected the Tanner Creek Stream Diversion Project (Phase III) as its EPA match project. City of Portland Capital Improvement Project matching funds will amount to $1.35 million for these first two EPA grants. Additional matching funds will be identified when future grants are awarded. The Tanner Creek Stream Diversion Project (Phase III), which will cost much more than the match amount and include many features for improving water quality and quantity, previously was evaluated in an EPA environmental assessment entitled, *Tanner Creek Basin Environmental Assessment* (City of Portland May, 1997). The environmental effects of the city's match project were determined to be not significant. Because EPA grant funds will not be spent on this match project, potential environmental effects of the match are not considered further in this document. The funding categories are described in detail in Chapter 2 of this environmental assessment.

The project elements are based on innovative technologies described in the Portland *Stormwater Management Manual 2.0*, the purpose of which is to provide stormwater management principles and techniques that help preserve or mimic the natural hydrologic cycle and achieve water quality goals for stormwater runoff quantity and pollution (City of Portland 2002). The *Stormwater Management Manual* provides design criteria for relatively simple approaches to selecting and designing facilities that provide multiple stormwater management benefits. City Code Chapter 17.38 includes the section of City Code that addresses stormwater management policies and standards, and officially recognizes the city's *Stormwater Management Manual*.

The *Stormwater Management Manual* is more than a collection of stormwater design criteria. It outlines performance standards and incentives for innovative approaches to stormwater management. For example, the manual, in concert with the Portland City Code, requires that significant new developments and redevelopments must:

- Remove 70 percent of total suspended solids (TSS) from runoff generated by a design storm up to and including 0.83 inches of rainfall over a 24-hour period
- Use surface retention facilities "to the maximum extent practicable"
- Provide on-site infiltration "to the maximum extent practicable"
- Ensure that on-site flow control is sufficient to maintain peak flows at their pre-development levels for the 2-year, 5-year, and 10-year runoff events

- Control stormwater volumes "to the maximum extent practicable"
- Ensure that runoff does not:
    - exceed the capacity of the receiving conveyance facility or water body
    - increase the potential for stream bank and stream channel erosion
    - add significant volume to an existing closed depression
    - create or increase any upstream or downstream flooding problems

The *Stormwater Management Manual* describes several incentives to encourage developers to implement innovative wet weather approaches. For example:

- Combine innovative wet weather approaches with city landscaping requirements (i.e., Portland City Code 33.258)
- Offset impervious surface area management requirements by incorporating innovative wet weather approaches into site design (i.e., Form SIM: Simplified Approach for Stormwater Management)
- Claim stormwater management credit for planting new trees and keeping existing tree canopy on-site

Details about the design linkages between the *Stormwater Management Manual* and the IWWP are given in Chapter 4, Table 4.1-1 of this environmental assessment.

This environmental assessment addresses only those projects that are funded, in whole or in part, by EPA's Innovative Wet Weather Program grant. The National Environmental Policy Act (NEPA) requires EPA to review the IWWP's potential environmental impacts through the use of federal funds. This environmental assessment will assist EPA in complying with the procedural requirements of NEPA and was prepared to assist EPA in determining whether a finding of no significant impact (FONSI) is warranted. The FONSI would be subject to a 30-day public review.

CHAPTER 2

Description of Alternatives, Including the Proposed Action

2.1 Proposed Action

The Innovative Wet Weather Program consists of numerous individual projects and activities at locations throughout the City of Portland. The IWWP will reduce the peak volume of stormwater entering the combined system and manage stormwater to reduce pollutant concentrations. Proposed projects are in five main categories:

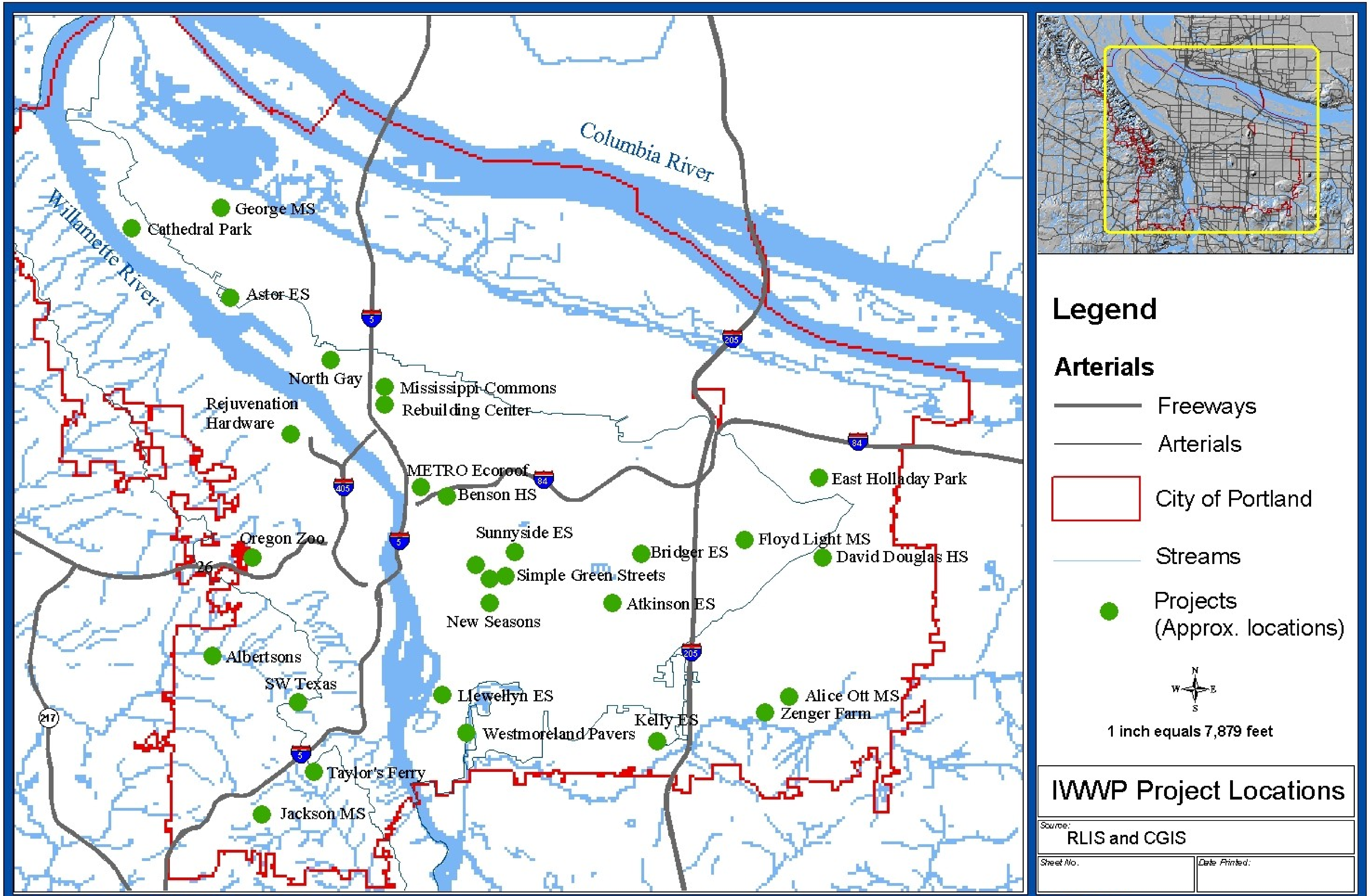
- Water quality-friendly streets and parking lots
- Downspout disconnections
- Eco-roofs
- Monitoring and feasibility studies
- Educational Efforts

A sixth funding category, grant and project management, provides for program and project management.

Most of the projects are targeted within the city's Combined Sewer Basin Boundary (see Figure 2.1-1, *City of Portland Watersheds and Basin Boundaries*). Some of the projects target the Separated Sanitary Sewer Area where peak inflows of stormwater into the storm sewer system need to be reduced. Many projects will be located in the public right-of-way and institutionally zoned parcels (such as streets and schools) owned by the City of Portland, Tri-Met, or other government agencies, while others will be sited on private property (commercial buildings, church parking lots, etc.) in cooperation with the property owners.

The IWWP consists of projects and activities in varying stages of development and design at the time of grant application. In some cases, the location and specific types of actions are reasonably well known or predictable. In others, the implementation locations and probable project elements are only known in general. Examples of more well-developed projects are included in the following descriptions of project categories and Table 2-1. In all cases, they would be consistent with the Portland *Stormwater Management Manual* (BES, 2002) and propose facilities that would provide multiple stormwater management benefits, including pollution reduction, peak flow and volume control.

The IWWP will be further refined as specific projects within each of the work categories are either implemented as outlined, removed from the list, or added as new projects. The selection of new projects would be based upon feasibility, opportunity, potential benefits, and existing


Columbia River
Willamette River
George MS
Cathedral Park
Astor ES
North Gay
Mississippi Commons
Rebuilding Center
Rejuvenation Hardware
METRO Ecoroof
Benson HS
East Holladay Park
Oregon Zoo
Sunnyside ES
Bridger ES
Floyd Light MS
David Douglas HS
Simple Green Streets
Atkinson ES
New Seasons
Albertsons
SW Texas
Llewellyn ES
Alice Ott MS
Zenger Farm
Kelly ES
Westmoreland Pavers
Taylor's Ferry
Jackson MS
Legend
Arterials
Freeways
Arterials
City of Portland
Streams
Projects (Approx. locations)
N
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1 inch equals 7,879 feet
IWWP Project Locations
Source:
RLIS and CGIS
Sheet No.
Date Printed:

priorities. However, in all cases, the probable environmental effects of projects would be predictable and describable within reasonably well-defined bounds. Any projects added would fit within the categories of projects described in this chapter and evaluated in Chapter 4 of this environmental assessment. None of the funded projects would be regulatory requirements or mitigation actions of other funded initiatives.

2.1.1 Water Quality-Friendly Streets and Parking Lots (“Green Streets”)

Water quality-friendly streets and parking lots (“Green Streets") capture and detain rainwater in landscaped areas. The Portland *Stormwater Management Manual*, adopted July 1, 1999, and revised September 1, 2002, refers to these projects as stormwater-friendly street designs (BES, 2002). They manage stormwater as it sheet flows through swales and allow stormwater to infiltrate into the ground instead of being routed to the combined or separated sewer system. Typical design criteria include: Vegetated swales, Grassy swales, Vegetated filters, Planter boxes, Vegetated infiltration basins, Sand filters, Soakage trenches, Lowered Planter Strips, Porous pavement, Side Swales, and Trees. Examples of project details are illustrated in Figures 2.1.1-1 through 2.1.1-4. The water quality-friendly streets and parking lots projects are intended to do the following:

- Reduce CSO frequency and volume
- Reduce pollution entering the Willamette River and its tributaries, including Johnson Creek in southeast Portland, Tanner Creek in southwest Portland, and other west side creeks
- Increase vegetation in the city to help reduce heat island effects, provide habitat for wildlife and create green spaces for people

Porous pavement—pervious pavement or unit pavers on sand—would be used to facilitate stormwater infiltration in Green Streets. Depending on specific site conditions, the city typically uses shallow vegetated swales or vegetated areas on parking lots and streets to manage water quality and infiltrate stormwater. The stormwater management measures and facilities adhere to the Portland *Stormwater Management Manual*. The vegetated swales are shallow depressions that collect and infiltrate stormwater. The vegetated areas could include raised stormwater planters or landscaped islands at ground level with no depression. When combined with revegetation, projects would include upland plantings and natural treatment wetland construction. Natural areas would emphasize vegetation that is native to Portland (City of Portland, 1998). Typically, seed and plant materials are selected from 37 grass species, 15 shrub species, and 13 tree species to ensure diverse plant communities.

The water quality-friendly streets and parking lots projects would be sited primarily within the combined sewer basin boundary. Several potential and representative projects and sites have been identified, including the following:

TABLE 2-1. INNOVATIVE WET WEATHER PROGRAM PROJECTS CONDITIONALLY FUNDED, IN WHOLE OR IN PART, BY EPA GRANTS

Project Category	Description	Possible Locations
Water Quality-Friendly Streets And Parking Lots	Captures, detains, and manages stormwater runoff using surface infiltration systems such as porous pavement, swales, and sheet flow to landscaped areas	• N. Gay Avenue • Westmoreland Permeable Pavers • SE Division/New Seasons • SW Texas Avenue • Simple Green Street Side Swales • Cathedral Park • Oregon Zoo • Kelly Elementary School • East Holladay Park Porous Parking Lot • Zenger Farm • David Douglas School District Parking Lot Retrofits • Albertson's Parking Lot
Downspout Disconnections	Redirects stormwater runoff from roof drains to lawns, planter boxes, and gardens at commercial, industrial, and institutional properties	• Portland Public Schools • The Rebuilding Center • George Middle School Stormwater Planter • Mississippi Commons
Eco-Roofs	Captures and detains stormwater on roofs using soil and vegetation	• Rejuvenation Hardware Warehouse • Metro Eco-Roof • Others
Monitoring and Feasibility Studies	Monitors the effectiveness of best management practices (BMPs) in reducing pollution concentrations and the volume of stormwater runoff; conducts conceptual and preliminary engineering designs; monitoring projects will be limited to the amount of funds in this funding category	• Stormwater Infiltration Feasibility Studies • Other selected projects within the IWWP
Educational Efforts	Reduces CSOs volume and pollutant loading in streams by educating citizens to take action to reduce stormwater runoff	• City wide
Grant and Project Management	Ensures projects are completed on time, within budget, and according to the work scope and regulatory requirements; performs quarterly monitoring of program and project performance to EPA; directs matching city funds required by the EPA grant from the Tanner Creek Stream Diversion Project (Phase III)	• Program wide

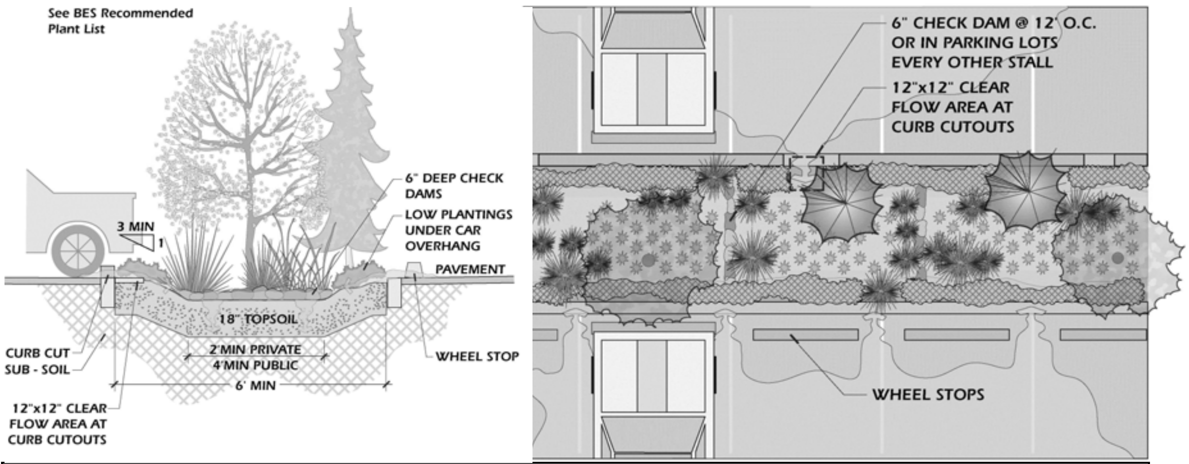

Figure 2.1.1-1. Typical section and plan of Vegetated Swale

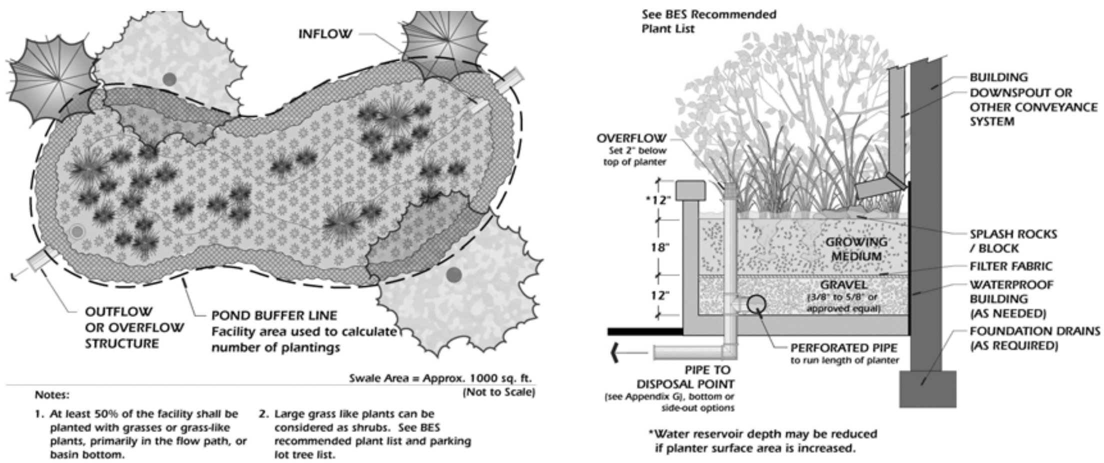

Figure 2.1.1-2. Plan of Vegetated Infiltration Basin and section of Planter Box

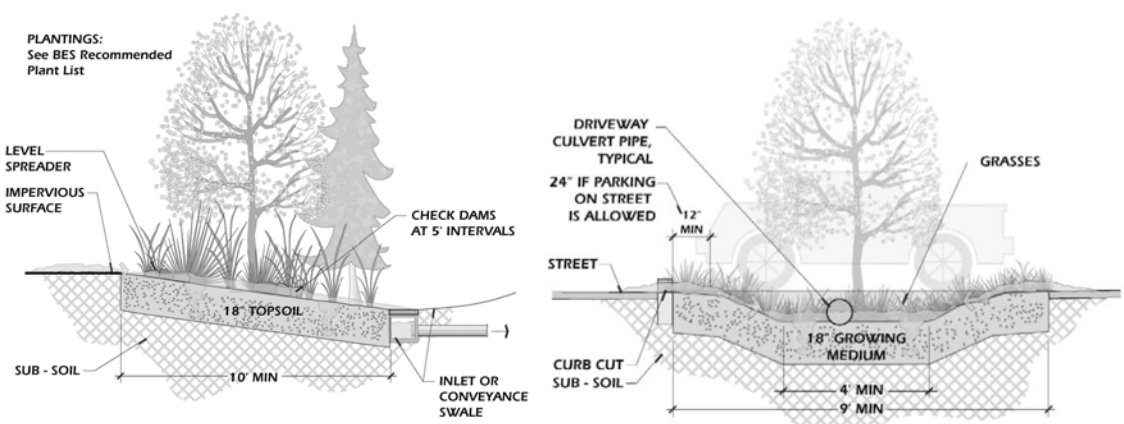

Figure 2.1.1-3. Typical sections of Vegetated Filter and Side Swale

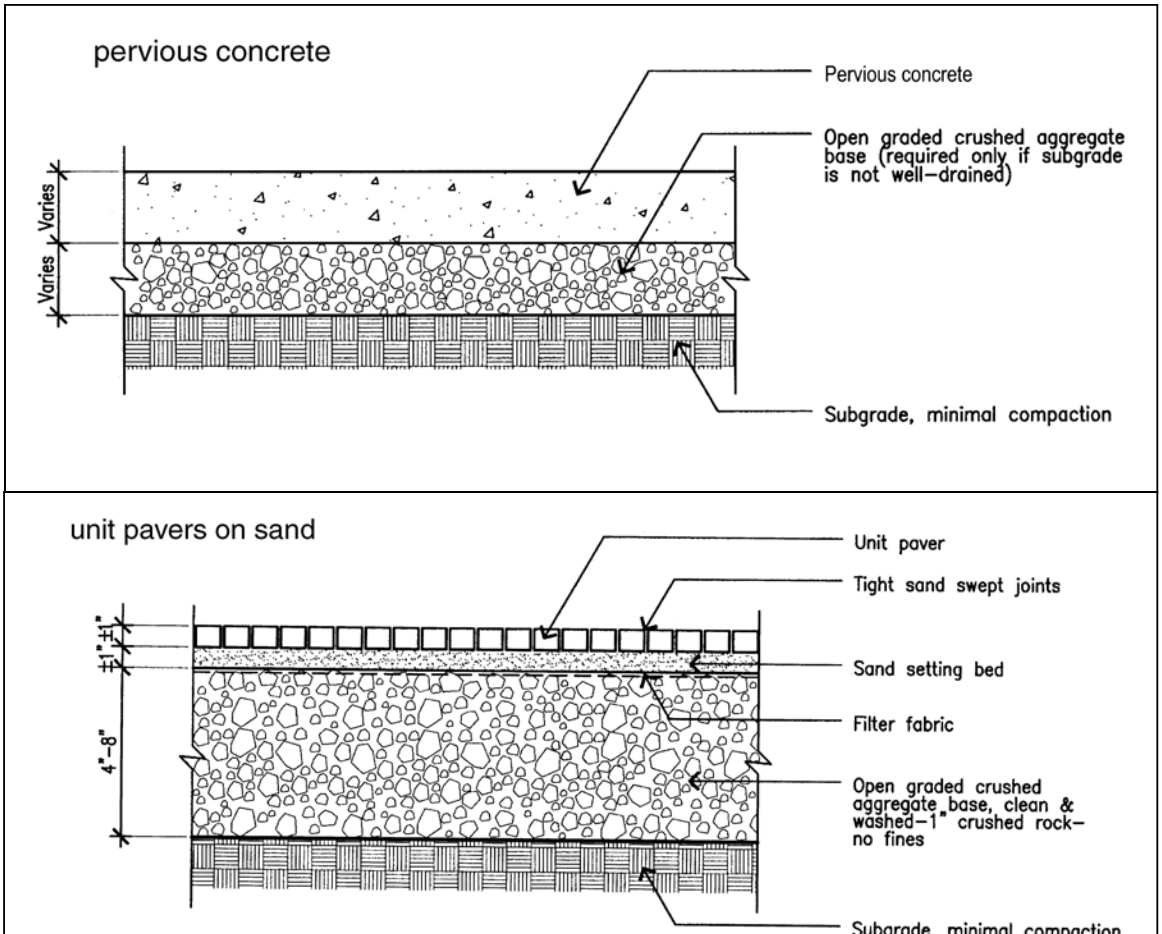

Figure 2.1.1-4. Typical sections of Pervious Concrete and Unit Pavers.

Green Street Projects

- ***North Gay Avenue***. This Green Street project demonstrates the use of porous pavement techniques. Four blocks, approximately one acre, of North Gay Avenue would be improved to satisfy current street standards and repaved using porous concrete, pavers, or other porous materials. The public street drainage would be retrofitted so that stormwater percolates through the pavement and into the ground. Two blocks would have full-width porous pavement, and two blocks would have porous pavement in the parking strips only. All of the stormwater from this surface would be removed from the combined sewer system for all storm events, which would amount to just less than 1 million gallons of stormwater each year. The pavement would be monitored for infiltration performance over time, constructability, durability, maintainability, and water quality. Results may be used to develop new city Green Street standards for urban streetscapes. $212,500 of IWWP funds has been budgeted for this project.

- ***Westmoreland Permeable Paver Project***. Existing asphalt/concrete residential streets would be removed throughout the three-block project and would be replaced with permeable interlocking paving blocks designed to let stormwater soak through the street surface and into the ground. The paving would include:

- Curb-to-curb paving of the 2100 block of SE Knapp Street with permeable paver blocks; and
- Paving of SE 21st from Rex to Knapp plus the 2000 block of Rex as follows: a seven-foot-wide strip of paver blocks on each side of these streets in the curb lane, a 12-foot-wide asphalt lane in the middle of the street, and one-foot-wide concrete "dividers" between the pavers and the asphalt.

The permeable pavers look like bricks, but they are made out of high-strength concrete designed to withstand the stress of a residential street. The paving blocks have been used locally in parking lots and driveways, but not on a public street.

This project will provide an opportunity to observe how well the permeable blocks handle stormwater, and how well they stand up to the stress of residential street use. The pavement would be monitored for infiltration performance over time, constructability, durability, maintainability, and water quality. Results may be used to develop new city Green Street standards for urban streetscapes. $80,000 of IWWP funds has been budgeted for this project.

- ***SE Division/New Seasons***. This project has identified many different approaches to manage stormwater from SE Division and SE 20th streets and private property. Stormwater runoff from a portion of SE Division Street will be redirected, on the surface, into the landscape median between the sidewalk and street curb. On SE 20th street, stormwater runoff that would otherwise enter the combined sewer system will be captured within two stormwater curb extensions where it can be slowed, infiltrated, and cleansed. The New Seasons Market property hopes to achieve 100% on-site stormwater management by predominately surface stormwater conveyance into stormwater planters, parking lot swales, and a landscaped infiltration basin. $50,000 of IWWP funds has been budgeted for this project.
- ***SW Texas Avenue***. This project will incorporate a green street design using bioswales in the right-of-ways and a bio-retention pond. It treats 1.25 acres. It is a retrofit of an unimproved right of way, improving stormwater conveyance down Texas Street to a vacant lot, on both private and public property - street right of way and along the back side of a house (project co-sponsor). $77,000 of IWWP funds has been budgeted for this project.
- ***Simple Green Street Side Swale Projects***. BES will work with the city's Bureau of Maintenance (BOM) to do side swales when installing new or replacing old curb sections. Projects will likely include 3-4 blocks of side swales off a list of potential blocks (all blocks still need to be field verified and prioritized by BES and BOM). $20,000 of IWWP funds has been budgeted for this project.

Parking Lot Retrofits

- ***Cathedral Park***. Currently, stormwater from the 2.6-acre parking lot at Cathedral Park discharges directly to the Willamette River without treatment. Stormwater runoff would flow into a swale for water quality management and percolation into the ground. Some revegetation and slope bioengineering might be applied at the river, and vegetation maintenance (weeding, mulching, inter-planting, watering, litter and debris removal, inspection of soil and repair eroded areas) would be performed to ensure success. $90,000 of IWWP funds has been budgeted for this project.

- ***Oregon Zoo***. Currently, stormwater runoff from the 67-acre campus and 4.8-acre parking lot at the Oregon Zoo discharges into the Tanner Creek combined system (see Section 2.1.4 of this EA). The project would retrofit facilities with designs from the *Stormwater Management Manual,* such as routing stormwater flow into vegetated flow-through planters for water quality management and detaining flow as previously described for parking lot retrofits. $225,000 of IWWP funds has been budgeted for this project.

- ***Kelly Elementary School***. Stormwater from parking lots and other impervious surfaces at Kelly Elementary School would be rerouted and discharged into swales and planting strips vegetated with native plants. Volunteers from the schools and surrounding communities, including students and adults, would participate in designing the swales and planting the vegetation. $25,000 has been budgeted for this project.

- ***East Holladay Park Porous Parking Lot Project***. This is a Portland Parks & Recreation parking lot project that includes a bioswale and pervious pavement for the entire 6,380 sf lot. Parks staff will seek complete on-site stormwater treatment, as well as extensive run-off reduction. The construction of a new parking lot is needed for the new dog off-leash area because the site lacks street frontage for parking. The bioswale will be sized according to the final size of the paved area, runoff calculations, and the infiltration potential of the soils. Plantings will be sized at installation to provide for parking lot screening. $45,000 of IWWP funds has been budgeted for this project.

- ***Zenger Farm***. There are four components to this project: 1) Stormwater Parking Area: Using Pervious Paving, Eco Pavers, Buffer Trees, and Planting areas to reduce urban heat island effect with drought tolerant and native trees, shrubs and ground covers; 2) Pedestrian Circulation: Using Pervious Concrete Walks; 3) Driveway: Using gravel paving for circulation beyond parking area to access the remainder of the farm, potential use of "Rainstore3" (or similar system) to capture and store water for landscape irrigation; and 4) Foster Rd. Improvements: New planting strip to accommodate new planting of drought tolerant and/or native trees and groundcovers. $50,000 of IWWP funds has been budgeted for this project.

- ***David Douglas School District Parking Lot Retrofit Projects***. To date, four schools have been identified as possible sites for disconnection work. Additional schools are being considered. Stormwater runoff would discharge onto lawns and vegetated areas. Projects are a combination of roof downspout disconnections, impervious area removal, and redirection of parking lot runoff. They currently include: 1) Alice Ott Middle School - Parking lot retrofit using curb cuts and asphalt berms to direct water to grassy areas; 2) Floyd Light Middle School - Parking lot retrofit using curb cuts and asphalt berms to direct water to landscape medians; 3) David Douglas High School - Parking lot retrofit using curb cuts and asphalt berms to direct water to landscape medians; 4) David Douglas District Offices - Parking lot retrofit using re-stripe, asphalt berms and curb cuts to direct water to landscape medians. $30,000 of IWWP funds has been budgeted for this project.

- ***Albertson's Parking Lot Retrofit***. BES has worked with Albertson's in the past on a revegetation project along Fanno Creek which is adjacent to their store and parking lot. This project would address pollutants coming from the parking lot into Fanno. Since the lot slopes toward the creek and the property includes an unpaved picnic area along the creek, a swale could be sited below the lot or include removal of asphalt in the lot. More than 10,000 square-feet of the Parking lot will be treated by this project. $20,000 of IWWP funds has been budgeted for this project.

Revegetation

Typical revegetation projects involve planting trees in parking strips along streets and parking lots. Trees intercept rain, reducing the amount of stormwater entering the combined sewer system or the amount discharged directly to receiving streams. Generally, each tree captures and evaporates at least 35 percent of the rain that falls on it, which amounts to about 12 inches per year. Revegetation would be performed where improvements are needed in the volume and timing of stormwater entering the sewer system or where there is opportunity to improve sites with local partners. The revegetation projects would involve clearing undesirable vegetation, soil preparation, planting, seeding, mulching, erosion control, and vegetation maintenance during the plant establishment period. $40,000 of IWWP funds has been budgeted for these projects.

2.1.2 Downspout Disconnections

Under these projects, roof drains from commercial and institutional buildings would be disconnected and redirected onto lawns and planter boxes. Possibly some residential disconnections may be completed, but the focus would be on commercial and industrial buildings due to the shear volume of stormwater coming from these sites. Engineering evaluation would determine how stormwater flows from large roof areas to the ground and how the runoff can be directed over the ground to a single point for treatment and discharge, or infiltration. (Some of the schools may discharge the stormwater using pipes that are inside the buildings.) They manage stormwater as it sheet flows through swales and allow stormwater to infiltrate into the ground instead of being routed to the combined or separated sewer system. Typical design criteria from the *Stormwater Management Manual* (BES, 2002) include: Vegetated swales, Vegetated filters, and Vegetated basins. Examples of project-specific aspects include redirection of overland flow to accommodate these additional flows, construction of catch basins and stormwater collection pipelines, stormwater bioswales, and best management practices for erosion control (Figure 2.1.2-1). Also, each project includes design and construction of landscaping that is appropriate for sites that could have high volumes of stormwater in winter but be completely dry in summer.

The downspout disconnection projects are intended to: (1) reduce CSOs into the Willamette River, which would reduce the quantity of bacteria in the river; (2) reduce the volume of stormwater flowing directly to receiving streams; and (3) enhance upland habitat areas. These projects also result in increased vegetation in the city, which helps reduce the urban heat island effect and provides habitat and some green space. Potential project sites include the following:

- ***Portland Public Schools***. To date, six schools have been identified as possible sites for disconnection work. Additional schools are being considered. Stormwater runoff would discharge onto lawns and vegetated areas instead of into the storm or combined sewer systems. Projects are a combination of roof downspout disconnections, impervious area removal, and redirection of playground runoff. They currently include: 1) Bridger

Elementary School - Downspouts will be disconnected to stormwater planters and paved play areas will be removed for landscape infiltration; 2) Benson High School - Install a series of above ground stormwater planters to manage stormwater runoff from the F-wing and half of the C-Wing of the Benson High School building complex. These planters would be located within a central courtyard that is already being redesigned to provide for a porous surface; 3) Llewellyn Elementary School - Install stormwater treatment swales within the planting strip areas on SE 14th street and on the backside of the school; 4) Sunnyside School - Removal of impervious area in the locked northern courtyard. There is space and ample downspout opportunities to disconnect into the newly exposed soil area, disconnect two downspouts into a swale on the western side of the building, and remove partial or full concrete slabs in the playground area. There is a radials board design in the concrete play area to the north of the school. There is an opportunity to remove the wooden expansion joints and replace them with gravel, remove a swath of the southern portion of the concrete to create an infiltration trench or to remove the entire concrete area; 5) Atkinson Elementary School - Downspout disconnection on the northern part of the school building and pavement removal throughout the playgrounds south of the school; 6) Astor Elementary School - Pavement removal and installation of a swale on the east courtyard. $60,000 of IWWP funds has been budgeted for these projects.

- ***The Rebuilding Center***. Downspouts will be disconnected to stormwater planters, specifically: Two infiltration planter boxes covering a total of 1,206sf to manage roof runoff from a new building (Michigan Canopy) with coverage of 17,685sf; Two infiltration planter boxes covering 345sf and one flow-through planter box covering 359sf to manage roof runoff from a new building (Mississippi Canopy) with coverage of 13,300sf. $45,000 of IWWP funds has been budgeted for this project.
- ***George Middle School Stormwater Planter***. The George Middle School Stormwater Planter Project is a retrofit of an existing planter box in front of the main entrance to the school. The L-shaped planter box is approximately 690sf. One connected downspout that drains approximately 4,000sf of the roof is located in the northeast corner of the planter bed. Opportunity exists to retrofit the existing planter to create a flow-through stormwater planter box. $15,000 of IWWP funds has been budgeted for this project.
- ***Mississippi Commons***. This is a mixed-use redevelopment project utilizing an internal "rain drain" system that will collect stormwater from over 20,000sf of roof area (that is currently connected to the city system) and sent to a courtyard swale. The swale is designed as an architectural feature for this buildings public space. $25,000 of IWWP funds has been budgeted for this project.

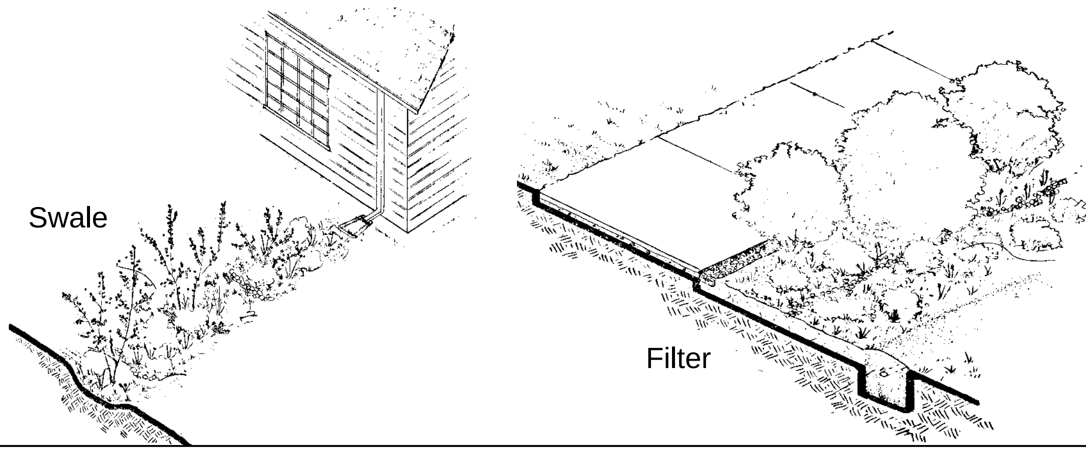

Figure 2.1.2-1. Downspout disconnections with Vegetated Swale and Filter

2.1.3 Ecoroofs

Ecoroofs would be constructed to detain stormwater runoff and reduce the amount of stormwater delivered to the sewer system. The intent is to reduce CSOs into the Willamette River and stormwater flows into receiving streams. These innovative roof designs are composed of an impermeable membrane covered with soil and vegetation instead of conventional roofing materials such as asphalt or wood shingles. Typical design criteria from the *Stormwater Management Manual* (BES, 2002) include: Ecoroof and Roof Garden (see Figures 2.1.3-1 and 2.1.3-2). The soil and vegetation hold the stormwater and return a significant amount directly to the atmosphere through evapotranspiration. The roofs detain about 30 percent of the annual precipitation that falls on them. By detaining stormwater, eco-roofs reduce peak flows in the sewer system. In addition, ecoroof projects in Portland provide educational opportunities regarding stormwater for students, parents, business owners, and the broader Portland community. A proposed ecoroof site is an example of a private project opportunity:

- ***Rejuvenation Hardware Warehouse***. An existing commercial building with a 50,000-square-foot roof would be retrofitted with an ecoroof. A predesign would need to be completed on this project to determine hydrological performance. The design may include stormwater planters and downspout disconnection (see Section 2.1.2 of this EA). The privately owned Rejuvenation Hardware Warehouse is located in a highly developed industrial area and would provide an educational opportunity for other business owners in a particularly impervious area of the city. $85,000 of IWWP funds has been budgeted for this project.
- ***Metro Ecoroof***. This retrofit project will transform 2,500sf of the 3rd floor rooftop from a ballasted roofing system to a vegetated rooftop. Metro is a public facility. If the pilot is successful, Metro would consider expanding the ecoroof at such future time as it replaces the current roof membrane. $35,000 of IWWP funds has been budgeted for this project.

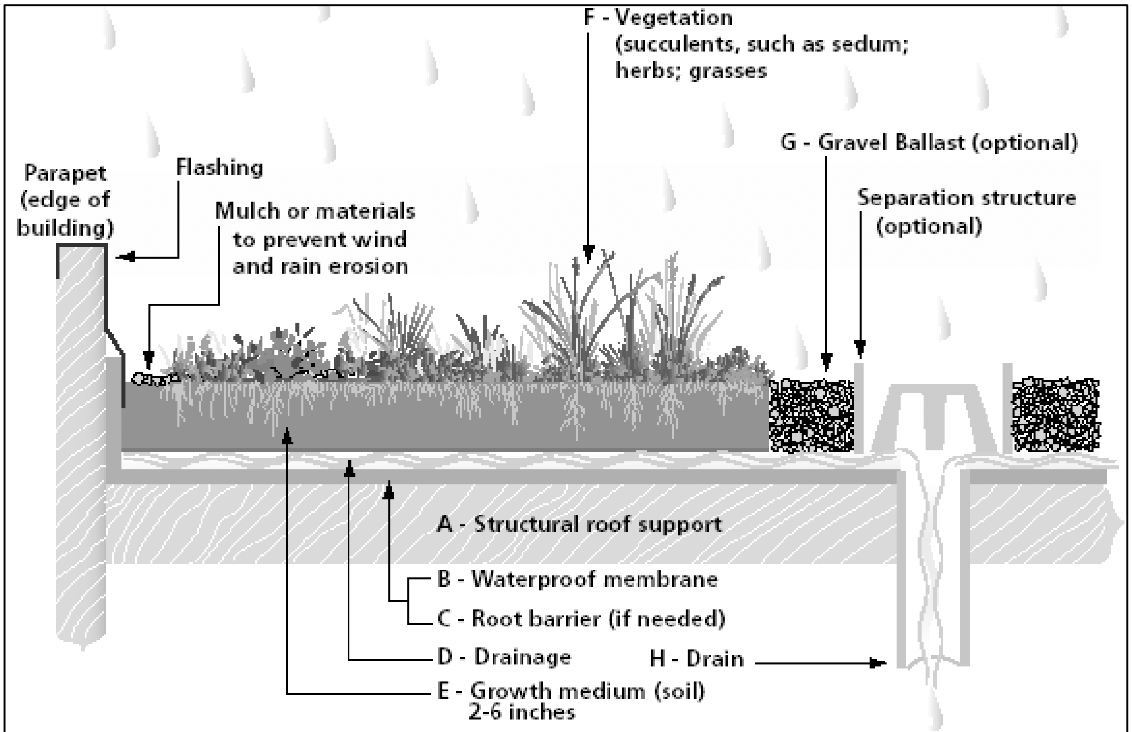

Figure 2.1.3-1. Typical Eco-Roof diagram

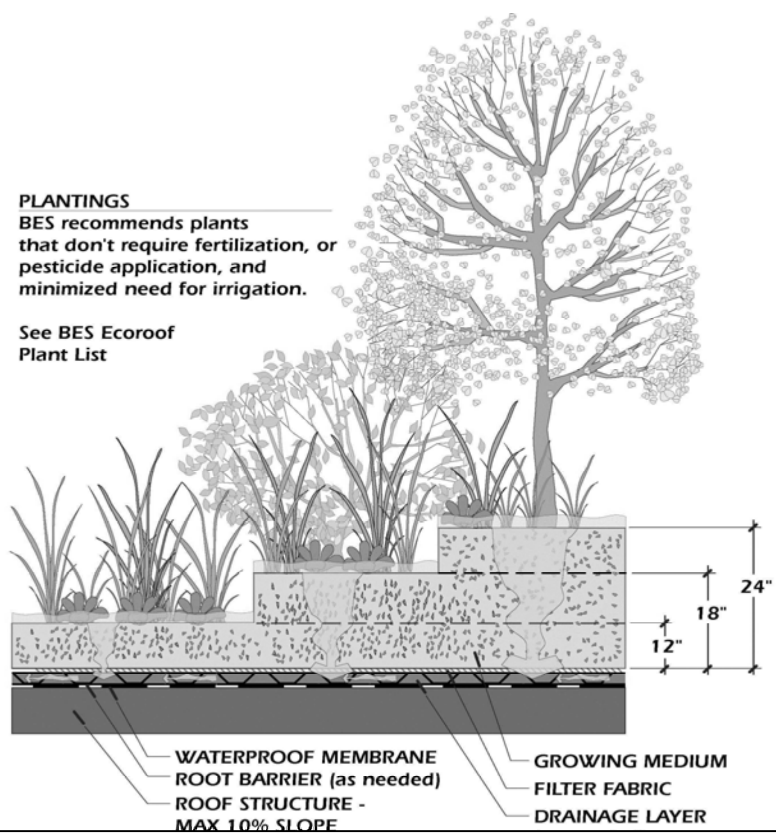

Figure 2.1.3-2. Typical section of Roof Garden

2.1.4 Monitoring and Feasibility Studies

Monitoring and feasibility studies help to ensure that innovative IWWP projects are successful. However, funds in this category would not be used to construct individual projects. Some examples of monitoring and feasibility studies are as follows:

Monitoring. The IWWP projects and other IWWP-type projects promote new technologies, especially in commercial, industrial, and institutional settings. Many are intended to be demonstration projects or provide a basis for continual improvement in approaches to urban stormwater management. Thus, it is desirable to obtain data on program successes and areas for improvement and to share and use the data in other settings within and outside Portland.

The objectives of monitoring projects are as follows:

- Focus on IWWP action-oriented construction projects (Green Streets, downspout disconnections, and eco-roofs), and non-program projects using similar technologies, to determine the performance and effectiveness of stormwater best management practices (BMPs)
- Assess the contribution that innovative technologies make to controlling flows, and reducing stormwater pollution, the volume of stormwater runoff, and CSOs
- Provide data to inform others about the success of using these types of technologies to reduce CSOs and improve watershed health
- Assess maintenance and implementation issues
- Provide data for quarterly program monitoring reports that will be submitted to EPA

Monitoring would help to ensure that innovative IWWP projects are successful, and to assess the contribution that IWWP solutions make to controlling flows, reducing pollution and CSOs, and improving watershed health. Monitoring projects would address key policy and technology questions that arise during program implementation. Monitoring projects would be limited to the amount of funds available in the Monitoring and Feasibility Studies funding category.

At the level of program monitoring, the IWWP would submit quarterly reports to EPA on the status of funded projects. At the individual project and technology levels, representative designs, facilities, and BMPs from each action-oriented construction project category would be subsampled for use as indicators of effectiveness toward meeting the goals of the IWWP.

IWWP monitoring will provide a basis for continual improvement in approaches to urban stormwater management. For example, future revisions to the Portland *Stormwater Management Manual* (BES, 2002) will benefit from monitoring IWWP projects.

Specific monitoring projects have not yet been designed; rather, they would be developed to address key policy and technology questions that arise during program implementation. Water quality compliance monitoring will not be funded by the EPA grant. $100,000 of IWWP funds has been budgeted for this project.

Stormwater Infiltration Feasibility Study. Generally, feasibility studies are used for the purposes of developing conceptual plans and conducting preliminary engineering.

At some sites stormwater disposal is very complex. This is particularly true in dense urban areas. Stormwater infiltration feasibility studies examine areas of the city to determine whether innovative stormwater management approaches can provide flow control and reduce stormwater pollution. One example of a feasibility study is Centennial Mills, which is a large, publicly owned building on the bank of the Willamette River. Site and location constraints pose challenges for stormwater infiltration at Centennial Mills. Other sites might be addressed in feasibility studies, and all would have unique constraints such as contaminated soils or limited land available for infiltrating stormwater. $45,000 of IWWP funds has been budgeted for this project.

2.1.6 Educational Efforts

Educational materials provide a tremendous opportunity to further leverage on-the-ground projects addressing problems associated with stormwater. The number of property owners interested in doing their own work to minimize impact to their watershed would increase through the creation of materials providing background information on particular projects and methods used to reduce the amount of stormwater entering the system. Potential educational projects include interpretive signs at project sites, videos and displays, workshops, and printed materials such as brochures and maps. Many efforts would involve citizens in protecting and enhancing their local watersheds. Education projects are intended to further reduce CSOs entering the Willamette River by active public participation in managing their stormwater. $65,000 of IWWP funds has been budgeted for this project.

2.1.7 Grant and Project Management

A sixth funding category, grant and project management, is assigned to ensure compliance with federal grant and procurement requirements. However, EPA funds in this category would not be used to design or construct individual projects.

A city staff member would be the grant manager and also manage many of the individual tasks and projects. The grant manager is the primary point of contact for the City of Portland on the federal grant. Existing city staff, primarily engineers, landscape architects, outreach specialists, project managers, and construction managers, would work on the IWWP projects and charge authorized time and local travel costs on grant-funded projects to the grant. City staff would hire a consultant to conduct monitoring and feasibility studies (see section 2.1.4 above).

The grant manager performs quarterly monitoring of IWWP program and project performance to EPA. $150,000 of IWWP funds has been budgeted for grant and project management.

Budget. Table 2-2 provides a summary budget for the IWWP. This budget is based upon EPA grant awards to the IWWP for FY2002 and FY2003 amounting to $1,649,000. Additional federal grants for similar project types are expected. City of Portland Capital Improvement Project matching funds will amount to $1,350,000 for these first two EPA grants. Additional matching funds will be identified when future grants are awarded.

The IWWP consists of projects and activities in varying stages of development and design at the time of grant application and EA submission. Project details, including IWWP funds budgeted for each project, are presented as known at this time. EPA will be notified prior to finalizing decisions on each of the projects and be given the opportunity to provide input.

TABLE 2-2. INNOVATIVE WET WEATHER PROGRAM SUMMARY BUDGET

Projects	EPA IWWP Funds	City Matching Funds
▪ **Water Quality-Friendly Streets and Parking Lots**		
Green Street Projects		
North Gay Avenue	$212,500	
Westmoreland Permeable Pavers	$80,000	
SE Division/New Seasons	$50,000	
SW Texas Avenue	$77,000	
Simple Green Street Side Swales	$20,000	
Parking Lot Retrofits		
Cathedral Park	$90,000	
Oregon Zoo	$225,000	
Kelley Elementary School	$25,000	
East Holladay Park	$45,000	
Zenger Farm	$50,000	
David Douglas School District Parking Lot Retrofit Projects	$30,000	
Albertson's Parking Lot Retrofit	$20,000	
Revegetation	$40,000	
▪ **Downspout Disconnections**		
Portland Public Schools	$60,000	
The Rebuilding Center	$45,000	
George Middle School Stormwater Planter	$15,000	
Mississippi Commons	$25,000	
▪ **Ecoroofs**		
Rejuvenation Hardware Warehouse	$85,000	
Metro Ecoroof	$35,000	
▪ **Monitoring and Feasibility Studies**		
Monitoring	$100,000	
Stormwater Infiltration Feasibility Studies	$45,000	
▪ **Educational Efforts**	$65,000	
▪ **Grant and Project Management**	$150,000	
Match Project – Tanner Phase 3		$1,350,000
▪ **Contingency/Unidentified Projects**	$59,500	
Total	$1,649,000	$1,350,000

Match Project. The IWWP selected the Tanner Creek Stream Diversion Project (Phase III) as its EPA match project. The Tanner Creek Stream Diversion Project is one of the projects developed for managing CSOs to the Willamette River, and incorporates many features for improving water quality and quantity. City of Portland Capital Improvement Project matching funds will amount to $1.35 million for these first two EPA grants. No EPA grant funds would be spent on this match project.

The project was identified in the *Combined Sewer Overflow Management Plan (Final Facilities Plan)* (City of Portland, 1994) to remove a large volume of stormwater from the combined sewer system. Tanner Creek historically flowed naturally through Portland’s northwest hills. Phase 3 begins near the Oregon Zoo, separates the storm flows that drain to the Sunset Highway corridor, and ends near SW Jefferson Street where it joins prior separation projects. Separation is accomplished by restoring and rerouting stormwater and the stream, which has been put into the sewer system. Separating the stormwater from the combined sewer system would reduce CSOs from the system and avoid the costs of conveying and treating stormwater at a wastewater treatment plant. CSO events contribute bacteria, floating solids, and biological oxygen demand that negatively affect water quality.

The Tanner Creek Stream Diversion Project collects treated stormwater from the upper reaches of the watershed and pipes it separately to the Willamette River. The drainage area that the storm-only system would serve is approximately 730 acres. The Oregon Zoo parking lot retrofit is one of several related projects that would detain and cleanse stormwater close to its source in the upper watershed (see Section 2.1.1 of this EA). Other facets of the Tanner Creek Stream Diversion Project may include:

- Slope bioengineering to control soil and stream channel erosion and sediment delivery to Tanner Creek from uplands. These activities would increase surface roughness and delay surface stormwater runoff.
- Upgrading of existing stormwater systems to reduce local flooding problems in basements and streets.
- Spill control facilities to control unintended discharges along Highway 26.
- Interbasin transfer of stormwater from the Montgomery system to the Tanner Creek system to match the amount of stormwater in a basin with the capacity of the storm sewer to convey it. Interbasin stormwater transfer would alleviate street and basement flooding issues in susceptible neighborhoods, allowing more opportunities for IWWP projects. For example, innovative wet weather projects cannot be implemented at the Market and 17th Subbasin (Montgomery neighborhood) because the existing storm sewer is at capacity. Interbasin transfer of some of that subbasin's storm flows to Tanner Creek Stream Diversion Project Phase 3 frees up conveyance capacity and enables neighborhood downspout disconnections and eco-roof projects to move forward.

The design for Tanner Creek Phase 3 is currently at 60 percent of completion. There already has been extensive public involvement on this match project. The project is described in detail in the *Tanner Creek Basin Environmental Assessment* (City of Portland, 1997). The environmental effects of the city's match project were determined to be not significant.

2.2 No Action Alternative

Under the No Action Alternative, the EPA would not fund the IWWP and the city would not conduct the actions established for the IWWP during the next few years. Projects falling into the five categories—water quality-friendly streets and parking lots, downspout disconnections, eco-roofs, monitoring and feasibility studies, and educational efforts—would not be funded, nor would grant and project management. Consequently, CSOs would continue unaffected by these projects. Furthermore, no data or new knowledge would be generated about the effectiveness of IWWP projects, and fewer people would be educated about the water quality benefits of the IWWP projects and technologies. Eventually, IWWP-type projects will occur regardless of EPA funding because of the water quality benefits they provide. However, the increased probability that construction projects will be implemented, and the ability to accelerate the implementation schedule, will not occur without the funding decision.

CHAPTER 3

Affected Environment

3.1 Introduction

General Characteristics

Portland, the Innovative Wet Weather Program area, is situated at 20 feet above sea level, near the confluence of the Columbia and Willamette rivers, about 65 miles inland from the Pacific Ocean. It lies midway between the lower Coast Range to the west and the high Cascades Range to the east, each of which is about 30 miles distant. Portland's varied topography includes steep hills, isolated volcanic cones, low rolling hills, and extensive flat areas. The area is composed primarily of alluvial deposits and Columbia River basalts. Much of the city is located in the Willamette Valley Plains ecoregion, although steeper portions of the Tualatin Hills on the west side are characteristic of Willamette Valley Hills and Coastal Mountains ecoregions (Clarke et al., 1991).

Portland has a mid-latitude, West Coast marine climate that is heavily influenced by the mountain ranges east and west of the city. The Coast Range protects the Portland area from Pacific storms, while the Cascades prevent colder continental air masses from invading western Oregon. The Cascades also lift moisture-laden westerly winds from the Pacific, driving local rainfall patterns. Average annual rainfall in the Portland area is approximately 37 inches. Nearly 90 percent of the annual rainfall occurs from October through May. Only 9 percent of the annual rainfall occurs between June and September, with 3 percent in July and August. Precipitation falls predominantly as rain, with an average of only 5 days per year recording measurable snow.

Summers are comparatively dry and cool, and winters are mild, wet, and cloudy. In summer the average temperature is 65°F with an average daily maximum of 74 to 78°F (Rockey, 2002). In winter, the average temperature is 40°F and the average minimum temperature is 34°F.

The City of Portland's 2001 population was 523,000 (U.S. Census Bureau, 2002). Land uses in the Portland area include industrial, commercial, low- and high-density residential and open space.

3.2 Air Quality/Noise

The Oregon Department of Environmental Quality (DEQ) and EPA have jurisdiction over air quality and noise in the Portland area. Ambient air quality standards for air pollutants have been established by federal and state agencies to protect public health (primary standards) and welfare (secondary standards). Areas in which pollutant concentrations exceed allowable ambient air quality standards are designated as nonattainment areas for that pollutant. Portland is classified as a nonattainment area for carbon monoxide (CO) and ozone. Ozone is controlled by regulating nitrogen oxide (NO_x) and nonmethane hydrocarbon (NMHC) or volatile organic compound (VOC) emissions in the area. Air pollutants of interest in evaluating the impacts of the projects include CO, VOC, NO_x, and particulates.

Air quality in the Portland area has improved in recent years. The number of days classified as “good” has steadily increased, and the number of days classified as “moderate” or “unhealthful” has decreased. The state implementation plan developed by DEQ and approved by EPA includes enforceable emission limitations, related control measures, and schedules or timetables for compliance with ambient air quality standards.

Major noise sources in the project area include highways (Highway 26, I-5, and I-405), busy roads, Portland International Airport, and railroad operations. Noise receptors are for the most part people who live in residential neighborhoods and work within or adjacent to the commercial, industrial, and institutional land uses. Wildlife, where present, could be sensitive to noise, particularly during nesting and breeding.

3.3 Water Resources

The Willamette River flows through Portland for 17 miles before joining the Columbia River. More than 11,500 square miles of land in the Willamette watershed, including most of Portland, drain into the Willamette River, making the river the tenth largest by volume in the continental United States (City of Portland, 2001). Typical Willamette mainstem flow rates through the city range from 5,000 cubic feet per second during the summer to approximately 80,000 cubic feet per second during high flow periods in the winter and spring. Peak flows after heavy rains can swell to between 200,000 and 400,000 cubic feet per second.

Watersheds

A number of tributaries to the Willamette River pass through the City of Portland, including Tryon Creek, Fanno Creek (via the Tualatin River), Johnson Creek, the Columbia Slough, and the Willamette River watershed, which includes a series of small tributaries draining the Tualatin Hills, Forest Park, and east Portland. The city’s five primary watersheds are depicted in Figure 3.3-1. A general overview of existing water resource conditions within the five primary watersheds is provided in this section (City of Portland, July 1999; City of Portland, November 2002).

Over the past 150 years, an estimated 260 of the Portland’s original 476 miles of streams have vanished—most of them paved over, piped, culverted, or filled while the city grew (see Figure 3.3-2). As the streams disappeared, patterns of runoff, streamflow, and water quality changed, especially in watersheds with the greatest proportion of stream loss.

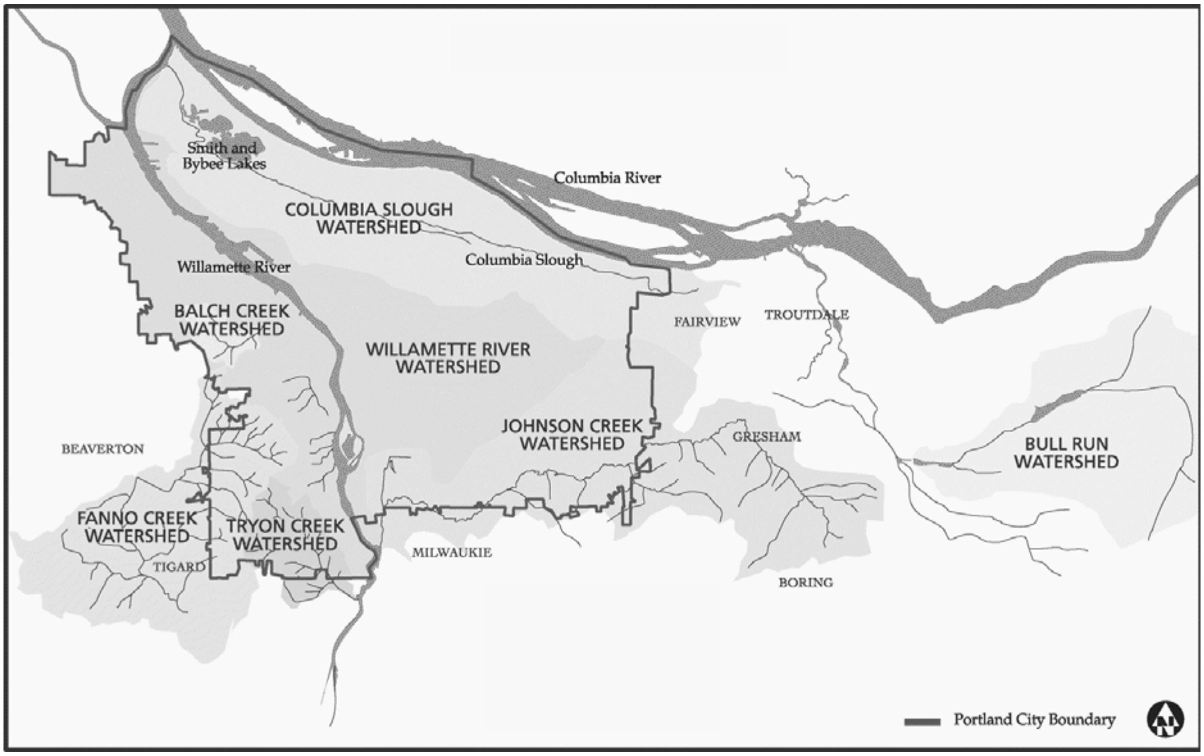

FIGURE 3.3-1. CITY OF PORTLAND WATERSHEDS

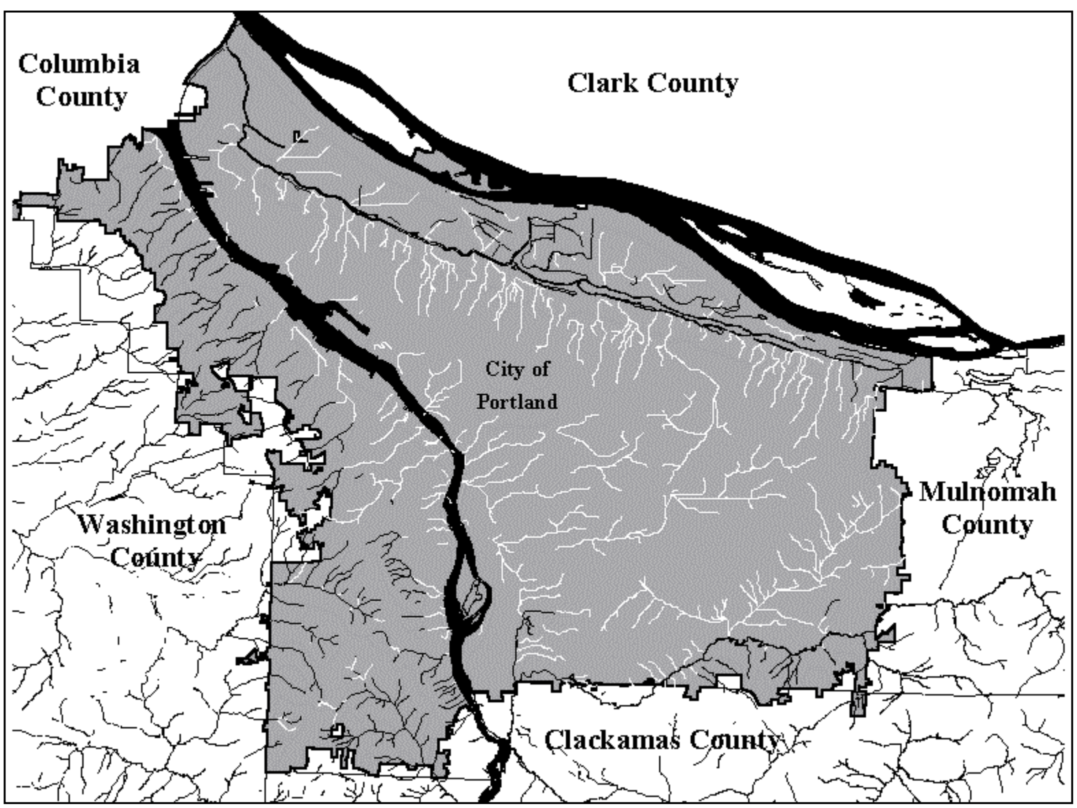

FIGURE 3.3-2. HISTORICAL STREAM LOSS IN THE CITY OF PORTLAND (CITY CLUB OF PORTLAND 1999). WHITE LINES INDICATE LOST STREAMS.

Wet Weather Management

The City of Portland estimates that there are approximately 35,000 acres of impervious surfaces in the city (City of Portland, November 2003). About one-third of those acres are roof top areas; the rest are primarily street surface, parking lots, sidewalks, and driveways. Impervious surfaces could expand to more than 50,000 acres in the future based on current comprehensive land use zoning (City of Portland, November 2003).

BES provides sewer and stormwater drainage services in an area that covers more than 94,000 acres (BES website, 2003). The agency owns and operates more than 2,250 miles of pipes and more than 90 pump stations that transport sewage to two treatment plants. More than 26,000 acres of the service area is served by 845 miles of combined sewer pipes that mix sanitary sewage and stormwater runoff. Each year, on average, about 9.9 billion gallons of stormwater flows into the combined sewer system. During wet weather, the capacity of the system is exceeded, and frequently the combined sewer system overflows. Stormwater inflows cause CSOs that discharge about 6 billion gallons to the Willamette River each year, during about 50 events (City of Portland, December 1994).

About 80 percent of a CSO is stormwater (City of Portland, December 1994). Average pollutant concentrations in CSOs are higher than in separated stormwater but much less than in domestic sewage (Table 3.3-1).

TABLE 3.3-1. AVERAGE POLLUTANT CONCENTRATIONS FOR SEWAGE, CSOs, AND STORMWATER

Pollutant	Domestic Sewage	CSO	Stormwater
TSS, mg/L	265	120	59
BOD_5, mg/L	260	28	10
TKN, mg/L	68	7.8	1.2
Copper, mg/L	0.068	0.020	0.014
Lead, mg/L	0.015	0.016	0.021
Zinc, mg/L	0.158	0.090	0.083
E. coli bacteria, CFU	1-10 million	10-100 thousand	1000

TSS = total suspended solids.
BOD_5 = 5-day biochemical oxygen demand.
TKN = total kjeldahl nitrogen.
CFU = Colony Forming Units.
Source: City of Portland, December 2003.

The separated stormwater system is designed and operated to collect and safely convey stormwater flow for discharge to local receiving waters. The stormwater system consists of 15 basins, each with its own independent network of conduits (pipelines and culverts), ponds, and stream channels (City of Portland, July 1999). Surface stormwater management facilities are designed and constructed according to Portland's *Stormwater Management Manual* (BES, 2002).

In 1999, the *Public Facilities Plan* (City of Portland, 1999) recommended numerous projects to improve combined sewers, sanitary sewers, and stormwater sewers in Portland (City of

Portland, 1999). The plan recommended wet weather improvements at numerous locations throughout the combined sewer area, representing a shift toward watershed-based approaches to stormwater management.

Willamette River Watershed

The Willamette River is a tributary to the Columbia River at approximately River Mile [RM] 102. It is the tenth largest river in the contiguous United States in terms of streamflow. The entire Willamette Basin is 11,460 square miles in size; it constitutes 12 percent of the land area of Oregon, and about 70 percent of Oregon's population lives there (Willamette Restoration Initiative, 1999). The Willamette Basin is divided into 12 subbasins. The lower reach of the Willamette—the subbasin that includes the City of Portland—extends from the mouth upstream to the falls at Oregon City (River Mile 26.5 of the Willamette River).

Historically, the Willamette River in the Portland area consisted of an extensive and interconnected system of active channels, open slack waters, emergent wetlands, riparian forest, and adjacent upland forests on hill slopes and Missoula Flood terraces. Today, the channel is diked and dredged throughout the Portland Harbor. The channelized characteristics of the Portland Harbor and surrounding area have adversely modified the habitat types and the localized flow regime. The urban setting minimizes the presence of riparian vegetation and the input of new large wood from riparian areas.

Water quality in the lower Willamette River is fair to poor. The Portland Harbor was recently placed on the National Priorities List ("Superfund") for elevated levels of DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals. The lower Willamette River is listed on the 303(d) list of impaired waterbodies for temperature, bacteria, biological criteria (fish skeletal deformities), and toxics (mercury, arsenic, and pentachlorophenol). DEQ also identified lead and copper as potential water quality concerns in a 1997 analysis (Oregon Department of Environmental Quality, 1997). These parameters are being investigated further to evaluate whether they should be included on the 303(d) list, using ultraclean sampling and analysis methods and improved detection limits.

Forest Park Streams (Balch Creek, Miller Creek, and Other Tributaries)

The Forest Park streams contain a number of small watersheds such as Balch and Miller creeks that flow to the Willamette. The Forest Park watersheds are probably among the least altered watersheds within Portland when compared with their historical hydrological conditions because many are protected by Forest Park. The hydrographs of these small watersheds are probably reasonably comparable to historical conditions because of the low overall percentages of imperviousness and small amounts of stormwater drainage to them.

Water quality is generally good, but excessive amounts of fine sediment may occur in sections of these streams near residential or industrial development. Summer temperatures may be unsuitable in certain areas where riparian areas are narrow and unvegetated. Toxic contamination may be an issue in reaches receiving CSO and stormwater discharges. One example is the Tanner Creek combined sewer system, which conveys wastewater, hillside stormwater, the historical Tanner Creek stream, and groundwater through underground pipes along Highway 26, then under the downtown area. The Tanner Creek Stream

Diversion Project was described previously in an environmental assessment prepared for EPA (City of Portland, May 1997).

Exceptions to the general conditions of Forest Park streams occur in the lower reaches where each stream must pass under Highway 30 and through the heavily industrialized port and industrial areas along the banks of the Willamette River. The streams typically pass through pipes for considerable lengths through this section and receive stormwater and combined sewer overflow discharges before discharging to the Willamette. Consequently, stream biota in these areas no longer reflect historical conditions.

Wet Weather Management in the Willamette River Watershed

The Willamette River Watershed in Portland west of the mainstem comprises about 12,801 acres and consists of seven combined sewer basins, two sanitary sewer basins, and three stormwater basins. The combined sewer basins in the western Willamette River Watershed tend to have significant basement flooding problems where the steep topography in the upper watershed transitions to moderate slopes in the lower watershed. Recommended improvements include sewer separation projects, increasing pipe diameters, increasing pumping capacity, and further incorporating stream separation projects to reduce the size and extent of flood control facilities. Stream separation entails diverting stream flow from the combined conveyance system to its natural stream path for discharge to the Willamette River.

The eastern Willamette River Watershed in Portland comprises about 15,546 acres and consists of 16 combined sewer basins, 1 sanitary sewer basin, and 2 stormwater basins. Most of the combined sewer basins in the eastern Willamette River Watershed have significant capacity problems, which result in basement flooding. Problems are caused by undersized conveyances, flat slopes, and very long connection networks. The *Public Facilities Plan* (City of Portland, 1999) recommended sewer replacement to obtain greater capacity (which may also address structural deficiencies), inflow reduction measures, inline storage, and partial sewer separation (meaning sewer separation in some portions of some basins) to address the remaining basement flooding problems.

For the separated stormwater system, steep slopes in the western watershed contribute to high stream velocities that cause erosion and loss of riparian vegetation. High erosion rates in the upper channels deliver debris, cobbles, and dirt to the lower ends of each steam where the materials settle out. At Balch Creek, for example, erosion leading to sedimentation harms fish spawning areas. The *Public Facilities Plan* (City of Portland, 1999) recommended replacing or improving undersized culverts, addressing sedimentation problems by improving channels and increasing maintenance activities, limiting soil exposure, and retrofitting the storm system with water quality protection features (such as trapped catch basins, water quality inlets, and oil/water separators). The piped system in the eastern Willamette River Watershed is adequate to convey stormwater flows, and there are minimal stormwater facilities.

Tryon Creek Watershed

Tryon Creek is a 7-mile free-flowing stream located in a 4,237-acre watershed. The stream flows in a southeasterly direction from the West Hills of Portland to the Willamette River near Lake Oswego. It is primarily a moderate gradient stream with steep sideslopes. The upper watershed has been subject to common impacts associated with urban development, including increased stream velocities and stream bank erosion (City of Portland Bureau of Environmental Services, 1997). The increased amount of impervious surface in the upper watershed has resulted in higher volume peak flows.

The channel condition is typical of a moderate-gradient stream with steep sideslopes. Approximately 60 to 75 percent of the slopes within the watershed exceed a 30 percent grade (City of Portland Bureau of Environmental Services, 1997). This results in a high degree of mass wasting and erosion. In addition, soils in the watershed are from a silt loam series (Cascade) that are underlain by a fragipan that impedes water infiltration and root penetration. This results in a high incidence of wind throw, mass wasting, channel incision, and bank erosion. The most serious problems for salmonids resulting from this type of watershed are siltation of spawning gravels and a decrease in substrate and habitat complexity.

Historically, Tryon Creek provided important habitat for sea-run cutthroat, steelhead, coho and possibly chinook salmon. However, development activities, particularly culvert and road crossings, have resulted in degraded habitat and migration barriers. Habitat in Tryon Creek has been evaluated in Oregon Department of Fish and Wildlife (ODFW) stream surveys (Oregon Department of Fish and Wildlife, 2000) and a City of Portland corridor assessment (City of Portland Bureau of Environmental Services, 1997). Instream habitat ranged from marginal to optimal in a few areas, with most of the marginal habitat within the more heavily urbanized upper watershed. Highest quality habitats were located within Tryon Creek State Park, which had wide and relatively undisturbed riparian buffers.

Arnold Creek, one of the larger tributaries to Tryon, has good instream habitat but with suboptimal percentages of fines. Bank erosion and incision are the primary forms of degradation within the creek's lower reaches. Falling Creek, another major tributary to Tryon, has poor to marginal instream habitat, with a lack of instream cover, poor bank and riparian structure, and excessive fine sediments.

Water quality in Tryon Creek is good to fair. Tryon Creek is on DEQ’s 303(d) list for summer temperature. The City of Portland is currently monitoring the concentrations of 13 water quality parameters. A preliminary examination of the data indicates that with the exception of temperature, water quality generally meets water quality standards.

Impairment of fish access to habitat by culverts is a significant issue throughout the Tryon Creek watershed. A large culvert is present at the mouth of Tryon Creek just above its confluence with the Willamette River (at RM 19.9). Although baffles are present within this culvert, it is likely that the culvert impairs salmonid movements into and out of the watershed. An impassable culvert is present at Boones Ferry Road. Above this, there are many additional impassable culverts on Tryon and Arnold creeks that limit movements of resident fish through the watershed. A series of waterfalls and rapids at Marshall Park (at RM 2.7) that are considered a natural barrier would have limited anadromous fish access prior to the presence of culverts.

Fanno Creek Watershed

Fanno Creek is a tributary to the Tualatin River Basin. The creek drains about 20,500 acres, but most of this is outside the city limits (City of Portland Bureau of Environmental

Services, 1997). Instream habitat quality in Fanno Creek and in two tributaries—Vermont and Woods Creeks—was rated as extremely impaired or threatened, primarily as a result of adverse effects from excessive amounts of fine sediment (City of Portland Bureau of Environmental Services, 1997). High channel erosion is present through much of the watershed within the city as a result of lack of bank vegetation, large wood, and rock. These factors result in limited habitat complexity and instream cover. Channel morphology is generally poor and dominated by pools or glides with very few riffle areas. Isolated areas with comparably higher habitat values are present in some reaches in relatively undeveloped areas or in headwater reaches.

Fanno Creek has TMDLs for temperature, phosphorous, dissolved oxygen, and bacteria. Urban and suburban development within the watershed has contributed to these water quality problems as a result of reduced riparian vegetation, increased nutrient loading and stream temperatures.

Wet Weather Management in the Tryon Creek/Fanno Creek Watersheds

The Tryon Creek/Fanno Creek watersheds in Portland comprise about 15,763 acres and consist of six combined sewer basins, six sanitary sewer basins, and six stormwater basins. Stream separation is one effective approach for addressing capacity problems and providing CSO control benefits in these watersheds (City of Portland, July 1999). Inline storage solutions are limited in this watershed because they require construction at steep slopes.

Stormwater basins in these watersheds are typically small urban streams, with culverts routing flows under roads and fills as the streams meander toward the receiving waters. In some cases, these basins are served by neighborhood water piping networks that discharge to the streams. Several reaches throughout the basins have undersized culverts and a history of streambank flooding. Numerous areas have excess velocities in the channels, erosion, degraded instream and riparian habitat, sediment deposits, and poor structural conditions. The *Public Facilities Plan* (City of Portland, 1999) recommended stabilizing streambanks, increasing culvert capacity, repairing culverts, and improving biofiltration capabilities of the riparian zone to meet water quality requirements and provide optimum flooding and water quality benefits.

Johnson Creek Watershed

Johnson Creek originates in the hills east of Portland and flows westward approximately 25 miles to its confluence with the Willamette River. The stream receives water from several major tributaries, including Crystal Springs Creek, Kelley Creek, Mitchell Creek, Butler Creek, Hogan Creek, Sunshine Creek, and Badger Creek. Land use in the entire 34,560-acre Johnson Creek watershed ranges from heavily developed urban areas (the cities of Portland, Milwaukie and Gresham) to rural farm and nursery lands (headwaters).

Johnson Creek has been substantially altered from its historical configuration. Diking, channelization, and other alterations of the natural floodplain have eliminated many of the areas that once absorbed and conveyed floods through the watershed. One of the most significant alterations occurred in the 1930s when the Works Progress Administration widened, deepened, rock-lined, and channelized 15 miles of the 25-mile stream in an attempt to control flooding. These alterations have had long-lasting and marked effects on the habitat and hydrology of the watershed.

Flow monitoring indicates that low-flow conditions in Johnson Creek may adversely affect aquatic life. The Oregon Department of Fish and Wildlife has set minimum flow targets to protect salmonids in Johnson Creek (Meross, 2000). Flows in the middle and upper watershed frequently do not meet those minimum flows, particularly in spring and summer months. Below Crystal Springs, which provides consistent and abundant groundwater flows, minimum instream flows are typically met.

There is also evidence of adverse impacts from excessive peak flows, primarily in the winter. Statistical evaluation of flow since 1940 indicates some increase in the flashiness of peak flows over the period of record (Clark, 1999). Significant impacts on peak flows in Johnson Creek also appear to be affected by alterations in the stream channel and floodplain that change the way floods flow through Johnson Creek.

Fish access to habitat is impaired by culverts throughout the watershed. Although there are no culverts on the mainstem until high in the watershed, they are present on nearly all the tributaries to Johnson Creek. Crystal Springs, a channel used by local and migratory Willamette salmonids, has a series of partially impassable culverts along its length. Some of the least developed tributaries along the southern side of the middle watershed also have culverts along their confluences with the mainstem.

Water quality in Johnson Creek is rated as fair to poor. Johnson Creek was placed on the 303(d) list by DEQ for bacteria, summer temperature, and toxics (DDT and dieldrin). The 303(d) listing includes the entire stream, from the mouth to headwaters. The numerous investigations of temperature in Johnson Creek over the years have consistently indicated that elevated temperatures are a problem throughout the watershed.

Wet Weather Management in the Johnson Creek Watershed

The Johnson Creek Watershed comprises about 14,070 acres in the City of Portland and consists of two combined sewer basins, one sanitary sewer basin, and one stormwater basin. The two combined sewer basins serve approximately 10 percent of the watershed however, no CSOs are directed to Johnson Creek. There are few hydraulic problems in the small Lents 1 basin in the southwest portion of the watershed; however, there are potential areas of basement flooding from peak storm flows. The larger Lents 2 basin northeast of Lents 1 has significant capacity problems that result in basement flooding. Problems are due to undersized conveyances, flat slopes, and very long collection networks. The focus of the city's relief and reconstruction program in this watershed is to address basement flooding problems and critical sewer pipes in poor structural condition. Recommended projects include sewer replacement for increased capacity (which may also address structural deficiencies), inflow reduction measures, inline storage, and partial sewer separation.

The single separated stormwater basin in the watershed encompasses approximately 90 percent of the watershed area within the Urban Services Boundary and includes the natural stream system, storm drain pipelines, culverts, and detention ponds. Johnson Creek has been severely altered by urbanization, including development and channel-straightening projects. Frequent flooding characterizes the Johnson Creek mainstem. The stream responds rapidly to precipitation during saturated conditions, primarily in the Lents and Powellhurst neighborhoods. Several culverts are undersized. The *Public Facilities Plan* (City of Portland, 1999) recommended one stormwater channel improvement project and improvements to

Johnson Creek that integrate flood management, water quality, and fish and habitat improvements.

Columbia Slough Watershed

The Columbia Slough extends 19 miles from Fairview Lake on the east to the Willamette River at Kelley Point Park on the west. It drains about 34,711 acres of varied land uses, including portions of Portland International Airport and Portland's "industrial sanctuary." The northern half is relatively flat, with shallow groundwater, and the southern part includes Alameda Bluff. The slough's channel configuration and flow regime have been altered significantly from historical conditions. It is now a highly managed water conveyance system with dikes and pumps that provide watershed drainage and flood control, maintaining a highly artificial hydrograph.

Water quality in the Columbia Slough watershed is highly degraded. DEQ has placed the Columbia Slough on the 2002 303(d) list for 3 parameters (iron, manganese, and temperature). DEQ has already established TMDLs for pH, DO, and phosphorus.

In addition to the main Columbia Slough, the watershed contains the relatively good habitat at Smith and Bybee, Wilkes Creek, Fairview Lake, Fairview Creek and tributaries, as well as numerous wetlands that receive area stormwater and groundwater flow.

Wet Weather Management in the Columbia Slough Watershed

The Columbia Slough Watershed consists of 11 combined sewer basins, 5 sanitary sewer basins, and 6 stormwater basins. Stormwater runoff in the watershed goes mainly to infiltration sumps, pipes to the Columbia Slough, and pipes to the POTW, which discharge to the Columbia River. In general, the four stormwater basins in the northwestern half (approximately) of the watershed are primarily industrial and consist mainly of open channels and culverts that convey flow to the Columbia Slough. The two stormwater basins in the southeastern part of the watershed are highly developed mixed residential and commercial uses and are served by piped systems or stormwater infiltration sumps.

The combined sewer system area has received significant stormwater and collection system improvements as part of the CSO Management Program. Since 1994, the city initiated several programs throughout the watershed to reduce stormwater inflow to the combined sewer system. Stormwater infiltration sumps have been installed, roof downspouts have been disconnected to surface infiltration, and new stormwater conduits have been constructed. The "Big Pipe" also was installed and a majority of stormwater either goes to the water treatment plant (and thence to the Columbia River) or is piped to Ramsey Lake wetland for stormwater treatment (and thence to the Columbia Slough).

The *Public Facilities Plan* (City of Portland, 1999) for stormwater recommended pollution reduction facilities, riparian restoration, and slough infrastructure improvements to improve conveyance. Projects recommended to address basement flooding problems include sewer replacement for increased capacity (which may also address structural deficiencies), inflow reduction measures, inline storage, stream separation, and regional detention.

3.4 Geology and Soils

Geology

The program area is located in the Portland Basin physiographic province, in which consolidated and unconsolidated sediments overlie basalt (Woodward-Clyde Consultants, March 1995; Parametrix, June 1994; Madin, 1990). From youngest (and shallowest) to oldest (and deepest), the geologic units consist of the following formations:

1. Late Pliocene to Holocene Age volcaniclastic conglomerates, loess, terrace deposits, catastrophic flood deposits, and alluvium (Swanson et al., 1993)
2. Late Pliocene and Pleistocene Age Boring Lavas that are locally intruded into the sedimentary rocks and younger deposits (Mabey et al., 1993)
3. Troutdale Formation, consisting of quartzite-bearing conglomerate and sandstone (Trimble, 1963)
4. Sandy River Mudstone, consisting of mudstone, siltstone, sand, and claystone
5. Miocene Age Columbia River Basalt

Portland lies in a moderately active seismic region and is south of the more active St. Helens seismic zone. The nearest mapped fault trends northwest–southeast and parallels the shoreline of the Willamette River between Mocks Bottom and Southeast Hawthorne Boulevard (Beeson et al., 1991). The Portland Hills Fault parallels the eastern foot of the Portland Hills and is inferred to extend beneath downtown Portland (Beeson et al., 1991).

Soils

The *Soil Survey of Multnomah County* (Soil Conservation Service, 1983) describes the soil resources occurring in Portland. In addition to the native soils, fill materials ranging from miscellaneous waste materials to clean, crushed rock may be encountered during construction because of the developed, industrialized nature of some areas of the city. None of the soil types are classified as prime or unique farmlands by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (formerly the Soil Conservation Service).

Willamette River Watershed

Soils in the upper elevations of the western Willamette River Watershed are silt loam with moderate permeability. They are characterized by a slow infiltration rate and high runoff potential. Extreme slopes accelerate runoff. Soils in the lower elevations and on some of the hillsides are primarily gravelly loam. They are well drained, with a moderate rate of permeability.

The majority of the watershed east of the Willamette River is relatively flat; slopes are usually less than 3 percent, but Mt. Tabor, Kelly Butte, and Rocky Butte have slopes ranging from 8 to 60 percent. The bluffs along the Willamette River serve as a dividing point between two different soil types. The low-lying areas along the Willamette River range from excessively drained to very poorly drained silt loams, silty clay loams, and sands.

High groundwater in these areas makes them generally unsuitable for infiltration facilities. The higher areas to the east are characterized as moderately drained or well-drained loams and silt loams. Other areas east of the river are sand or silty loam and are generally very porous. The easternmost portion of the watershed readily absorbs rainfall; consequently, generation of stormwater is lower and the residential areas have a large number of infiltration sumps. Because the watershed is highly developed, about 50 percent of it is impervious surface area.

Tryon/Fanno Creeks Watersheds

Upland slopes in some parts of the watershed exceed 30 percent. Soils mostly range from moderately drained to poorly drained silt loams that are often saturated during the rainy season, resulting in surface runoff and erosion.

Johnson Creek Watershed

Slopes generally range from 1 to 10 percent, but steep hillsides also exist in this watershed, including Mt. Scott and Powell Butte. Slopes on Mt. Scott range from 10 to 30 percent, with a few approaching 50 percent.

Johnson Creek forms a divide between two distinct soil types. South of Johnson Creek, the soils primarily range from moderately well-drained to somewhat poorly drained silt loams. Soils north of Johnson Creek are generally well-drained loams and silt loams.

Columbia Slough Watershed

The Columbia Slough lies within the floodplain of the Columbia River, an area that is characterized by relatively level ground that generally slopes down to the slough. Existing undisturbed soils in the slough area consist of alluvial materials. These soils may be soft or loose and saturated. Because of their silt and clay content, these soils are sensitive to water and can be slippery, heavy, and difficult to handle when wet.

The low-lying areas, generally north of NE Columbia Boulevard, range from excessively drained to very poorly drained silt loams, silty clay loams, and sands; high groundwater is common. Soils to the south of NE Columbia Boulevard are generally moderately or well-drained loams and silt loams. The soils throughout this watershed have been disturbed over time by construction, cutting, and filling.

3.5 Floodplains and Wetlands

Floodplains

Floodplains are dry in some seasons, but inundated when heavy rain, snow melt, tide, increased rate of surface runoff, or other conditions cause streams or rivers to overflow their normal channels. A 100-year floodplain is submerged by a flood level occurring once every 100 years. Standards for development in 100-year floodplains, which are specified in the federal Flood Hazard Insurance Act, must be met for Portland to qualify for federal flood insurance assistance. The density of development in natural flood hazard areas is controlled consistent with the provisions of the city's Building Code, Chapter 70, the Floodplain Ordinance and the Subdivision Ordinance.

Willamette River Watershed

Historically, connectivity of floodplain habitat was high both longitudinally along the river and laterally from the vegetated riverbanks to the upland forests. Gradually, floodplain habitats along the Willamette River have been destroyed, degraded, or disconnected through construction of dams throughout the Willamette and Columbia rivers and from development along the riverbanks (City of Portland, November 2002). Large expanses of black cottonwood/Pacific willow forest and spirea/willow wetland have been filled and developed, leaving small strips of riparian forest, wetland, and associated upland forests. These remnants are few or entirely lacking in large reaches through the downtown and industrial segments of the river. Most of the historical off-channel habitats, such as side channels, oxbow lakes, and marshes, have long since been cut off from the channel and filled. Connectivity and maintenance of these habitats have been reduced or eliminated as a result of marked alteration of the seasonal hydrograph, particularly a dramatic reduction of peak flows. Connection of many tributary habitats to the mainstem is eliminated or reduced by culverts. Within the Portland downtown and harbor areas, the river’s banks are typically steep and are primarily composed of bank stabilization and fill materials such as sheet pile, riprap, seawall, and concrete fill. Riparian vegetation is generally sparse to absent and frequently consists of nonnative plants and shrubs.

A few small areas of higher quality habitat remain within the highly urbanized reaches of the Willamette. Remnant habitats of high quality—or with the potential to provide important functions if reconnected or restored—include Powers Marine Park, Ross Island, lower Stephens Creek, Oaks Bottom, Willamette Park, Kelley Point Park, the Forest Park watersheds, and Smith and Bybee lakes.

Channel conditions of subbasins draining the Forest Park area range from mature forested stands with good bank stability in the middle and upper sections to underground pipes that carry the streamflow through industrial areas and then out to the Willamette River via a pipe outlet in the lower sections.

Tryon Creek Watershed

Highest quality habitats are located within Tryon Creek State Park, which has wide and relatively undisturbed riparian buffers. Even within this protected area, however, wood volume is low and channel incision is evident. Above the park, the stream becomes highly segmented by road crossings and their associated culverts, and it is affected by intensive urban development.

Arnold Creek has good instream habitat but is highly segmented by culverts from road and driveway crossings. In addition, invasions of nonnative plants are evident even within the higher quality areas of Arnold Creek and Tryon Creek State Park. Falling Creek has poor to marginal instream habitat, with a lack of instream cover, poor bank and riparian structure, and excessive fine sediments.

Fanno Creek Watershed

Drainages in this watershed are typically small urban streams, with culverts routing flows under roads and fills. In some cases, neighborhood water piping networks have replaced floodplains and wetlands. There are numerous areas along Fanno Creek and its tributaries where excess velocities in the channels have caused erosion and degraded riparian habitat. Sediment deposits and poor structural conditions also are evident.

Johnson Creek Watershed

The historical floodplain of Johnson Creek is disconnected or minimally connected through much of the stream's length (City of Portland, November 2002). The lack of floodplain connection means that flood flows cannot spread out and attenuate on the floodplain. Instead they are directed and concentrated into the main channel, where they increase scour and degrade instream habitat.

ODFW conducted habitat surveys throughout Johnson Creek (Oregon Department of Fish and Wildlife, 2000). The department's findings indicate that Johnson Creek has extremely low wood volumes, a high percentage of hardened banks, lack of refugia through many reaches, channel incision, and high levels of fine sediment. Riparian vegetation is minimal or lacking throughout much of the watershed. Riparian vegetation is as lacking in the upper watershed as it is in the lower watershed.

Columbia Slough Watershed

The Columbia Slough is located on the southern 100-year floodplain of the Columbia River between Fairview Lake and the Willamette River. The U.S. Department of the Interior (USDI) Fish and Wildlife Service's National Wetland Inventory shows that the slough system is primarily riverine and palustrine wetlands. Currently a maintained channel, it is a remnant of former marshes, wetlands, lakes, and side channels that characterized the historical floodplain system.

Over the years, extensive development has resulted in a watershed that has lost a vast percentage of its upland, wetland, and aquatic habitat. Large amounts of open water areas and wetlands have been eliminated as a result of urban development, and the hydrologic connectivity of the entire system has been greatly reduced. The creation of the levee on which Marine Drive is located has blocked the direct connection between the Columbia Slough and the Columbia River system, severing the river from its floodplain. A levee and pump station at NE 18th Avenue blocks passage of fish into the middle and upper parts of the slough. Consequently, juvenile salmonids from the lower Willamette River that are seeking out rearing habitats have access only to the lower section of the slough.

Wetlands

Wetlands include streams, ponds, marshes, and swamps. The majority of the wetlands are in the regional riverine hydrogeomorphic (HGM) class (41%), while 23% are in HGM classes atypical to the region due to human manipulation (Kentula and Gwin 2002). Most wetlands are in fair or marginal condition with 14% rated good and 35% poor (Kentula and Gwin 2002).

About 26% of all wetland resources are small wetlands <2 ha, and over half (57%) of small wetlands are palustrine emergent/open water wetlands (PEM/POW). Small (<2 ha) PEM/POW wetlands are the wetland types most often disturbed or lost in the rapidly developing areas of Portland (Kentula and Gwin 2002). About 40% of the small wetlands have been altered during the last two decades, mostly during the 1980s despite development pressure throughout the 1990s.

3.6 Vegetation and Habitats

Vegetation

The vegetation of Portland's watersheds is listed in the *Portland Plant List* (City of Portland, June 1998). Many listings are native—historically found in Portland—while others are introduced or nonnative to Portland. They include trees and arborescent shrubs, shrubs, and ground covers found among the wetland, riparian, forest, forested slopes, thicket, grass, and rocky habitats of the City of Portland. Native, naturalized, and exotic plant categories include "nuisance" plants. Nuisance plants either dominate plant communities (40 species) or are considered harmful to people (four species).

Five plant species are prohibited from use in all reviewed landscaping plans because they pose a serious threat to the health and vitality of native plant and animal communities. Prohibited plants include Scot's broom (*Cytisus scoparius*), English ivy (*Hedera helix*), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), and Himalayan blackberry (*Rubus discolor*). Revegetation projects often aim to control these prohibited species.

Threatened and Endangered Plants

The USDI Fish and Wildlife Service has identified six federally listed plant species that may occur in Multnomah County (USFWS, 2002): golden paintbrush (*Castilleja levisecta*, threatened), Willamette daisy (*Erigeron decumbens* var. *decumbens*, endangered), howellia (*Howellia aquatilis*, threatened), Bradshaw's lomatium (*Lomatium bradshawii*, endangered), Kincaid's lupine (*Lupinus sulphureus* var. *kincaidii*, threatened), and Nelson's checkermallow (*Sidalcea nelsoniana*, threatened). Of these species, golden paintbrush, Willamette daisy, howellia, Kincaid's lupine, and Nelson's checkermallow are on the *Portland Plant List (*City of Portland, June 1998). A search of the Oregon Natural Heritage Information Center's records of rare, threatened and endangered plant records for Portland led to the following conclusions about species presence (ONHIC, 2003).

Golden paintbrush typically occupies fescue grasslands at elevations below 300 feet and is often rooted in glacial outwash or deposits. It is unlikely that golden paintbrush occurs in Portland because no known populations have been recorded and the species is commonly believed to be extirpated from Oregon.

The Willamette daisy occupies areas of native wetland prairie in low, flat regions of the Willamette Valley where flooding creates anaerobic and strongly reducing soil conditions. The species is not known to occur in Multnomah County and is unlikely to occur because native wetland prairie communities are not present.

Howellia is not known to exist in the program area. The nearest documented population is at the Ridgefield National Wildlife Refuge, approximately 15 miles north of Portland (personal communication, L. Todd, ONHP, June 29, 1995). The species prefers still water and shaded areas in the floodplains of the Columbia River and ash woods and vernal pools.

A high degree of water clarity, which is important to Howellia, is rarely present in the urban waters, where turbidity is often high (personal communication, J. Christy, ONHP, July 5, 1995).

Bradshaw's lomatium typically occurs in wet prairies of the Willamette. There are no known occurrences of Bradshaw's lomatium in Portland, and there are no native wet prairies. It is unlikely that this lomatium is present in the project vicinity.

Kincaid's lupine occurs in the native upland grassland habitats within the Willamette Valley, on heavier soils with mesic to slightly xeric soil moisture levels. There are no known occurrences in Portland, and there are no native grassland habitats in the city. It is unlikely that this lupine is present in the project vicinity.

Nelson's checkermallow most frequently occurs in ash swales and meadows with wet depressions, along streams, and in wetlands within remnant prairie grasslands, but it may also occur in roadside ditches and mowed hayfields. There are no known occurrences of Nelson's checkermallow in the city and no native prairies are present. It is unlikely that this plant occurs in the IWWP area.

Additionally, the USDI Fish and Wildlife Service has identified 13 species of concern that may occur in Multnomah County (USFWS, 2002): Howell's bentgrass (*Agrostis howellii*), white top aster (*Aster curtus*), tall bugbane (*Cimicifuga elata*), cold-water corydalis (*Corydalis aquae-gelidae*), pale larkspur (*Delphinium leucophaeum*), peacock larkspur *(Delphinium pavonaceum*), Howell's fleabane (*Erigeron howellii*), Oregon daisy (*Erigeron oreganus*), white meconella (*Meconella oregona*), Howell's montia (*Montia howellii*), Barrett's penstemon (*Penstemon barrettiae*), Columbia cress (*Rorippa columbiae*), and Oregon sullivantia (*Sullivantia oregana*).

There are no records of Howell's bentgrass, cold-water corydalis, peacock larkspur, Howell's fleabane, white meconella, or Barrett's penstemon occurring in Portland. Consequently, these species are unlikely to occur in the area.

White top aster is assumed to be extirpated in Portland.

Tall bugbane has been reported in Forest Park and on Powell Butte and Sentinel Hill. It is found in moist areas within open forest (for example, Douglas-fir woodland).

Pale larkspur is known to occur in Sandy, Lake Oswego, and Milwaukie, but not in Portland.

Howell's montia, which prefers moist lowland areas, has been reported on Sauvies Island. It has not been reported in the program area.

Columbia cress has been documented along the north shore of the Sandy River delta. It is not known to occur in the program area.

Oregon sullivantia is known to occur at Sauvies Island, Milwaukie, and Elk Rock, but not in Portland.

Habitats

Three broad classes of habitat that support fish and wildlife are present in the Portland area: aquatic, riparian, and upland (City of Portland, November 2002). The health of biological communities is directly affected by the types and condition of specific habitat features.

Aquatic Habitat

Mainstem Rivers

The mainstem Willamette River is a running-water habitat with slow-rising, extensive, and long-lasting floods that drive disturbances. Tree falls and bank erosion are common, and logjams are scattered along the shoreline near the high-water line, at the end of islands and bars, and submerged in the channel. Most of the solar input reaches the river, although penetration can be limited by river depth. The sunlight supports the production of phytoplankton, periphyton, and rooted vascular plants that are dominant in food webs. Floodplain inundation is critical to providing the organic inputs necessary to support productivity.

Tributaries

Tributaries to the mainstems are running-water systems with irregular flood patterns strongly influenced by local precipitation events. Direct contact between the stream and adjacent hillsides results in frequent landslides, debris flows, dam-break floods, and bank erosion. Channel form is more likely to be influenced by mass wasting and alluvial processes (Naiman et al., 1992).

Tributary streams generally have smaller channels and narrower floodplains with larger rocks and boulders and poorly sorted gravels (Gurnell, 1995). Pools, riffles and glides are common habitat features of properly functioning streams. Wood may be large enough to span the channel and is not easily dislodged in headwater streams. In larger, low-gradient streams such as Columbia Slough and Johnson Creek, sediments are sorted by size and generally include abundant fine particles of silt and clay. Channel roughness, shallow-water areas, and deep pools define aquatic habitats. In less disturbed tributary streams, relatively little sunlight reaches the stream; however, many Portland streams have little vegetation to shade the water, or they are piped.

Riparian Habitat

Riparian areas are the environments adjacent to rivers and streams, a zone of direct interaction between terrestrial and aquatic ecosystems. Although many historical riparian habitats have been eliminated by the urban landscape, where present, riparian vegetation influences adjacent aquatic systems by providing important components of the food web; it can also play a significant role in the structure of aquatic communities.

Where streams are connected to historical floodplains, annual flooding allows for the interchange of organic material and nutrients between the riparian and aquatic environments. Riparian vegetation can act as a barrier that reduces sediment and debris transport, slows surface flows, and encourages infiltration. Riparian areas also can filter sediments, pollutants, metals, and excess nutrients.

In intact riparian areas, water can be stored and transported into the atmosphere, vegetation, stream channels, the floodplain, soil, and shallow or deep groundwater aquifers.

The leaves, needles, and branches in the canopy and on the ground can absorb precipitation and prevent it from reaching the ground, or they slow its progress, thus reducing the amount of erosion and runoff. When present, riparian vegetation creates a microclimate that influences both the riparian area and stream environment by affecting soil moisture and temperature, air temperature, water temperature, wind speed, and relative humidity.

Changes to Portland's riparian vegetation have influenced associated benthic communities, birds and mammals, and herpetofauna. Historical changes include reductions of the following:

- Diversity of vegetation species and structure
- Unique vegetation assemblages
- Corridors and migration routes
- Habitat features for wildlife
- Ongoing restoration efforts are attempting to improve these conditions.

Upland Habitats

Upland habitat refers to all areas that are not riparian, wetland, or open water habitats. Johnson and O'Neil (2001) describe five upland habitat types present in the Portland area. These include Westside Lowlands Conifer-Hardwood Forest, Westside Oak and Dry Douglas-fir Forest and Woodlands, Westside Grasslands, Agriculture Pasture and Mixed Environs, and Urban and Mixed Environs. Eighty-nine percent of all terrestrial species in the Portland area are associated with upland habitats, with at least 28 percent depending on these habitats to meet their life history requirements.

Of the five habitat types, the Westside Lowlands Conifer-Hardwood Forest is most widespread and prevalent, and the Urban and Mixed Environs are widely distributed but patchy. Urbanized habitats are characterized by buildings and other structures, impervious surfaces, reduced wildlife diversity, nonnative species, reduced canopy cover and habitat features, elevated temperatures, and increased background lighting and wind velocities (Penland, 1984; Puchy and Marshall, 1993). Frequent human disturbance is normal in urban habitats, and species that are disturbance-sensitive tend to be absent or reduced in numbers (Marzluff et al., 1998). There are no species at risk dependent upon this habitat.

3.7 Fish and Wildlife

Aquatic Species

Generally, game fish found in Portland include salmonids, black crappie, white crappie, blue gill, yellow perch, brown bullhead, warmouth, large mouth bass, and white sturgeon. Nongame species common throughout the area include large-scale sucker, carp, goldfish, stickleback, pea mouth, cottids, sculpin, mosquitofish, and crayfish. The poor water quality, turbidity, lack of rooted vegetation, muddy substrate, and effects of tidal water movement within waters such as the Columbia Slough contribute to the dominance of nongame species (U.S. Army Corps of Engineers, July 1992).

Benthic abundance is not particularly high because of the silty nature and lack of detritus of the urban streams and sediments (U.S. Army Corps of Engineers, July 1992). Aquatic invertebrates include cladoceranes, rotifers, oligochaete worms, chironomid larvae, clams, and midge fly larvae. The populations and abundance of species vary seasonally. Also, microscopic algae are part of the aquatic ecosystems. The extent and abundance of aquatic species vary among Portland watersheds, influenced by habitat features and historical disturbances.

Willamette River Watershed

The aquatic biota of the lower Willamette River have changed significantly from historical conditions. Extirpations of sensitive species have occurred, and introductions of nonnative species have resulted in increased competition for food and habitat for native species. The existing fish community in the lower Willamette River consists of warm-water, cool-water, and cold-water fish. Several listed salmonid evolutionarily significant units (ESUs) use the lower Willamette River. At least 33 other native and introduced species of both warm-water and cool-water fish inhabit the river (Oregon Department of Fish and Wildlife, 1994).

The biota of the Forest Park streams probably are altered relative to historical conditions. The piping of streams and installation of culverts have blocked habitat access for anadromous fish; this has resulted in the extirpation of native anadromous fish species. Resident cutthroat trout are still present in many of these watersheds.

Tryon Creek Watershed

Historically, Tryon Creek provided important habitat for sea-run cutthroat, steelhead, coho, and possibly chinook salmon. However, development activities, particularly culvert and road crossings, have resulted in degraded habitat and migration barriers.

Fanno Creek Watershed

Most of Fanno Creek within the City of Portland is inaccessible to anadromous fish because of impassable culverts downstream of city limits. The City of Portland sampled fish populations in 1993 and found reticulate sculpin, redshide shiner, cutthroat trout, and peamouth present in the upper reaches.

Johnson Creek Watershed

The fish community in Johnson Creek is dominated by redside shiners, reticulate sculpin, and speckled dace (Johnson Creek Corridor Committee, 1995). Large-scale suckers are abundant in the lower reaches. Adult salmonids that have been observed in the stream include coho salmon, chinook salmon, cutthroat trout, and steelhead (ODFW unpublished data, as cited in Ellis, 1994).

Columbia Slough Watershed

The biological communities in the Columbia Slough are degraded as a result of the extensive degradation of flow, habitat, and water quality conditions. Salmonids are restricted to the lower slough. Fish communities are dominated by nonnative warm-water fish species such as common carp and bluegill. Benthic macroinvertebrate communities are extremely sparse.

Threatened and Endangered Fish Species

Information about threatened and endangered fish species was obtained from the USDI Fish and Wildlife Service (USFWS, 2002) and Beak Consultants (1998). The listed fish species that may occur in the city's waterways include chum salmon (Lower Columbia River) (*Onchorhynchus keta*, threatened), steelhead (Lower Columbia, Middle Columbia, Upper Willamette, and Snake River Basin) (*Onchorhynchus mykiss*, threatened), sockeye salmon (*Onchorhynchus nerka*, endangered), Chinook salmon (Lower Columbia, Upper Willamette, and Snake River) (*Onchorhynchus tshawytscha*, threatened), and bull trout (Columbia River) (*Salvelinus confluentus*, threatened). Coho salmon (Lower Columbia River) (*Onchorhynchus kisutch*) is a candidate species for listing. Coastal cutthroat trout (*Onchorhynchus clarki clarki*) was formerly proposed for listing as threatened, but the southwestern Washington/ Columbia River population became "Not Listed" in July 2002. Green sturgeon (*Acipenser medirostris*) became a candidate species for listing in January 2003. Pacific lamprey (*Lampetra tridentata*) are listed as species of concern.

Changes to stream flows and the loss of side channels and floodplains as a result of diking and filling have reduced the historical distribution of threatened and endangered fish species. Many areas of Portland are able to support only temporary rearing of individuals from populations of steelhead and chinook that are emigrating out of larger tributaries in the upper portion of the Willamette River watershed.

Many Portland watersheds are blocked near the mouth by culverts that allow anadromous fish access to, at best, only a thousand or so feet of stream. These areas offer opportunities for fish to temporarily move off the mainstem of the Willamette, and fish in these areas most likely are coming from more productive watersheds such as the Clackamas River. However, anadromous fish use some Portland stream reaches as described below.

Willamette River Watershed

Given the extensive culverting of streams emptying into the Willamette within Portland, there is very little stream habitat that is accessible to salmonids for spawning and rearing in the tributaries. All of the Forest Park streams that historically flowed into the Willamette River have been blocked by culverts. Balch Creek was isolated in 1921 when the lower part of the creek was diverted and incorporated into the City of Portland’s sewer system.

In the lower Willamette River, juveniles of winter steelhead and spring chinook use habitats available in the shallower margins of the river or off-channel sites where available for rearing as they out-migrate through the lower river (City of Portland, November 2002). Adult steelhead and spring chinook have been documented holding up in the lower mainstem for a period of time before moving upriver (City of Portland, 1999). Adult spring chinook come in as late as December and hold in the main river before crossing Willamette Falls. Adult steelhead have been documented entering the mouth of the Clackamas River with a darkened coloration, indicating that they have been in freshwater for some time (City of Portland, 1999).

Fall chinook juveniles exhibit similar near-shore and off-channel behaviors as spring chinook and steelhead juveniles with a series of migrating and rearing strategies as they move down the Willamette River in the vicinity of Portland.

There are several small streams where temporary off-channel rearing of out-migrating juvenile steelhead may be occurring where habitat exists between culverts and the river. For example, there is documentation of off-channel rearing of steelhead and/or rainbow trout in the lower portion of Miller Creek below St. Helens Road (City of Portland, 1992). When conditions are appropriate, the lower reach of Stephens Creek may offer temporary rearing opportunities to out-migrating juvenile steelhead spawned in tributaries upstream in the Willamette watershed.

Cutthroat trout have been documented in several streams that drain into the Willamette River. Cutthroat trout have been observed in Miller Creek (Gram and Ward, 2002), and a population of 2,000 to 4,000 resident cutthroat trout has been documented in Balch Creek (Johnson, 1993). Also, cutthroat trout are found in Stephens Creek, which has been cut off from the Willamette River by culverts. This evidence suggests that similar isolated populations of cutthroat may exist in Forest Park streams where appropriate flows and habitat exist.

Tryon Creek Watershed

Steelhead and/or rainbow trout have been documented in Tryon Creek (Gram and Ward, 2002; Pacific Habitat Services, 1997; Reed and Smith, 2000). The documented findings of spawning and rearing steelhead suggest that these are an independent population. Tryon Creek is one of two watersheds within the metropolitan area that is accessible to migrating steelhead. (A culvert under Highway 43 near the mouth of Tryon Creek has been determined to be passable by an Oregon Department of Fish and Wildlife inventory. However, there has been speculation that the culvert is impassable at certain times of the year, depending on water levels [personal communication, C. Prescott, City of Portland, 2002].) Also, when conditions are appropriate, the lower reach of Tryon Creek may offer temporary rearing opportunities to out-migrating juvenile steelhead spawned in tributaries upstream in the Willamette watershed.

Cutthroat trout are found in Tryon Creek, where access to habitat is unimpeded by culverts.

Fanno Creek Watershed

Steelhead and/or rainbow trout have been documented in the Tualatin Basin (Friesen and Ward, 1996), but not in Fanno Creek, which has been cut off from the Willamette River by culverts. However, cutthroat trout are found in Fanno Creek.

Johnson Creek Watershed

Adult chinook have been documented spawning in lower Johnson Creek over the years but in such small numbers as to prompt Ellis (1994) to speculate that these fish may be strays. Juvenile chinook have been documented in the lowest reaches of Johnson Creek and Crystal Springs Creek (Ellis, 1994; Reed and Smith, 2000). Given the limited information that is available regarding the number of adult chinook that have returned to spawn, the evidence suggests the possibility that juveniles that have spawned in other watersheds may be using these areas as temporary off-channel sites as they migrate through the area.

Johnson Creek Watershed is one of the two watersheds within the metropolitan area that is accessible to migrating steelhead. Steelhead and/or rainbow trout have been documented in the Crystal Springs Creek tributary to Johnson Creek, the lower 9.6 miles of Johnson

Creek (from roughly SE 145th to the confluence with the Willamette River) (Ellis, 1994), and the Kelley Creek tributary of Johnson Creek (Ellis, 1994; Reed and Smith, 2000). The documentation of steelhead juveniles in surveys between 1992 and 1999 in the Kelley Creek subwatershed to Johnson Creek and documentation of possible overwintering juveniles (Reed and Smith, 2000), combined with ongoing observations of spawning steelhead adults, suggest the continued presence of a small population and not just sightings of occasional strays. Also, when conditions are appropriate, the lower reaches of Johnson Creek may offer temporary rearing opportunities to out-migrating juvenile steelhead spawned in tributaries upstream in the Willamette watershed.

Cutthroat trout are found in Johnson Creek, where access to habitat is unimpeded by culverts.

Columbia Slough Watershed

Juvenile chinook have been documented in Smith and Bybee lakes (Fishman Environmental Services, 1987). It is probable that juveniles that spawn in other watersheds are using this area as a temporary off-channel site as they migrate through Portland.

Essential Fish Habitat

Under the Magnuson-Stevens Act, Essential Fish Habitat (EFH) for the Pacific coast salmon fishery (chinook and coho salmon) means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. To achieve that level of production, EFH must include all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon. In the estuarine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the Exclusive Economic Zone offshore of Washington, Oregon, and California north of Point Conception. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon, except areas upstream of certain impassable man-made barriers (as identified by the Pacific Fisheries Management Council), and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). EFH for various life stages of chinook and coho salmon is found within the mainstem Columbia and Willamette Rivers and their tributaries in the IWWP area, although many of the historical EFH streams have "disappeared" from the urbanizing landscape of Portland.

EFH for Pacific coast groundfish is defined as the aquatic habitat necessary to allow for groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. The groundfish EFH includes all waters from the mean higher high water line, and the upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon and California seaward to the boundary of the U.S. Exclusive Economic Zone. Estuarine groundfish EFH are found in the mainstem Columbia and Willamette Rivers within the IWWP area.

Wildlife

The Portland metropolitan area is fortunate to have retained some important natural areas such as Forest Park, the East Buttes, Cooper Mountain, and other habitat that is essential for maintaining a diversity of wildlife species within the urban area (Houck and Cody, 2000). The following discussion is based on Metro's species list of Portland wildlife (Metro, 2002).

Amphibians

There are sixteen extant native amphibian species in the Portland metro area, including twelve salamanders and five frogs. An additional species, the bullfrog, is introduced and places considerable pressure on native species.

Amphibians and birds are the two groups in the area most dependent on aquatic and riparian habitats. In the Portland area, 69 percent of native amphibian species (salamanders, toads, and frogs) rely exclusively on stream- or wetland-related riparian habitat for foraging, cover, reproduction sites, and habitat for aquatic larvae. Another 25 percent use these habitats during their life cycle. Six Portland-area amphibian species are state-listed species at risk; four species are considered at risk at the federal level.

Reptiles

Thirteen native reptile species inhabit the Portland area, including two turtle, four lizard, and seven snake species. This is the least riparian-associated group; even so, 23 percent of native reptile species depend on water-related habitats and another 46 percent use water-related habitats during their lives. Although most lizards and snakes are associated with upland habitats, many species use riparian areas extensively for foraging because of the high density of prey species and vegetation. Both of the native turtle species—the western pond turtle and the painted turtle—are riparian/wetland obligates and rely on large wood in streams and lakes for basking (Kauffman et al., 2001). These two turtles are state and/or federal species at risk. Several nonnative turtle species have established breeding populations in Portland, and they compete with native turtle species.

Birds

According to the Metropolitan Service District, birds represent the majority of vertebrate diversity in this region, and 209 native bird species occur in the Portland area. An additional four nonnative species have established breeding populations in the area. The Portland Audubon Society lists 233 bird species observed in Portland, including 48 "accidentals" (Davis 1984)

In the Portland area, about half (49 percent) of native bird species depend on riparian habitats for their daily needs, and 94 percent of all native bird species use riparian habitats at various times during their lives. Twenty-two bird species are state or federal species at risk. Nineteen of these are riparian obligates or regularly use water-based habitats. An additional riparian obligate, the yellow-billed cuckoo, is extirpated in the Portland area.

Mammals

Mammals are another diverse group of species in the Portland area, with 54 native species. This is the terrestrial group with the highest number of nonnative species (eight species, or 15 percent of total species; most are rodents). Of native species, 28 percent are closely associated with water-based habitats, with another 64 percent using these habitats at various points during their lives. Six out of nine bat species and three native rodent species are state or federal species at risk.

Mammals can profoundly influence habitat conditions for other animals, including fish. Historically, beavers were nearly extirpated from the Willamette Valley as a result of trapping, but populations have rebounded (Oregon Department of Fish and Wildlife, 2001). The introduced nutria can damage streambanks and consume riparian vegetation. Large herbivores such as deer browse on herbs and shrubs, which can promote vigorous growth (Kauffman et al., 2001). Medium-sized carnivores keep rodent and small predator populations in check, with important implications for bird nest success. Bats help regulate insect populations and may contribute to nutrient cycling, particularly in riparian areas (LaRoe et al., 1995).

Threatened and Endangered Wildlife Species

There are three species of threatened or endangered wildlife that may occur in Multnomah County: Columbian white-tailed deer (*Odocoileus virginianus leucurus*, endangered), bald eagle (*Haliaeetus leucocephalus*, threatened), and northern spotted owl (*Strix occidentalis caurina*, threatened) (USFWS, 2002). Columbian white-tailed deer migrate along the Columbia River, including Burlington Bottoms, but are not found in the urban areas of the city. Bald eagles are occasional flyovers, and nests have been observed along the mainstems of the Willamette and Columbia rivers and the Smith and Bybee lakes area. Northern spotted owls are not known to occur in the city, and are unlikely to be found because they are associated with interior forest habitat.

The streaked horned lark (*Eremophila alpestris strigata*) is a candidate species for listing. They nest in areas of sparse to no vegetation such as agricultural lands, pastures, prairies, desert shrublands, and alpine areas. This lark may occur in the program area, although there are no recorded occurrences in the city.

Also, the USFWS identified 25 species of concern—five invertebrates, four amphibians, one reptile, seven birds, and eight mammals. The invertebrates are California floater (*Anodonta californiensis*), Mt. Hood primitive brachycentrid caddisfly (*Eobrachycentrus gelidae*), Great Columbia River spire snail (*Fluminicola columbianus*), Columbia Gorge neothremman caddisfly (*Neothremma andersoni*), and Wahkeena Falls flightless stonefly (*Zapada wahkeena*). None of these invertebrates has been recorded in Portland.

The amphibians and reptiles are the tailed frog (*Ascaphus turei*), northwestern pond turtle (*Clemmys marmorata marmorata*), Larch Mountain salamander (*Plethodon larselli*), northern red-legged frog (*Rana aurora aurora*), and Cascades frog (*Rana cascadae*). The northwestern pond turtle has been recorded at ponds and lakes in the Portland area, including Fanno Creek, but there are no records of its occurrence in Portland. The northern red-legged frog has been recorded at relatively undisturbed tree-covered streamsides in Forest Park and at Johnson Creek. None of the other amphibian and reptile species has been recorded in Portland, and they are unlikely to occur because they inhabit emergent wetlands, lakes, and slow-moving streams or sloughs.

The birds are the northern goshawk (*Accipiter gentilis*), tricolored blackbird (*Agelaius tricolor*), olive-sided flycatcher (*Contopus cooperi* (=*borealis*)), little willow flycatcher (*Empidonax traillii brewsteri*), harlequin duck (*Histrionicus histrionicus*), yellow-breasted chat (*Icteria virens*), and Oregon vesper sparrow (*Pooecetes gramineus affinis*). The tricolored blackbird has been recorded along Blind Slough in north Portland. No records of the other species were found; however, it is possible that they may rarely occur in woodlands and marshes of the program area.

The mammals are the Pacific big-eared bat (*Corynorhinus* (=*Plecotus*) *townsendii townsendii*), silver-haired bat (*Lasionycteris noctivagans*), California wolverine (*Gulo gulo luteua*), long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), long-legged myotis (*Myotis volans*), Yuma myotis (*Myotis yumanensis*), and Camas pocket gopher (*Thomomys bulbivorus*). The Pacific big-eared bat was found in Portland decades ago, but not recently. Yuma myotis has been found in Burlington, but not Portland. None of the others has been recorded in Portland, and it is unlikely that they occur because suitable habitat is lacking.

3.8 Land Use

The City of Portland's Comprehensive Plan and Map, and Zoning Code have shaped the urban landscape since 1980 (City of Portland, January 1999). Land uses in the Portland area are diverse. Table 3.8-1 provides the 1994 land use distribution by watershed, based on zoning designations rather than actual land use (City of Portland, July 1999). Commercial and industrial land uses have the greatest percentages in the Columbia Slough and Willamette watersheds.

TABLE 3.8-1. LAND USE DISTRIBUTION AS A PERCENTAGE OF THE WATERSHED

	Land Use (%)					
Watershed	Multifamily Residential	Single-family Residential	Commercial	Industrial	Parks/ Open Space	Other
West Willamette	3	15	4	18	45	15
East Willamette	12	56	8	19	4	0
Tryon Creek/ Fanno Creek	6	71	6	0	11	6
Johnson Creek	16	56	5	4	13	0
Columbia Slough	7	33	5	37	12	5

Willamette Watershed

Land uses within the Willamette River watershed are urban/industrial, residential, and rural/agricultural (City of Portland, November 2002). Many of the state's heaviest industrial users are present in the lower Willamette Watershed, which has been heavily urbanized and industrialized for decades. Land use within subbasins draining Forest Park is largely open space, although there also are residential, industrial, and transportation uses.

Tryon Creek/Fanno Creek Watersheds

Most of the watershed is currently developed, except for small land parcels scattered throughout the watershed and the higher elevations of the West Hills. About 77 percent of the existing urban development is zoned residential, 6 percent is zoned commercial, and 11 percent is zoned for parks and open space. Highly impervious commercial, residential, and roadway areas predominate in the lower elevations. Single-family residential homes are surrounded by natural open space in the upper elevations. Impervious areas, which are connected to a stormwater drainage system, make up 21 percent of the watershed, and 12 percent of the watershed consists of impervious areas that are not connected to the storm drain system.

Johnson Creek Watershed

About 72 percent of the Johnson Creek Watershed is currently zoned residential, 5 percent is zoned commercial, 4 percent is zoned industrial, and 13 percent is zoned for parks and open space. Land use is typically a mixture of single-family and multifamily developments, with commercial uses concentrated along major arterial streets. The watershed is not fully developed, and agricultural land uses occur upstream and east of Portland, so the existing land use is expected to change in the near future. A moderate amount of commercial development is expected to occur, and significant residential growth is anticipated in the undeveloped southern and eastern portions (which include the Pleasant Valley urban reserve area).

Columbia Slough Watershed

The Columbia Slough drains residential neighborhoods, vegetable farms, industrial areas, and transportation corridors (City of Portland November, 2002). Over the years, extensive urban, agricultural, and industrial development have profoundly altered the watershed. Land uses within the Columbia Slough watershed are primarily industrial and residential. Many of the region's heaviest industrial users are present in the Columbia Slough watershed.

3.9 Cultural Resources

The following summary of cultural resources within the IWWP area is based on information from the U.S. Army Corps of Engineers (July 1992) and the City of Portland (December 1994 and 1995). The State Historic Preservation Office was not contacted for this resource summary because the volume of recorded sites is known to be large and site-specific records probably would not be relevant given the programmatic nature of this environmental assessment.

Prehistoric and Early Historic Conditions

The prehistoric subsistence economy was organized around the topographic distribution and seasonal availability of productive natural habitats and food resources. Environmental characteristics of the Columbia floodplain provided adequate resources to sustain large populations, and long-term occupation resulted in recognizable patterns in the archaeological data.

In 1805, Lewis and Clark mentioned the abundance, availability, and intensive use of the area resources. In addition to the two villages noted in the Lewis and Clark journals, there were approximately 25 other ethnohistorically documented villages in the Portland Basin, but many of these sites remain undiscovered (Saleeby, 1984).

Recent Historic Conditions

Early settlers in the bottomlands cleared their land and sold logs; others raised cattle and sold supplies to Fort Vancouver. The historic records frequently mention the heavily timbered areas that were cleared by the early settlers. These efforts prepared the bottomlands for agricultural purposes and provided logs to sell. The Willamette River and Columbia Slough were used as commercial waterways in the 1800s for rafting logs to sawmills. Later, companies competed for business along the waterways. The Vancouver Road conveyed travelers and commerce between Portland and the ferry landing on the South Shore of the Columbia (Barber, 1977).

The Historic Resource Inventory (City of Portland, 1984) lists approximately 5,000 historic resources that are protected from demolition. This inventory includes districts, buildings, trees, and landmarks of historic value.

3.10 Recreation

Portland offers a wealth of outdoor recreational opportunities. Portland Parks & Recreation (PP&R) is responsible for 239 parks covering more than 10,000 acres, which represent about 9.9 percent of all city land (PDC, 2002; City of Portland, 2000a). Public park land in Portland includes traditional neighborhood parks with sports fields and picnic areas, urban plazas with benches and fountains, natural areas with valuable habitat, and acres of greenspace. PP&R's parks range from Forest Park, one of the nation's largest wooded city parks, to Mill Ends, which, at 24 inches in diameter, is one of the world's smallest parks. Between these two extremes fall 6 botanical gardens, 25 community gardens, 35 community parks, 4 golf courses, 47 habitat parks, 98 neighborhood parks, 12 regional parks, and 12 urban parks.

The city's preeminent geographic feature, the Willamette River, provides countless opportunities for recreation and habitat preservation. The river is a magnificent resource that is the center of Portland's parks. The recently completed South Waterfront Park, on the west side of the river, is a nationally recognized park project that provides an abundance of beauty and recreational opportunities. The Eastbank Riverfront Park on the opposite bank does the same. Renovation of Tom McCall Waterfront Park, now used primarily for festivals and major events, provides river recreation and public gathering places in the heart of the city. The Willamette River and other large waterbodies are used for boating, swimming, fishing, and other water-based recreation.

Included in PP&R's responsibilities are 7,500 acres of natural resource areas, miles of bike and pedestrian trails, and the urban forest. Natural areas and the urban forest contribute to the ecological health of the city, and provide residents with opportunities for bird watching, wildlife viewing, and connections to nature. Bike and pedestrian trails fall both within and outside park boundaries. The Springwater Corridor, for example, is a regional trailway and wildlife corridor of which nearly 20 miles are built. In many areas of the city, traffic volume, topography, streams, or unsafe pedestrian connections limit park access.

Table 3.10-1 summarizes the type and amount of park land and recreation spaces found among the city's watersheds. These lands vary according to the landscape character, geography, and history of land use (City of Portland, 2000a).

TABLE 3.10-1. TYPE AND AMOUNT OF PARK LAND AND RECREATION SPACES FOUND AMONG THE CITY'S WATERSHEDS

Sub-Area	Type	Amount
Central City/ Northwest	• Majority is in Forest Park, with few programmed areas or facilities for its size • Three botanical gardens	• 56 percent of Portland's park land • Has the most urban parks and plazas in the city • Fewest neighborhood and community parks
North	• Best balance of park types • Regional parks include West Delta Park, Heron Lakes Golf Course, and Portland International Raceway	• 1,215 acres of park land • Nearly 50 percent of the city's regional park acreage
Northeast	• Almost no habitat park land • East Delta Park is a regional park	• Smallest total acreage of all park types (508 acres) • Average amount of neighborhood and community parks (191 acres)
Outer East	• Second-largest habitat park in the system (Powell Butte) • Leach Botanical Garden • Springwater Corridor • No regional parks	• Second smallest amount of total park land (879 acres) • Smallest amount of community parks • Largest acreage of neighborhood parks (130 acres)
Southeast	• Few habitat parks • Limited regional park land • Contains part of the Springwater Corridor	• 898 acres of park land • Largest amount of community park land (221 acres)
Southwest	• Large natural areas, difficult to access because of hilly, wooded topography	• 838 acres of park land • Some regional park land • Modest amount of habitat park land • Average amount of community and neighborhood park land

3.11 Human Health and Safety

Human health and safety relates to the groups of individuals that will be affected by the proposed IWWP projects. These groups include the workers performing construction, the public that comes in contact with the projects during construction, the neighborhoods surrounding the projects, the recreational users, and the future visitors to the completed projects.

Potentially hazardous materials in soil or water may be encountered during construction of the projects because the urban area has a history of general industrial use. For example, the Tanner Creek basin may contain contaminated soil. However, the exact locations of all contaminated sites are unknown.

Surface water does not meet Oregon water quality criteria. Surface water, sediments, and fish in the city's waters contain a variety of metals and organic compounds (Dames and Moore, 1995; Parametrix, 1995). Primary chemicals of potential concern (COPC) for human and wildlife exposure risks (ingestion and dermal contact) that were identified in Portland's most polluted waters are PCBs and benzidine. The City of Portland posts signs warning the public about swimming in waters contaminated with raw sewage discharged from combined sewer overflow pipes. For risks associated with consumption of crayfish and fish (fillet or whole body), the COPCs are PCBs, DDE/DDT, and arsenic. Dioxins are also found in fish. PCBs and pesticides bioaccumulating in fish tissue may pose threats to human health and wildlife through fish consumption and may cause developmental effects and cancer.

3.12 Traffic/Transportation

Portland's urban transportation system serves an area of approximately 147 square miles and a population of 523,000 people (City of Portland, December 2002; U.S. Census Bureau, 2002). Portland's street system includes arterials, collectors, local streets, and other important noncollector street connections.

According to the 1996 *Transportation System Plan Inventory* (PDOT, 1996), the number of lane miles in Portland's street system is 3,678, including 1,179 arterial and 2,499 local street lane miles. In addition, the Oregon Department of Transportation (ODOT) maintains 12 state highways within the city boundaries. The Portland street system increased by 43 percent between 1984 and 1994, primarily through annexation. Of all improved streets for which the Portland Department of Transportation (PDOT) is responsible, 93 percent are hardsurfaced asphalt or concrete and 7 percent are oil or gravel.

In addition to streets, the structures inventoried in 1996 include 158 bridges, 202 retaining walls, 15 miles of guardrails, 169 stairways, and the harbor wall along the Willamette River. Also inventoried were 128 miles of bikeways, 31,027 street segments, 2,102 miles of sidewalks, and nearly 3,000 miles of curbs (City of Portland, December 2002). There are thousands of ditches, culverts, and crossdrains that convey stormwater across the roadways.

Tri-Met is the transit provider for Portland. As of the 1996 inventory, Tri-Met operated 90 bus routes (six of which provide crosstown service) and Eastside MAX, a light rail line extending from downtown Portland to downtown Gresham. Since the inventory, Westside MAX and Airport MAX have been built, and the Interstate MAX line is currently under construction.

Other transportation systems include aviation, marine, and rail. The Port of Portland operates Portland International Airport and five marine terminals and owns industrial property adjacent to the Portland Harbor (PDC, 2002). Rail lines run primarily along the Willamette River and Interstate 84 corridors.

A large proportion of Portland's impervious surfaces are streets, sidewalks, and parking lots. Important amounts are associated with public facilities (schools, parks, etc.), commercial and industrial operations, and other institutions (such as churches). Most were constructed prior to current standards for surface water quality treatment and implementation of BES's *Stormwater Management Manual* (BES, 2002). Many convey potentially polluted stormwater directly to receiving waters. Newer Green Streets and water quality-friendly parking lots detain and filter stormwater runoff using surface infiltration systems such as swales and sheet flow to landscaped areas (see Section 3.3 of this EA).

3.13 Socioeconomics

In 2001, Portland had a household population of 523,000; 265,000 (51 percent) females and 258,000 (49 percent) males (U.S. Census Bureau, 2002). The median age was 34.9 years. Twenty-two percent of the population were under 18 years of age, and 11 percent were 65 years and older. About one-third of the population (36 percent) lives in the Willamette River watershed, and one-third (30 percent) lives in the Columbia Slough watershed, with the remaining one-third in the Johnson Creek watershed (18 percent) and Fanno/Tryon Creek watersheds (16 percent) (City of Portland, July 1999). Since 1990, Portland's population has been growing by about 2.3 percent annually (PDC, 2002). In 2001, Portland had a total of 240,000 housing units, including 151,200 single-family and mobile homes (U.S. Census Bureau, 2002).

At times the Portland metropolitan region has enjoyed a strong and growing economy. Growth in the manufacturing sector, especially high-technology manufacturing, over the past two decades dramatically shifted the regional economy away from one primarily dependent on the natural resources sector. Trade makes up a significant share of the regional economy, and much of the region's growth is due to its strategic location along primary traffic corridors (railway, highway, and waterway) and the availability of deep-water ports.

Portland's employment by industry sector in 2001 is given in Table 3.13-1 (State of Oregon, 2002). The 2001 median income of households in Portland was $39,928 (U.S. Census Bureau, 2002). Over the past eight years, total employment in Portland grew consistently at an average rate of 3.3 percent per year, with total employment in 2002 reaching 958,700 (PDC 2002; FHWA 2002). Manufacturing employment is divided among electronics (36 percent), machinery and transportation (18 percent), primary and fabricated metals (13 percent), printing and publishing (7 percent), food and kindred products (7 percent), lumber and wood products (6 percent), paper and allied products (5 percent), and other (8 percent) (State of Oregon, 2002).

TABLE 3.13-1. PORTLAND EMPLOYMENT BY INDUSTRY SECTOR (STATE OF OREGON 2002)

Industry Sector	Relative Employment (Percent)	Industry Sector	Relative Employment (Percent)
Agriculture, forestry, fishing and hunting, and mining	0	Finance, insurance, real estate, and rental and leasing	7
Construction	5	Professional and business services	14
Manufacturing	12	Education, health, and social services	20
Wholesale trade	4	Leisure and hospitality	10
Retail trade	11	Other services (except public administration)	5
Transportation, warehousing, and utilities	5	Public administration	3
Information	3		

CHAPTER 4

Environmental Impacts

4.1 Introduction

The Innovative Wet Weather Program, or Proposed Action, includes a range of projects with a common goal: to improve water quality and watershed health in Portland. This would be accomplished by reducing CSOs, reducing stormwater runoff volume and peak inflows to the sewer system, managing associated pollutants, and continuous improvement through monitoring the effectiveness of green solutions. Many of the projects involve construction or other activities that may affect the physical environment. Construction and operation of stormwater facilities require short-term disturbances and hydraulic changes, but will improve surface water quality over the long term by treating stormwater. Other projects share the long-term goal of improving water resources but have little or no direct environmental impact. For example, stormwater monitoring will enable the city to study the characteristics of urban stormwater discharges with the objective of increasing the ability to control stormwater and surface water pollution. However, stormwater monitoring itself has negligible environmental impact.

This chapter describes the potential environmental impacts from funded IWWP projects, and compares them to the No Action alternative. Chapter 2 of this environmental assessment provides descriptions of typical projects and project examples (see Figure 2.1-1). The IWWP project categories are:

- Water quality-friendly streets and parking lots (green streets)
- Downspout disconnections
- Eco-roofs
- Monitoring and feasibility studies
- Educational efforts
- Grant and project management

Grant and project management includes the city's grant matching project—the Tanner Creek Stream Diversion Project (Phase 3). The potential environmental effects of the Tanner Creek Stream Diversion Project (Phase 3) were evaluated in a separate environmental assessment entitled, *Tanner Creek Basin Environmental Assessment* (City of Portland, May 1997). The environmental effects of that IWWP project were determined to be not significant and they are not considered further in this document.

Of the six IWWP project categories, three—monitoring and feasibility study, educational efforts, and grant and project management—are presumed to have no associated environmental consequences because they do not require ground-disturbing activities. Therefore, these IWWP projects are not evaluated further in this chapter.

The remaining three project categories—green streets, downspout disconnections, and eco-roofs—require at least some physical actions, which could produce environmental effects. These are referred to in this document as the construction projects.

Table 4.1-1 summarizes the typical components and physical actions associated with the three action-oriented construction project categories. Also, Table 4.1-1 suggests some of the design approaches to wet weather management that are identified in the *Stormwater Management Manual* (BES, 2002), although actual designs will vary among projects.

TABLE 4.1-1. GENERIC PHYSICAL ACTIONS ASSOCIATED WITH THE THREE ACTION-ORIENTED CONSTRUCTION PROJECT CATEGORIES.

IWWP Project Category	Primary Components	Design Criteria in *Stormwater Management Manual*[1]	Physical Actions
Green Streets	• Streetscapes • Parking lot retrofits • Water quality facilities • Vegetated swales and areas • Stormwater conveyance systems	• Vegetated swales • Grassy swales • Vegetated filters • Planter boxes • Vegetated infiltration basins • Sand filters • Soakage trenches • Lowered Planter Strip • Porous pavement • Side Swale • Trees	• Earthwork • Paving • Concrete work • Erosion control • Revegetation • Irrigation • Traffic control • Operation (e.g., pollutant loading, sediment management)
Downspout Disconnections	• Catch basins • Stormwater collection pipelines • Stormwater bioswales • Stormwater planters	• Vegetated swales • Vegetated filters • Vegetated basins	• Minor earthwork and structural work • Landscaping • Erosion control
Eco-Roofs	• Commercial, industrial, and institutional roof retrofits	• Eco-roofs • Roof gardens	• Facility construction

[1] *Stormwater Management Manual 2.0* (BES, 2002).

4.2 Air Quality/Noise

4.2.1 Impacts to Air Quality/Noise from the Proposed Action

Intended effects of green streets, downspout disconnection, and eco-roof projects are to return water to the atmosphere through interception and absorption by plants, then evaporation and transpiration. Other intended effects are to reduce urban heat islands, which occur when there is a high percentage of pavement that causes local air to increase in temperature. Green streets projects would reduce urban heat island effects by planting trees that shade streets, parking lots, and roofs.

All construction projects could have short-term, mitigable impacts to local air quality. While construction is in progress, a short-term increase in motor vehicle use would produce localized and temporary increases in vehicle exhaust emissions (such as NO_x, CO, NMHC, and, to a lesser extent, particulate matter and sulfur oxide (SO_x)). Given the limited area and duration of construction, air quality impacts from construction vehicles would be minor, particularly from downspout disconnection and eco-roof projects.

Dust emissions could occur during IWWP construction projects from clearing, excavation, grading, stockpiling, and operation of heavy equipment. Vehicles entering and exiting the project areas would produce minor increases in particulate emissions. Dust emissions would vary depending on the level of activity, the type of operation, and weather conditions. The green streets projects are more likely to generate noticeable amounts of dust than downspout disconnection and eco-roof projects.

No significant odor-related impacts are anticipated from the IWWP projects, including the water quality facilities. Odors from sewage overflows would become less frequent where CSOs are reduced. Asphalt and concrete operations would cause temporary odors that are detectable near the project sites.

Eco-roofs provide about 25 percent reduction in noise transmission compared to alternate roof types. Projects that promote vegetation provide some long-term buffering of ambient noise.

Project construction would produce short-term, mitigable noise impacts. Construction noise would be generated by the operation of heavy, diesel-powered excavation and grading equipment; large dump and cement trucks; and other gasoline-powered equipment, such as portable power generators, jackhammers, or pavement cutters. To a lesser extent, construction workers would generate noise as they commute in automobiles to and from project job sites. However, the noise environment in most urban neighborhoods is dominated by local traffic and other local noise sources, so most project noise impacts only would be detectable near the sites and during construction. After the projects are constructed, project-related noise would cease except for minor and infrequent facility and landscape maintenance activities.

4.2.2 Impacts to Air Quality/Noise from No Action

The No Action alternative would produce no air quality or noise-related effects. Air and noise quality in the program area would continue to be dominated primarily by existing land uses and transportation infrastructure.

4.2.3 Mitigation

Air. Erosion and sediment control prevents soil and dust from leaving a construction site and migrating into the air, the storm drainage system, or bodies of water. The city requires that all ground-disturbing activities include erosion and sediment control, even if a development permit is not required. The city's erosion and sediment control regulations are found in Title 10 of the Portland City Code. Required practices follow the *Erosion Control Manual* (City of Portland, 1994), which provides technical guidance for temporary and permanent erosion prevention and sediment control to be used by site designers, developers, contractors, and local government agencies during the construction process, before, during, and after clearing, grubbing, grading and excavation. The control practices could include watering, covering stockpiles, dirt and dust removal, and reducing freefall distances. The erosion and sediment control regulations require a minimum of four inspections: preconstruction inspection, interim compliance inspections and monitoring, permanent erosion and sediment control inspection, and final/follow-up erosion and sediment control inspection (approximately 6 months after construction is completed).

Odor. Potential odor problems would be addressed by the City's *Combined Sewer Overflow Management Plan* (*Final Facilities Plan*; December 1994).

Noise. All construction activities would comply with City of Portland noise control regulations (Title 18, Nuisance Abatement and Noise Control). Furthermore, all engine-powered equipment would be required to have mufflers installed according to manufacturer specifications, and all equipment would be required to comply with pertinent EPA equipment noise standards.

For major work, BES would develop a plan for public involvement and outreach in consultation with the affected neighborhood. BES would use this public involvement program to identify ways to schedule construction activities to reduce construction noise and traffic annoyances in the neighborhood during the time that construction would occur. The city would work with neighborhood associations and business groups to schedule construction to minimize interference with community events and business activities, and it would maintain close communication with the neighborhood to keep it updated on the project's construction schedule.

4.3 Water Resources

4.3.1 Impacts to Water Resources from the Proposed Action

IWWP construction projects would reduce the volume and extend the timing of stormwater runoff (flow control), improve runoff quality, and increase surface infiltration. Some of the runoff would flow overland or to the stormwater system after detention and treatment, but much of this water would be intercepted or infiltrate into the ground. All of these projects involve vegetation planting and the provision of areas to promote soil infiltration by stormwater.

All projects would provide improved flow control (stormwater detention and retention) by collecting water from developed areas in a designated system, then returning the water to a conveyance system at a slower rate (detention) and lower volume (retention) than when it entered the system. The facilities would help infiltrate or retain water onsite. Managing flows in this way attempts to mimic the site's rainfall runoff response that occurred before development (see Figure 4.3.1-1). Flow control would reduce the potential for stream bank

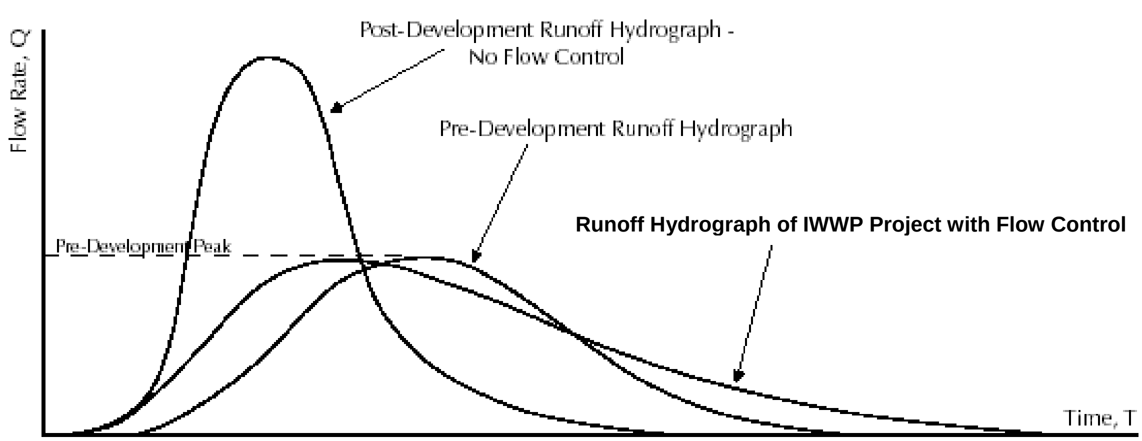

FIGURE 4.3.1-1. EFFECT OF IWWP PROJECTS ON THE STORMWATER RUNOFF HYDROGRAPH

and stream channel erosion, reduce upstream and downstream flooding problems, and help to keep water out of Portland's combined sewer systems.

Of the water that infiltrates to ground, some would eventually return to the atmosphere, but other water would enter shallow groundwater. However, negative groundwater quality impacts from the IWWP are expected to be minor, and projects would not have the effect of significantly increasing flow to groundwater.

Pollutant removal efficiencies of vegetated swales vary, but many swales perform well compared with alternative stormwater management practices (Table 4.3-1). Metals removal is particularly good. Although Davis and others (1998) reported somewhat lower removal effectiveness, they too indicated important levels of stormwater improvement.

TABLE 4.3-1. POLLUTANT REMOVAL EFFECTIVENESS OF STORMWATER MANAGEMENT PRACTICES FOR PARKING LOTS.

Stormwater Management Practice	Pollutant Removal Effectiveness (%)					
	Total Susp. Solids	**Total Phosphorus**	**Total Nitrogen**	**Metals**	**NO_x**	**Bacteria**
Vegetated Swales[1]	N/A	65	49	95-97		
Vegetated Swales[2]	81	29	49	51-71	38	58
Dry Swales[1]	93	83	92	70-86		
Surface Sand Filters[1]	87	59	32	49-80		
Infiltration Trench[1]	N/A	100	100	N/A		

[1] Winer, 2000
[2] Davis et al., 1998

Short-term, indirect impacts from IWWP projects could include temporary increases in sediment and turbidity from construction impacts, but these potential effects are controllable through mitigation. Long-term benefits of the projects are summarized in the following sections.

Green Streets

Green Street projects incorporate design criteria to reduce stormwater runoff, retain existing natural habitat, and add more vegetation at transportation corridors. They use trees and other types of vegetation planted in pervious surfaces that capture and detain stormwater instead of delivering it directly to the city's stormwater conveyance system. Some of the captured water returns directly to the atmosphere via evaporation and transpiration by plants, which relieves storm and CSO flows.

Porous pavement at water quality-friendly streets (for example, the N. Gay Avenue project) enables stormwater to infiltrate through otherwise impervious surfaces. Parking lot retrofits provide similar water quality benefits. Their shallow vegetated swales or planter strips (the Oregon Health & Science University project, for example) increase pervious surfaces and vegetated soil areas. They increase stormwater detention and quality before discharging to a stormwater conveyance system, CSO, natural area, or receiving water (for example, the Oregon Zoo project). When incorporated into projects, restoration of native plant communities, vegetation maintenance, slope bioengineering, and stream habitat improvement further improve water quality. Water quality improvement occurs by using tree shade to reduce water temperatures, stabilizing slopes to prevent or control erosion and scour, reducing sediment delivery to streams, improving the productivity of riparian and aquatic habitats, and promoting diverse and productive biotic communities (an example would be the Cathedral Park project).

Shallow vegetated swales and vegetated areas (such as with the Kelly Elementary School project) are incorporated into the urban fabric to treat and detain stormwater near its source before discharging it to a stormwater conveyance system or receiving water, releasing water to the atmosphere, or letting it infiltrate to the ground.

Water quality facilities would be designed to remove pollution from stormwater before pollutants can enter waterbodies, many of which are already impaired. The facilities could be natural or engineered structures. Natural structures are constructed primarily of natural materials such as soil, rock, and vegetation, and mimic natural water quality improvement processes. Compact, engineered structures constructed of man-made materials for enhanced treatment performance are used where space is limited. All facilities would need to be maintained during operation to remain fully functional.

Revegetation associated with green street projects aims to restore degraded stream banks and upland areas. The restoration work improves water quality, controls erosion, and reduces stormwater pollution by improving vegetation health.

Downspout Disconnections

The downspout disconnection projects redirect stormwater from storm drains onto vegetated surfaces adjacent to the downspout, preventing stormwater from directly entering the city's stormwater conveyance system. Several Portland district schools have been identified for disconnections. The stormwater from buildings is rerouted to lawns, gardens, and swales where it is detained and treated by soil, plants, and shallow detention basins before it could enter storm sewers or combined sewers (an example is the Good Samaritan Hospital Recycling Center project). Stormwater detention reduces peak stormwater flows and, in turn, helps to reduce the magnitude and frequency of CSO events.

Eco-Roofs

Eco-roofs capture and detain stormwater on buildings (such as the Rejuvenation Hardware Warehouse). Plants return some of the captured water directly to the atmosphere via evaporation and transpiration before it could enter the city's stormwater conveyance system. Captured stormwater is detained and treated by soil and plants before it could enter storm sewers or combined sewers, which would reduce peak stormwater flows and, in turn, help to reduce the magnitude and frequency of CSO events. Eco-roofs can reduce stormwater runoff by about 60 percent (City of Portland, March 2000).

4.3.2 Impacts to Water Resources from No Action

Under the No Action alternative, water quality and the natural environment of the city’s watersheds would degrade. This alternative is considered unreasonable because it does not meet the following underlying needs for the IWWP actions:

- The Willamette River and its tributaries would continue to be water quality impaired, thus increasing the potential harm to salmonids and other beneficial uses of the city's water resources.
- Until the city meets its CSO goals, CSOs would continue, thus undermining water quality for fish, macroinvertebrates, and humans.
- Flood management would continue to be a problem.

4.3.3 Mitigation

Temporary impacts to water quality could occur during in-water construction projects and projects that require work in drainageways and stormwater flowpaths. However, temporary water quality impacts during construction would be mitigated through several mechanisms:

- IWWP projects will follow the City's *Stormwater Management Manual* (BES, 2002).
- All projects would undergo Portland Bureau of Planning land use and permit reviews.
- Portland has two environmental overlay zones—the environmental protection zone and the environmental conservation zone. These overlay zones are designed to implement state land use goals for the conservation of water quality and other resources. They serve to ensure protection of streams, wetlands, and riparian areas; however, most IWWP projects would be located in uplands.
- Erosion and sedimentation controls would be implemented in accordance with City of Portland specifications. In addition, new construction would follow the City of Portland's *Erosion Control Manual* (City of Portland, 1994). Appropriate erosion control, construction methods, and mitigation would be addressed during the project design and permitting processes.
- City of Portland *Local Street* standards would be followed to address many issues facing stormwater management for green streets, parking lot retrofits, and urban streetscaping.
- Existing or updated City of Portland *Tree and Landscape* standards would be implemented to complement IWWP projects (Portland Code Titles 33, 17, 24, and 20).
- Some projects could require federal, state, or city permits. Those projects would undergo environmental review by the designated agencies to ensure that impacts would be avoided, minimized, and mitigated. Endangered Species Act and Magnuson-Stevens Act consultations would occur, if necessary, during federal regulatory processes.
- City project managers and cooperating property owners would comply with DEQ's underground injection control program if underground injection control structures are used in a project.
- The City of Portland's Endangered Species Act Program would provide technologies and directions for ensuring water quality and habitat protection.
- Ongoing city water quality sampling studies would monitor groundwater quality and quantity. If any adverse impacts to groundwater quality or quantity are observed, BES

would develop mitigation actions in consultation with DEQ. The existing city groundwater monitoring network would be used to monitor potential groundwater effects.

4.4 Geology and Soils

4.4.1 Impacts to Geology and Soils from the Proposed Action

IWWP projects, and the investment in them, could be damaged or harmed by geologic hazards. Although the probability of damage to the proposed IWWP projects resulting from fault ground displacement or seismic shaking is believed to vary across the city, generally it is low. Seismic activity can shake structures and cause soil movements in the form of liquefaction of saturated soils, settlement of unsaturated soils, lateral spreading, and dynamic slope instability. These soil movements can cause damage to constructed facilities, slumps in streambanks, and interruptions in established water flow patterns.

Landslides in natural slopes under static conditions have a low probability of occurrence, but prior development may increase landslide risks. Soft or loose soils are primarily a concern for foundations because settlement of weak soils can cause foundation damage.

For green streets, downspout disconnections, and eco-roofs, the risks of faults, seismic shaking, or landslides and the related soil movements can be considered relatively minimal because the proposed structures generally are not lifeline facilities and are easily repaired. On the other hand, geologic hazards have the potential to cause important impacts to larger sewer separation projects if they become damaged.

IWWP projects could disturb geology and soils. Construction projects could disturb the native soils, introduce new fill materials, or destabilize geologic hazard areas at the project sites. Potential direct negative effects include soil erosion and muddied streets from construction vehicles. The adverse effects would be of short duration, lasting about as long as the construction period. Other potential negative effects would be long term, such as contamination of native soils from introduction of fill materials.

The introduction of stormwater to the ground in landslide-prone areas could pose a problem for soil stability, particularly in the west hills (for example, the Oregon Zoo). In addition, it is possible that portions of sewer separation projects could increase risks associated with geologic hazards where they cause deep cuts or fills across geologically unstable areas, or they could discharge stormwater down slopes.

The positive effects of the projects would be long term. Direct positive impacts include reduced soil erosion as a result of controlling and directing stormwater flows, reducing impervious surfaces, bioengineering, revegetating, armoring erosion-prone sites, and amending soils and landscaped sites.

4.4.2 Impacts to Geology and Soils from No Action

Geologic hazards related to faults and seismicity exist in the Portland area whether or not the proposed IWWP's projects are constructed. The short-term direct effects related to disturbing geology and soil during construction would not occur if no action is taken.

However, the consequences of no action would be continued deterioration of the soil and water resources and the habitats they support.

4.4.3 Mitigation

The IWWP projects would be designed and constructed to meet minimum seismic design criteria. Ground improvements would be implemented if necessary to mitigate the effects of seismic shaking.

Where appropriate, projects would recreate more natural hydrological processes and institute slope stabilization where hazards are known to exist. The potential for landsliding at constructed slopes would be minimized through engineering design and the use of suitable materials placed at stable grades and heights. Soil evaluations would be used to determine acceptable sites for stormwater infiltration.

The presence or absence of soft or loose soils would be evaluated by drilling soil borings or excavating test pits before construction of major structures. Mitigation methods could include relocating the projects away from soft soils, excavating the soft soils and replacing them with compacted fill, or mechanically stabilizing the earth. If ground improvement is required at a project site, the most practical, cost-effective method would be selected and applied. If it is not possible to mitigate impacts, another site would be selected.

Soil impacts would be minimized by salvaging and reapplying topsoil at pipeline construction sites. Equipment access at construction sites would be limited to minimize soil compaction and disturbance, and compacted soils would be restored to support revegetation. Disturbed surfaces would be returned to their original grades or reconstructed. Using clean fill materials would prevent potential contamination of native soils by introduction of fill materials. Soil erosion would be mitigated by minimizing the amount of area cleared and stripped of vegetation during construction, implementing erosion control measures, preventing soil from leaving the construction site, and revegetating the project areas as soon as practicable. In addition, new construction would follow the City of Portland's *Erosion Control Manual* (City of Portland, 1994) and *Stormwater Management Manual* (BES, 2002).

4.5 Floodplains and Wetlands

4.5.1 Impacts to Floodplains and Wetlands from the Proposed Action

The IWWP projects could have minor direct or indirect impacts on floodplains and wetlands; however, most projects would occur within the urban landscape where few floodplains and wetlands exist. Generally, the construction projects would be sited upgradient of floodplains and wetlands to avoid them and would treat water before discharging to them. Occasionally, floodplain or wetland encroachment might be unavoidable. Where unavoidable, affected wetlands typically would be small, isolated, stormwater-driven, or artificially created on poorly drained lands.

Typical impacts to floodplain surfaces would be small, and floodplain storage capacity would be unaffected. Trenching, pipeline construction, clearing, and grubbing could cause temporary, mitigable floodplain or wetland impacts. Sewer separations projects such as the

Tanner Creek Stream Diversion Project would not drain existing wetland and stream systems because post-separation groundwater and stormwater flows would be sufficient to maintain them. Generally these projects would not result in structures that would displace or impede floodwaters in a floodplain.

Action projects that increase pervious surfaces, soil infiltration, vegetation interception, length of flow paths, stream channel roughness, and stormwater detention would contribute to a more natural hydrograph for floodplains of receiving waters. In other words, the projects could reduce peak stormwater discharges and increase the flood control capabilities within floodplains and wetlands. Simultaneously, construction projects may reduce the velocity of potentially soil- and sediment-scouring stormwater discharges to receiving waters.

Upgrades to stormwater pipelines and culverts would improve flow conveyance, debris passage, and flood dissipation. Under Phase 3 of the Tanner Creek Stream Diversion Project, for instance, the potential interbasin stormwater transfer from the Montgomery stormwater basin to the Tanner stormwater basin would alleviate flooding in the Montgomery neighborhood.

Improved quality of treated stormwater discharges and revegetation projects could improve the habitat quality of floodplains and wetlands. Sewer separation and the downspout disconnections would reduce the number of CSO events, improving water quality and reducing the amount of floatables that could be deposited in adjacent wetland areas.

4.5.2 Impacts to Floodplains and Wetlands from No Action

Under the No Action alternative, floodplains and wetlands would be unchanged. They would not benefit from improved water quality, stormwater flow control, or native revegetation efforts.

4.5.3 Mitigation

All projects would undergo Portland Bureau of Planning land use review. In addition, new construction would follow the City of Portland's *Erosion Control Manual* (City of Portland, 1994) for erosion and sedimentation control and the *Stormwater Management Manual* (BES, 2002) for new stormwater facilities to protect downstream floodplains and wetlands.

If wetlands or waters could be affected, the projects would undergo environmental review by the U.S. Army Corps of Engineers and Oregon Division of State Lands to ensure that impacts are avoided, minimized, and mitigated. Water quality facilities would be built on uplands if possible. Appropriate resource replacement mitigation would be required to prevent net losses. Mitigation for wetland loss could involve wetland restoration, creation, or enhancement; improved flow; removal of existing fill in waterways; increased habitat and cover for fish and wildlife; native revegetation; or better fish movement opportunities. All projects are expected to be self-mitigating.

4.6 Vegetation and Habitats

4.6.1 Impacts to Vegetation and Habitats from the Proposed Action

All IWWP construction projects would increase the quality and quantity of vegetation at project locations. At a minimum, new and disturbed ground surfaces would be covered with plants for permanent erosion control or water quality improvements. Slope bioengineering would aim to introduce or increase vegetation on steep or unstable slopes and streambanks (for example, the Oregon Health & Science University project). Trees would be planted in and around impervious surfaces where few or no trees exist, such as urban streets, parking lots, and urban landscapes. Generally, the extent of vegetation increases as the amount of pervious surface increases. The productivity of some vegetated areas would benefit from soil amendments and irrigation.

Revegetation would increase the diversity of vegetation and the representation of native plant communities. Vegetation maintenance could involve replanting, interplanting, weed and brush control, watering, pruning, thinning, and animal damage control. Prohibited species, such as Himalayan blackberry, reed canarygrass, and English ivy, would be controlled. The quality and extent of natural habitats should increase commensurately with vegetation efforts. All habitat types could benefit.

An indirect program benefit to vegetation would be the future development and refinement of city standards for urban landscaping and green streets design, in part based on program monitoring.

Threatened and Endangered Plant Species

Impacts are not expected to six potentially occurring federally listed plant species for the following reasons:

- The species generally do not occur in the urban landscapes where projects would be implemented.
- The species known to be present in Portland are rarely encountered and their locations are well documented in the Oregon Natural Heritage Program Database.
- Some species are not known to exist in Portland.
- Project-level botanical investigations would be performed at potential wetland sites, which would have the highest likelihood of occurrence.

4.6.2 Impacts to Vegetation and Habitats from No Action

Under the No Action alternative, there would be no minor temporary adverse impacts from IWWP projects. However, there also would be no vegetation and habitat improvement activities, such as urban street and parking lot plantings, native species restoration, control of prohibited plant species, wetland creation and enhancement, and stream habitat improvement. The current mixes of vegetation and habitats would remain.

4.6.3 Mitigation

All projects would undergo Portland Bureau of Planning land use review. Projects would be designed to avoid existing trees and mature vegetation where practicable. Native species from the *Portland Plant List* (City of Portland, June 1998) would be used in most revegetation efforts. Vegetation monitoring and maintenance would be performed to increase the probability of plant survival and successful revegetation throughout the regulatory, warranty, and plant establishment periods.

4.7 Fish and Wildlife

4.7.1 Impacts to Fish and Wildlife from the Proposed Action

Fish

Activities associated with construction projects could temporarily increase sedimentation and turbidity, which would have temporary negative impacts to fish.

Tree planting in green streets, retrofitted parking lots, vegetated swales and areas, revegetation areas, and riparian areas provide shading, which help reduce solar heating of surface water and maintain water temperatures. Tree planting and bioswales help to reduce the amount of stormwater that falls to the ground and runs off, moderate surface flows by natural detention, and reduce pollutant loading and turbidity.

The downspout disconnections and eco-roof projects benefit fish because they reduce CSOs and, thereby, improve water quality.

Potential impacts would be evaluated in detail during project-level federal and state environmental permitting, Endangered Species Act consultation, and Magnuson-Stevens Act consultation.

Threatened and Endangered Fish Species

The funded IWWP projects are unlikely to negatively affect federally-listed fish species. The known and probable project locations do not include stream segments that support listed fish or species of concern. Direct impacts to the Willamette and Columbia rivers would be completely avoided. More natural flow patterns benefit headwaters and tributary drainages, but changes in flows would not be measurable in receiving waters that support listed fish. Water quality improvements would be realized downstream in waters inhabited by listed species.

Coastal cutthroat trout, formerly proposed for listing as threatened but not currently listed, occur at number of the potential tributary streams that could be affected by the program. Potential impacts would be evaluated in detail during project-level federal, state, and city environmental permitting.

Wildlife

By improving water quality, removing toxic substances and pollutants from stormwater, and increasing the diversity and productivity of streams, wetlands, and riparian areas, the IWWP should have beneficial effects on wildlife in riparian areas and adjacent upland areas.

Any temporary adverse impacts from construction to wildlife would be short term, localized, and readily mitigated.

Through Green Street projects, tree planting would diversify and improve the wildlife habitat in urban environs and along drainage corridors. Tree planting and naturescaping in neighborhoods and at Green Street and parking lot retrofits increase natural habitat and habitat connectivity. Associated water quality facilities could include a variety of water treatment options, such as vegetated swales and wetlands, that would increase the wildlife habitat in the area.

Some attracted wildlife could include less desirable types, such as rodents and mosquitoes. However, animal pests prefer sites with prolonged inundation or stagnant water. Such conditions generally would be limited to catch basins, wetland enhancements, and possibly stream daylighting, but primarily at sites where these species already occur. Water quality facilities and swales generally would not attract pest species because they are designed to drain, holding water only long enough for treatment or detention.

The downspout disconnections and eco-roof projects improve water quality by reducing the incidence of CSOs, and the improved water quality benefits wildlife. The managed stormwater flows provide a more varied hydrology and promote a wider diversity of habitats.

Threatened and Endangered Wildlife Species

Adverse impacts to the three federally listed wildlife species are unlikely. Colombian white-tailed deer mainly occur along the Columbia River, which is not a location targeted by the IWWP. The northern spotted owl occurs primarily in interior forest habitats with old forest attributes, which generally are not found in the urban landscapes where IWWP projects would be implemented. The streaked horned lark, which is a candidate species, is unlikely to be affected because it nests in native grasslands and prairies, which are nearly absent in Portland.

The project could affect bald eagles in two general ways: (1) bald eagles in the IWWP area could be disturbed; and (2) the IWWP projects could improve habitat over the life of the project. Bald eagles are not known to nest or roost near potential project sites in urban areas of the city, but could occasionally fly overhead and may occasionally perch near the project sites. However, project sites probably will be in commercial, industrial, and institutional land use areas that are continually subjected to high levels of noise and human disturbance.

On the basis of the information available, it appears that, overall, the species of concern found in the potential project areas would benefit from the IWWP, which is designed to improve water quality and restore habitats. IWWP projects such as tree planting and revegetation create more diverse habitats for special status wildlife.

4.7.2 Impacts to Fish and Wildlife from No Action

Under the No Action alternative there would be no short-term impacts from construction, such as noise, erosion, siltation, and temporary disturbance of existing habitat. However, water quality would not improve as quickly, and the city's waterways would continue to be water quality limited, which would directly affect fish and aquatic species and the wildlife that rely on these species. Toxic contaminants would continue to bioaccumulate in the food chain.

4.7.3 Mitigation

Construction at waters and wetlands would require federal and state permits and would be managed to minimize impacts to fish and wildlife (for example, by limiting turbidity, using sediment controls and traps, and reseeding disturbed areas). Erosion and sediment control measures and plans required by applicable permits and biological opinions would minimize impacts to fish and prevent temporary negative impacts resulting from increases in water turbidity or losses in aquatic habitat. The environmental permitting processes would be undertaken once the project locations and designs are known; impacts and mitigation could be determined in more detail at that time.

4.8 Land Use

4.8.1 Impacts to Land Use from the Proposed Action

Impacts to land use include changes of zoning or use. Although the city does not anticipate land use impacts, there is a low probability that land use impacts could occur if connected uses are severed (for example, through stream daylighting) or if existing uses are displaced (through new stormwater facilities, riparian area setbacks, etc.). More likely, parking areas may be displaced by vegetated areas and water quality facilities.

No property or easements would be acquired or condemned with funds of the IWWP's EPA grant. It is very unlikely that IWWP projects would trigger a change in current district zoning, although some facilities may be located in public easements.

On the contrary, the program would enable existing land uses to become more compatible with their environmental settings, or it would enhance the ability of future projects to better manage water resources and comply with water resource regulations.

4.8.2 Impacts to Land Use from No Action

Under the No Action alternative, the current land uses and land use designations would remain unchanged.

4.8.3 Mitigation

No land use land use impacts are anticipated. However, in the event of a proposed land use change, no change would occur without the property owner's consent. Furthermore, any change in land use designations would require public involvement and approval.

4.9 Cultural Resources

4.9.1 Impacts to Cultural Resources from the Proposed Action

The IWWP construction projects have the potential to cause short-term, but mitigable, adverse impacts to archaeological sites. Ground-disturbing operations such as grading and excavation could disturb archaeological sites if they are present. The greatest probability of encountering archeological deposits during construction is at undeveloped sites. It is not likely that cultural resources would be encountered because most project sites are in the built environment or at previously disturbed properties.

Although the State Historic Preservation Office (SHPO) and the City of Portland maintain inventories of cultural and historic resource sites, searches of their records were not conducted for this programmatic environmental assessment. IWWP projects were not reviewed in terms of their potential to affect known cultural resource sites because the exact locations of many project sites have not been determined and the potential to affect archaeological resources is generally site specific. However, as specific projects are known, particularly those that involve ground-disturbing activities, the City will consult with SHPO and provide EPA with documentation of consultation activities.

Significant adverse impacts to cultural resources are unlikely for several reasons. First, all proposed IWWP actions are subject to compliance with the National Historic Preservation Act. Second, as projects are defined and proceed into design and permitting, further investigative work (for example, records searches at the SHPO and field inventory) would help identify any cultural resources that may be present. Third, sites potentially eligible for listing in the National Register of Historic Places would be formally evaluated, and those sites determined eligible for listing would be avoided or impacts would be mitigated in accordance with federal regulations and guidelines. Further, in the event that cultural resource sites are discovered during construction, the City of Portland's construction contract requirements set forth procedures that protect the sites.

4.9.2 Impacts to Cultural Resources from No Action

The No Action alternative would prevent construction-related impacts to archaeological sites, and the sites would continue to remain undisturbed except for natural degradation. In cases where archaeological sites are easily detectable, unauthorized artifact collection or vandalism could be a problem.

4.9.3 Mitigation

The effects of IWWP projects on cultural resources would be considered during the detailed siting and design of the IWWP projects. Each area of new construction or subsurface disturbance would be investigated in accordance with applicable laws and regulations. A summary of applicable state, federal, and local laws, regulations, and planning directives that govern cultural resource management is provided by the *Cultural Resources Protection Plan* (City of Portland, 1996).

Because the IWWP projects receive federal funding from EPA, they are subject to relevant federal environmental regulations that require assessment of the effects of their actions on sites listed or eligible for listing in the National Register of Historic Places (for example, Section 106 of the National Historic Preservation Act and subsequent regulations 36 CFR 800 and 36 CFR 60 and 61). All activities are coordinated through the SHPO and the President's Advisory Council on Historic Preservation, Native American tribal governments, and other interested individuals, as necessary. The SHPO maintains the statewide inventory of historic and archaeological resources as well as sites listed or eligible for inclusion in the National Register of Historic Places. The SHPO promulgates archaeological survey and reporting standards and facilitates consultations with local tribes. Also, under state law, the SHPO is the lead agency for protecting Oregon's archaeological resources that are located on public lands or that can be affected by federal actions.

The process that will be followed to reduce impacts to cultural resources is to conduct inventories, evaluations, and mitigation (City of Portland, 1996). There are some exceptions to this, especially with respect to Native American burials or traditional cultural properties. For most projects, the first step is to ascertain if there are, in fact, cultural resources that would be affected by the undertaking. A qualified archaeologist would check archaeological site records on file with the SHPO (records search). The archaeologist would then conduct a field inventory (that is, a site discovery).

The City of Portland (1996) has adopted standard specifications for construction contracts that spell out procedures for the protection of cultural resources that are inadvertently discovered by construction crews. The protocol spells out the specific duties of city staff, the consulting archaeologist, and the construction contractors, and the role of interested tribes.

4.10 Recreation

4.10.1 Impacts to Recreation from the Proposed Action

A number of parking lot retrofit projects target city parks. The projects would not have negative impacts on recreation, except possible short-term access restrictions during project construction.

The IWWP projects have a positive impact on water-based recreation in the city because they would improve water quality and aquatic habitats. For example, overflows from combined sewers, which contribute to poor water quality, fish contamination, and health threats, would be reduced. Projects that increase the area or aesthetics of open spaces or improve habitat quality through vegetation restoration and enhancements, such as Green Streets and sewer separations, have a positive impact on passive recreation. A few projects may improve recreation opportunities by enhancing access or connectivity between recreation destinations. For example, the proposed Stormwater Infiltration Feasibility Study at Centennial Mills could produce concept plans for improving connectivity between open space along the Willamette River and inland parks. The vegetation enhancements associated with vegetated swales and areas would augment recreation experiences at those locations.

4.10.2 Impacts to Recreation from No Action

If No Action is taken, no adverse impacts to recreation would occur, but the recreational benefits of the IWWP projects probably would not occur.

4.10.3 Mitigation

No recreation mitigation is proposed because no significant recreational impacts are expected to occur.

4.11 Human Health and Safety

4.11.1 Impacts to Human Health and Safety from the Proposed Action

IWWP projects may invoke construction safety issues. Human health and safety have the potential to be adversely affected in the short term by construction. Short-term effects are related to typical construction activities and the potential of encountering hazardous materials during construction. Threats to human health and safety as related to construction activities include trip/slip hazards posed by disorderly maintenance of equipment and materials, fall hazards around open excavations, and collision hazards near heavy construction equipment.

In the long term, human health and safety would be positively affected by the IWWP projects. Long-term effects are related to the impact of the projects on the quality of water in the city's waterways.

Human health and safety hazards associated with the presence of hazardous materials in soil or water include inhaling, ingesting, or making skin contact with materials that cause short- or long-term negative health effects. A threat to human health and safety may exist for construction workers when potentially hazardous materials are encountered during project construction. Hazardous constituents may be present at any of the proposed IWWP project sites because of historical and present urban, commercial, and industrial uses of the area. Members of the public in or near construction areas also could be exposed to potentially hazardous materials. In addition, hazardous materials present a threat to human health and safety when stored onsite, transported on public rights-of-way, or disposed of in solid or hazardous waste landfills.

It is possible that some IWWP projects could attract pathogens, mosquitoes, or other vectors of disease, although most would have little effect on existing populations. Other IWWP projects would remove potential pathogens and mosquito breeding sites. Most health risks are primarily endemic. However, West Nile virus, already in 46 states, could be detected in Oregon within months. West Nile virus is an infection that lives in birds and is spread to humans by mosquitoes that have fed on an infected bird. National health experts do not believe that West Nile virus will be a health emergency for residents of Multnomah County. Many people who are exposed never become sick. In rare cases, however, the virus can cause serious illness or even death.

In general, the potential for negative effects on human health and safety would be of short duration during construction of the IWWP projects and would be fully mitigable. However, the positive benefits of constructing the projects would be long term and would include reducing health and safety risks for humans, reducing flooding frequency, improving water quality and wildlife habitat, and improving the value of the city's water resources.

4.11.2 Impacts to Human Health and Safety from No Action

No construction activity–related hazards to human health and safety would occur if the IWWP projects are not constructed. Hazards to human health and safety resulting from disturbance, characterization, handling, storage, transportation, and disposal of potentially hazardous materials or sediments also would not occur if the projects are not constructed.

However, the consequences of no action would result in long-term, continued poor quality of water and continued risks to human health and safety. Stormwater and CSO discharges vary from event to event, but frequently contain high levels of bacteria, metals, and toxic constituents. Also, local flooding problems would remain untreated.

4.11.3 Mitigation

Construction safety hazards would be mitigated by following the standard safe work practices set forth by the Occupational Safety and Health Association (OSHA) and other state and local rules and regulations, examples of which follow:

- The construction site would be clearly identified, and access by the public would be restricted by a method appropriate to the project site (for example, fencing, barricading, signage, or flagging).
- Traffic control, if needed, would be performed according to applicable city, state, and federal Department of Transportation requirements.
- Utilities would be located before any excavation is performed.
- Construction personnel would wear work clothing, including long pants, steel-toed boots, hard hat, gloves, safety glasses, and hearing protection, where needed.
- Personnel would wear orange safety vests if heavy equipment is involved in the construction.
- Equipment and materials would be stored in an orderly, organized, and secure manner.
- All personnel would be made aware of emergency procedures, the chains of communication and responsibility, the nearest telephone, and the nearest hospital.
- Equipment would be maintained in good condition, be fitted with reverse beepers, and be operated in a safe manner (within the limitations of the equipment) by trained operators.
- Trenches would be shored or sloped in stable configurations with a method of egress provided, in accordance with OSHA, state, and local rules and regulations.
- All excavations would be clearly marked with blockades, signs, or construction tape and covered if the excavation cannot be filled in before the end of the workday.
- Construction vehicle wheels would be cleaned of debris before entering public roadways.

Potential hazards to human health and safety posed by the presence of hazardous materials would be mitigated by the following methods:

- Hazardous materials and spill control would be installed, if practicable, to capture potentially hazardous substance in the runoff.
- The location of each IWWP project with respect to listed sites would be verified, and the potential for the presence of hazardous materials at the project site would be evaluated by means of a site reconnaissance, a review of listed sites, and a review of DEQ files.

- An OSHA-compliant health and safety plan would be prepared for IWWP projects that (based on the detailed review of listed sites) involve the potential for exposure to hazardous materials. These plans address general and project-specific practices and procedures for the protection of public and worker health and safety.
- A health and safety coordinator with responsibility for administering the health and safety plan would be assigned to each project of the IWWP that involves the potential for exposure to hazardous materials.
- Each project of the IWWP would be implemented using OSHA health and safety–trained personnel at sites where hazardous materials may be encountered, in accordance with the health and safety plan.
- Conditions at project sites where hazardous constituents are suspected to be present would be field-monitored, and if monitoring indicates that unknown conditions are encountered, sampling and characterization would be conducted.
- Construction personnel would wear personal protective equipment (PPE) appropriate for the type, concentration, and quantity of hazardous constituent(s) present at the site.
- All potentially hazardous project-derived wastes would be stored, characterized, and disposed of in accordance with applicable local, state, and federal rules and regulations.

Potential diseases of human health posed by the presence of mosquitoes or other vectors of disease would be mitigated by the following methods:

- All stormwater management facilities described in the *Stormwater Management Manual* (BES, 2002) are design to drain within 48 hours of a peak storm.
- Public health officials monitor the West Nile virus and other infectious diseases. The City of Portland works with Multnomah County Vector and Nuisance Control to monitor and control mosquitoes in stormwater ponds, local wetlands and streams, and the public drainage system. If mosquitoes carrying disease such as West Nile virus are detected, the Multnomah County Health Department provides guidance to the City of Portland and works directly with Vector Control to implement more aggressive control measures if needed. If a public health threat is imminent, adulticides (pesticides which suppress the flying, biting adult mosquitoes) may be used.

4.12 Traffic/Transportation

4.12.1 Impacts to Traffic/Transportation from the Proposed Action

IWWP projects have the potential to cause adverse short-term construction-related traffic/transportation impacts, including restricted access. Eco-roofs, many downspout disconnections, and projects involving habitat improvement or slope bioengineering usually would be constructed away from roads. On the other hand, green streets, parking lot retrofits, sewer separations, and some downspout disconnections would require in-street construction, which would involve partial road closures, local detours and traffic rerouting, limited availability of alternate routes, and loss of business (this would be the case with the, N. Gay Avenue project). The amount of traffic could shift among roads and arterials within the immediate vicinity of the particular project. Short-term impacts on transportation and traffic would include introduction of commuting work crews and slow-moving and heavy or oversized vehicles to local roads, along with removal of pavement to facilitate access to storm and sewer pipes.

For the most part, construction impacts would vary on a daily or seasonal basis depending on the nature of the specific project being constructed. In general, road construction activities could result in short-term increases in travel time for motorists and transit riders and cause temporary increases in response time for emergency vehicles. Temporary or permanent parking lot displacements could increase walking distances for affected commuters (at the Oregon Zoo project, for example). However, traffic/transportation effects would be limited in extent and duration.

Generally, road condition and function would be improved according to city roadway and urban street standards. All IWWP stormwater management facilities would have adequate access for low-frequency operation and maintenance activities. Each facility would have an access route at least 8 feet wide, not to exceed 10 percent in slope. Where structural surfaces are needed to support maintenance vehicles, access routes would be constructed of gravel or another permeable paving surface.

4.12.2 Impacts to Traffic/Transportation from No Action

Under the No Action alternative, none of the construction projects that make up the IWWP would occur, and neither would the short-term construction-related impacts described above.

4.12.3 Mitigation

Construction activities would be coordinated with the Portland Department of Transportation to develop plans to minimize traffic impacts. A Work Zone Traffic Control Plan would be prepared in accordance with the City of Portland's General Technical Requirements, Section 202 (Temporary Traffic Control). The traffic plan would ensure that construction could proceed with the least possible obstruction and inconvenience to the public and would protect pedestrian and vehicular traffic.

In addition to the measures required in Section 202, the City of Portland would prepare and deliver notices to affected residents and businesses within the project area indicating when construction is likely to occur. If particularly heavy construction traffic is expected during particular times, separate notices would be sent to local residents and businesses indicating the schedule.

4.13 Socioeconomics

4.13.1 Impacts to Socioeconomics from the Proposed Action

Minor disruption to business patronage could occur during construction of IWWP projects; however, construction projects would benefit local employment.

All surface access and excavation for project components would take place on city property, existing road rights-of-way, temporary easements, public property, and private property.

No property would be acquired by using funds from the EPA grant. All projects, especially those on private property, would be conducted only with the property owner's or manager's approval and cooperation. Once construction is completed, all roads would be restored to fully operational conditions.

Generally, no negative impacts would occur from operation of facilities. Project funding would not cause rate increases for city services. The project site owners probably would incur facility maintenance costs; however, the costs could be similar to, and sometimes less than, traditional stormwater management practices. Consequently, the projects are not anticipated to be a financial burden to minority and low-income populations. Positive operational impacts would be associated with improvements in water quality resulting from more natural stormwater hydrology patterns, improved stormwater quality treatment, and reduction in the frequency and volumes of CSOs. Contaminants of concern with respect to human health are projected to decrease.

The City of Portland has a high proportion of environmental justice, or minority and low-income, populations. However, there would not be negative operational impacts or adverse impacts to any minority or low-income populations in the project areas. The project locations would be selected primarily by the needs for improved stormwater management, water quality improvement, and flood and CSO reduction.

No impacts related to population growth would occur. The program is designed to improve stormwater management, reduce CSO releases, and improve water quality. No additional sewer capacity beyond what has been already planned for by the City of Portland would be provided by the program. The program would minimally decrease flows to the city's treatment plants and reduce capital costs for upgrading the existing treatment plants and collection system.

Green streets and projects involving vegetation planting and revegetation in urban neighborhoods would benefit the communities by providing shade and improved aesthetics. Urban trees provide environmental, community, wildlife, and visual benefits. Tree planting would provide amenities that would benefit residential neighborhoods with incomes below the median for the Portland area. The downspout disconnection and eco-roof projects would directly benefit the participating communities by providing jobs for area residents.

4.13.2 Impacts to Socioeconomics from No Action

No IWWP projects would be constructed under this alternative. As a result, there would be no disruptions to business activity.

4.13.3 Mitigation

No socioeconomic mitigation is proposed because no significant socioeconomic impacts are expected to occur.

4.14 Financing the Program

The city's IWWP matching funds are already budgeted and accounted for through the rates citizens pay for sewer services. No rate increases or fee assessments would occur as a result of this program. Also, no loans will be taken to supplement the IWWP budget.

4.15 Cumulative Environmental Impacts

The IWWP is intended to generate improvements to water resources and watershed health across the city's watersheds. Ideally, the overall program improvements and environmental benefits would be greater than the sum of the individual projects; however, no quantitative evaluation of cumulative benefits has been performed. Unfortunately, there are many more innovative wet weather project opportunities in Portland to improve urban water resources than can be funded under the current project.

Although analyses have not been conducted to assess the potential cumulative negative impacts, the proposed IWWP projects, even in conjunction with independent past, present, and future development projects within Portland's watersheds and communities, are not expected to contribute to significant cumulative negative effects for the resources addressed in this EA; that is, negative impacts would not exceed the sum of negative effects from the individual projects.

Air Quality/Noise. The individual IWWP projects could be implemented at the same time that other IWWP, city, or private development projects are under construction within a watershed or community. However, the potential construction effects would be short-term and subject to city, state, and federal environmental regulations for construction.

Water Resources. The cumulative impacts to water quality from the IWWP projects would generally improve surface water quality in the city. The innovative wet weather projects planned for the watersheds are designed to correct the impacts of past activities and to anticipate and prevent future impacts. No cumulative negative impacts to groundwater are expected.

Geology and Soils. No cumulative effects are anticipated from multiple projects within a watershed. If all of the proposed projects take place at the same time, a short-term cumulative decrease in water quality could occur in receiving waters as a result of soil erosion from all of the sites combined. However, this potential cumulative effect would be mitigated by following mandated erosion control procedures.

Floodplains and Wetlands. No cumulative impacts to floodplain or wetlands are expected from the IWWP because no permanent project-specific impacts to these resources are expected.

Vegetation and Habitats. The various components of the IWWP would increase and diversify vegetation at project locations in Portland neighborhoods. The program would mandate native species revegetation.

Fish and Wildlife. The various components of the IWWP increase and improve fish and wildlife habitats in the city and foster biological diversity. Overall, cumulative effects on fish and wildlife habitat and on threatened and endangered species are positive.

Land Use. The City of Portland gradually undergoes land use changes within the framework of the city's land use program and relevant plans and zoning codes. The IWWP would not contribute to the land use transformation of the city; instead, the IWWP would help improve habitat and water quality values at project locations.

Cultural Resources. To the extent that potential short-term construction-related effects on cultural resource sites are avoided or mitigated through compliance with applicable laws, regulations, or planning mandates, construction of these projects should have no potential cumulative impacts on cultural resources.

Recreation. The various components of the IWWP in conjunction with other efforts to improve water quality and develop open space would increase passive recreation opportunities in the city. Generally, impacts on recreation would be positive and limited to the direct effects of individual projects; however, a few projects could disproportionately improve recreation opportunities by enhancing access or connectivity between recreation destinations. For example, the Centennial Mills Feasibility Study could improve connectivity between open space along the Willamette River and inland parks.

Human Health and Safety. The cumulative adverse effect of constructing several or all of the projects at the same time would be negligible because prevention and mitigation measures would be incorporated into the projects. In addition, if more than one project is constructed in a given area, preventive and mitigation measures would be coordinated among the projects. The long-term cumulative impacts of all of the IWWP projects would be positive. The projects improve water quality for beneficial uses, which benefits human health and safety.

Traffic/Transportation. Short-term cumulative construction-related effects on transportation are not anticipated because the individual IWWP projects would cause relatively small disturbances and impacts would be mitigated through coordination and planning with the Department of Transportation.

Socioeconomics. Various components of the IWWP, in conjunction with other efforts to improve water quality in the city, would have socioeconomic impacts. Generally, these impacts would be positive, especially with respect to neighborhoods and community livability.

4.16 Compliance with Environmental Laws and Executive Orders

Use of federal funds awarded by EPA to the Innovative Wet Weather Program must comply with the applicable federal regulations listed in Table 4.16-1.

TABLE 4.16-1. LIST OF REGULATIONS APPLICABLE TO THE INNOVATIVE WET WEATHER PROGRAM

Federal
Clean Water Act
Clean Air Act
Fish and Wildlife Coordination Act (16 U.S.C. 1451)
Noise Control Act
Endangered Species Act
Magnuson-Stevens Fishery Conservation and Protection Act
Executive Orders
Protection of Wetlands (E.O. 11990)
Floodplain Management (E.O. 11988)
Protection of Children from Environmental Risk (E.O. 13045)
Environmental Justice (E.O. 12898)
Consultation and Coordination with Indian Tribal Governments (E.O. 13084)

There are currently no planned or identified IWWP projects that would require a federal permit for construction. The only required permits to construct the current list of IWWP projects would be those required by the city of Portland through the city's Bureau of Development Services. The IWWP will apply for any necessary federal permits associated with current or future project construction.

4.17 Irreversible and Irretrievable Commitment of Resources

Construction activities require a one-time expenditure of government funds and the use of energy (primarily fossil fuels) is not retrievable. The projects would occur primarily within the urban areas of the City of Portland, primarily on city property, the property of other public entities, or property owned by cooperating private parties. Therefore, permanent irreversible and irretrievable loss of biological resources is not expected to occur.

Some nonrenewable materials would be used in the construction of IWWP projects. For example, concrete and steel would be used to construct pipelines, eco-roofs, water control structures, green streets, and parts of the vegetated swales and areas.

However, some of the projects would make use of natural processes using renewable resources rather than mechanical processes using nonrenewable materials. For example, the vegetated swales are designed to use the ability of soil and plants to remove pollutants to treat stormwater instead of relying upon conventional, mechanized wastewater treatment. Overall, the goal of the IWWP is to restore the natural productivity and diversity of the city's waterways.

4.18 Short-Term Use of the Environment versus Maintenance of Long-Term Productivity

During construction, there would be a temporary disruption of traffic and an increase in noise and dust, which could temporarily inconvenience nearby residences and businesses. These impacts would be mitigated by proper construction techniques, traffic control to prevent accidents, minimizing delays, ensuring access to homes and businesses, and using properly muffled motorized equipment. Also during construction, there could be short and controlled incidents of erosion and sediment transport from sites, but these would be mitigated by appropriate erosion and sediment control standards. In aggregate, the completed projects should provide direct improvements to water quality and habitats in the city.

The IWWP would require the use of some nonrenewable resources and would involve some short-term mitigable environmental impacts. In the long term, however, the IWWP would help to restore the environmental health of the urban watersheds by improving their water quality and the diversity and extent of natural habitats. These actions would lead to long-term increases in the health and ecological productivity of the water resources environment.

CHAPTER 5

Public Participation

5.1 Introduction

For more than a decade, the City of Portland has been implementing a comprehensive public involvement program to educate, reach, and involve citizens in the issues, management solutions, and costs of reducing combined sewer overflows to the Willamette River and its tributaries (City of Portland December, 1994). The public participation efforts have enabled BES to reach and inform a substantial number of residents and stakeholders about virtually every element of potential Innovative Wet Weather Program projects. This chapter describes current and future public education and involvement for the Innovative Wet Weather Program.

5.2 Environmental Education

Numerous means of informing the public about Portland's CSO situation have been employed by the City. Some of them are:

- Media coverage—briefings, events, advisories and news releases, media inquiry and response, media monitoring
- Speakers Bureau—presentations to at least 73 neighborhood organizations, 5 regional neighborhood groups, and 38 civic/business/interest groups, some more than once
- *Clean River Review Newsletter*—general CSO information mailed to nearly 10,000 addresses
- *CSO Update Newsletter*—technical periodical mailed to more than 1,000 individuals and groups
- Direct mailers—multiple informational publications mailed to all 282,000 Portland postal customers
- Billing inserts—information about CSOs reached about 120,000 water/sewer customers
- CSO videotape—more than 100 copies distributed and used in classroom presentations
- *Combined Sewer Overflows, Issues and Choices Booklet*—information about alternatives for dealing with CSOs; 50,000 copies distributed mostly to neighborhood associations
- *Classroom and field education programs*—focused on watershed health, CSOs, Stormwater, and water quality issued. Specific field programs include Green Solutions tours of innovative stormwater management techniques and boat tours focusing on CSOs and the Willamette River.
- *School Projects*—naturescaping, downspout disconnections, bioswales, riparian restoration. Classroom and field education programs for K-12 students on watershed health, CSOs, Stormwater, and water quality issued. Specific field programs include Green Solutions tours of innovative stormwater management techniques and boat tours focusing on CSOs and the Willamette River.

- Commissioned Assembly Program—including plays, storytelling and music about Clean Rivers targeted toward school children
- *Clean River Quest*—educational computer software about water pollution in Portland shown to hundreds of adults and school children
- *Oregon Museum of Science and Industry (OMSI) CSO Exhibit*

5.3 Public Involvement

In addition to public education, a substantial effort has been made to involve the public in activities relating to reducing CSOs. Several examples illustrate the effort that has been made:

- Public meetings—dozens of well-advertised opportunities to testify before citizen committees and the City Council
- Creative Alternatives Workshop—engaged a wide range of stakeholders in discussions about CSO abatement alternatives
- Clean River Funding Task Force—recommended policies and principles governing the allocation of CSO program costs
- Clean River Committee—appointed a range of stakeholders to look at technical and funding options for reducing CSOs
- Clean River Confluence—interactive conference addressing water quality standards, stormwater pollution, and CSOs
- Design charrettes—work sessions involving design and planning professionals in sewer separation projects, etc. (for example, the Tanner Creek stream diversion project)
- Community leader interviews—interviews of more than 70 civic leaders and stakeholders about CSOs. This is an ongoing process.
- General public telephone survey—a poll to determine the public's understanding of CSOs and their effect on water quality
- Focus groups—solicited views from a cross section of Portland residents about CSOs and water quality

5.4 Public Scoping

From the public participation efforts, the City has learned about public issues and concerns for the CSOs in general and IWWP projects in particular (City of Portland, December 1994). Some of the major and recurring themes are as follows:

- Improve water quality as a high public priority
- Prevent CSOs from entering the rivers through a process that fosters community support and recognizes financial constraints
- Increase emphasis on stormwater runoff reduction incentives for residences and businesses

- Approach the planning and implementation at the neighborhood level, subbasin by subbasin
- Seek opportunities for multiple benefits in all CSO program alternatives
- Demonstrate the City's leadership in enhancing and preserving the entire Willamette River
- Spread the program costs equitably
- Continuing efforts to inform and involve citizens in decision-making processes

5.5 Project Implementation

Public education and involvement in IWWP projects will continue during future implementation phases. Future public participation will target the groups most affected by the individual IWWP projects and will include adjacent property owners who could be affected by projects involving construction.

Public involvement activities for projects will focus on ways to include stakeholders in the design process, find additional community benefits that may arise from a particular project, and mitigate construction impacts on local residents and businesses. Members of the community will work directly with the BES design teams. BES will continue to work with affected groups to find additional community benefits that can come from construction and ways to mitigate any negative impacts of construction. An example is the ongoing public participation effort for the IWWP Tanner Creek stream diversion project (City of Portland, May 1997).

For each individual project or group of similar projects, BES will develop a public involvement plan. Typically, public involvement plans will outline the following:

- Goals, objectives, and timelines of the individual projects
- Message and target audiences
- Public meetings to inform individual neighborhoods
- Communication tools necessary to convey the message
- Tools necessary for effective public participation, including citizen committees where appropriate
- Coordination with other activities that could be affected by the project
- Use of program identity in all informational materials
- Media relations
- Advertising

People who are interested in improving water quality in Portland will have opportunities to get involved with projects, not only with planning and design but with construction, operation, and monitoring (this could include students, teachers, and parents at school sites).

BES will notify EPA in advance of conducting these public involvement activities for each of the IWWP projects and give EPA the opportunity to provide input regarding the level of community outreach efforts. EPA's comments will be integrated into each of the final IWWP project public involvement plans.

5.6 NEPA Process

In addition to ongoing public involvement in the IWWP projects, the City is planning to further inform the public about the program by making this environmental assessment available for review and comment. Depending on the nature of the feedback it receives, the City will consider conducting a public hearing to provide yet another opportunity to involve the public.

CHAPTER 6

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CHAPTER 7

Acronyms

BES	City of Portland Bureau of Environmental Services
BMPs	best management practices
CO	carbon monoxide
COPC	chemicals of potential concern
CSO	combined sewer overflow
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DEQ	Oregon Department of Environmental Quality
EA	environmental assessment
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESU	evolutionarily significant unit
FHWA	Federal Highway Administration
FONSI	finding of no significant impact
IWWP	Innovative Wet Weather Program
LTCP	Long Term Control Plans
Metro	Metropolitan Service District
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NMHC	nonmethane hydrocarbon
NO_x	nitrogen oxide
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transporation
OHSU	Oregon Health & Science University
ONHIC	Oregon Natural Heritage Information Center
ONHP	Oregon Natural Heritage Program
OSHA	Occupational Safety and Health Act
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PDC	Portland Development Commission
PDOT	Portland Department of Transportation
PFMC	Pacific Fisheries Management Council
PPE	personal protective equipment
PP&R	Portland Parks & Recreation
RM	River Mile
SHPO	State Historic Preservation Office
SO_x	sulfur oxide
TMDL	total maximum daily load
TSP	Transportation System Plan
UIC	underground injection control
USDA	U.S. Department of Agriculture

USDI	U.S. Department of the Interior
USFWS	USDI Fish and Wildlife Service
VOC	volatile organic compound

CHAPTER 8

Glossary

Anadromous fish: Fish that hatch in fresh water, migrate to ocean water to grow and mature and return to fresh waters to spawn; includes salmon, steelhead, and sea-run cutthroat trout.

Aquatic habitat: The water-based locality or geographic area in which a plant or animal species naturally lives or grows.

Average dry weather flow: The average wastewater flow during dry weather, normally during the non-rainfall period of July through September.

Basin: A portion of a watershed, delineated separately for each type of sewer: combined, sanitary, and stormwater. Basins boundaries are based on the routing of sewer flows to major trunk sewers or interceptors. Within one watershed, there may be combined sewer basins, sanitary sewer basins, stormwater basins, or a combination of each.

Benthic macroinvertebarates: Animals without backbones found on the floor of a stream or river. Benthic macroinvertebrates are a food source for fish.

Biofiltration: The use of natural materials and vegetation to trap and remove pollutants from stormwater.

Biological diversity (biodiversity): Variety of plant and animal life coexisting in a specific habitat.

Clean Water Act: A law passed by the U.S. Congress in 1972 that makes illegal the discharge of pollution into surface or ground waters without a permit, and that encourages the use of the best achievable pollution control technology to reduce the impact of discharged effluent.

Combined sewer overflows (CSOs): Overflows that contain both stormwater and sanitary sewage and are discharged to receiving waters. CSOs occur during moderate to heavy precipitation when combined sewage flows overwhelm the system, and excess (untreated) flows are released through overflow pipes (outfalls) to the Willamette River or Columbia Slough.

Combined sewer system: The network of pipelines and pump stations that collect and convey combined stormwater and wastewater.

Conduit: A restricted natural passageway such as a stream; a conduit is more limiting than a corridor.

Confluence: The junction or union of two or more streams; a body of water produced by the union of several streams.

Corridor: A linear natural area and habitats primarily reserved for wildlife needs.

Culvert: A pipe through which surface water can flow under a road fill.

Design phase: The development of engineering plans, specifications, and cost estimates with sufficient detail to enable the accurate bidding of the construction of a project.

Design storm: A theoretical storm event, of a given intensity, duration, and frequency, used in the analysis and design of a stormwater facility. For example, a 25-year design storm has a probability of occurring once in 25 years at any given time (i.e., occurs on average once every 25 years).

Detention: The temporary storage of stormwater in a facility (e.g., a pond) to control outflow and reduce peak flow rates and to provide settling of pollutants.

Ecological services: The functions that a natural resource provides to benefit the environment and human uses.

Ecosystem: The living and nonliving components of the environment that interact or function together; includes plant and animal organisms, the physical environment and the energy systems in which they exist.

Endangered Species Act: A law passed by the U.S. Congress in 1973 that established programs for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service maintains the list of threatened and endangered species.

Floodplain: The area adjacent to streams that becomes inundated when water overtops the bank.

Flow: The volume of water, often measured in cubic feet per second (cfs), flowing in a stream.

Habitat: The locality or geographic area in which a plant or animal species naturally lives or grows.

Heat island: Urban areas with air temperature that can be 6-8°F warmer than air temperature in surrounding rural areas.

Impervious: Having an impenetrable or hard surface; impeding the infiltration of water (e.g., the natural infiltration of stormwater into the ground).

Impervious surface: An impermeable ground coverage or surface, such as paved roads, sidewalks and structures, that alters the natural flow and quality of water.

Infiltration: The percolation of water into the ground.

Infiltration sump: An underground vault (drywell) that is perforated or slotted to facilitate the infiltration (downward movement) of water from the ground surface to the subsoil.

Infrastructure: Physical improvements such as paved streets and utilities (water, sewer, gas, electricity, etc.) that provide the necessary services to support land development.

Inline storage: The installation of oversized pipes to provide storage capacity for high flows during storm events in order to reduce the hydraulic overload in downstream pipelines.

mgd: million gallons per day

Mitigation: The creation, restoration or enhancement of a wetland area to maintain the functional characteristics and processes of the wetland, such as its natural biological productivity, habitats and species diversity; unique water features; and water quality.

msl: mean sea level

Off-channel habitat: The physical environment necessary and natural to fish that is located adjacent to or connected to the primary in-stream flow.

Passage: The movement of migratory fishes through, around or over dams, reservoirs and other obstructions in a stream or river.

Peak wet weather flow: The instantaneous peak (maximum) flow during a storm event (wet weather) at any given point in the system.

Permeable: Having a penetrable surface; having pores or openings that allow water to pass through.

Predesign phase: The development of preliminary construction plans, specifications, and cost estimates that define general facility layouts; equivalent to a 10 percent design.

Reach: A section of stream between two specified points.

Refugia: Locations and habitats that support populations of organisms limited to small fragments of their previous geographic range.

Resident fish: Fish that do not migrate to the ocean but instead remain in freshwater for the entirety of their lives.

Riparian: Of or relating to the banks of a waterbody.

Riparian zone: The border of moist soils and plants next to a body of water.

Runoff: Precipitation that is not retained by vegetation, surface depressions, or infiltration and therefore flows over the land.

Sanitary sewer system: The network of pipelines and pump stations that collect and convey wastewater.

Sedimentation: The process of soil particles (sediment) being deposited into a river, stream, lake, or wetland and settling on the bottom.

Slough: An inlet on a river or a creek in a marsh or tide flat.

Spill: To release water through a spillway rather than through turbine units at a hydro-electric projects; water released in such a way.

Stormwater system: The swales, ponds, channels, creeks, sloughs, culverts, and pipe systems that convey and treat stormwater runoff from the land.

Stream separation: Collecting stormwater that currently enters the combined sewer system from natural areas and diverting it into either natural drainage channels or stormwater pipes for discharge to water bodies.

Swale: A natural depression or wide shallow ditch with grass or other vegetation that can be used to temporarily store, convey, and/or filter runoff.

Total maximum daily loads: A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources; the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources to ensure that the waterbody can be used for the purposes the state has designated.

Tributary: A stream feeding a larger stream or a lake.

Urban reserve areas (URA): Areas contiguous to the City of Portland's urban services boundary (USB) that may be included in the USB in the future.

Urban services boundary (USB): The boundary defining the area within which the City of Portland currently provides or is likely to provide urban services. The USB includes some areas outside the current city limits.

Watershed: A geographic area within which all surface water drains to a common point of discharge (e.g., river, stream, or slough). There are five major watersheds within the City of Portland: Fanno; Tryon; Willamette; Columbia Slough; and Johnson Creek.

Wetland: Land areas where excess water is the dominant factor determining the nature of soil development and the types of plant and animal species living at the soil surface. Wetland soils retain sufficient moisture to support aquatic or semi-aquatic plant life.

Atkinson Elementary School

5800 SE Division Street, Portland, Oregon

PROJECT SUMMARY

Project Type:	Public school stormwater retrofit – demonstration project
Technologies:	Downspout disconnection to grassy swales; asphalt removal for tree planting
Major Benefits:	• Runoff from 9,000 square feet of rooftop was rerouted from the sewer system to a grassy swale. • Eight 8-foot by 8-foot squares of asphalt (512 square feet total) were removed and eight trees were added.
Cost:	$17,854 total, with $16,104 paid by EPA funds
Constructed:	August 2004 through March 2006

Overview of the Stormwater System

- Eight 8-foot by 8-foot squares of asphalt (512 square feet total) were removed from the playground (Figure 1). The squares were backfilled with topsoil and compost and planted with eight large-caliper trees to reduce impervious area and provide shade (Figure 2).
- A long grassy swale was installed in an existing grassed area along the northeast building, backfilled with topsoil, and seeded with native grasses for erosion control and low-maintenance groundcover (Figures 3 and 4). Three downspouts draining 9,000 square feet of rooftop were disconnected to the grassy swale with splash blocks (Figure 5).

Figure 1: Asphalt removed from playground

Figure 2: Installed trees

Figure 3: Grassy swale construction

Figure 4: Grassy swale following construction

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Figure 5: Downspouts disconnected to grassy swale

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STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater facility was designed in accordance with the City of Portland's 2002 *Stormwater Management Manual*.

System Components

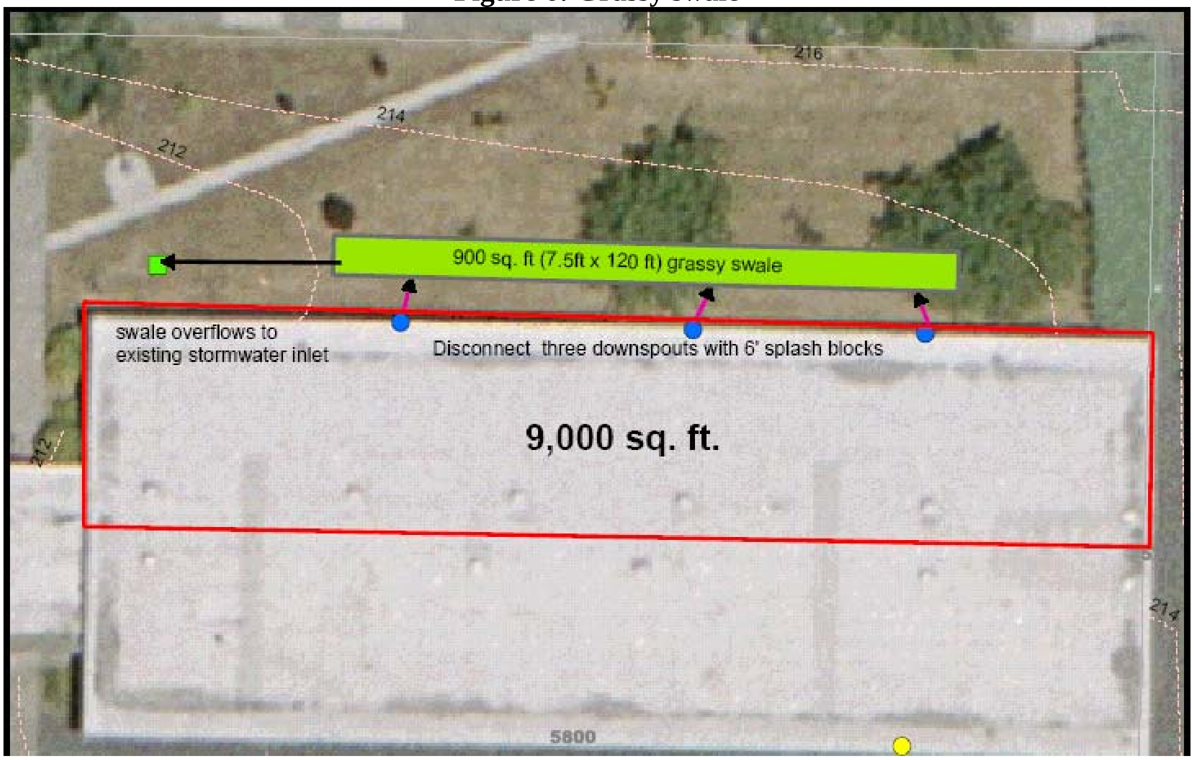
Grassy Swale
Catchment area: 9,000 square feet
Facility footprint: 900 square feet
Overflow: Existing field inlet to combined sewer
(See Figure 6)

Landscaping
Once the swale was excavated and backfilled with topsoil, it was seeded with a native grass mixture for erosion control and low-maintenance groundcover. The following 2002 *Stormwater Management Manual*-approved grassy swale mix was used. No irrigation is provided for the mixture.

Hobbs and Hopkins Pro-Time 835, Bio-filter Summer Green Vegetative Cover

Perennial ryegrass	*Lolium perenne*
Eureka hard fescue	*Festuca ovina duriuscula* 'Eureka'
Dwarf white yarrow	*Yarrow millefolium*
Dutch white clover	*Trifolium repens*

Figure 6: Grassy swale



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Trees

Under the direction of Friends of Trees, Atkinson Elementary School students installed eight large-caliper trees (two Japanese zelkovas, three forest green oaks, and three English hedge maples). Friends of Trees will maintain summer irrigation for the trees by water barrels for 3 years. If necessary, Friends of Trees will replace non-surviving trees.

NOTE: Vandals cut down all eight trees in May 2006. The trees were replaced in fall 2006, using volunteers and donations.

BUDGET

The Atkinson Elementary School project cost $17,854 for construction, landscaping (including plant installation using volunteer labor), and permits.

Item	Item Cost	Volunteer Effort	Total Cost
Construction			**$11,517**
Excavation and backfilling of stormwater facility BES contract oversight	$6,729 $2,543		
Downspout disconnection plumbing	$2,245		
Subtotal	***$11,517***		
Landscaping			**$5,771**
Plant material (trees, grasses)	$938		
Geotextile fabric	$1,350		
Vegetation installation – volunteers (175 students for 1 hour at $10/hour)		$1,750	
Irrigation and plant warranty	$1,410		
Topsoil	$323		
Subtotal	***$4,021***	***$1,750***	
Permitting			**$566**
Commercial permit	$461		
Plumbing permit	$105		
Subtotal	***$566***		
TOTAL	**$16,104**	**$1,750**	**$17,854**

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Budget Elements

Non-Construction Activities
The cost for design and overall project management was not included in the budget because these elements were considered a part of existing staff responsibilities and were not tracked separately for this project.

Construction Activities
A contractor with an existing BES on-call services contract completed the construction of multiple school site projects. The contractor billed the work for each school site by general type of activity (labor, machinery used) and did not break down costs by specific project activity (excavation, backfilling, grading, landscaping).

Cost Components

Construction

Construction cost $11,517 or 72 percent of the overall project cost (excluding volunteer labor). The contractor did not have a great deal of experience in stormwater retrofit projects, resulting in final costs higher than the original bid.

Landscaping

Landscaping cost $4,021 (excluding volunteer labor), or 25 percent of the overall project cost (excluding volunteer labor).

Permitting

The permits for this project cost $566, or 3 percent of the overall project cost (excluding volunteer labor).

Cost Comparisons

This project had a relatively simple design that used the existing grading of the vegetated swale site and the existing location of the nearby field inlet. The project is a good example of potential retrofits for existing development. Similar private-sector projects with more experienced contractors might cost less and take less time.

MAINTENANCE AND MONITORING

Portland Public Schools is responsible for the facility and its maintenance. Atkinson Elementary is responsible for any future vegetation or other modifications or enhancements to the project sites. After project completion, students planted native shrubs and groundcover under each of the trees for additional habitat. No monitoring will be performed at this site, but BES staff will make regular visits to photograph the site and ensure overall performance.

PUBLIC INVOLVEMENT

A one-page handout (Attachment 1) was developed to educate the local community about the benefits of the project. Copies were provided for each student at Atkinson Elementary School to take home, and extra copies were provided to school office staff to give to people who had questions (approximately 800 copies total). Seven classes of students (175 total students) were involved in planting the trees.

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SUCCESSES AND LESSONS LEARNED

Retrofit Projects at School Sites: Project sites at schools should be initiated by the schools when possible. A new principal came to this school one month before project construction and was unaware of the parent-led effort to place a stormwater facility onsite. If there is not a constant contact person within the school district (a teacher or other staff member) who advocates at the school for a stormwater retrofit project, it is difficult to coordinate with teachers and students for effective outreach and education. Project initiation by the school would better ensure that school calendar concerns, curriculum, and other school priorities are identified and met. In addition, stewardship-type projects are more likely to be maintained over the long term if they are initiated by the school. Outside partners that initiate projects—whether parents, non-governmental organizations, or governmental staff—should be willing to take on maintenance activities unless the site is specifically designed to have low or no maintenance.

Construction Budget: The contractor billed multiple school site projects by general activity rather than by project phase, making it difficult to make detailed cost comparisons.

Plumbing: Following construction of the swale, it was very difficult to find a plumbing contractor to disconnect the downspouts to the swale. The scope of work was too small and did not attract a bidder through the informal bidding process. The project manager contacted unions and MWESB (minorities, women and emerging small businesses) and publicly advertised the project. After much time and effort a contractor was finally hired. It would be more effective to bid the entire project to a prime contractor and let that contractor be responsible for finding a plumbing subcontractor.

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Attachment 1: Public Involvement Fact Sheet

Atkinson Elementary School

Innovative Wet Weather Project

September 2004

working for clean rivers, healthy watersheds, and a livable, sustainable community

You've probably noticed construction on the east side of the school grounds. Portland's Environmental Services is working with Portland Public Schools on a project to reduce stormwater runoff from the school grounds. The project has two parts:

- Disconnecting three downspouts outside the northeast classrooms and re-routing stormwater to a new swale.
- Removing some pavement in the playground area to make room to plant eight trees.

After construction, the playground will be re-striped to replace play features, like four-squares.

Environmental Benefits

Removing asphalt lets more rainwater soak into the ground like it did before it was paved over. Instead of flowing into sewer pipes, the water will now help refresh natural groundwater supplies. Stormwater in sewer pipes can cause basement flooding and it contributes to combined sewer overflows (CSOs) to the Willamette River.

The disconnected downspouts will direct rainwater into the swale instead of into sewer pipes. The swale will allow pollutants to settle and filter out as water soaks into the ground.

The new trees will shade and help cool the school and the playground, and will attract wildlife. Trees also capture rainwater on their leaves and branches allowing it to evaporate, and they help reduce erosion by holding soil together with their roots.

A New Look

The swale will be a shallow, narrow depression planted with grass. The playground tree wells will be seeded with the same grass to prevent erosion until the trees are planted. Environmental Services and the school are working with Friends of Trees to schedule springtime planting days for students to plant deciduous and evergreen trees.

Environmental Education

Environmental Services has worked with Portland Public Schools to make the swale a safe and attractive part of the school grounds, as well as an educational resource. Over the next year, an Environmental Services educator will teach Atkinson students about water quality and stormwater management. The activities will show students how to be stewards of the new stormwater management areas on their own school campus.

For More Information

If you have questions or concerns about site activities please contact:

Amber Marra, City of Portland
Bureau of Environmental Services
503-823-4356
amberm@bes.ci.portland.or.us

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

Dan Saltzman, Commissioner   Dean Marriott, Director   Printed on recycled paper. PL 0471

Astor Elementary School Water Garden
5601 N Yale Street, Portland, Oregon

PROJECT SUMMARY

Project Type:	Public school stormwater retrofit—demonstration project
Technologies:	Asphalt removal; downspout disconnection; vegetated swale; vegetated infiltration basins; cistern
Major Benefits:	• Approximately 289,000 gallons of stormwater are infiltrated and treated onsite each year instead of entering the combined sewer system. • Stormwater stored in a cistern can be used for onsite irrigation. • The addition of native landscaping improves the urban environment and the aesthetic appeal of the property. • The project involved considerable education of and participation by students and community members.
Cost:	$130,384 - Funding included an $8,500 EPA grant and a $25,000 Community Benefit Opportunity Program grant.
Constructed:	2003-2005

Overview of the Stormwater System

- The Astor Elementary School Water Garden is a joint project of the Bureau of Environmental Services (BES), Portland Public Schools, and Urban Water Works (a local non-profit organization).

- An 8,000-square-foot asphalt courtyard was removed and replaced with a water garden—an interrelated, linked system comprised of a cistern, three infiltration basins, and a vegetated swale. (See Figures 1 to 6.)

- Two downspouts were disconnected from the school's roof and directed to the cistern. Overflow from the cistern exits to a spiral-shaped infiltration basin.

- Three other downspouts were disconnected from the school's roof and directed to two infiltration basins shaped like fish. A graded connection links these two infiltration basins with the spiral infiltration basin.

- The spiral infiltration basin overflows to a long, narrow vegetated swale.

- A portion of existing sidewalk also drains to the new vegetated area.

- In addition to providing stormwater management, the water garden functions as an outdoor classroom, green space, and place for students to explore nature and art. Features include gravel pathways, bridges, and a stage area constructed of brick pavers.

Figure 1: Footprint of Astor School before retrofit

Figure 2: Astor courtyard before asphalt removal

Figure 3: Water garden under construction

Figure 4: Water garden under construction

Figure 5: Completed water garden

Figure 6: Completed water garden

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater management goal was to provide onsite stormwater infiltration and reduce the volume of stormwater entering Portland's combined sewer system. The project was designed in accordance with the City of Portland's 2002 *Stormwater Management Manual*.

Geotechnical Evaluation/Infiltration Test

Site-specific infiltration tests were not conducted because local drainage characteristics had been adequately documented by other projects in the vicinity. The Natural Resources Conservation Service (NRCS) soil survey for Multnomah County classifies the soils as 50A - Urban Land/ Multnomah Complex. The survey indicates the soils typically have been disturbed and mixed with fill material. The predicted infiltration range is 0.6 – 2.0 inches per hour.

System Components

(See plan on page 4)

Facility footprint: 1,500 square feet (1,060 square feet for the spiral infiltration basin and vegetated swale; 440 square feet for the fish-shaped infiltration basins)

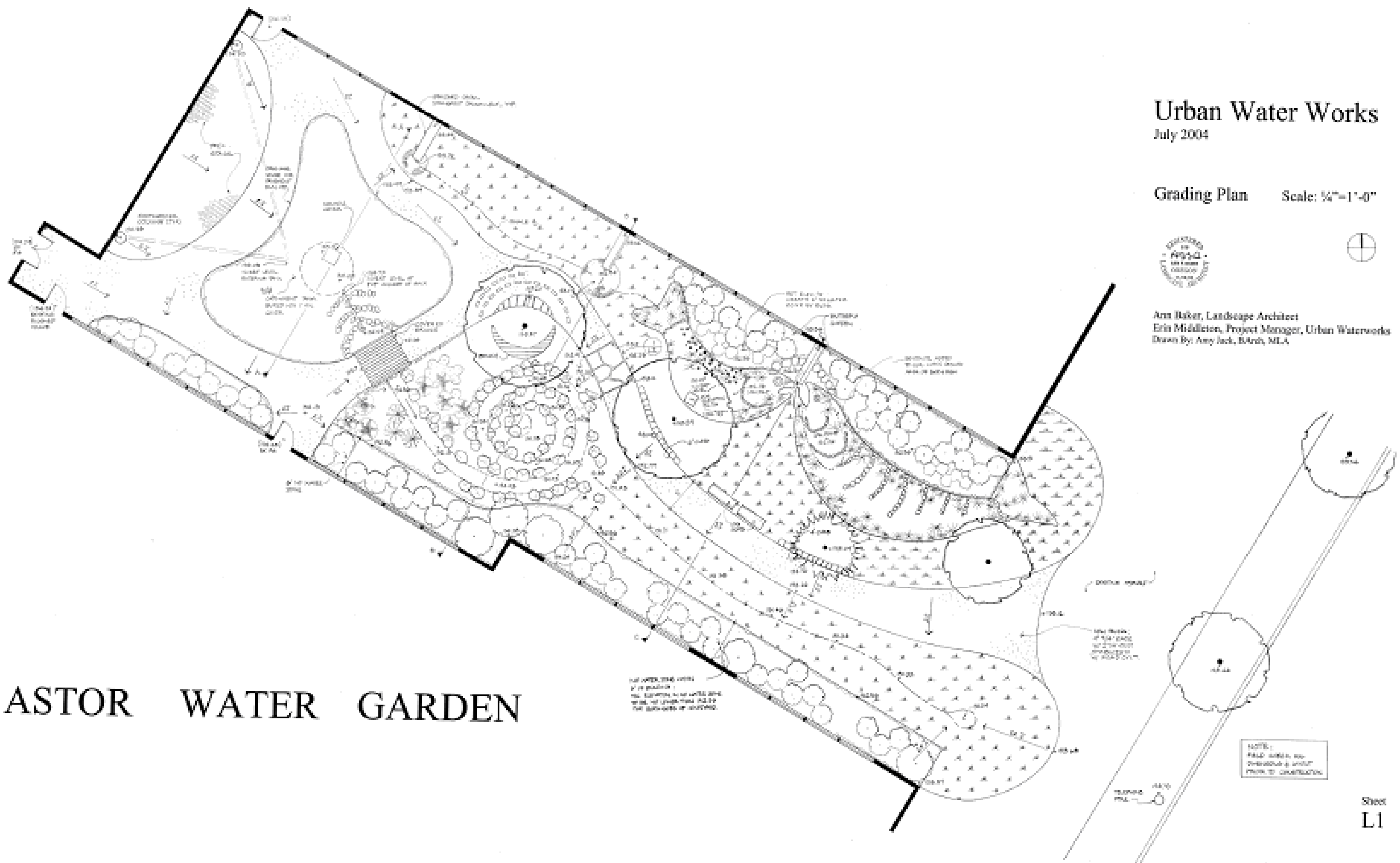
Catchment area: 17,700 square feet (9,000 roof; 8,000 asphalt removal; 700 sidewalk)

Cistern: 3,000 gallons - Runoff from two downspout disconnections is piped to the cistern, which is partly below grade on a small hill. A 180-square-foot stage area covers the places where the downspouts direct the flow underground into the cistern. During heavy rains, overflow from the cistern exits on the southeast side of the hill in a waterfall effect, continues under a footbridge, and flows into the spiral-shaped infiltration basin.

Infiltration basins: The three infiltration basins are shallow depressions (typically 6 inches deep) that capture and infiltrate runoff. The two fish-shaped basins contain check dams to slow flow, and small areas are lightly lined with bentonite to temporarily retain some water. Channels provide for overflow between the two fish-shaped basins.

Vegetated swale: Wetland plants in the long, narrow vegetated swale filter and slow any overflow from the spiral-shaped infiltration basin.

Overflow: During large storm events, any overflow from the basin/swale system enters an existing onsite storm inlet connected to the combined sewer system or flows to street inlets.



Urban Water Works
July 2004
Grading Plan
Scale: ¼"=1'-0"
Ann Baker, Landscape Architect
Erin Middleton, Project Manager, Urban Waterworks
Drawn By: Amy Jack, BArch, MLA
ASTOR WATER GARDEN
Sheet
L1

Landscaping: The landscaping includes mostly native plants—trees, shrubs, grasses, and wildflowers selected for their tolerance to dry and moist soil conditions. Prairie grass plugs and eco-lawn seed were planted on the hill as an alternative to a standard lawn. Trees and tall shrubs were placed in strategic locations to help reduce the seasonal heating and cooling needs for the building. Clean fill was imported to grade the landscape areas as basins. The imported soil consisted of a blend of composted (weed-free) yard debris and soil.

A concealed PVC irrigation system was installed to support irrigation of the plants during the 2-year establishment period. Because the landscape contains native plant species adapted to regional climate conditions, supplemental summer irrigation will typically not be required after the vegetation is established. However, the cistern has a hand pump for summer irrigation if needed.

BUDGET

The total project cost was $130,384, including management, design, and construction. Of this total, $45,531 (35 percent) was cash expenses, and $84,853 (65 percent) was volunteer contributions (donated services, materials, and labor). The table on the following page summarizes the project budget.

Funding sources included:

- $8,500 from an EPA Innovative Wet Weather Projects (IWWP) grant (through BES)
- $25,000 from a BES Community Benefit Opportunity Program grant
- Grants from Metro (in partnership with the U.S. Fish and Wildlife Service) and the Regional Arts and Culture Council (RACC)
- Private donations

Budget Elements

Non-Construction Activities

Non-construction activities included project design, project management, construction management, public education activities, and permitting.

Construction Activities

Construction activities included demolition, excavation, and grading; construction (bridges, pathways, cistern, downspout disconnection, plumbing); and landscaping.

Item	Total Cost	Volunteer Effort	Cash Expense
Project Design, Project Management, and Construction Management			
Project manager	$ 14,320.00	$4,550.00	$ 9,770.00
Design manager	$ 5,239.77	$1,000.00	$ 4,239.77
Project assistance/interns	$ 8,280.25	$3,525.00	$ 4,755.25
Design: landscape contractors and designers ($30/hr)	$ 15,000.00	$15,000.00	$ -
Landscape drawings	$ 500.00	$500.00	$ -
Accountant	$ 1,000.00	$1,000.00	$ -
Design charette, artists, educational activities	$ 6,772.00	$5,800.00	$ 972.00
Subtotal	**$ 51,112.02**	**$31,375.00**	**$ 19,737.02**
Demolition, Excavation, Grading			
Remove asphalt and sub-base (8,000 sq. ft.)	$ 7,300.00	$ 7,300.00	
Excavate stormwater management facilities	$ 4,500.00	$ 4,500.00	**$ -**
Grading plan	$ 1,500.00	$ 1,500.00	**$ -**
Subtotal	**$ 13,300.00**	**$ 13,300.00**	**$ -**
Construction			
Bridge/site improvements/supplies	$ 4,866.38		$ 4,866.38
Cistern	$ 2,130.00		$ 2,130.00
Modify office downspouts (downspout disconnect)	$ 4,010.00	$ 1,000.00	$3,010.00
Temporary fencing and erosion control	$ 1,657.02		$ 1,657.02
Rental equipment	$ 201.15		$ 201.15
Subtotal	**$ 12,864.55**	**$ 1,000.00**	**$ 11,864.55**
Landscaping			
Plant material (trees, shrubs, seed, groundcover)	$ 7,689.73	$ 2,500.00	$ 5,189.73
Rock and gravel	$ 4,552.05	$ 1,500.00	$ 3,052.05
Irrigation (hose bibs and soaker hoses)	$ 1,171.74	$ 1,000.00	$ 171.74
Soil	$ 893.73		$ 893.73
Subtotal	**$ 14,307.25**	**$ 5,000.00**	**$ 9,307.25**
Unpaid Volunteer Labor			
Installation - volunteers ($7.25/ hr)	$ 8,917.50	$ 8,917.50	$ -
Installation - school personnel and volunteers ($15/ hr)	$ 20,100.00	$ 20,100.00	$ -
Installation - school principal ($30/ hr)	$ 4,500.00	$ 4,500.00	$ -
Subtotal	**$ 33,517.50**	**$ 33,517.50**	**$ -**
Permitting			
Permit - planning/zoning/land use	$ 2,383.39		$ 2,383.39
Subtotal	**$ 2,383.39**		**$ 2,383.39**
Other Materials, Misc.			
Transportation	$ 352.83		$ 352.83
Art/design materials	$ 1,763.95	$300.00	$ 1,463.95
Copying, printing/promotional materials	$ 781.98	$ 360.00	$ 421.98
Subtotal	**$ 2,898.76**	**$ 660.00**	**$ 2,238.76**
TOTAL	**$ 130,383.47**	**$84,852.50**	**$ 45,530.97**
Percentage of investment	100.00%	65.08%	34.92%

Cost Components

Non-Construction Activities

Activity	Total Cost/ % of Total Project Budget	Cash Expense / % of Total Cash Expenditures	Volunteer Contributions/ % of Total Volunteer Contributions
Design, project/ construction management, public education	$51,112/39%	$19,737/43%	$31,375/37%
Permitting	$2,383/2%	$2,383/5%	-
Total	**$53,495/41%**	**$22,120/48%**	**$31,375/37%**

Construction Activities

Activity	Total Cost/ % of Total Project Budget	Cash Expense / % of Total Cash Expenditures	Volunteer Contributions/ % of Total Volunteer Contributions
Demolition, excavation, grading	$13,300/10%	-	$13,300/16%
Construction	$12,865/10%	$11,865/26%	$1,000/1%
Landscaping	$14,307/11%	$9,307/20%	$5,000/6%
Unpaid volunteer labor	$33,518/26%	-	$33,518/40%
Other materials, misc.	$2,899/2%	$2,239/5%	$660/1%
Total	**$76,889/59%**	**$23,411/51%**	**$53,478/63%**

Cost components can also be broken down as follows:

Activity	Percentage of Total Budget (Cash and Volunteer)
Project/construction management	39%
Design	3%
Public education activities	1%
Permitting	2%
Excavation, grading, and construction	20%
Landscaping (labor and materials)	36%
Total	**100% (rounded)**

Cost Comparisons

Because of the large amount of donated services, materials, and labor, actual project costs were lower than they would be for private-sector projects of this scope.

MAINTENANCE AND MONITORING

Urban Water Works is responsible for maintenance of the water garden until 2010. A Friends of the Astor Water Garden group has been formed to assist Urban Water Works. That group includes students, teachers, parents, and community members and has committed to ongoing implementation of an operations and maintenance plan.

BES and Urban Water Works staff will periodically assess the performance of the water garden.

PUBLIC INVOLVEMENT

The first year of the project included a cross-disciplinary curriculum at Astor School. Over 350 students and 12 teachers took part in classroom and after-school activities that investigated watersheds, urban pollution, plants, insects, recycling, and art. This prepared them for the garden design process, which also included parents, neighbors, and design professionals.

The second year involved removal of the asphalt and activities to design, build, and plant the garden. Students provided input through in-class workshops, and community input was obtained through evening design charrettes. Volunteers did most of the labor during weekend work parties. In total, a largely volunteer labor force of parents, neighbors, and school personnel contributed an estimated 4,077 hours to the project. (See Figures 7 and 8)

A permanent interpretive sign will be installed at the project site to provide information about the sustainable stormwater management techniques used.

SUCCESSES AND LESSONS LEARNED

Community and school involvement: Strong advocates within the school and the community drove this project and will likely continue to serve as ongoing stewards through maintenance and education activities. This kind of interest and support is very important for initiating and completing this kind of project and ensuring its long-term success.

Role of organizer: Although the project enjoyed considerable school and community support, the role of the adjunct organizer was very important in creating context (bringing in supporting information), ensuring continuity (managing a calendar of activities amid competing priorities), and providing support/fundraising (acquiring contributors beyond those already identified).

Figure 7: Design charette

Figure 8: Design process

Demonstration project: The project is a good example of a site retrofit with a mix of simple components (downspout disconnection, excavated shallow landscape depressions) and more complex components (replumbing of roof drains, asphalt removal and earth recontouring). The components clearly demonstrate to residential homeowners and public and commercial property owners the different ways a site can be assessed and retrofitted for stormwater management.

Optional planting areas: A small portion of the new landscape area has been set aside for two do-it-yourself planting areas that are open for the school community to compose seasonally. These areas enable teachers and parents to grow any of their favorite plants. This is not related to the stormwater management function of the garden, but rather is intended to nurture ownership and engagement. The parent community is vocal about the need for this freedom and signature-making—a kind of relief from the native plantings that form the majority of the garden.

Plugs versus seeds: Native grasslands were selected for the upland area because they are deep rooted, require no supplemental irrigation, and provide habitat for a variety of insects, including pollinators. After the hill was seeded, the grasses became established quickly. The first year's maintenance did not involve cutting the grasses, and the area soon became impenetrable. Sheet mulching is now underway, with students participating in soil preparation for the next round of eco-grass. For future gardens, Urban Water Works recommends installing plugs of three native perennial bunchgrasses, as well as seeds and plugs of a variety of native wildflower species. Plugs are typically more expensive and require more labor to plant than seeds, but tend to have a higher success rate than many seeds. This approach would produce a high-quality cover of diverse species.

Contouring: The project manager provided expert oversight to produce the relatively subtle slope needed to convey runoff into the landscape facilities. The success of similar projects is expected to require the same degree of oversight.

Irrigation: A temporary irrigation system helped the initial plantings become established quickly and well. Irrigation may be important for future gardens developed on school property where watering during the first two years must be sufficient to handle summer drought.

Project coordination: This project involved multiple parties: public agencies, private contractors, and volunteers. It is essential for all parties to maintain clear communication of expectations, agreed-upon performance standards and measures, and accountable project documentation. These elements sometimes fell short, detracting from the project's efficiency and cost-effectiveness.

East Holladay Park
NE 130th and Holladay Street
Portland, Oregon

PROJECT SUMMARY

Project Type:	Parking lot construction with pervious pavement—demonstration project
Technologies:	Pervious pavers
Major Benefits:	• Stormwater is infiltrated and treated onsite, rather than entering the piped storm sewer system. • The project enhances a neighborhood park and provides a unique educational opportunity.
Cost:	$165,000 with $45,000 paid by EPA grant funds
Constructed:	December 2005 through May 2006

Overview of the Stormwater System

- Because a new off-leash dog area was approved for East Holladay Park, a new parking lot was needed to accommodate additional vehicle traffic. The 5,225 square foot parking lot was surfaced completely with pervious pavers.
- Landscaped areas adjacent to the parking lot were designed to capture any overflow from the entire parking lot.
- The project results in complete onsite stormwater treatment and infiltration.

Figure 1:East Holladay Park Parking Lot Before

Figure 2: East Holladay Park Parking Lot After

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal was to provide onsite stormwater infiltration for the parking lot and demonstrate a stormwater management technique for parking lots. East Holladay Park has the first Portland Parks & Recreation parking lot to use pervious pavers for stormwater management.

System Components

Facility footprint: 5,225 square feet
Catchment area: 5,225 square feet

Pervious Pavers

The pervious pavers allow rain to soak into the soil below the parking lot, keeping it out of storm drains. Fine rock and soil filter the rain before it recharges the groundwater.

Landscaped Areas

Landscaped areas north of the parking lot are graded to capture overflow stormwater runoff from the parking lot and allow it to infiltrate into the soil. Curb openings at low points in the parking lot allow the runoff to enter the landscaped areas. The planting bed surface is covered with river rock instead of the usual bark mulch to slow the water and prevent erosion.

The landscaped areas have drought-tolerant, low-maintenance plants that are adapted to Portland's climate, reducing watering requirements. The vegetation includes black tupelo, cedar of Lebanon, goldenrain tree, rock rose, rugosa rose, California lilac, barberry, creeping Oregon grape, and red flowering currant. The black tupelo trees tolerate both standing water and summer draught and have beautiful fall color.

BUDGET

The East Holladay Park project cost about $165,000, broken down as follows:

- Construction: $100,400 (61% of the project cost)
- Design and Project Management: $22,000 (13% of the project cost)
- Consultants and other costs outside the construction contract (permits, printing, water meter): $42,500 (26% of the project cost)

Portland Parks & Recreation provided $119,542, and an EPA Innovative Wet Weather Projects grant to the Bureau of Environmental Services provided $45,000.

Because the soils at this site are porous, an additional gravel base below the pervious pavers was unnecessary. This was a cost-saving benefit.

Cost Comparisons

The installed pervious pavers, including aggregate base (which was low-cost at this site, as noted above), cost $10.00 per square foot. Conventional asphalt paving (including aggregate base) would cost $3.50 to $4.00 per square foot.

MAINTENANCE AND MONITORING

Portland Parks & Recreation maintains this site. Weeding and mowing are incorporated into the regular maintenance schedule. The joints between pavers will be cleaned and refilled with fine crushed rock every few years to ensure long-term system infiltration. Once the drought-tolerant plants are established in about two years, irrigation will be limited to reestablishing replacement plants if needed.

The pervious pavers will be monitored to determine how they handle stormwater and how they perform as a parking lot surface.

PUBLIC INVOLVEMENT

The Park Bureau worked with the local community to site and size the parking lot. It was important to Parks to construct a parking lot that was unique and beautiful.

SUCCESSES AND LESSONS LEARNED

This is the second pervious paver project in a Portland city park. This high-quality parking lot is more suited to the small scale of the site and proximity to neighbors than porous asphalt. Neighbors have indicated that they like the appearance of the parking lot.

By visibly demonstrating appropriate stormwater management, the project provides a unique environmental education opportunity for outer northeast Portland. An educational sign has been installed to identify the project’s environmental benefits.

Mississippi Commons
3721-3727 N Mississippi Avenue
Portland, Oregon

PROJECT SUMMARY

Project Type:	Complete onsite stormwater management for mixed-use commercial redevelopment—demonstration project
Technologies:	Downspout disconnection, innovative conveyance, infiltration planter, drywell, pervious gravel
Major Benefits:	• 500,000 gallons of stormwater is infiltrated and treated onsite each year instead of entering the combined sewer system. • The stormwater facilities are designed as amenities that contribute to the property's public space. • The project adds a vegetative landscaped component to the surrounding built environment.
Cost:	$42,105; $25,000 paid by EPA grant funds
Constructed:	2004

Overview of the Stormwater System

- The Mississippi Commons redevelopment project converted a collection of buildings from light industry to mixed-use artist space, offices, and retail. Part of the project involved providing complete onsite stormwater management.

- Two downspouts were disconnected from the roof and directed to a two-level, steel-lined basin. The basin empties into a grate-covered trench in the ground, which in turn flows into an infiltration planter. Vegetation, soil, and material in the planter slow and filter the stormwater before it soaks into the ground.

- The infiltration planter is designed as an architectural feature for the building's public courtyard.

- A third downspout is piped under the concrete and bubbles into the planter by way of a pipe.

Mississippi Commons Before

Mississippi Commons After, with Stormwater Infiltration Planter

- During large storm events, overflow enters a stand pipe within the planter and is directed underground to a drywell on the property. Overflow also spills onto an adjacent pervious gravel courtyard through an opening in the planter wall.

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal was to provide complete onsite stormwater infiltration and treatment and reduce the volume of stormwater entering Portland’s combined sewer system.

Downspouts disconnected to collection basin and conveyed along a trench to the planter

System Components

Facility footprint: 550 square feet (infiltration planter)

Catchment area: 25,000 square feet (21,800 roof and 3,200 pervious gravel courtyard)

Overflow system: Drywell; pervious gravel courtyard

Infiltration planter: The infiltration planter has a 12-inch sub-base of washed ¾-inch gravel, which is separated from approximately 24 inches of soil by a layer of filter fabric.

Landscaping: The largely native vegetation in the infiltration planter includes *Juncus patens*, Grooved rush; *Cornus stolonifera*, Red twig dogwood; *Viburnum trilobum*, American cranberry bush; *Camassia leichtlinii*, Camas lily; *Sisyrinchium*, Yellow-eyed grass, *Scirpus acutus*, hardstem bulrush, and *Carex rupestris*, Curly sedge.

BUDGET

The cost for the stormwater management system was $42,105, with $25,000 paid for by an EPA Innovative Wet Weather Projects (IWWP) grant. Of this total, $12,496 (30%) was spent on non-construction activities, and $29,609 (70%) was spent on construction activities, as shown below.

Roof runoff conveyed to the newly vegetated planter

Budget

Non-Construction Activities

Design and engineering:	$9,716
Construction management	2,780
	$12,496

Construction Activities

Demolition, Excavation, grading, drywell:	$10,560
Stormwater collection and conveyance:	8,500
Planter construction:	4,024
Landscaping (soil, plants, drip irrigation):	6,525
	$29,609

MAINTENANCE AND MONITORING

The property owner is responsible for facility maintenance.

The Bureau of Environmental Services (BES) provides periodic visual assessment of the facility.

PUBLIC INVOLVEMENT

A permanent interpretive sign at the project site provides information about the sustainable stormwater management techniques used.

The project is used as an example of innovative stormwater management on the BES website and on tours of sustainable stormwater management facilities.

SUCCESSES AND LESSONS LEARNED

Positive project example: Mississippi Commons is a good example of a successful public/private project. It is in a highly visible location in a fast-redeveloping area of the city, with other sustainable development projects occurring nearby. These projects provide opportunities for the public to become more aware of innovative stormwater management techniques, and other developers have expressed interest in using similar approaches.

Stormwater Infiltration Planter, looking north

Creative approach: The steel stormwater basin and conveyance system are a creative and innovative approach to capture and convey runoff from the building roofs.

Bubbler: One downspout is directed underground to a bubbler within the infiltration planter; however, it does not work effectively and, when it is not raining, water remains stagnant in the pipe, creating a potential habitat for mosquito breeding.

Stormwater rate reduction: Under the City's Clean River Rewards program, the onsite stormwater management measures will allow the property owner to reduce a portion of the stormwater rates for the site.

Plant survival: Since this was an early demonstration project, it was not known how some plants would behave in periodic standing water. All species appear to have survived except *Polystichum munitum,* sword fern; and *Fragaria chiloensis* strawberry; the *Mahonia aquilfolium,* Oregon grape, is surviving but is not growing with vigor. Continued visual assessments will determine the long term viability of the existing plants.

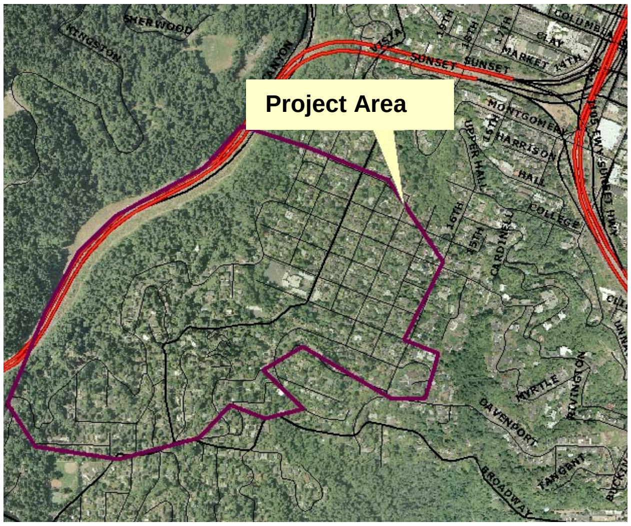
SW Montgomery Stormwater Flow Diversion Feasibility Study Portland, Oregon

PROJECT SUMMARY

Project Type:	Feasibility study to determine if stormwater flows could be directed out of the combined sewer system and into the storm sewer pipe constructed for the Tanner Creek Stream Diversion Project
Technologies:	Storm sewer separation and diversion
Major Benefits:	The feasibility study concluded that: • Runoff from 10 acres of impervious street and rooftop surfaces could be removed from the combined sewer system • The stormwater facilities built as part of Tanner Phase 3 could treat 2.6 million gallons of diverted stormwater runoff • Diversion could protect public health by minimizing the current level of basement flooding on SW Montgomery Drive
Cost:	$20,000 for feasibility study; up to $2.6 million for capital construction
Study Completed:	August 2004
Project Constructed:	Not yet constructed; not currently in the city's Capital Improvement Program (CIP)

Overview of the Stormwater System

Figure 1: SW Montgomery Feasibility Study Area



The study area is located between SW Montgomery Drive and SW 18th Avenue from Myrtle Avenue west to Patton Road. This 10-acre drainage area is within the larger 172-acre Market and 17th sub-basin. Most of the study area is zoned single-family residential, with 33% to 37% impervious cover. The Market and 17th sub-basin drains to the combined sewer.

The Market and 17th sub-basin has been studied as part of the West Side combined sewer overflow (CSO) and Basement Flooding Relief programs. The sub-basin has 31 potential pipe flooding locations, and 64 of the sub basin's 701 lots have a risk of basement flooding.

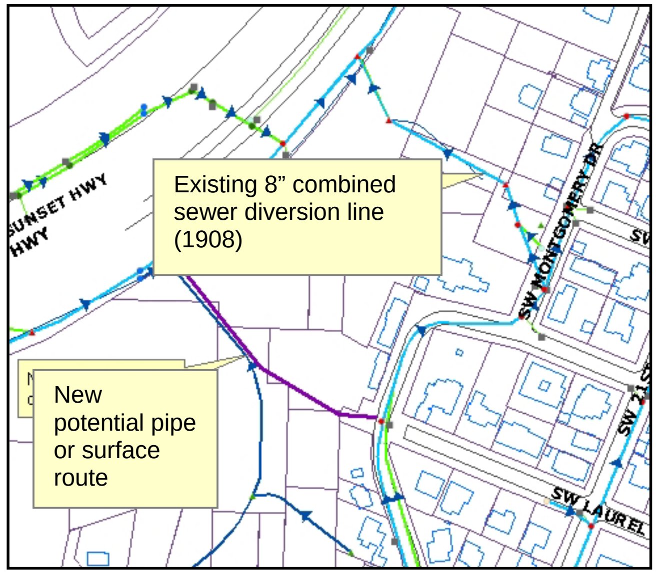
SW Montgomery Drive is a street of interest because it has limited or no public drainage facilities, a concentration of potential system surcharge points, and recorded basement flooding complaints. Of the five recorded complaints of basement flooding in the sub-basin as of 2001, three are along SW Montgomery Drive, including a location where a house foundation repair of over $250,000 generated a reimbursement claim by the homeowner.

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal is to divert residential runoff out of the existing Market and 17th combined sewer system and into the new Tanner Creek storm sewer pipe. The feasibility study explored three alternatives:

Figure 2: Alternative Stormwater Route



- 1 - Continue to route stormwater into the existing 8-inch combined sewer pipe going down the hill, and remove sanitary flows to make the pipe stormwater only. This alternative proposed adding a new SW Montgomery storm sewer line and disconnecting 50% of residential rooftops and driveways so runoff would go to the street, which would capture three acres of flow and divert it away from the combined sewer system. This alternative proved to have limited impact on abating combined sewer overflows and basement flooding. In addition, a few downslope sanitary connections were very problematic.

- 2 - Run a new 15-inch stormwater line or surface flow drainage down the slope to the Tanner Phase 3 system. In addition to the SW Montgomery line and disconnections of alternative 1, this alternative would add adjacent catchments to the enhanced storm conveyance capacity, and take 5.6 acres of impervious area would off the combined sewer pipe.

Figure 3: Montgomery Drive – Typical Street

- 3 - Route the entire drainage study area into a new storm-only line down the hill. Using the entire storm line capacity would direct drainage from 9.9 acres of impervious area away from the combined sewer system. A variety of tools would be added to capture flows, including additional pipe segments and flow slipping (see page 3).

The modeling analysis results are more fully explained in an August 3, 2004 technical memorandum.

Geotechnical Evaluation/Infiltration Test

No specific geotechnical investigations were made. However, each of the alternatives was extensively modeled, and geotechnical issues were identified as part of the engineering review.

System Components

New stormwater pipe: All three alternatives call for a new stormwater pipe in SW Montgomery Drive and elsewhere in the study area. That pipe would collect and route water into new collection system locations.

Flow slipping: Many of the existing streets are underserved or not served by standard inlet and pipe drainage systems. A number of areas were identified where runoff could be routed across the street or adjacent landscaped surface into desired inlet locations.

Downspout disconnection: To enhance the amount of flow a new system could accommodate, various residential, commercial, and two school properties were evaluated to determine if building downspouts could be disconnected and flow routed across paved or landscaped surfaces and into street collection systems. Because of tight soils, no infiltration into landscape areas would be expected or desired, which differs significantly from the city's Downspout Disconnection Program.

BUDGET

Feasibility Study Cost

The feasibility study cost $20,100. About $10,000 was used to develop the area model and run the three alternatives. The final predesign report – which included maps, model profiles, pre-design pipe layouts, and gross project cost estimates – cost an additional $10,000.

Item	Unit Cost	Alternative 2	Alternative 3
Design	20% of project total	$183,200	$370,900
Permitting	3% of project total	$27,500	$55,600
Materials Costs			
Direct pipe cost	$116 to $200 per linear foot, depending on diameter and depth	$732,780	$1,483,500
Construction			
Inspection, project management, testing	15% of project total	$137,400	$278,165
Startup and closeout	1% of project total	$9,160	$18,550
Contingency	25% of project total	$183,200	$370,890
TOTALS (rounded up)		$1,300,000	$2,600,000

Construction Costs

Alternative 1 was dropped from consideration because it had minimal impact on combined sewer overflows and basement flooding. Rough costs were developed for alternatives 2 and 3.

SUCCESSES AND LESSONS LEARNED

Field Evaluation: It was extremely helpful to have field evaluation work done to ground-truth various study area sub-catchments and to evaluate the likelihood of safe building disconnects and flow slipping opportunities. The fieldwork required four staff members for half a day to walk the entire study area.

Mapping System Use: The first alternative was eventually discarded because it would have limited benefits and because of issues discovered during catchment mapping. City plumbing and piping records were used to identify a subbasement sanitary connection in one household that would make this alternative substantially more complex.

Citizen Response: This project was initiated after a request by a school parents' group to disconnect some school buildings from one pipe system into another pipe system. This larger project concept resulted from the field and mapping work to approve or deny the parents' request. The initial request was denied because of significant combined sewer system capacity issues. If either Alternative 2 or 3 were implemented, the school disconnection would be a significant system benefit.

New Seasons Market
2543 SE 20th Avenue
Portland, Oregon

PROJECT SUMMARY

Project Type:	Redevelopment—demonstration project
Technologies:	Stormwater swales, stormwater planters, innovative conveyance
Major Benefits:	• Stormwater from the site and from a portion of public right-of-way is infiltrated and treated onsite. The stormwater facilities have the potential to prevent up to one million gallons of stormwater runoff from entering the combined sewer system annually. • The project achieves multiple benefits of stormwater management, site enhancement, and neighborhood satisfaction.
Cost:	$50,000 for stormwater facilities, paid by EPA grant; additional costs were paid for by the private developer.
Constructed:	Completed August 2005

Overview of the Stormwater System

- The New Seasons Market redevelopment project involved remodeling and adding to an existing structure. The project included onsite stormwater management for the private property as well as stormwater management for a portion of adjacent public right-of-way.

- Interconnected stormwater swales and planters encircle the New Seasons Market building and parking lot. They capture runoff from the entire rooftop, the entire parking lot, sidewalks, and a portion of SE Division Street. The runoff slows as it enters the landscaped areas, water soaks into the ground, and the vegetation filters pollutants.

- Runoff from one of the roof downspouts is directed through an ornamental scupper to shower a sculpture at the building's northeast corner. It then passes through a culvert to a swale.

- All runoff initially goes to one of the vegetated facilities, where it is detained and filtered. A large portion infiltrates into the ground; the facilities currently prevent approximately 500,000 gallons of stormwater runoff from entering the combined sewer system annually. However, 100% retention has not been achieved. During large storm events, overflow runs off to catch basins and enters the combined sewer system. (See Successes and Lessons Learned, below)

- Stormwater management is integrated into the building and site design. The design takes advantage of landscape spaces for managing runoff as a resource rather than a waste. The landscape spaces reduce total impervious surface; this will also reduce stormwater management charges, which are based on impervious surface area.

Figure 1: Green Street along SE Division

Figure 2: Green Street along SE Division with rain

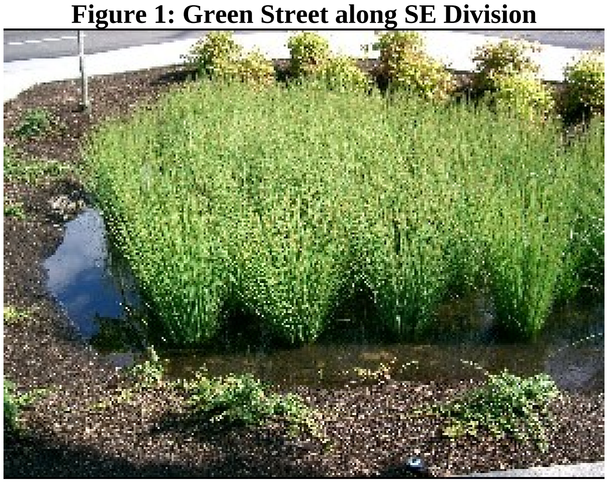


Figure 3

Figure 4

Figure 5

Figure 6

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal was to provide complete onsite stormwater infiltration and treatment and reduce the volume of stormwater entering Portland's combined sewer system. The project was designed in accordance with the City of Portland's 2004 *Stormwater Management Manual.*

System Components

Facility footprint: 4,500 square feet (swales and planters)

Drainage area: 51,500 square feet (26,000 roof, 20,500 parking lot, and 5,500 right-of-way)

Landscaping: Vegetation in the swales and planters is groove rush, common rush, and slough sedge. In keeping with landscaping code, additional vegetation is planted around the perimeter of the swales and planters, including decorative plants, western red cedars, and other trees.

BUDGET

The stormwater facilities cost $50,000, which was paid for by an EPA Innovative Wet Weather Projects (IWWP) grant.

Cost Comparisons

The onsite facilities reduced the amount of piping and inlets that would have been used with a traditional stormwater management approach. Because of the complexity of the project, however, total costs were probably comparable to the costs of a traditional approach. A bonus is that a portion of runoff from the public right-of-way is also managed.

MAINTENANCE AND MONITORING

The property owner has agreed to provide all maintenance associated with onsite facilities. The city is responsible for maintaining the facility located in the public right-of-way, but the property owner is voluntarily maintaining the vegetation and removing trash from that facility also.

The city is conducting soils tests to track the accumulation of stormwater pollutants in the facilities. The city is also conducting visual monitoring of the vegetation, infiltration capacity, and overall flow and conveyance functions.

PUBLIC INVOLVEMENT

New Seasons Market, the Hosford-Abernethy Neighborhood Association, and the Bureau of Environmental Services worked together to develop innovative, sustainable stormwater solutions for this project. The property owner and neighborhood were strongly interested in creating an environmentally responsible development that would enhance neighborhood aesthetics.

A permanent interpretive sign at the project site provides information on the sustainable stormwater management techniques used.

SUCCESSES AND LESSONS LEARNED

Positive project example: New Seasons Market is a good example of a successful private/public project. The stormwater facilities are well integrated into the overall site design and function, adding interest and appeal to the property. The project is in a visible location, providing an opportunity for the public to become more aware of innovative stormwater management techniques.

Early integration into the project: The stormwater facilities were not part of the site design from the beginning of the project. If they had been integrated into the design process earlier, there probably would have been some savings in cost and time.

Construction details: The project was complex and provided good information about technical details that will be instructive for other projects.

Infiltration: The subsoils are not infiltrating as well as anticipated, so the facilities are not achieving 100% retention. As the vegetation matures, the infiltration capacity of the facilities will increase, with the potential for complete retention. This would remove about one million gallons of runoff from the combined sewer system annually.

ReBuilding Center
3625 N Mississippi Avenue
Portland, Oregon

PROJECT SUMMARY

Project Type:	Complete onsite stormwater management for non-profit commercial redevelopment—demonstration project
Technologies:	Infiltration planters, flow-through planters, pervious concrete, drywells
Major Benefits:	• Over 870,000 gallons of stormwater infiltrated and treated onsite each year instead of entering the combined sewer system • Highly visible example of sustainable stormwater approaches • Adds green space and habitat to the urban environment
Cost:	$108,232 for stormwater management components, with $45,000 paid by EPA grant funds
Constructed:	2005

Overview of the Stormwater System

- The ReBuilding Center is a non-profit community enhancement organization dedicated to the reuse of discarded building materials. It is a popular destination for people interested in building with affordable, environmentally low-impact materials. When the center built two new warehouse-type canopy structures adjacent to an existing warehouse, the design included onsite stormwater management for the new buildings and parking lot.

- Roof runoff from the new Michigan Canopy warehouse is directed into two landscaped infiltration planters facing N Michigan Avenue. The infiltration planters have open bottoms, so the stormwater filters through plants, soil, and gravel into the ground.

Infiltration planters along the Michigan canopy structure

Infiltration planter

- Roof runoff from the new Mississippi Canopy is directed into two flow-through landscaped planters facing N Mississippi Avenue and one flow-through planter facing the back alley. The flow-through planters have solid bottoms. After stormwater filters through plants, soils, and rock sub-base, a perforated pipe at the bottom carries excess water to two drywells buried below the parking lot.

- A 3,800-square-foot pervious concrete parking lot allows rain to soak into the ground. The pervious concrete is on top of crushed rock, which temporarily stores water as it soaks into the soil below. An inlet at the lowest point of the parking lot conveys overflow to an existing catch basin.

The ReBuilding Center's existing warehouse before the addition of the Mississippi canopy structure

The flow-through planters in front of the new Mississippi Canopy with existing warehouse in the background

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal was to provide onsite stormwater infiltration and treatment and reduce the volume of stormwater entering Portland's combined sewer system. The stormwater facilities were designed in accordance with the City of Portland's 2002 *Stormwater Management Manual.*

System Components

Facility footprint: 2,125 square feet (planters)

Catchment area: 38,800 square feet (35,000 roof area and 3,800 parking lot)

Overflow system: Drywells; existing catch basin

Landscaping: The largely native vegetation in the planters includes red twig dogwood, Baltic rush, highbush cranberry, Pacific ninebark, tufted hairgrass, slender rush, Nootka rose, Pacific crabapple, Douglas spiraea or hardhack, common camas, yellow monkey flower, Douglas iris, and slough sedge.

BUDGET

The cost of stormwater components for this project was $108,232, with $45,000 paid for by an EPA Innovative Wet Weather Projects (IWWP) grant. Of this total, an estimated $21,930 (20%) was spent on non-construction activities, and $86,302 (80%) was spent on construction activities, as shown below.

Budget

[Note: Budget elements are estimates from the larger project costs.]

Non-Construction Activities

Project design and engineering:	$18,215
Project management:	1,675
Permits and inspections:	2,040
	$ 21,930

Construction Activities

Porous concrete parking lot:	$34,155	
Infiltration planters:	11,603	
Flow-through planters:	11,171	
Drywell:	6,900	
Landscaping (plants, soil, irrigation):	22,473	
		$ 86,302

A downspout disconnected into the infiltration planters on Michigan Street

MAINTENANCE AND MONITORING

The property owner is responsible for maintaining the facilities to ensure proper function and appearance. Maintenance may involve removal of nuisance and invasive plant species, removal of debris and sediment, and preventing impedance of stormwater flow into, or overflow from, the facility. The pervious concrete parking lot will require occasional maintenance to ensure it doesn’t clog with sediment.

The Bureau of Environmental Services (BES) will monitor the flow-through planters facing N Mississippi Avenue to determine their effectiveness. Flow monitoring equipment will record the amount of water that flows through to the perforated pipe at the bottom of the planters, indicating the volume of stormwater runoff that is not absorbed by the plants and soil. Data will be downloaded and recorded monthly. A manhole unit will house the equipment and allow BES staff to access and record the data.

BES will provide periodic visual assessment of the pervious parking lot and infiltration planters to determine plant viability and facility function.

Manhole for accessing monitoring equipment

Burying the manhole in landscaping area adjacent to the flow-through planters on Mississippi Street

PUBLIC INVOLVEMENT

A permanent interpretive sign at the project site provides information about the sustainable stormwater management techniques used.

The project is used as an example of innovative stormwater management on the BES website and on BES tours of sustainable stormwater management facilities.

The ReBuilding Center hosts dozens of tours each year to inform local, national, and international groups of its sustainable practices, including the stormwater management features. Following its renovation, the ReBuilding Center anticipates up to 300 visitors daily.

SUCCESSES AND LESSONS LEARNED

Positive project example: The ReBuilding Center is a good example of a successful public/private project. It is in a highly visible location in a fast-redeveloping area of the city, with other sustainable development projects occurring close-by. These projects provide opportunities for the public to become more aware of innovative stormwater management techniques, and other developers have expressed interest in using similar approaches. In addition, the center's customers benefit from seeing examples of the kind of onsite stormwater management they can implement on their own properties.

Integration into the built environment: The pervious concrete parking lot and stormwater planters are commendable examples of how stormwater management can be integrated into small urban spaces and fit seamlessly with the building design.

Modified design: Monitoring by the landscape architect showed that the flow-through planters along N Mississippi Avenue were not infiltrating at the minimum two inches per hour rate requested by the engineer. Discussions followed about whether this was caused by clogged filter fabric, undersized facilities for the catchment drainage (approximately 75% of capacity)*, too many fines in the soil mix, or only six to eight inches of storage capacity on top of the soil (freeboard). It was also possible that, given time, infiltration may have improved with plant establishment.

The landscape architect concluded it was a combination of several of these issues. Because the facility sizing could not be modified, the following modifications were implemented to restore the function of the flow-through planters:

- The plants, soil, and filter fabric were removed, and the rock subbase was reduced from 18 inches to 12 inches (in accordance with the construction specifications and *Stormwater Management Manual* requirements).

- Freeboard was increased to 12 inches.

- The clogged filter fabric was replaced with a non-woven fabric, which was layered between the gravel subbase and six inches of washed pea gravel; this is expected to serve as an additional filter for settling fines. The fabric extends from edge to edge rather than up the sides of the planter wall.

- The soil was replaced with a mix of approximately 70% sandy loam, 20% digested paper fiber, and 10% organic compost and installed in six-inch lifts to ensure uniform soil matrix distribution.

- The downspouts were taken off-line temporarily (approximately three months) and diverted to the bottom perforated pipe to allow the soil to settle and bind before heavy storm events occurred.

Drywells – The drywells for the flow-through planters are under the parking lot pavement. It is typical to place a manhole cover at the surface to allow access for monitoring and occasional cleanout when needed. Drywells can potentially fill with sediment, which could reduce their capacity to accept overflows from the planters.

Pervious pavement – Soon after the pervious concrete parking lot was constructed, one third of the parking lot needed replacing because rainfall was puddling on top rather than infiltrating through the concrete. The manufacturer determined that the replaced section was a more dense mixture than was poured for the other two-thirds of the parking lot.

*** The project was approved and constructed under the sizing guidelines in the City's 2002 *Stormwater Management Manual*. These guidelines considered the entire catchment area rather than the drainage area to individual facilities; some planters could be oversized and some undersized as long as the aggregate square footage was correct. The subsequent 2004 manual revised the sizing requirements.**

Sunnyside School
3421 SE Salmon Street, Portland, Oregon

PROJECT SUMMARY

Project Type:	Pavement removal
Technologies:	Asphalt removal; porous asphalt; gravel and landscaped areas
Major Benefits:	Approximately 1,615 square feet of impervious area was removed and replaced with materials that can infiltrate stormwater.
Cost:	$11,890
Constructed:	August 2004 through November 2004

Overview of the Stormwater System

- Asphalt was removed in three locations: in a locked, gated courtyard; near the northwest entrance by the kindergarten; and in four radial strips holding wooden expansions joints in the concrete play area.
- The courtyard asphalt (Figure 1) was replaced with gravels and other crushed rock to allow for infiltration (Figure 2). This removed approximately 1, 135 square feet of impervious area.
- The asphalt near the kindergarten area (Figure 3) was replaced with topsoil and seeded with grass, removing approximately 200 square feet of impervious area (Figure 4).
- The radial wooden expansion joints (Figure 5) were replaced with porous asphalt (Figure 6), removing approximately 280 square feet of impervious area.

Figure 1: Courtyard area

Figure 2: Courtyard with crushed gravels

Figure 3: Kindergarten area

Figure 4: Kindergarten area with grass landscaping

Figure 5: Wooden expansion joints

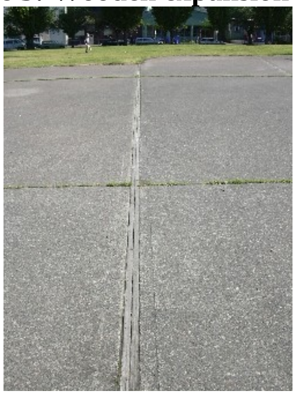


Figure 6: Porous asphalt radials

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

Figure 7: Site plan

The stormwater management goal was to reduce stormwater runoff by replacing asphalt with areas that could infiltrate stormwater.

System Components

(See Figure 7.)

Pavement Removal

Approximately 1,135 square feet of impervious area was removed from the gated courtyard and replaced with drain rock. Approximately 200 square feet of asphalt was removed in the kindergarten area and replaced with grass.

Porous Asphalt

Porous asphalt replaced the radial wooden expansion joints on Portland Parks and Recreation property adjacent to the school. The porous asphalt was dyed harvest gold to tie in to future enhancement projects related to the radial pattern design. The four porous asphalt radials are approximately 6 inches wide and ranged in length, averaging about 80 feet. This area drains approximately 3,000 square feet of playground area.

Landscaping

After the asphalt was removed from the kindergarten area, topsoil was added and seeded with a sterile grass mixture for erosion control. No irrigation was installed for the grass mixture. School students and staff later planted the kindergarten area with decorative flowers, which eventually died out.

BUDGET

The Sunnyside School project cost a total of $11,890, including construction, landscaping, and permitting.

Item	Item Cost	Total Cost
Construction		**$10,886**
Construction (including impervious area removal for porous installation) BES contract oversight	$7,606 $1,075	
Porous asphalt installation	$2,205	
Subtotal	***$10,886***	
Landscaping		**$442**
Gravel, topsoil, erosion control grass seed	$442	
Subtotal	***$442***	
Permitting		**$562**
Commercial permit	$562	
Subtotal	***$562***	
TOTAL	**$11,890**	**$11,890**

Budget Elements

Non-Construction Activities

The cost for design and overall project management was not included in the budget because these elements were considered a part of existing staff responsibilities and were not tracked separately for this project.

Construction Activities

A contractor with an existing BES on-call services contract completed multiple school site projects. The contractor billed the work for each school site by general activity (labor, machinery used) and did not break down costs by project activity (excavation, backfilling, grading, landscaping).

Cost Components

Construction

Construction elements cost $10,886, or 92 percent of the total budget. The manufacturer of the porous asphalt required a minimum production order of 3 cubic yards, which was much more than needed for this project. One cubic yard was used at Sunnyside, and the other 2 cubic yards were used at BES's Columbia Boulevard Wastewater Treatment Plan. Even though the excess porous asphalt was used at a separate site, this increased the price of the porous asphalt actually needed at the school because a minimum order had to be produced, distributed, and installed in two locations.

Landscaping
Landscaping elements cost $442, or 4 percent of the total budget.

Permitting
Permits costs $562, or 5 percent of the total budget.

Cost Comparisons

The costs per square foot of mitigated area were relatively high: approximately $7.35 per square foot.

MAINTENANCE AND MONITORING

Portland Public Schools is responsible for general maintenance of the created landscape area. Sunnyside School is responsible for any future vegetation or other modifications or enhancements to the project sites. BES later gave the school a gift certificate for the purchase of native plants.

PUBLIC INVOLVEMENT

A one-page handout (Attachment 1) was developed to educate the local community about the benefits of the project. Copies were provided for each student at Sunnyside School to take home, and extra copies were provided to school office staff to give to people who had questions (approximately 800 copies total).

SUCCESSES AND LESSONS LEARNED

Retrofit Projects at School Sites: Projects at school sites should be initiated by the schools when possible. This project was initiated by parents and the PTA, and onsite teachers were introduced partway through the project. If there is not a constant contact person (teacher, parent, or other staff) who advocates at the school and within the school district for a stormwater retrofit project, it is difficult to coordinate with teachers and students for effective outreach and education. This project was also proposed at a time when the school was undergoing grade expansion (from middle school to K-8), and a large magnet program (Environmental School) was establishing itself in the neighborhood. In addition, stewardship-type projects that were initiated by the school took precedence. Given these other activities and priorities, an externally proposed project did not receive a lot of attention or focus. Project initiation by schools would better ensure that issues concerning the school calendar, curriculum, and other school priorities are identified and met.

Figure 8: Pervious areas being used as storage for future raised garden beds

After construction was complete, school staff and volunteers used project sites for purposes different from those originally proposed. The future option of disconnecting downspouts to the pervious areas was eliminated because the space that would be needed for landscaped infiltration was used for storage instead (Figure 8). Sunnyside also began to vegetate the kindergarten area (Figure 9), reducing opportunities for other stormwater projects at this project site.

Soil Problems: The contractor used topsoil with high clay content to backfill the kindergarten area, which ponded water after heavy rains in fall 2004. Soil types should be carefully checked prior to initial installation. New soil specifications that will be included in the City's 2007 *Stormwater Management Manual* should help address this issue.

Porous Asphalt: It is possible that the porous asphalt is too narrow to be maintained properly or that staff training on proper maintenance practices was inadequate.

Figure 9: Non-native potted vegetation in kindergarten area

Figure 10: Porous asphalt clogged with debris

Attachment 1: Public Involvement Fact Sheet

Sunnyside Elementary School

Innovative Wet Weather Project

September 2004

working for clean rivers, healthy watersheds, and a livable, sustainable community

You've probably noticed construction in several areas on the north side of the school grounds. Portland's Environmental Services is working with Portland Public Schools on a project to reduce stormwater runoff from the school. The project has three parts:

- Removing asphalt from the fenced courtyard area on the east side of the gym and disconnecting four downspouts to allow stormwater from surrounding roofs to soak into the soil;
- Removing asphalt near the doors to the kindergarten classrooms, planting the area with grass and disconnecting a downspout to direct stormwater from the roof to the planted area (students and teachers will add more plants over time);
- Removing thin sections of pavement in the playground and installing porous pavement that lets stormwater soak into the ground.

Environmental Benefits

Removing asphalt lets more rainwater soak into the ground like it did before it was paved over. Instead of flowing into sewer pipes, the water will now help refresh natural groundwater supplies. Stormwater in sewer pipes can cause basement flooding and it contributes to combined sewer overflows (CSOs) to the Willamette River. The plantings will also help shade and cool the building and parking lot, and will provide new wildlife habitat.

A New Look

The courtyard will become gravel, which will be good for environmental education and planting activities. The planter near the kindergarten will be planted with grass now and native plants will be added later. Three gold colored "sunrays" on the new porous pavements in the playground will complement the school's sundial.

Most of the construction will be done by late October. Students will plant native vegetation before next spring.

Environmental Education

Environmental Services has worked with the school to make the courtyard, entry planters, and play area a safe and attractive part of the school grounds, as well as an educational resource. This fall, an Environmental Services educator will teach Sunnyside students about water quality and stormwater management. The activities will show students how to be stewards of the new stormwater management areas on their own school campus.

For More Information

If you have questions or concerns about site activities, please contact:
Dawn Hottenroth, City of Portland
Bureau of Environmental Services
503-823-7767
dawnh@bes.ci.portland.or.us

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

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Lewellyn Elementary School

6301 SE 14^{th} Avenue

PROJECT SUMMARY

Project Type:	Pavement removal
Technologies:	Asphalt removal; trees
Major Benefits:	• 1,280 square feet of asphalt was removed from the right-of-way and replaced with grassed infiltration areas that manage stormwater runoff from approximately 10,000 square feet of impervious area. • Large canopy street trees were added to increase evapotranspiration and infiltration.
Cost:	$19,664 total, with $19,364 paid by EPA funds
Constructed:	August 2004 through January 2005

Overview of the Stormwater System

- The existing site grading at the back of Lewellyn Elementary School directs stormwater runoff from the school's loading and delivery area to the parking strip median. This project removed approximately 1,280 square feet of asphalt in the parking strip median (Figures 1 and 2) and replaced the asphalt with soil that was then seeded with grass (Figure 3).
- Large canopy street trees were planted (Figure 4) to reduce stormwater runoff through evapotranspiration and infiltration.
- The grading will continue to direct stormwater runoff from the school site to the new landscaped area. Concrete pavers placed across the median at regular intervals provide pedestrian access.

Figure 1: Asphalt parking strip median (middle dark grey areas to right)

Figure 2: Parking strip medians with grass and concrete pavers for pedestrian access

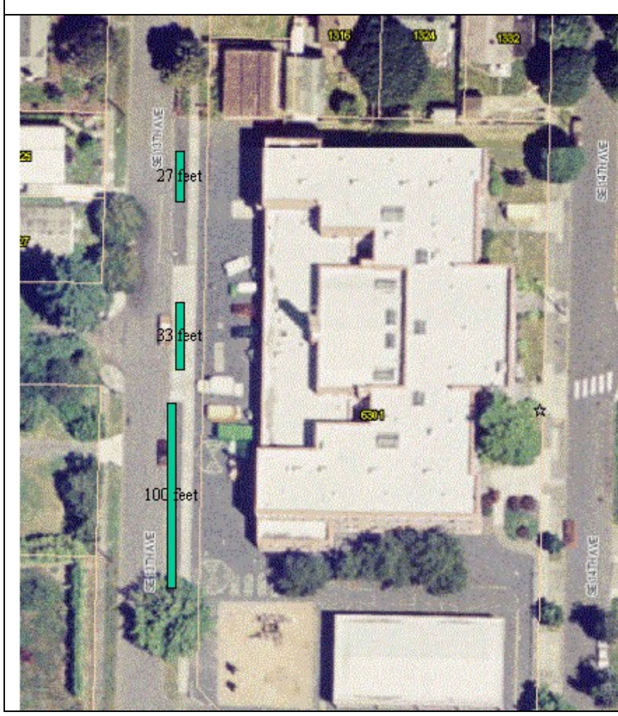
Figure 3: Completed project with street trees

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater management goal was to reduce stormwater runoff by replacing asphalt with grassed landscape areas and adding large canopy trees.

Figure 4: Site Plan



System Components

(See Figure 4.)

Infiltration Areas

Three separate strips of asphalt in the planting strip were removed to create space for infiltration of runoff.

Catchment area: The new infiltration areas drain approximately 10,000 square feet of impervious area.

Facility footprint: The three infiltration areas are each 7 feet, 8 inches wide and 27 feet, 33 feet, and 100 feet long, respectively (north to south).

Overflow: All flows will fill the depressed areas and overflow to the street, either over the curb or across the vehicle cuts.

Additional information: Concrete pavers were added at regular intervals for pedestrian access.

Landscaping

After the asphalt was removed and topsoil was added, the area was seeded with a native grass mixture for erosion control and low-maintenance groundcover. The following grassy swale mix, approved by the City of Portland's 2002 *Stormwater Management Manual,* was used. No irrigation is provided for this grass mixture.

Hobbs and Hopkins Pro-Time 835, Bio-filter Summer Green Vegetative Cover

Perennial ryegrass	*Lolium perenne*
Eureka hard fescue	*Festuca ovina duriuscula* 'Eureka'
Dwarf white yarrow	*Yarrow millefolium*

Friends of Trees planted 12 Raywood ash trees along the landscaped area. Friends of Trees will maintain summer irrigation for the trees by water barrels for 3 years and, if necessary, will replace non-surviving trees.

BUDGET

The Lewellyn Elementary School project cost a total of $19,664 for construction, landscaping (including volunteer tree installation), and permits. Because the project required sidewalk and curb replacement work within the right-of-way, it was implemented by the City's Bureau of Maintenance (BOM). The BOM costs may not reflect true project costs if the work were completed by an outside contractor.

Item	Item Cost	Volunteer Effort	Total Cost
Construction			**$16,090**
BES construction oversight	$3,273		
Bureau of Maintenance excavation, curb installation, topsoil	$12,817		
Subtotal	***$16,090***		
Landscaping			**$3,410**
Plant material (trees, grass seed)	$1,469		
Tree installation – Friends of Trees neighborhood tree planting (15 volunteers for 2 hours at $10/hour)		$300	
Concrete pavers	$58		
Irrigation and plant warranty	$1,583		
Subtotal	***$3,110***	***$300***	
Permits			**$164**
Right-of-way permit	$164		
TOTAL	**$19,364**	**$300**	**$19,664**

Budget Elements

Non-Construction Activities
The cost for design and overall project management was not included in the budget because these elements were considered a part of existing staff responsibilities and were not tracked separately for this project.

Figure 5: New curb and sidewalk installation

Construction Activities
The existing curb and sidewalk were in disrepair. BOM required a new street curb and sidewalk to be installed to support the soil and meet new construction standards (Figure 5).

Cost Components

Construction
The construction elements, including the new curb and sidewalk, cost $16,091, or 83 percent of the total project cost (not including volunteer labor).

Landscaping
The landscaping cost $3,110, or 16 percent of the total project cost (not including volunteer labor).

Permitting
The right-of-way permit for the project cost $164, or 1 percent of the total project cost (not including volunteer labor).

Cost Comparisons

This was a fairly simple retrofit project. If there were no concerns about access, vegetation, existing utilities, and the state of the existing infrastructure (sidewalk and curb), this type of project would be relatively inexpensive.

MAINTENANCE AND MONITORING

Portland Public Schools is responsible for the right-of-way and its maintenance. BES staff will make regular visits to photograph the site and ensure overall performance. Friends of Trees is committed to 3 years of summer watering of the trees and overall tree survival.

PUBLIC INVOLVEMENT

A one-page handout (Attachment 1) was developed to educate the local community about the benefits of the project. Copies were provided for each student at Llewellyn School to take home, and extra copies were provided to school office staff to give to people who had questions (approximately 500 copies total). Friends of Trees was contracted to manage the tree planting during one of its neighborhood planting events in the Sellwood-Moreland neighborhood and provided general environmental education to volunteers at the tree planting event.

SUCCESSES AND LESSONS LEARNED

Construction Budget: The need to construct a new street curb and sidewalk increased costs significantly from initial estimates.

Overall Design: The simple design and existing site grading site allowed for a relatively simple retrofit. If concerns about access, vegetation, existing utilities, and the state of existing infrastructure (sidewalk and curb) can be met, this type of facility is a relatively easy project. Where curbs and sidewalks are in disrepair, this kind of project could be added to other planned repairs.

Facility Damage: The new landscape areas suffered a series of “drive-through” accidents shortly after construction, before the street trees were installed. Waste haulers and parents picking up students drove through the facility by accident, not realizing or remembering that the asphalt was no longer there. Adding street trees (or some other large visual cue such as stakes or a rope fence) shortly after construction could help reduce tire damage to the grass and soil.

Lewellyn Elementary School

Innovative Wet Weather Project

September 2004

working for clean rivers, healthy watersheds, and a livable, sustainable community

You've probably noticed construction on the west side of the school grounds along 13th avenue. Portland's Environmental Services is working with Portland Public Schools on a project to reduce stormwater runoff from the school's back parking areas. Sections of asphalt in the planting strip between curb and sidewalk will be removed and replaced by a series of vegetated swales. The Portland Bureau of Maintenance will also build new curbs and sidewalks around the swales.

The swales will be shallow, narrow grassy depressions that will collect stormwater runoff and allow pollutants to settle and filter out as water soaks into the ground. Stepping stones, which the students will help create, will provide a good walkway across the swales. Friends of Trees will also work with the school to plant 13 street trees in the swales.

Environmental Benefits

Removing pavements reduces stormwater runoff and lets rain soak into the ground. Instead of contributing to basement flooding and combined sewer overflows (CSOs), the rainwater will help refresh the natural groundwater system.

The new trees will also reduce stormwater runoff by holding rainwater on their leaves and branches. Trees also help prevent erosion and provide wildlife habitat.

A New Look

The swales are designed to enhance the appearance of the existing landscape. Students and teachers at Llewellyn are exploring the possibility of planting more native vegetation in the future. New, white curbs will replace old, cracked curbs surrounding the swales and sidewalks. Construction should be finished by October.

Environmental Education

Environmental Services has worked with the school community to make the swales a safe and attractive part of the school grounds, as well as an educational resource. An Environmental Services educator will visit the school this fall to teach students about water quality and stormwater management, and how to be good stewards of the new stormwater management areas.

For More Information

If you have questions or concerns about site activities please contact:
Dawn Hottenroth, City of Portland
Bureau of Environmental Services
503-823-7767
dawnh@bes.ci.portland.or.us

ENVIRONMENTAL SERVICES
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Kelly Elementary School
9030 SE Cooper Street, Portland, Oregon

PROJECT SUMMARY

Project Type:	Public school parking lot stormwater retrofit—demonstration project
Technologies:	Asphalt removal; vegetated swales
Major Benefits:	• 1,950 square feet of asphalt was removed from the existing parking lot, and vegetated swales were created to manage parking lot runoff. • 1,600 square feet of asphalt was removed to create a pervious Head Start playground.
Cost:	$45,237 total, with $43,237 paid by EPA funds
Constructed:	August 2004 through October 2005

Overview of the Stormwater System

- Runoff in the parking lot previously drained to existing central stormwater inlets. The parking lot had three long, 6-foot-wide areas between facing parking spaces that could be converted into swales for stormwater infiltration (Figure 1).
- Asphalt was removed from the three 6-foot-wide, 108-foot-long rows. These areas were filled with topsoil and mulch and grass seeded for erosion control and groundcover (Figure 2). The swales manage runoff from 4,500 square feet of impervious parking lot area.
- Tire stops were added to keep cars from accidentally driving through the swales. Concrete pavers were added for pedestrian access at regular intervals along the swales.
- Kelly Elementary School students planted trees, shrubs, and other groundcovers (Figure 3).
- Approximately 1,600 square feet of asphalt playground was removed to create a pervious vegetated Head Start play area (Figure 4).

Figure 1: Asphalt between facing parking spaces

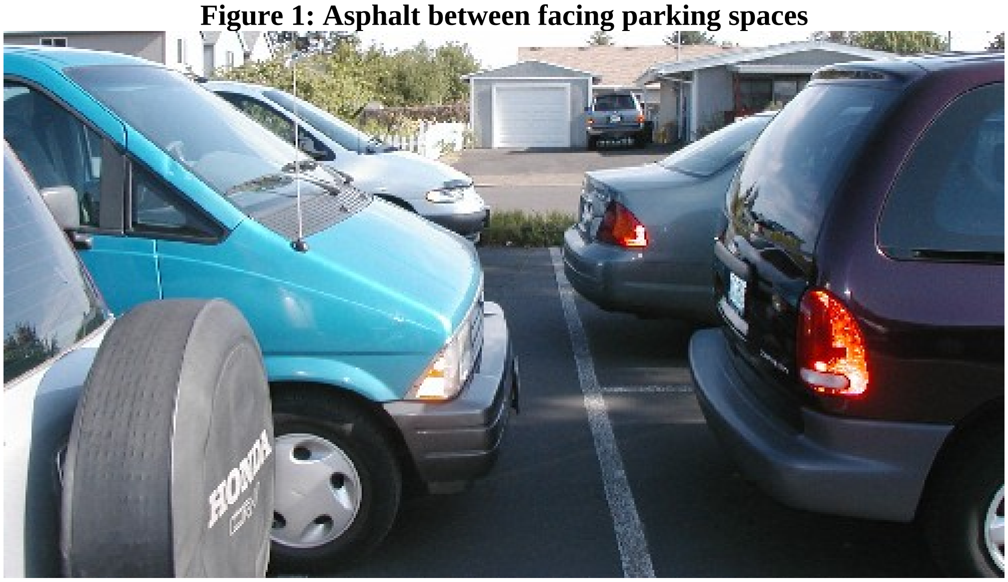


Figure 2: Swales excavated, backfilled, and grass seeded

Figure 3: Vegetated swales

Figure 4: Completed Head Start play area

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater facilities were designed in accordance with the City of Portland's 2002 *Stormwater Management Manual*.

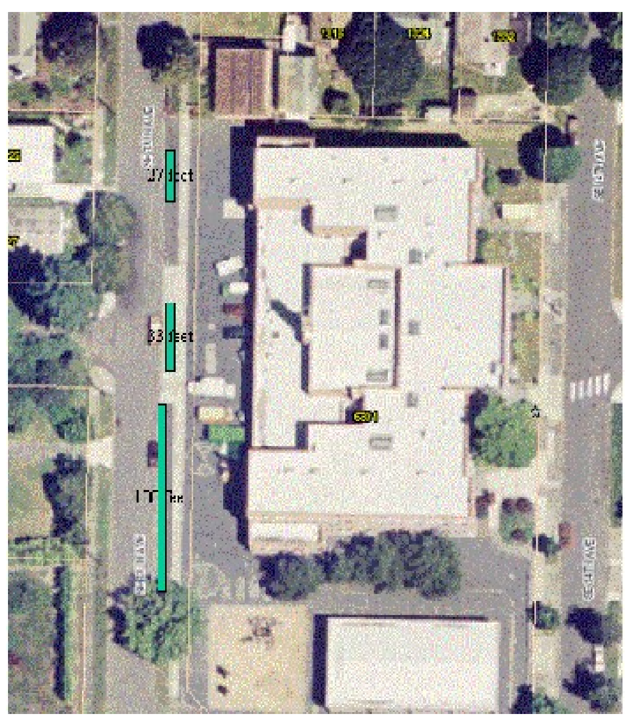
System Components

Vegetated Swales

(See Figure 5.)

Catchment area: The parking lot is approximately 28,500 square feet. Approximately 4,500 square feet drains to the outer two swales. It is difficult to determine how much drains from the inner two parking aisles to the middle swale because some of that drainage goes directly to the stormwater inlets.

Figure 5: Site Plan



Facility footprint: The three swales are each 6 feet wide and 108 feet long, or 648 square feet each, for a total of 1,944 square feet.

Overflow: Two central stormwater inlets in the center of the parking lot provide for safe overflow in case of heavy rains.

Additional information: Concrete pavers were added for pedestrian access at regular intervals along the swale. Recycled rubber tire stops were added to prevent tire damage and reduce accidental driving into the swales.

General Landscaping

Once the swales were excavated and backfilled with topsoil, they were seeded with a native grass mixture for erosion control and low-maintenance groundcover. The following 2002 *Stormwater Management Manual*-approved grassy swale mix was used. No irrigation is provided for the grass mixture.

Hobbs and Hopkins Pro-Time 835, Bio-filter Summer Green Vegetative Cover

Perennial ryegrass	*Lolium perenne*
Eureka hard fescue	*Festuca ovina duriuscula* 'Eureka'
Dwarf white yarrow	*Yarrow millefolium*

At a planting with Kelly Elementary students, Friends of Trees planted 18 native trees: 5 Western dogwood, 5 Indian plum, 4 grand fir, and 4 quaking aspen. The students helped plant the trees and install shrubs and other groundcovers, including slough sedge, spreading rush, kinickinick, western yarrow, field strawberry, small flowered lupine, creeping foxtail, and creeping Oregon grape. Friends of Trees will maintain summer irrigation for the trees by water barrels for 3 years. If necessary, Friends of Trees will replace non-surviving trees.

BUDGET

The Kelly Elementary School project cost a total of $44,237 for design, construction, landscaping, and permits (including volunteer labor by students).

Construction			**$35,754**
Construction and BES contract management	$15,484 $3,217		
Head Start area asphalt removal	$3,000		
Bureau of Maintenance repairs	$11,463		
Tire stops	$2,590		
Subtotal	***$35,754***		
Landscaping			**$7,780**
Topsoil and gravel	$1,375		
Vegetation (grass seed, trees, shrubs, groundcovers)	$3,877		
Vegetation installation by Kelly Elementary students (100 students for 1 hour at $10/hr)		$1,000	
Concrete pavers	$93		
Summer irrigation and plant warranty	$1,525		
Subtotal	***$6,780***	***$1,000***	
Permitting			**$703**
Commercial permit	$703		
Subtotal	***$703***		
TOTAL	**$43,237**	**$2,000**	**$44,237**

Budget Elements

Non-Construction Activities
The staff cost for design and overall project management was not included in the budget because these elements were considered a part of existing staff responsibilities and were not tracked separately for this project.

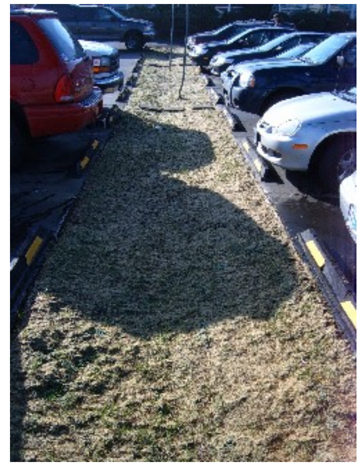
Construction Activities
A contractor with an existing BES on-call services contract completed the construction of multiple school site projects. The contractor billed the work for each school site by general activity (labor, machinery used) and did not break down costs by project activity (excavation, backfilling, grading, landscaping).

Cost Components

Construction
Construction elements cost a total of $35,754, or 83 percent of the overall project cost (excluding volunteer labor). Contractor work and BES contract oversight cost $18,701, or 43 percent of the overall project cost (excluding volunteer labor).

Heavy rains that occurred shortly after construction was completed in fall 2004 highlighted several problems. The soil mixture that was used had a higher clay percentage than originally specified and was not allowing for infiltration. The swales were overflowing and causing the parking lot to be muddy. The site was also plagued by weeds (including poison hemlock) that were in the topsoil mixture or arrived through wind deposition. The Bureau of Maintenance (BOM) was contracted to fix these problems, and the final cost for the BOM repair work was $11,811, or 27 percent of the total project cost (excluding volunteer labor). The repair included excavation of the two outer swales and the addition of new topsoil and erosion control (jute and grass seed) (Figure 6).

Figure 6: Jute mat and grass seed erosion control in repaired swale



Asphalt removal for the Head Start playground cost $3,000, or 7 percent of the overall project cost.

Landscaping

Landscaping elements cost $6,780 (excluding volunteer labor), or 15 percent of the overall project cost.

Permitting

The permits for this project cost $703, or 2 percent of the overall project cost (excluding volunteer labor).

Cost Comparisons

The parking lot did not need to be restriped or refigured, and the stormwater facilities could fit into the existing space, reducing potential costs. Because of necessary repairs, however, this project cost more than originally estimated. Private-sector projects with similar simple design plans might cost less and take less time if more experienced contractors are used.

MAINTENANCE AND MONITORING

Portland Public Schools is responsible for the facility and its overall maintenance. Friends of Trees is committed to 3 years of summer watering of the trees and overall tree survival. Kelly Elementary is responsible for general site maintenance and any potential enhancements to the project site. No water quality monitoring will be performed at this site, but BES staff will make regular visits to photograph the site and ensure overall performance.

PUBLIC INVOLVEMENT

A one-page handout (Attachment 1) was developed to educate the local community about the benefits of the project. Copies were provided for each student at Kelly Elementary School to take home, and extra copies were provided to school office staff to give to people who had questions (approximately 500 copies total). A BES environmental educator provided watershed health and stormwater programs to four classes at Kelly Elementary School; all of these classes were later involved in planting trees and vegetation.

SUCCESSES AND LESSONS LEARNED

Schedule Delays: Construction should occur as early in the dry season as possible. Heavy rains occurred shortly after construction was completed in fall 2004, delaying vegetation installation by a year. The soils did not allow infiltration, which created ponding water and muddy overflows to the parking lot and necessitated repair of the swales. Construction of this project had to be scheduled around the school calendar; if this is the case, the project should be scheduled for as early in the school year as possible.

Construction Budget: The contractor billed multiple school site projects by general activity, rather than by project phase, making it difficult to make detailed cost comparisons.

Grading: The subtle grading of the site makes it difficult to assess exactly how much of the parking lot is directed to swales prior to overflow to the inlets.

Facility Damage: The swales suffered a series of "drive -through" accidents shortly after construction, before trees were installed. Adding trees (or some other large visual cues such as stakes or a rope fence) shortly after construction could help reduce tire damage to the grass and soil.

Kelly Elementary School

Innovative Wet Weather Project

September 2004

working for clean rivers, healthy watersheds, and a livable, sustainable community

You've probably noticed construction in the parking lot on the north side of the school. Portland's Environmental Services is working with Portland Public Schools on a project to reduce stormwater runoff from the school. Some of the parking lot asphalt will be removed and replaced with a series of vegetated swales. New speed bumps will help water flow into the swales.

Environmental Benefits

Removing asphalt lets more rainwater soak into the ground like it did before it was paved over. Instead of flowing into sewer pipes, the water will now help refresh natural groundwater supplies. Stormwater in sewer pipes can cause basement flooding and it contributes to combined sewer overflows (CSOs) to the Willamette River.

The swales will be shallow, narrow depressions planted with native trees, shrubs and groundcovers. Both Friends of Trees and Kelly students will do the planting. Stormwater runoff from the parking lot will flow into the swale. Pollutants will settle and filter out as water soaks into the ground.

The new trees will shade and help cool the school and the parking lot, and will attract wildlife. Trees also capture rainwater on their leaves and branches allowing it to evaporate, and they help reduce erosion by holding the soil together with their roots.

A New Look

The swales are designed to enhance the existing landscape. Asphalt speed bumps across the aisleway will direct stormwater into the swales. Tire stops made of recycled rubber will keep cars from driving into the swales. Most of the construction should be done by late October.

Environmental Education

Environmental Services has worked to make the courtyard, entry planters, and play area a safe and attractive part of the school grounds, and an educational resource. This fall, an Environmental Services educator will teach Kelly students about water quality and stormwater management. The activity will show students how to be stewards of the new stormwater management areas on their own school campus.

For More Information

If you have questions or concerns about site activities, please contact:
Dawn Hottenroth, City of Portland Bureau of Environmental Services
503-823-7767
dawnh@bes.ci.portland.or.us

Environmental Services
City of Portland
working for clean rivers

Dan Saltzman, Commissioner   Dean Marriott, Director   Printed on recycled paper. PL 0471

David Douglas Administration Site

1500 SE 130th

Project Summary	
Project Type:	Public school stormwater retrofit – demonstration project
Technologies:	Redirecting parking lot flows into two bioswales
Major Benefits:	• Removing 1,200 square feet of impervious parking lot area and replacing with vegetated swales • Redirecting 62,475 square feet, or 1.43 acres, of parking lot drainage into two infiltration swales
Cost:	$9,960
Constructed:	March 2005 through June 2007

Overview of the Stormwater System

- Approximately one acre of parking lot drainage to the south of the David Douglas Administration buildings was diverted from an onsite drywell into two infiltrating bioswales.

Figure 1 - site map (south swale sizing modified later)

Figure 2 – south swale pre-construction

Figure 3 – east swale post construction

Figure 4 – south swale post construction

--Stormwater Capacity and System Components

<u>Stormwater Management Goal</u>

The stormwater facility was designed in accordance with the 2004 Stormwater Management Manual guidance for vegetated swales.

System Components

Vegetated Swales

East Swale

Catchment area: 25,850 sq. ft. *Facility footprint:* 560 sq. ft.

Overflow: At southern end into existing drainage collection system that overland flows into the main parking lot sump

West Swale

Catchment area: 25,850 sq. ft. *Facility footprint:* 640 sq. ft. (this size was modified by original plan, see Lessons Learned section)

Overflow: At west end of the facility into existing drainage sump

Landscaping

While students participated in construction of the project, David Douglas School District horticultural staff installed landscaping. Each swale was planted per the specifications of the city's Stormwater Management Manual. Each 100 foot long swale was planted with five trees, 30 shrubs and about 100 groundcovers. The following species were planted:

Groundcovers

95	Juncus effuses	Common / Soft Rush
110	Scripus Microcarpus	Small Flowering Bulrush

Shrubs

20	Symphorica Albus	Snowberry
28	Vaccinim Ovatum	Evergreen Huckleberry
12	Mahonia Aquafolium	Oregon Grape
12	Cornus Sericea Isantii	Red Twig Isantii Dogwood
8	Rosa Nutkana	Nootka Rose

Trees

1	Cericidiohyllum Japonicum	Katsura Tree
10	Acer Cirinatum	Vine Maple

No irrigation system was provided for these plantings, and hose irrigation will be used during the establishment period.

Budget

The David Douglas Administration Parking Lot project cost $9,960 with $7,050 billed out for student installation labor and materials and $2,000 for in kind work by David Douglas staff. Overall design was completed by Environmental Services staff and David Douglas School District teachers and students. Design was not included in these costs.

Item		Item Cost	DDS Staff INKS	Total Cost
Construction				**$6,142**
Excavation and backfilling of stormwater facility:	Rentals	$930	$1500	
	Student Labor	$1,372		
	New Extruded Curbing	$840		
	Drain Rock / Backfill	$1,500		
	Subtotal	***$4,642***		
Landscaping				**$2,907**
	Plant Material (trees, grasses)	$1,947		
	Mulch	$185		
	Vegetation installation	$275	$500	
	Subtotal	***$2,407***		
Permitting				**$911**
	Site Development + Commercial Building Permit	$911		
	Subtotal	***$911***		
	TOTAL	**$7,960**	**$2,000**	**$9,960**

Budget Elements

Non-construction activities

The cost of design was not included in the budget and was a joint effort of the school district and BES staff. Overall project management was estimated as in kind services.

Construction Activities

The David Douglas School District Construction Technology CAM instructor, Bill Ekroth, managed the construction of this site. Construction Technology CAM students participated in project installation, except landscape installation, which was completed by district horticultural staff.

Cost Components

Construction

Construction cost $6,142 (including David Douglas School District in kind services), or 62% of the overall project cost. The majority of the work was completed by one excavation contractor and proceeded with few issues.

Landscaping

Landscaping cost $ 2,907 (including school district in kind services), or 29% of the overall project cost. These costs were entirely for plant purchase from a native plant nursery.

Permitting

The permits for this project cost $911, or 9% of the overall project cost (excluding volunteer labor).

Cost Comparisons

This project had a relatively simple design: minimal grading of two 6-foot by 96-foot swales (with an additional 8x10 foot section removed in the southern swale) in the paved parking area south of the District Administration offices. Because of student resources and in-kind staff support from the David Douglas School District, this project cost well below the low cost range of swale construction:

$ 0.16 per square foot of impervious area treated
$ 0.12 per square foot of basin constructed

This project is likely a non-replicable example of volunteer and student installed retrofits for existing development.

Maintenance and Monitoring

David Douglas Schools is responsible for the facility and its maintenance. No monitoring will be performed at this site, but BES staff will make regular visits to photograph the site and ensure overall performance.

Public Involvement

David Douglas Administrative parking lot was a very cost effective retrofit site. There was good involvement of students and district staff, but interest waned over the long implementation period. Limited outreach to other school classes and parents has been made.

Successes and Lessons Learned

This project pilot tested a variety of implementation elements including:

- ***Student / teacher led design***. BES and DDS teaching staff met several times onsite to discuss design concepts. DDS teaching staff then finished design and submitted permits. It was good to have such ownership in the project, but it did result in a design that was only partially viable on the southern swale. The swale was initially located at a high point of the parking lot. BES helped modify the design to take out a parking space (approximately 8'x 10') toward the lower west end to provide a bay for flows to back up into the swale, which provided sufficient capacity for the drainage area. A permit modification was made to alter the submitted site plan with the Portland Bureau of Development Services. With some additional fill removal in the center of the swale, the facility seems to be working properly.
- ***Use of extruded curb for parking tire stops***. DDS staff is experimenting with extruded curb sections as tire stops. After almost six months of use, they appear to be working well. At about $40 for each stop, this was less costly than spending between $45 and $80 for rubber or concrete curbing.

Friends of Trees

Innovative Wet Weather Planting Projects

(various locations)

PROJECT SUMMARY	
Project Type:	Revegetation projects of school and church campuses
Technologies:	Pavement removal and tree planting
Major Benefits:	• Stormwater is captured and evaporated by tree leaves and trunks, rather than entering the piped sewer system • The project removed asphalt in some locations, providing pervious infiltration areas • The project enhances neighborhood churches and schools, providing a unique educational and public involvement opportunity for local groups
Cost:	$40,000 paid by EPA grant funds
Constructed:	March 2005 to November 2005

Overview of the Project and Drainage Systems

- Overall, the project was split into two parts – specific revegetation support for the school projects ($12,500), and outreach and support for tree installation in priority combined sewer overflow (CSO) watersheds ($27,500 - see attached initial area map).

- Most of tree planting locations were either areas were paved surfaces had been removed, or existing low grade, usually grassed, vegetation areas on church and school campuses.

- Drainage systems were predominantly combined sewer, although some of the school sites were in storm sewer and groundwater sump system areas.

Revegetation Sites

Site	Location	Percentage of Trees or Pavement Removed
Schools		
Astor Elementary	5601 N Yale St	Pavement removal only
Atkinson Elementary	5800 SE Division	8
Cleveland High School	3400 SE 26th	6
Duniway Elementary	7700 SE Reed College Dr	4
Jackson Middle School	10625 SW 35th	13
Kelly Elementary	9030 SE Cooper	18
Llewellyn Elementary	6301 SE 14th	5
Madeline	3240 NE 23rd Ave	4
Phillip Foster	5205 SE 86th Ave	5
Reed College	3203 SE Woodstock Blvd	4
Richmond Elementary	2276 SE 41st Ave	5
Rose City Park Elementary	2334 NE 57th	1
Sabin Elementary	4013 NE 18th	5

St Agatha Elementary	1516 SE Miller St	1
Vestal Elementary	161 NE 82nd Ave	7
Wilcox	833 NE 74th	1
Churches		
Bethel Lutheran	5658 N Denver Ave	3
Bodhi Tree Education Center	5403 SE Center Street	3
Cathedral of Praise	1821 SE 39th	5
First Free Methodist	5000 SE Lincoln	8
Holy Trinity Lutheran Church	7220 SE 39th	3
Lincoln Street Baptist Church	3240 SE Lincoln St	4
Mallory Baptist Church	3535 NE Mallory Ave	4
Metonia Peace Community Church	2116 NE 18th	3
Moreland Church Of The Nazarene	7805 SE 17th	Pavement only
Our Lady of Sorrows Church	5221 SE Knight	2
Portland Temple Wings Of Healing	2030 SE Hawthorne Blvd	5
Richmond Community Church	3941 SE Division SE 40th	10
St Andrews	4919 NE 9th	15 + 13 shrubs
St. John's Ukrainian Baptist	8014 SE 16th	5
Trinity United Methodist Church	3915 SE Steele	13
University Park Baptist Church	4340 N Lombard	3
Waverly Heights Church	3300 SE Woodward St	3

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal
To provide enhanced rainfall containment and reduce flows to the city combined sewer system

Project Components
Trees / Pervious Landscaped Areas
Trees and landscaped areas provide a variety of stormwater management functions, including capturing precipitation, evapotranspiration, infiltration and soil holding. Trees also cool buildings and paved surfaces. Landscaping beautifies communities and creates habitat.

BUDGET
$12,500 of the project budget supported the vegetation installation of the 6 IWWP school projects (under separate covers). The remaining $27,500 was used for community outreach and tree planting on school and church campuses.

Cost Comparisons
This project installed 43 trees on Portland Public School campuses and 101 trees on church campuses.

Tree purchase, pavement removal, installation, and maintenance cost approximately $189 per tree.

MAINTENANCE AND MONITORING

There has been some die off of the trees planted. On the six IWWP project sites, the Atkinson trees were vandalized and replaced in the fall 2006. Ten of the Jackson School and Kelly school trees have died and will be replaced.

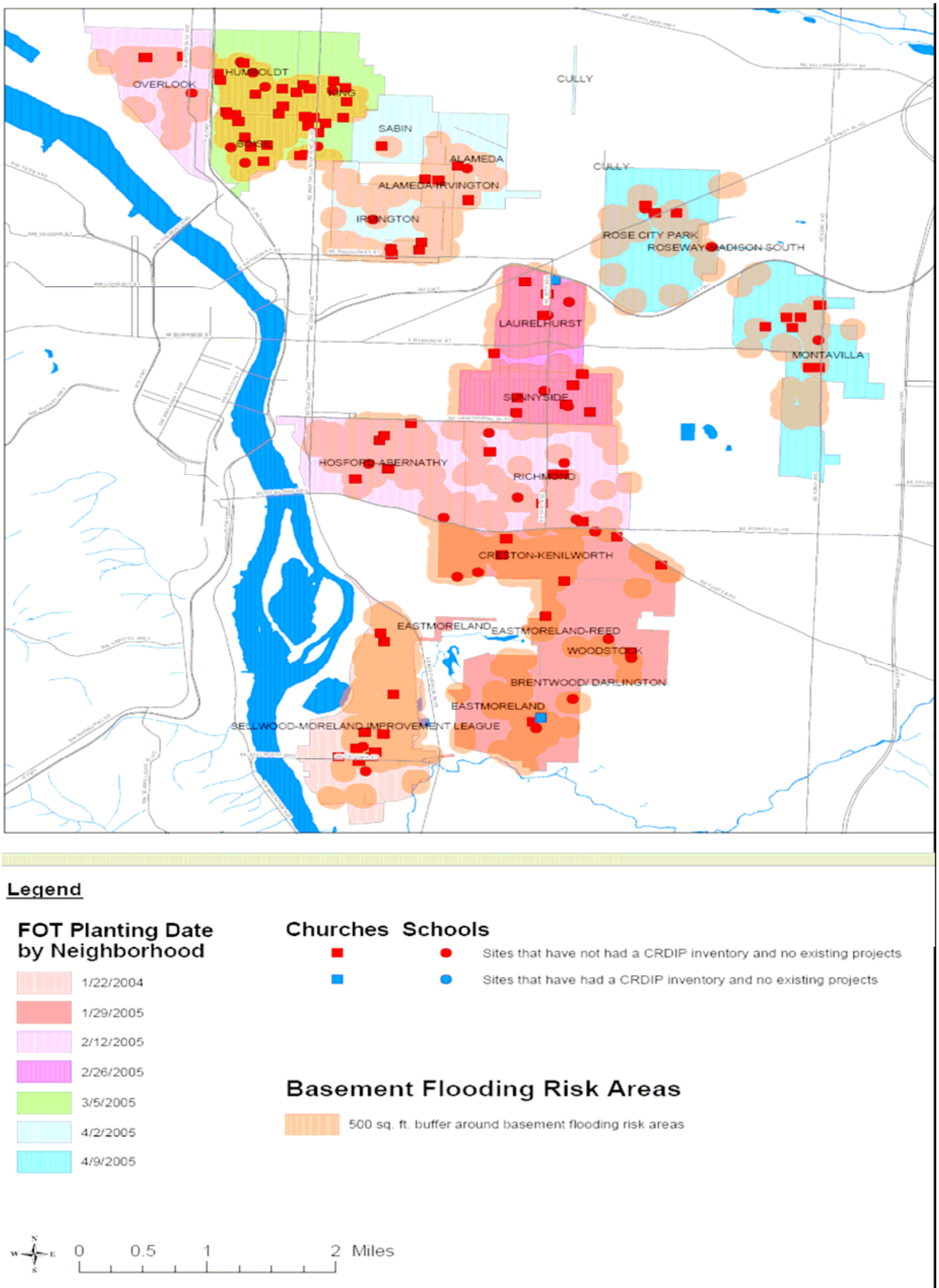
PUBLIC INVOLVEMENT

Friends of Trees outreach efforts included direct mail flyers, community newspaper and event outreach, and neighborhood association outreach.

SUCCESSES AND LESSONS LEARNED

Because Friends of Trees (FOT) was an already successful community non-profit, city funds leveraged additional benefits from FOT program efforts funded by other staff. FOT staff was also very helpful in oversight of school children that installed plantings at the 6 IWWP project sites. This contract also gave the city some assurance that trees would be maintained and watered during their two-year establishment period.

PRIORITY BASIN OUTREACH MAP



Metro Regional Government Headquarters Ecoroof
600 NE Grand Avenue, Portland, Oregon

PROJECT SUMMARY

Project Type:	Roof replacement with ecoroof—demonstration project
Technologies:	Ecoroof
Major Benefits:	• The ecoroof will prevent more than 25,000 gallons of rainwater annually from discharging to the combined sewer system. • The ecoroof provides additional green space and enhances the outdoor terrace for building occupants. • The ecoroof helps cool the building. • The project demonstrates environmentally beneficial building practices that can improve urban livability. • The ecoroof will reduce peak stormwater runoff by more than 80%.
Cost:	• $105,975 total. The total cost includes monitoring and maintenance for two years. Funding included $40,000 from an EPA Innovative Wet Weather Projects (IWWP) grant and additional matching grants from Metro's Sustainability and Solid Waste programs. Note: planting, soil and irrigation cost $20,000 of the total.
Constructed:	August 2005

View from 6th floor, May 2006

View from 4th floor, May 2006

Overview of the Stormwater System

- Metro is the regional government that provides integrated resource management for the 25 cities and unincorporated areas in the Portland, Oregon, metropolitan area. In May 2003, the Metro Council adopted a resolution to endorse a sustainable business model for internal business operations. In 2005, Metro elected to replace a section of damaged roof on its central office building with an ecoroof. This project not only meets the Council's resolution, but also demonstrates an environmental building design that manages stormwater and helps reduce energy consumption.

- The 2,500-square-foot ecoroof portion accounts for about 6 percent of the building's entire roof area.

- The ecoroof is intended to manage all of the rain that falls on it.

- The design introduces an innovative conveyance system, using drainage channels that convey overflow to the roof drain. The drainage channels are filled with cinder rock. This method saves costs compared with more expensive drainage systems and gives the roof an artistic quality.

- Monitoring equipment was installed to compare stormwater retention from the ecoroof with retention from a similarly sized portion of the roof that remains in conventional rock ballast.

- Based on the success of this project, additional ecoroof could be installed when the remaining 38,000 square feet of the roof needs to be replaced.

Cinder Rock Drainage Channels

Metro Ecoroof Monitoring Equipment at the Roof Drain

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The overall stormwater management goal was to reduce peak runoff and volume that would otherwise contribute to combined sewer overflow (CSO) events in the Willamette River. BES staff estimates that the ecoroof will reduce stormwater runoff by approximately 50 percent, although the ecoroof's performance will vary, depending on a number of factors—e.g., storm size, soil moisture content, and temperature. Although the project did not trigger the requirements of the City's *Stormwater Management Manual*, it meets general standards for ecoroofs.

System Components

Ecoroof Components

- **Structural roof support:** A structural analysis concluded that the existing roof would support a 12-pound-per-square-foot ecoroof.

- **Fiberglass and asphalt layer:** This layer is an integral part of any built-up (or modified bitumen) roofing system. In this instance, it was used as an adhesive for attaching the foam core insulation board to the existing concrete roof.

- **Foam core tapered insulation board**: This layer provides a positive drainage slope of ¼ inch per foot, with a minimum 1-inch thickness at the overflow drain.

- **Protection board:** A ¼-inch protection board was laid on top of the insulation board for increased compressive strength to protect the insulation board.

- **Waterproof membrane:** A single-ply, 60-millimeter EPDM membrane was fully attached to the insulation and up the parapet wall, under the flashing.

- **Root barrier:** The root barrier is an impervious IS 24-millimeter, scrim-reinforced HDPE (high-density polyethylene) membrane coated with LDPE (low-density polyethylene).

- **Filter fabric:** This is a non-woven, geotextile fabric that allows excess runoff to filter through the soil, to the roof drain, without transporting soil sediment.

- **Soil:** Approximately 10 tons of soil was imported and spread over the root barrier to a depth of 3 inches. The soil comprises 10 percent recycled paper fiber waste, 20 percent compost, and 70 percent pumice.

- **Drainage channels:** Red cinder rock drainage channels were placed on top of the root barrier and nestled within the layer of soil and vegetation to the same 3 inch depth as the soil. The artistically arranged drainage channels provide efficient conveyance of rainfall that is not absorbed. The drainage channels also appear to support sedum growth.

- **Vegetation:** See the Landscaping section.

- **Irrigation system:** See the Irrigation section.

- **Gravel ballast:** Rock from the original rock ballast roof was reused and placed around the roof perimeter and drains. It is a typical component for ecoroof systems.

Additional Information

- Walkway pads (30 inches by 30 inches) were placed to protect the membrane in areas designated for foot traffic (e.g., for access to monitoring equipment).

- Perforated metal edging was used at the main roof drain; this element is optional. No edging was used to separate the rock ballast perimeter or the drainage channels from the vegetated roof portion.

- A test of the saturated weight of the soil was required to determine the soil depth at 12 pounds per square foot.

Landscaping

- A mix of various wildflower species was broadcast over the soil in late September 2005 to provide interest and color through the growing season. The mix included *Castilleja exserta*, *Eschscholzia maritima*, *Gaillardia aristata*, *Lupinus nanus*, *Sisyrinchium bellum*, *Linaria reticulata*, *Gilia tricolor,* and *Chrysanthemum multicaule*. A reseeding of another 50% of the original mix was added in April 2006.

- Following the seeding, a slow release fertilizer consisting of nitrogen-phosphorus-potassium (14-14-14) was applied at 9.4 lbs. /1000 square feet and broadcast over the ecoroof section in late 2005. Fertilizer was used only for plant establishment.

- The following sedum sprigs were planted:
  - Blue: *Sedum rupestre erectum*, *S. anacampseros*
  - Green: *S. album balticum*, *S. oreganum*, *S. spurium* 'Dr John Creech'
  - Gold: *S. kamtschaticum variegatum* (small form)
  - Red: *S. spurium* 'Red Carpet', *S. album* 'Hillebrandtii' (broadcast over the top of the soil as the final layer in August 2005)

- In April 2006, a final broadcast planting of sedum consisted of :
  - Blue: *S. anopetalum glauca*, *S. ochroleuceum*, *S. lanceolatum*
  - Gold: *S. acre* ‘Krajinae’. *S. sexangulare*, *S. apoliepon*
  - Red: *S. spurium* ‘Bronze Carpet’. *S. spurium* ‘Elizabeth’. *S. album* ‘Murale’
  -

Flowers: Gilia tricolor
next to perforated metal edging at roof drain

Sedum grows into a carpet

Irrigation

- An overhead spray irrigation system of schedule 40 PVC piping was installed for plant establishment and minimal summer irrigation. The piping system is buried beneath the soil.

- Aluminum sleeves were placed around 6-inch pop-up risers to protect them from ultraviolet light and accidental damage. Drain rock was placed around the base of each riser for added stability.

- The irrigation system is connected to an automated control that is programmed to deliver, on average, no more than 75 gallons of water over the ecoroof area in a 24-hour period. A rain sensor will override the irrigation system if the roof receives rainfall.

BUDGET

The total project cost was $105,975. An EPA Innovative Wet Weather Projects (IWWP) grant to the Bureau of Environmental Services (BES) paid for $40,000 of the total project. Additional matching grants from Metro's Sustainability and Solid Waste programs also funded the project.

As shown in the table below, project expenditures can be broken down as follows:

Cost Summary for Ecoroof Construction			
Item	**Conventional Roof Expenditure [1]**	**Ecoroof Expenditure [2]**	**Total Expenditure**
Design:			
Engineering analysis of roof load		$4,890	$4,890
Scope of work for roof replacement and ecoroof	$6,056	$6,056	$12,112
Construction:			
Mobilization (includes permit)	$4,000		$4,000
Demolition (rock removal)	$6,000		$6,000
New EPDM roof (includes insulation, flashing)	$46,240		$46,240
Eco roof construction and irrigation (materials, labor, 2-year guarantee)		$18,425	$18,425
Miscellaneous		$672	$672
SUB TOTALS	**$62,296**	**$30,043**	**$92,339**
Monitoring: (Ancillary cost to ecoroof project)			
Materials		$5,961	$5,961
Installation		$7,675	$7,675
TOTALS	**$62,296**	**$43,679**	**$105,975**

Budget Elements

Design and Structural Analysis

Non-construction activities cost $17,002, or approximately 16 percent of the total project cost. These activities included an engineering analysis of roof load (attributed to the ecoroof portion only) and EPDM roof membrane replacement and the new ecoroof (split between the conventional roof portion and ecoroof portion). Additional activities include: soil specifications, planting design, irrigation design, construction specifications, and the Operations and Maintenance (O&M) Plan.

Construction of EPDM Roof

Construction of the EPDM roof cost $56,240, or approximately 53 percent of the overall project cost. The core construction activities included removal of the existing rock ballast; demolition of the existing roof; and installation of the insulation, flashing, and waterproof membrane. (All of these activities would be required for a conventional roof and are therefore attributed to the conventional roof portion.)

[1] Conventional Roof Expenditure: The cost incurred to address the damaged roof section without addition of the ecoroof components.
[2] Ecoroof Expenditures: The cost for the ecoroof components.

Note: it was discovered that a collar around a post was not installed correctly and led to a leak; The leak went away upon correction of the collar. Problem.

Construction of Ecoroof

Construction of the ecoroof cost $19,097, or 18 percent of the total project cost. The construction activities included the soil matrix, irrigation system, landscaping (with a 2-year maintenance guarantee), and irrigation system.

Monitoring

The cost of the monitoring system for both the ecoroof section and a similar ballasted roof section (as a control) was $13,636, or 13 percent of the total project cost.

Cost Comparisons and Savings

- The structural analysis concluded that the capacity of the existing roof section could support a 12-pound–per-square-foot ecoroof without additional structural reinforcement. This represented a cost savings compared with similar retrofit projects that may need additional reinforcement.

- Cost savings were achieved by reusing 2 of the 18 cubic yards of existing rock ballast roof to place around the ecoroof perimeter.

- The innovative cinder rock drainage channels were less expensive than a manufactured drainage mat component. The drainage channels also eliminate the possibility of a warm air layer under the soil that can occur with traditional drainage mats and desiccate plant roots.

- The low organic content of the soil matrix (30 percent) reduced cost, weight, and potential pollutants in the excess runoff.

- The sedum cuttings were broadcast over the soil matrix instead of using the more time-consuming and costly method of transplanting containerized plants. In addition, workers spent less time walking on the soil matrix with a broadcasting method, resulting in less soil compaction.

MONITORING AND MAINTENANCE

Monitoring

Metro will monitor the performance of the ecoroof for at least 2 years after the ecoroof is fully established. Metro installed two V-notch weirs and water level instruments at the drain on both the ecoroof section and the rock ballast roof test section. The weir dams the water to create a measurement pool, and the pool raises a float off the ground before the water reaches the bottom of the V-notch. A rain gauge (Unidata, 6506B) was located near the data collection site on the conventional roof, and a flow transducer was installed to measure the irrigation used on the ecoroof during the dry months while the plants are being established. A data logger gathers the information and downloads it. The entire monitoring system is powered by a solar photovoltaic cell.

The following information was collected from the first phase of the ecoroof monitoring project. Once the plants are more established and more data are available, these initial results will be reviewed and augmented.

- The ecoroof retains an average of approximately 55 percent of the rainfall that falls on it, compared with from 16 to 25 percent retention on the conventional rock ballast roof.

- The ecoroof attenuates approximately 25 percent more of the peak flows than the rock ballast roof section.

- The estimated runoff volume from the conventional roof is less than expected, possibly as a result of some retention in the surface fines and surface evaporation.

The monitoring data will help Metro design an effective ecoroof for the building's remaining roof section that will need replacing (approximately 6 to 8 years from the time of this ecoroof project).

Metro used the HELP model, a hydrologic model developed by EPA for landfills, to estimate the performance of an ecoroof with a thin soil layer. The purpose was solely for planning purposes to better estimate expected flows of stormwater. Metro did not calibrate the model; however, the modeling results will be compared with the observed data to determine if the predictions of stormwater diversion were accurate in comparing the ecoroof to the rock ballast roof.

Maintenance

Metro is responsible for all maintenance activities, including weeding, watering, and replanting as needed to maintain the full performance of the ecoroof.

SUCCESSES AND LESSONS LEARNED

- **Improve local reuse and recycling opportunities for roofing materials:** A lack of options for recycling or reusing the replaced EPDM roofing material and polystyrene insulation captured the attention of Metro. Although there continues to be a need for such a service, the industry is continuing to research opportunities and methods to arrive at a solution. Insulation installed within the building, as opposed to installing it on the rooftop, can increase longevity of the insulation and reduce the need for discarding the material when replacing a roof.

- **Determine the building's hydraulic pressure when designing the irrigation system:** The irrigation system was initially designed to operate with static pressure of about 30 pounds per square inch. The contractors discovered, however, that the pressure on the building's fourth floor was insufficient, so a second control valve and irrigation line was added for a cost of $700.

- **Verify all roof dimensions**: Metro discovered that the drain was incorrectly located on the original contract drawings. This resulted in a slight project delay because the installation plan for the tapered insulation had to be redrawn.

Westmoreland Pervious Pavers
Portland, Oregon

PROJECT SUMMARY

Project Type:	Street reconstruction with pervious pavement—demonstration project
Technologies:	Pervious pavement blocks
Major Benefits:	• Pervious pavement provides more natural stormwater management than a piped system, allowing stormwater to be absorbed, filtered, and cleaned before recharging groundwater. • Stormwater infiltration into the ground reduces combined sewer overflows to the Willamette River and reduces basement flooding caused by rain storms that overload sewers. • The project will provide information about how well different pavement materials, with different section geometries, manage stormwater and hold up as a street surface.
Cost:	$412,000, with $80,000 paid by EPA grant funds
Constructed:	2004

Overview of the Stormwater System

- Deep sewer construction in deteriorated streets in the Westmoreland neighborhood made it necessary to reconstruct four blocks of street surface. Rather than repaving all four blocks with traditional materials, this presented a unique opportunity to use an alternative, pervious material for demonstration and testing purposes.

- The four blocks were repaved as follows:
  - One block (SE Knapp Street from 21st to 22nd avenues) was paved curb to curb with interlocking pervious concrete paving blocks. This block is crowned.
  - Two blocks (SE 21st from Knapp to Rex and SE Rex from 20th to 21st) were paved with pervious concrete paving blocks in the parking strips along each curb and with standard asphalt in the center strip. One block is crowned, and one is flat.
  - One block (SE 20th from Lambert to Rex) was paved curb to curb with standard asphalt.

- Stormwater from the contributing catchment area falls directly on the pavers or travels to the pavers as sheet flow or very shallow concentrated flow. Runoff infiltrates through the paver core holes and interstitial spaces, collects in the base rock beneath the pavers, and infiltrates into the soil subgrade. If runoff from large storms (greater than a 25-year event) exceeds the capacity of the paver system, it collects and flows against the street curb to the existing combined sewer inlet.

- Street trees were planted to mitigate all surface area not managed by the pervious pavers.

Figure 1: Project during construction

Figure 2: Pavers along parking strips only

Figure 3: Pavers along the full length of the street

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The goal was to learn how well pervious paving blocks manage stormwater and perform as a street surface and how cost effective they are. The project was designed in accordance with the City of Portland's 2002 *Stormwater Management Manual.*

System Components

Facility footprint: 28,000 square feet. (Three pervious streets: 28 feet wide by 600 feet, 200 feet, and 200 feet, respectively = 28,000 square feet.) Assumes "facility" is the entire street width curb to curb, even though two blocks use pavers only in the only parking lanes (6 to 10 feet wide per side).

Catchment area: 60,984 square feet (roofs, driveways, lawns, sidewalks, and streets). The catchment area contributing runoff to the pervious streets is assumed to extend 30 feet from each curb into the residential lots fronting the project. It includes approximately half of the impervious roof area of each home, impervious driveway and sidewalk area, and some pervious lawn and landscaped area. The contributing catchment area also includes the impervious center-strip asphalt on two of the pervious pavers blocks, which will direct flow to either or both of the paver lanes, depending on the street section.

Pervious Pavement Blocks: The pavers are 3⅛-inch-thick (8 cm) concrete interlocking blocks placed over a 3-inch-thick leveling course of fine rock (⅜-inch minus #10 crushed rock). The fine rock is also packed in between the blocks and in the drainage cores. A geotextile fabric is under the fine rock. Under the fabric is a 6-inch to 15-inch-thick course of base rock (2-inch minus #10 crushed rock) for both structure and stormwater runoff storage. A second layer of geotextile fabric lies between the subgrade and the base rock. The geotextile fabric layers reduce pollutants carried into the soil as the water infiltrates. They also prevent fine soil particles from migrating into the void space within the base rock.

The pavers in the parking lanes were installed in fields approximately 6 feet 10 inches wide on each side of the street. New asphalt was laid in the center. A 12-inch-wide concrete divider strip was placed between the pavers and the asphalt center as both a structural member and an architectural detail. It separates the two flexible surfaces, which deflect differently under loads, and provided a rigid edge to lay pavers and compact against.

Intersections were reconstructed in standard asphalt to ensure compliance with Americans with Disabilities Act (ADA) requirements. ADA specialists in the Portland Office of Transportation advised that while the paver surface is arguably compliant with ADA rules, pavers should not be placed in crosswalks. At issue are the core holes and channelized surfaces that prevent smooth rolling of small-diameter wheels. The paver runs are designed to stop short of the crosswalks.

The existing water main and water services had to be replaced because the existing main was too old to bear up to construction loads once the street section was excavated. Also, existing services were above the proposed subgrade elevation.

The paver interception system is approximately 80 percent efficient, per industry design guides. This means that rainfall events within the design capacity of the infiltration system will result in some curb flow.

Street Trees: Street trees were planted to mitigate stormwater impacts from the impervious areas of the reconstructed streets that do not drain to pervious pavement surfaces, as required by the *Stormwater Management Manual.*

BUDGET

The construction cost was $412,000 for all four reconstructed blocks (including the block with standard asphalt, which cost about $45,000). This included $74,000 for water line replacement. An EPA Innovative Wet Weather Projects grant to the Bureau of Environmental Services (BES) paid for $80,000 of the project cost.

The costs for project management, contract management, design, and inspection are not included in the construction budget. These elements were tracked separately and funded by BES's Capital Improvement Program budget. They amounted to an additional $115,600, or 28 percent of the construction contract.

Cost Comparisons

The cost of the street reconstruction using pervious pavers was approximately 1.8 times the cost of standard construction. This does not include the costs of water line replacement.

Data gathered from the project indicate an estimated cost of $10.50 per square foot installed, including base rock, for the three blocks using pervious pavers. This includes the entire streets, curb to curb, including the asphalt center strips in two of the blocks.

MAINTENANCE AND MONITORING

Maintenance

The Bureau of Maintenance will vacuum sweep the pavers four to six times per year to prevent a build-up of soil and to dislodge grass and weeds that manage to germinate in the core fill material. Some initial problems occurred with maintenance, as described under "Successes and Lessons Learned," below.

Monitoring

The Bureau of Maintenance will periodically inspect the paver system and record its performance as a street surface (e.g., the occurrence of cracking or rutting), as well as the costs and challenges of maintaining the surface.

Two types of monitoring devices were installed with the paver system to collect water samples and monitor how well the pavement infiltrates water and helps improve water quality. One is a 3-inch-diameter PVC pipe subdrain that collects infiltrate and conveys it to a manhole; the sampling pipe protrudes inside the manhole within reach from the surface. The other is a 6-inch-diameter PVC standpipe that can be used for observation/measurement of the groundwater elevation and for sampling. These monitoring devices have not been successful, as discussed under "Successes and Lessons Learned," below.

PUBLIC INVOLVEMENT

Public involvement included informing and engaging residents with the project through mailings, door-to-door calls, public meetings, and local press coverage. Two open houses were conducted while construction was underway: one for the public, and one as an industry demonstration.

None of the residents fronting the pervious street projects was identified as unwilling or reluctant to have the project implemented. Some concerns were raised over issues related to the project—primarily basement flooding and weed control.

A permanent interpretive sign is planned at the project site to provide information about the sustainable stormwater management techniques used.

SUCCESSES AND LESSONS LEARNED

Pervious Pavement Performance: This is Portland's first application of pervious paving blocks on a public residential street. In 2005, the city installed pervious asphalt and pervious concrete pavement on four blocks of North Gay Avenue. The Westmoreland and North Gay projects will test how these three pervious paving materials perform on residential public streets.

Information Sources: The Portland Office of Transportation retained an interlocking paver specialist to assist with quality assurance/quality control for this project. The specialist reviewed the plans and specifications at two points in the design process and provided comments. His insight on products and installation methods added value to the project and served to confirm that more speculative aspects of the design were indeed correct.

Maintenance: Street sweeping occurred only three times during the first year. Weeds grew in the pavers, particularly in large zones in front of some driveways. This could partly be a result of residents' practices—e.g., washing cars in driveways or blowing mown grass into the street. Once weeds took hold in these areas, sweeping could no longer remove them. The Bureau of

Maintenance has now purchased a more powerful vacuum sweeper, and it is anticipated that more frequent use of this sweeper will eliminate the weed problem.

Settlement: Some localized settlement is visible in the parking lanes and is being monitored. It is probably caused by heavy loads from garbage trucks over areas that received insufficient compaction during construction. Corrective measures will involve picking up the pavers and much of the base rock, compacting the subgrade with a small plate compactor, and re-laying (and recompacting) the street materials.

Monitoring: The two monitoring devices are not working because water infiltrates into the ground so quickly that it does not appear in the stand pipes. The water drains past the perforated collection system in the subgrade that was intended to deliver a monitoring sample to the manholes. BES has not corrected these devices at this time. To do so would involve picking up the pavers, removing the rock, and laying a broad sheet of stainless steel or other inert material under the perforated pipe to trap and channel more infiltrate. The stand pipes would have to be removed and reconstructed at a deeper level.

Alice Ott Middle School
12500 SE Ramona Street, Portland, Oregon

PROJECT SUMMARY

Project Type:	Public school stormwater retrofit—demonstration project
Technologies:	Downspout disconnection to vegetated infiltration basins
Major Benefits:	• Roof runoff is filtered and treated by vegetation before it infiltrates into the ground, improving groundwater quality. • The project provides a unique educational opportunity for school students.
Cost:	$5,000 EPA grant funds. The school district also provided in-kind services.
Constructed:	Spring 2006

Overview of the Stormwater System

- Four downspouts were disconnected from the school's roof to discharge into four newly created vegetated infiltration basins (one downspout per basin). (See Figures 1 and 2.) The downspouts were previously connected to onsite sumps.

- During heavy rains, overflow from the basins flows over existing landscaping to the street for discharge to public sumps.

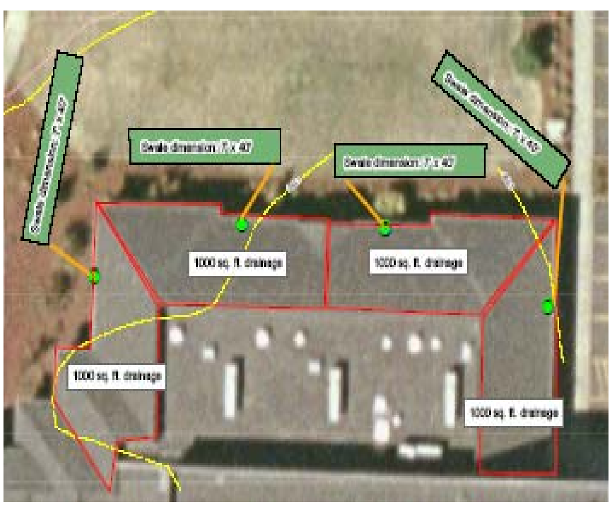


Figure 1: Site Map

Figure 2: Before Retrofit

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater management goal was to provide onsite treatment and infiltration of roof runoff. The project was designed in accordance with the City of Portland's 2004 *Stormwater Management Manual*.

System Components

Facility footprint: 1,120 square feet total. Each vegetated basin is about 280 square feet (7 feet by 40 feet) and 8 to 12 inches deep.

Catchment area: 4,000 square feet total. The roof area draining to each downspout is 1,000 square feet.

Landscaping: For each basin, 3 trees, 12 large shrubs/small trees, 17 shrubs/large grass-like plants, and 150 groundcover plants were installed. School students selected the vegetation from *Stormwater Management Manual* lists of native plants.

Figure 3: Infiltration Basin

Figure 4: Disconnected downspout

Figure 5 : Infiltration Basin

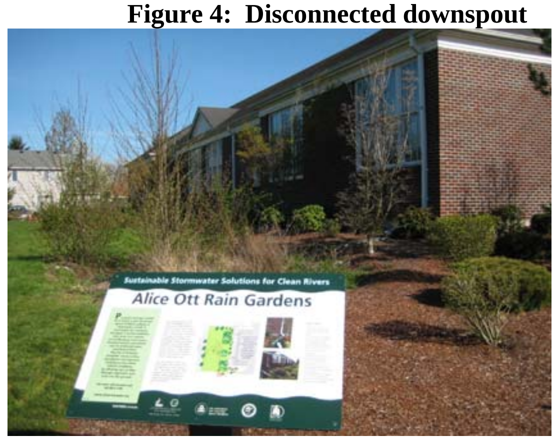


Figure 6: Official sign

BUDGET

An EPA Innovative Wet Weather Projects grant to the Bureau of Environmental Services (BES) paid for $5,000 of the project cost. The David Douglas School District contributed in-kind services, including design, excavation, project management, downspout disconnection, plants, budget management, and accounting.

Cost Comparisons

Because volunteers contributed to the design and planting, project costs were probably lower than they would be for similar private-sector projects.

MAINTENANCE AND MONITORING

Maintenance for this project will be incorporated into the school janitor's regular maintenance duties.

BES staff will periodically conduct a visual assessment of project performance.

PUBLIC INVOLVEMENT

BES partnered with the David Douglas School District and parents on the project. The school district provided many in-kind services.

Alice Ott students designed the infiltration basins as part of their math and science curriculum. Students also provided volunteer labor for planting the infiltration basins with native vegetation.

A permanent interpretive sign was installed at the project site to provide information about the sustainable stormwater management techniques used.

SUCCESSES AND LESSONS LEARNED

Public visibility: This project is highly visible in the front of the school, providing a constant reminder of sustainable stormwater management.

Partnerships: The contributions of the school district and students helped lower project costs. This kind of interest and support from school staff, students, and parents is very beneficial in initiating and completing a project and ensuring its long-term success.

George Middle School
10000 N Burr, Portland, Oregon

PROJECT SUMMARY

Project Type:	Public school planter box stormwater retrofit – demonstration project
Technologies:	Flow-through and infiltration stormwater planter cells
Major Benefits:	• Runoff from 1,260 square feet of rooftop was rerouted from the combined sewer system to an onsite stormwater planter. • Monitoring equipment was installed to assess how effectively the flow-through planter cell reduces stormwater flow and removes pollutants.
Cost:	$26,426 total, with $25,226 paid by EPA funds
Constructed:	August 2004 through February 2006

Overview of the Stormwater System

- An existing brick landscape planter was excavated to a depth of 44 inches. New concrete walls were added to divide the planter into three cells: an infiltration cell, a flow-through cell, and a monitoring cell (Figures 3 and 4).
- A waterproof liner was installed against the building foundation in the infiltration cell. The infiltration cell was backfilled with topsoil and planted with native vegetation. An existing downspout that drains approximately 1,260 square feet of rooftop was rehung and disconnected into the infiltration cell.
- The flow-through cell was completely lined with a waterproof liner. A perforated pipe was installed from the bottom of the flow-through cell through the wall of the monitoring cell to the monitoring equipment. The flow-through cell was filled with topsoil and planted with native vegetation.
- Water quality and quantity monitoring equipment was securely installed in the monitoring cell.

Figure 1: Site Plan

Figure 2: Original Landscape Planter

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater facilities were designed in accordance with the City of Portland's 2002 *Stormwater Management Manual*.

System Components

Flow-through Cell
Facility footprint: Approximately 36 square feet
Overflow: Infiltrates to a perforated pipe to an existing standpipe (connected to the combined sewer system)

Infiltration Cell
Facility footprint: Approximately 465 square feet total.
Overflow: None

Figure 3: Monitoring, flow-through, and infiltration cells of stormwater planter retrofit (from back to front of photo)

Figure 4: Installed monitoring eqiuipment

Landscaping

- Once the planter was excavated and backfilled with topsoil, it was planted with native vegetation. George Middle School students designed the overall planting plan and installed the vegetation. No irrigation was installed for the vegetation.
- The vegetation for the infiltration cell includes 2 vine maples, 2 western serviceberry, 2 mock-orange, 10 salal, 4 tall Oregon grape, 3 red flowering currant, 3 common snowberry, 10 brome grass, 10 western red fescue, 5 tufted hair grass, and 15 Oregon iris.
- The vegetation for the flow-through cell includes 1 Sitka willow, 1 Douglas spirea, 2 Pacific ninebark, 2 lady fern, 2 slough sedge, 2 slender rush, 2 spreading rush, and 2 western sword fern.

Figure 4: Stormwater planter with native plants in bloom

Figure 5: Disconnected downspouts in stormwater planter

BUDGET

The George Middle School project cost a total of $ 26,426 for construction, landscaping (including volunteer labor), and permits. The budget includes costs for needed repair work performed by the City's Revegetation Program and Bureau of Maintenance.

Item	Item Cost	Volunteer Effort	Total Cost
Construction			**$22,606**
Excavation and backfilling of stormwater facility BES contract oversight	$10,193 $3,551		
Bureau of Maintenance & Revegetation Program repair work	$3,669		
Monitoring vault construction and plumbing	$5,193		
Subtotal	***$22,606***		
Landscaping			**$2,612**
Plant material (trees, shrubs, grasses)	$795		
Vegetation installation – volunteers (60 student for 2 hours at $10/hour)		$1,200	
Topsoil and gravel	$617		
Subtotal	***$1,412***		
Permitting			**$1,208**
Commercial permit	$564		
Plumbing permits	$644		
Subtotal	***$1,208***		
TOTAL	**$25,226**	**$1,200**	**$26,426**

Budget Elements

Non-Construction activities

The cost for design and overall project management was not included in the budget because these elements were considered a part of existing staff responsibilities and were not tracked separately for this project.

Construction Activities

A contractor with an existing on-call services contract completed construction of multiple school site projects. The contractor billed the work for each school site by general activity (labor, machinery used) and did not break down costs by project activity (excavation, backfilling, grading, landscaping). The City's Revegetation Program and Bureau of Maintenance performed needed repair work. .

Cost Components

Construction

Construction elements cost a total of $22,606 or 90 percent of the overall project cost (excluding volunteer labor). The contractor did not have a great deal of experience in stormwater retrofit projects, resulting in final costs higher than the original bid.

The City's Revegetation Program had to replace the original topsoil used by the contractor, and the Bureau of Maintenance had to attach the waterproof lining to the planter wall. The cost to fix these problems was $3,669, or 15 percent of the overall project cost (excluding volunteer labor).

Landscaping

Landscaping elements (contractor materials and a direct buy at a local nursery) cost $1,412, or 6 percent of the overall project cost (excluding volunteer labor).

Permitting

The permits for this project cost $1,208, or 5 percent of the overall project cost (excluding volunteer labor). These costs were higher than expected because of the multiple plumbing permits needed for various project phases.

Cost Comparisons

This project had a relatively simple design. The landscape planter already existed, and only minor plumbing modifications were needed to fulfill *Stormwater Management Manual* requirements for safe disposal and overflow. The project is a good example of potential retrofits for existing development. Similar private-sector projects with more experienced contractors might cost less and take less time.

MAINTENANCE AND MONITORING

Portland Public Schools is responsible for the facility and its maintenance. Water quality monitoring will be performed at the site by BES. Effluent water quality samples will be collected to assess pollutant removal effectiveness. Flow samples will be collected to assess flow reduction effectiveness. Only the flow-through section will be monitored. The replacement soil type (potting soil) does not meet *Stormwater Management Manual* standards and has settled to less than the required soil depth for stormwater planters, so the monitoring results will not fully correspond to results for facilities that meet manual requirements.

PUBLIC INVOLVEMENT

A one-page handout (Attachment 1) was developed to educate the local community about the benefits of the project. Copies were provided for each student at George Middle School to take home, and extra copies were provided to school office staff to give to people who had questions (approximately 800 copies total). A BES environmental educator provided watershed health and stormwater programs to two classes at George Middle School; these classes were later involved in installing vegetation in the planter.

SUCCESSES AND LESSONS LEARNED

Construction Problems: The contractor used topsoil with high clay content, and heavy rains occurred shortly after construction was completed in fall 2004. The soil did not allow infiltration, causing standing water in the flow-through cell. The Revegetation Program was contracted to replace the topsoil with potting soil, which had a very high infiltration rate. Soil types should be carefully checked prior to initial installation. New soil specifications that will be included in the 2007 *Stormwater Management Manual* should help address this issue.
The original mastic used to attach the waterproof liner did not work well, and the original contractor cut the liner too short to allow for a 6-inch air gap above the soil layer, as required by the *Stormwater Management Manual*. The Bureau of Maintenance was contracted to attach the liner to the planter wall to protect the school building foundation.

Construction Budget: The contractor billed multiple school site projects by general activity, rather than by project phase, making it difficult to make detailed cost comparisons.

Plumbing: Following construction of the stormwater facility, it was very difficult to find a plumbing contractor to disconnect the final downspout to the infiltration cell. The scope of work was too small and did not attract a bidder through the informal bidding process. The project manager contacted unions and MWESB (minorities, women and emerging small businesses) firms and publicly advertised the project, but was unable to find a contractor. Eventually a plumber was hired through an existing contract with Portland Public Schools. It would be more effective to bid the entire project to a prime contractor and let that contractor be responsible for finding a plumbing subcontractor.

George Middle School

Innovative Wet Weather Project

September 2004

working for clean rivers, healthy watersheds, and a livable, sustainable community

You've probably noticed construction in the planter box in front of the school gym building and entrance to the front office. Portland's Environmental Services is working with Portland Public Schools on a project to reduce stormwater runoff from the school. The existing planter will be converted to a stormwater planter box, which will collect and filter stormwater from the gym roof.

This is a companion project of the two bioswales built on the west side of the school campus.. The swales have been treating water from the school rooftop for over a year.

Environmental Benefits

The vegetation in the converted stormwater planter box will filter stormwater from the gym roof and allow it to soak into the ground. This helps refresh natural groundwater systems and keeps stormwater from flowing into sewer pipes where it could contribute to basement flooding and combined sewer overflows (CSOs). In addition, the new plantings will help cool the building and will provide new wildlife habitat. The planter will be divided into two sections; one to filter roof runoff and one that allows the water to soak into the ground.

A New Look

The structure of the planter box won't change much but it will have new native plants that are good for filtering stormwater runoff. Students will plant native vegetation in the planter box this fall.

Environmental Education

Environmental Services has worked with Portland Public Schools to make the swales and the planter box safe and attractive, as well as an educational resource. This fall, an Environmental Services educator will teach George Middle School students about water quality and stormwater management. The activities will show students how be stewards of the new stormwater management areas on their own school campus.

For More Information

If you have questions or concerns about site activities please contact:

Dawn Hottenroth, City of Portland
Bureau of Environmental Services
503-823-7767
dawnh@bes.ci.portland.or.us

Environmental Services
City of Portland
working for clean rivers

Dan Saltzman, Commissioner Dean Marriott, Director Printed on recycled paper. PL 0471

North Gay Avenue
Portland, Oregon

PROJECT SUMMARY

Project Type:	Street reconstruction with pervious pavement—demonstration project
Technologies:	Pervious concrete; pervious asphalt
Major Benefits:	• Pervious pavement provides more natural stormwater management than a piped system, allowing stormwater to be absorbed, filtered, and cleaned before recharging groundwater. • Stormwater infiltration into the ground reduces combined sewer overflows to the Willamette River and reduces basement flooding caused by rain storms that overload sewers. • The project will provide information about how well different pavement materials manage stormwater and hold up as a street surface.
Cost:	$400,000 total, with $212,500 paid by EPA grant funds
Constructed:	Completed summer 2005

Overview of the Stormwater System

- This project was initiated by the construction of a 54-inch combined sewer pipe in North Gay Avenue. Rather than repaving the entire street with traditional concrete, this presented a unique opportunity to use alternative, pervious materials for demonstration and testing purposes.

- Each of the four blocks of North Gay in the project area was paved with different materials:

  - One block (between Wygant and Humboldt) was paved curb-to-curb with pervious concrete.
  - One block (between Alberta and Webster) was paved curb-to-curb with pervious asphalt.
  - One block (between Humboldt and Alberta) was paved with pervious concrete in the 8-foot-wide parking strips along each curb and with standard concrete in the middle travel lanes of the street.
  - One block (between Webster and Sumner) was paved with pervious asphalt in the 8-foot-wide parking strips along each curb and with standard asphalt in the middle travel lanes of the street.

- The pervious pavement allows most or all of the stormwater from four blocks of public right-of-way to filter through the street surface into layers of rock below the street and then into the ground. This runoff would otherwise drain into Portland's combined sewer system. Existing storm inlets remain to take any excess runoff; with the porosity of the pervious materials, however, runoff is not expected to reach the inlets.

Figure 1: Pervious Concrete

Figure 2: Pervious Asphalt

Figure 3: 8 foot wide pervious concrete parking strips with standard concrete in traffic lanes

Figure 4: 8 foot wide pervious asphalt parking strips with standard asphalt in traffic lanes

STORMWATER CAPACITY AND SYSTEM COMPONENTS

Stormwater Management Goal

The stormwater management goal was to learn how well pervious concrete and asphalt manage stormwater and perform as a street surface and how cost effective they are. The project was designed in accordance with the City of Portland's 2002 *Stormwater Management Manual.*

System Components

Facility footprint: 32,000 square feet
Catchment area: 50,000 square feet

Pervious Concrete

The pervious concrete section consists of 10 inches of pervious concrete mix on top of 6 inches of clean crushed aggregate. The base material is hydraulically connected to the roughly 20-foot by 20-foot granular sewer trench below. This provides excellent drainage through the pavement section and into the surrounding soils. The depth of the base rock was designed to contain a 25-year storm without backup into the pavement section.

The typical installation procedure for pervious concrete is:

1) Excavate to bottom of base coarse layer. Place filter fabric.
2) Place base rock and compact to desired percentage rate. Note that the base layer typically does not contain fines and therefore retains a high percentage of voids with compaction. Wet the base rock.
3) Pour the concrete in 8-foot to 10-foot-wide strips. As the concrete is poured, rake it to ½ inch above the finish elevation, cover in plastic, and compact (usually with a drum roller) to the final grade. Leave the plastic layer on the finished concrete for a number of days to allow for proper curing. Cure time is approximately 7 days.

Figure 5: Laying the concrete

Figure 6: Pervious concrete next to regular concrete

Pervious Asphalt
Pervious asphalt is installed in the same manner as traditional asphalt.

Figure 7: Pervious Asphalt

Figure 8: Pervious asphalt next to regular asphalt

BUDGET

The North Gay Avenue project cost a total of $400,000, broken down as follows:

- Design: $97,000 (24 percent of the overall project cost)

- Construction: $303,000 (76 percent of the overall project cost). This included:
  - $256,000 for porous pavement
  - $47,000 for water main replacement in North Gay Avenue at Alberta and Humboldt Streets

An EPA Innovative Wet Weather Projects grant to the Bureau of Environmental Services (BES) paid for $212,500 of the project cost.

MAINTENANCE AND MONITORING

It is important to control site erosion and sedimentation of pervious pavement surfaces to prevent clogging and maintain permeability. Cleaning or vacuuming the surface once or twice a year maintains porosity. Properly installed pervious paving systems last more than 20 years.

The City will evaluate the street surface for durability, maintainability, and public acceptance.

PUBLIC INVOLVEMENT

BES conducted several neighborhood outreach sessions on this project. BES and the Portland Office of Transportation also conducted an open house at Beach Elementary School. Neighbors were extremely supportive of the project, without any voiced opposition.

SUCCESSES AND LESSONS LEARNED

Pervious Pavement Performance: Pervious asphalt and concrete have been used locally in parking lots and private driveways, but not on a public street. In 2004, the city installed pervious paving blocks on a street in the Westmoreland neighborhood. The North Gay and Westmoreland projects will test how these three pervious paving materials perform on residential public streets.

Information Sources: Outside contacts provided key information for this project. The design team met several times with representatives from Tri-Met and concrete companies to learn about the pervious concrete product, refine specifications, and trouble-shoot the project. Lessons were learned regarding concrete placement technique and aggregate size.

Pervious Concrete Construction: With pervious concrete, construction technique greatly influences the quality of the finished product. The mix is extremely dry to begin with and can be difficult to remove from the concrete trucks during delivery. The method of placement can also cause the surface to be inconsistently dry and wet in places.

RiverEast Center
1515 SE Water Avenue
Portland, Oregon

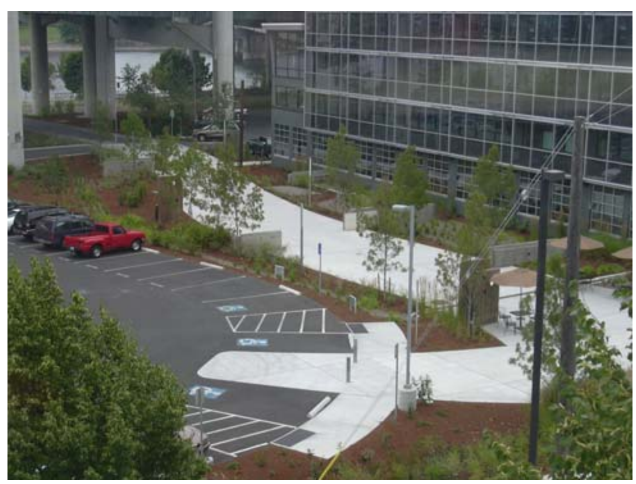
PROJECT SUMMARY

Project Type:	Commercial office remodel project
Technologies:	Flow-through planters, vegetated infiltration swale, downspout disconnects
Major Benefits:	• Runoff from 98,700 sq.ft. of impervious area is filtered and partially infiltrated, reducing the amount of pollutants entering the public stormwater system. • More than 42,000 sq. ft. of landscaping was added, improving the urban environment and the aesthetic appeal of the property and pedestrian plaza connecting to the Eastbank Esplanade.
Cost:	• Stormwater elements $120,000. IWWP grant $80,000
Constructed:	Winter/ Spring 2007

Overview of the Stormwater System

- Runoff from 43,500 sq. ft. of impervious parking lot and 8,200 sq. ft. of impervious sidewalk drain to the vegetated swales located throughout the project.
- Runoff from 8,000 sq. ft. of public street along Water Avenue drains to the eastern-most vegetated swale through two custom conveyance systems located within the sidewalk.
- Runoff from 39,000 sq. ft. of roof area has been disconnected and flows into two flow-through planters on the south side of the building and then overflows into vegetated swales.

Clay Street from above looking east pre-construction



Clay Street from above looking east post-construction

STORMWATER CAPACITY AND SYSTEM COMPONENTS

System Components

Total area of flow through planters and vegetated infiltration swale: 8,500 sq. ft.

Catchment area: 98,700 sq. ft. (roof and impervious asphalt/ concrete)

Overflow: The facility will fill to a depth of 6 inches before overflowing into the raised area drains. The drain pipe will then direct the water to the public storm system.

South parking lot looking south during construction

Vegetated Infiltration Swales: Four flow-through planters capture and infiltrate on-site and off-site runoff from impervious concrete and asphalt surfaces. They are typically 12 inches deep. One 12-inch deep flow-through planter captures and infiltrates 39,000 sq. ft. of impervious rooftop surface. The flow-through planters occupy 12,000 sq. ft. of landscaping.

Building Rain Drains: Roof runoff is piped down the south face of the building and discharged to two stormwater planters.

South parking lot looking south after construction

Removal and Replacement of Asphalt: A contractor removed 100,000 sq. ft. of existing on-site asphalt. 53,000 sq. ft. was repaved, 2,000 sq. ft. was graveled, and the rest was replaced with landscaping.

Geotechnical Evaluation/Infiltration Test

City staff did not require infiltration testing for the site, but previously collected information adequately documents the site's soil characteristics. The Natural Resource Conservation Service (NRSC) soil survey for Multnomah County classifies the soil as 50A. The predicted infiltration range is 0.6 to 2.0 inches per hour.

Landscaping

- The landscaping includes mostly native plants-trees, shrubs, and grasses selected for their tolerance to the Portland climate and soil conditions.
- Trees and shrubs were placed in strategic locations to minimize erosion and reduce the heat island effect on the plaza area.
- Most soil in the landscaping consists of four inches of loose subgrade with six inches of topsoil added on top.
- All imported topsoil consists of clean soil with added amendments.

- All new landscaping was covered with three inches of wood mulch in planting areas or two inches of rock mulch in the vegetated infiltration swales.

Irrigation

Temporary soaker hoses are installed beneath the mulch to irrigate the plants during the two-year establishment period. After two years, the plants should be established and the irrigation will be disconnected.

Emergency Overflow

At the low point of each swale there is an area drain that is elevated six inches above the ground surface. If the landscape facility reaches capacity, the water will flow into the area drain and be directed to the public storm system.

MAINTENANCE AND MONITORING

The property owner is responsible for maintaining the facilities to ensure proper function and appearance. Maintenance may involve removal of nuisance and invasive plant species, removal of debris and sediment, and preventing impedance of stormwater flow into, or overflow from, the facility.

The Bureau of Environmental Services (BES) will provide periodic visual assessment of the facility to determine plant viability and facility function.

Vegetated infiltration swales east side of site post construction

Vegetated infiltration swale along sidewalk

PUBLIC INVOLVEMENT

Two permanent interpretive signs, one at the entrance to the esplanade and the other at the plaza provide information about the sustainable stormwater management techniques used.

The project is used as an example of innovative stormwater management on the BES website and on tours of sustainable stormwater management facilities.

Public to private inlet at Water Street

SUCCESSES AND LESSONS LEARNED

Positive project example: RiverEast Center is in a highly visible location near the Eastbank Esplanade, a popular pedestrian and bike path that parallels the Willamette River. This project provides opportunities for the public to become more aware of innovative stormwater management techniques. In addition, the center's customers benefit from seeing examples of the kind of on-site stormwater management they can implement on their own properties.

Public private partnership: This project is the first public-private stormwater management partnership of its kind in Portland. RiverEast Center worked with the city to create a model stormwater system that treats runoff from the roof, parking lot, public plaza and adjoining city streets on private property. In addition, to expand the public's access to the river, a city street was turned into a public plaza connecting surrounding neighborhoods to the esplanade.

Stormwater reduction rate: Under Portland's Clean River Rewards program, the onsite stormwater management measures will earn the property owner a stormwater management charge discount.

Sustainable, creative, cost effective approach: The project retained 100% of its original structure and more than 95% of the construction waste was recycled for the sculptures, planters, site grading and fill.

Rain scupper at downspout basin after heavy rain

Plaza leading to Eastbank esplanade

Recycled concrete sculptures

SE Spokane Green Street Bicycle Boulevard Project

SE Spokane Street between SE 19th Avenue and SE 6th Avenue
Portland, Oregon

Project Summary

Project Type:	Green semi-diverter traffic barrier with stormwater management on existing residential street designated as a bicycle boulevard.
Technology:	Stormwater curb extension semi-diverter
Major Benefits:	• The curb extension captures runoff from 7,000 square feet of paved surfaces and has a surface area of 282 sq.ft. It treats and infiltrates most of the runoff it receives, providing volume and flow control and water quality benefits. • Runoff is managed onsite and is directed to one of the City's sumps. • Project includes ADA compliant curb ramps, pedestrian median refuge and striped crosswalks. • Leverages other traffic safety investments on the street including two traffic channelizer features at SE 15th and SE 7th; pedestrian refuge islands at SE 17th, and; additional traffic calming.
Cost:	The total project cost including project management, design and construction was $141,000. The total cost of the stormwater management features (including project management, design and construction) was $50,000.
Constructed:	November-December 2009
Maintenance:	The City of Portland maintains this facility.

Before

After

Other Leveraged Traffic Safety Investments

Channelizer Island at SE 15th Avenue

Channelizer Island at SE 7th Avenue

Pedestrian Refuge Islands at SE 17th Avenue

Additional Traffic Calming

Project Components

The SE Spokane Green Street feature at SE 13th Avenue is a 282 square foot unlined vegetated curb extension. Stormwater runoff from the west side of SE Spokane drains into an inlet on the west side of the facility; stormwater runoff also can drain into a metal grate inlet closer to the intersection on the southeast portion of the facility.

An existing storm sewer inlet located in the new facility was retained. It serves as an overflow outlet. The overflow outlet feature is a typical beehive dome grate. The top of the inlet is 2 inches below the top of the existing sidewalk northeast of the overflow outlet.

Budget

The total SE Spokane Green Street Bicycle Boulevard (sometimes called a Neighborhood Greenway) project budget was $141,000; $50,000 provided by an Innovative Wet Weather grant through the Bureau of Environmental Services and the remainder provided through the Portland Bureau of Transportation's Affordable Transportation Fund. Table 1 provides a cost summary organized by project elements phase. Because the intersection treatment at Southeast Spokane Street and 13th Avenue also required a median barrier, striped crosswalks, signage and pavement work on SE 13th – project costs beyond the green facility were funded by the Bureau of Transportation. The overall cost of the green semi-diverter was approximately $53,000 including curb ramp work. The cost of planting brings the total cost to approximately $56,000.

Table 1: Project Cost Summary by Element

Project Element	Cost
Green semi-diverter / median barrier / striped crosswalks & signage	$75,000
Two pedestrian refuge islands / striped crosswalks & signage	$34,000
Four Channelizing Islands / pavement marking & signage	$20,000
Speed Bump infill (5)	$12,500
Total	**$141,500**

Table 2: Project Cost Summary by Phase

Project Phase	Cost
Design	$23,495.12 (includes concept design, work orders, civil design and supervision)
Public Involvement	$5,792.49 (community meetings, notification, project coordination and community celebration)
Construction (BOM)	$109,008.16 (2 pedestrian refuge islands, 4 channelizing islands, speed bump infill, curb ramps, stormwater facility)
Planting (Parks Horticulture Services)	$ 3,271.49
Construction Management	$223.32
Total	**$141,790.58**

Successes and Lessons Learned

The facility has functioned properly since installation. The overflow appears to function well, and stormwater in the facility is infiltrating within 24 hours. The facility will be watched carefully to ensure it continues to drain well.

Because the facility has a parking lot across the sidewalk from it – parking stops should be included in any future facility with the same surrounding environmental conditions.

Post-construction adjustments include:

- Re-planting of some plants due to a motorist driving through the feature inadvertently from neighboring parking lot.

Owens Corning
3750 NW Yeon Avenue
Portland, Oregon 97210

PROJECT SUMMARY

Project Type:	Parking lot retrofit
Technologies:	Vegetated infiltration swale, flow-through planter, downspout disconnect
Major Benefits:	• Runoff from 31,000 square feet of impervious area is filtered and partially infiltrated, reducing pollutants entering the public stormwater system. • 3,010 square feet of impervious area was removed and replaced with a stormwater facility.
Cost:	• Stormwater elements $ 125,000. IWWP grant $ 96,398
Constructed:	Winter/Spring 2008

Overview of Stormwater System

The Owens Corning facility in Portland’s Northwest Industrial District produces roofing materials. In 2006, the city’s Bureau of Environmental Services (BES) and Owens Corning formed a partnership to construct sustainable stormwater facilities in the Owens Corning parking lot. The facilities manage stormwater runoff from the parking lot and the roof.

Five of the building’s downspouts were disconnected and the runoff from the roof and parking lot was directed to vegetated planters and swales. In addition to stormwater management, Owens Corning constructed a facility to recycle water and sand, which are used in the roof manufacturing process. The project was funded by Owens Corning, BES’s Innovative Wet Weather Program (IWWP) Grant Funds, and Metro’s Nature in Neighborhood funds. Also, volunteers participated in planting the vegetation in the stormwater facilities.

STORMWATER CAPACITY AND SYSTEM COMPONENTS

The stormwater management goal was to provide onsite stormwater infiltration and treatment and reduce the volume of stormwater discharging to the Willamette River. The stormwater facilities were designed in accordance with the City of Portland’s *Stormwater Management Manual*.

System Components

Total area of vegetated infiltration swales: 3,010 sq. ft.

Catchment area: 31,000 sq. ft.

Overflow: In a large storm event, runoff that does not infiltrate will flow from the loading dock facility through a runnel covered by a grate, and into the east facility. If the east facility fills, the runnel to the street will allow excess stormwater to flow into the street after being filtered through the vegetation. If the north facility overflows, some of the runoff will flow into the street and discharge directly into the Willamette River, and some will flow into the east facility.

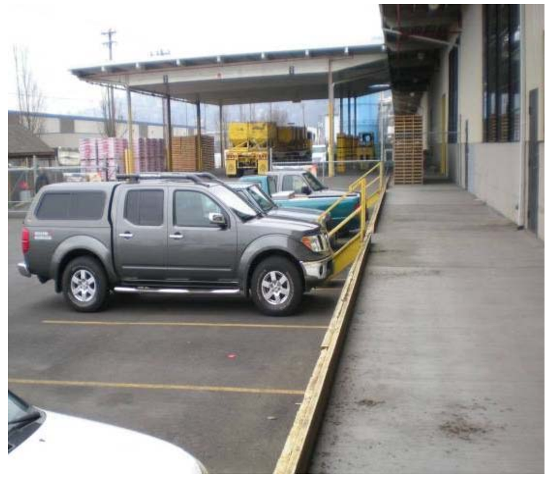
Vegetated Infiltration Planters: The planter at the loading dock collects runoff from three disconnected downspouts. Runoff from two of the disconnected downspouts flows through runnels cut into the loading dock to carry the runoff into the facility. The third downspout flows directly into the facility. The facility is 6 feet wide and 90 feet long.

The east facility runs parallel to a fence and a gate. Runoff from the parking lot and roof enters the vegetated swale by flowing between the wheel stops. The facility is 100 feet long and 8 feet wide.

The corner of the parking lot was excavated to create the north facility. Two downspouts were disconnected, and stormwater flows directly into these vegetated swales.

Soil Sampling and Infiltration Testing

Because the site is in a superfund area, BES sampled soil to determine the level of contamination. Soil samples were collected at four feet below surface level, which is the point where water from the facilities will infiltrate into the ground. In addition, soil percolation tests were conducted. The sampling found very little contamination. The results of the percolation test showed that water infiltrated into the ground very quickly. It was determined that infiltrating stormwater will not harm soil or groundwater.



Loading dock before construction

Loading dock after construction

Runnel on loading dock

Landscaping

The swales were planted with the following:

Ginkgo biloba 'Princeton Sentry'	Princeton Sentry Ginkgo
Nyssa sylvatica	Tupelo
Pseudotsuga menzeisii	Douglas Fir
Mahonia aquifolium 'Compacta'	Compact Oregon Grape
Mahonia repens	Creeping Mahonia
Mahonia nervosa	Long leaf Mahonia
Polystichum munitum	Sword Fern
Nandina domestica 'Moon Bay'	Moon Bay Nandina
Nandina domestica 'Sienna Sunrise'	Sienna Sunrise Nandina
Arctostaphylos uva-ursi	Kinnikinnick
Carex morrowii 'Ice Dance'	Ice Dance Sedge
Carex testacaea	New Zealand Sedge
Carex obnupta	Slough Sedge
Liriope muscari 'Royal Purple'	Royal Purple Lilyturf
Juncus patens 'Elks Blue'	Elks Blue Rush

Partnership

Environmental Services was looking for a project to demonstrate that stormwater can be managed sustainably in a heavy industrial area. This project combined Owens Corning's goals to improve the exterior of the building and reduce waste, and BES's goal to manage stormwater sustainably. Through an agreement signed by Owens Corning and BES, Owens Corning took the lead on hiring contractors to design and construct stormwater management facilities and BES provided funding and technical assistance.

Design

Owens Corning hired the landscape design firm Nevue Ngan to design the facilities. The concept plan was made based on: amount of stormwater managed, current and future use of the parking lot, and cost. Once the final concept was accepted, Nevue Ngan initiated design. BES and Owens Corning reviewed the design before construction began. In addition to the stormwater planters, Owens Corning constructed a water reuse/sand recovery system. The roof manufacturing process requires considerable amounts of water for cooling. Owens Corning constructed a wastewater recovery system to filter and reuse a large portion of this water within the facility. Owens Corning staff designed the system, purchased the needed materials, and constructed the system.

North facility before construction

North facility after construction

Permitting

At 90 percent completion, an application for permits was submitted. Through the permit review, no changes to the design were required, but additional soil and groundwater sampling was required. The water reuse system did not require permits.


East facility before construction

The second sampling event included collecting soil and groundwater samples at a depth of 15 feet below the surface. This depth was chosen because this is the lowest point that stormwater from the facility is expected to infiltrate. Results of this sampling were the same as the first sampling event—little contamination exists, and infiltrating stormwater was approved.

The City of Portland issued all permits for the project in fall 2007.

Construction

Through a competitive process, Owens Corning hired a contractor to construct the facilities. Four firms were contacted, including one M/W/ESB firm. Owens Corning selected JP Contractors based on cost (JP's bid was the lowest). JP addressed all aspects of construction from procuring materials and services to excavating the site and constructing the facilities.


East facility after construction

When JP first excavated the areas of the parking lot where the facilities would be constructed, additional material was found which resulted in a BES-approved change order. Fortunately, JP could recycle the material excavated from the parking lot.

JP constructed the concrete planters. Soil was placed in the planter and check dams were constructed with gravel, to slow the flow of water.

Friends of Trees volunteers planted trees, and JP's crew installed herbaceous plants in the swales and planters.

After planting, some construction details remained. JP relocated a fence, installed an irrigation system and a new sensor in an automatic gate, and generally cleaned up the site.

The final step was to disconnect the downspouts. Owens Corning hired a contractor they had used in the past to do this work. The gutters needed to be moved, which was tricky because they are about 30 feet off the ground.

Nevue Ngan conducted several inspections during construction to ensure the facilities were constructed according to the drawings.

BUDGET

Final Project Budget

Activity	Cost	Funding Source
Stormwater planters		
Design	$18,000	Owens Corning
Construction	$107,277	Metro NIN and BES IWWP
Change Order	$4,500	BES IWWP
TOTAL COST	$125,000	
Volunteers	11	Friends of Trees
Volunteer hours	48.5	Friends of Trees
Water Reuse/Sand Recovery System		
Materials	$24,500	Owens Corning
Construction	$25,500	Owens Corning
TOTAL COST	$50,000	

MAINTENANCE AND MONITORING

Maintenance and Follow-Up Activities

Owens Corning is required to maintain the facilities. They have an ongoing contract with a landscape company which will do the maintenance. Nevue Ngan will provide Owens Corning with a long-term maintenance manual.

The facilities will also be monitored:
- Five years monitoring of vegetation
- Annual visual survey of presence or absence of wildlife
- Quarterly monitoring of water used in manufacturing
- Quarterly monitoring of sand recovered from the manufacturing process

BES anticipates using this site to showcase how stormwater can be managed sustainably in a heavy industrial setting.

PUBLIC INVOLVEMENT

Friends of Trees did an excellent job organizing the planting event, signing up volunteers, providing training, and overseeing the planting.

The project is used as an example of innovative stormwater management on the BES website and on tours of sustainable stormwater management facilities.

SUCCESSES AND LESSONS LEARNED

Project Evaluation

The second round of soil and groundwater testing was unexpected, but not unwelcome. BES and Owens Corning were concerned about potentially impacting existing contaminated soil and/or groundwater. The second series of tests confirmed that infiltration was an acceptable approach to managing stormwater, and the data assured the partners that the project would not negatively impact the environment.

Friends of Trees volunteers planting the north facility

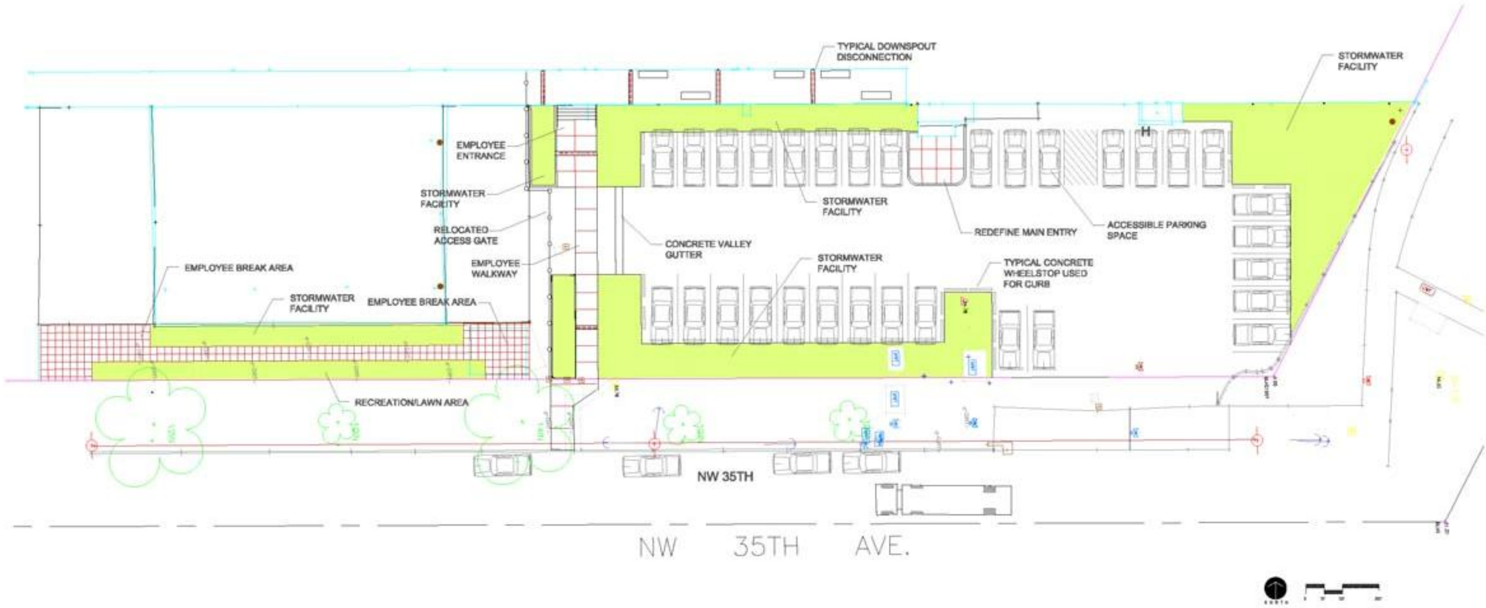
The excavation change order was anticipated. Because soil samples had been collected, BES had an idea of how thick the asphalt and concrete would be. BES could have done a complete characterization of the parking lot material, but this would have entailed considerable time and cost. Also, even with a full characterization of the material in the parking lot subsurface, something could have been missed and a change order would have been necessary. By anticipating a change order, BES and Owens Corning included contiguous budget and timeline.

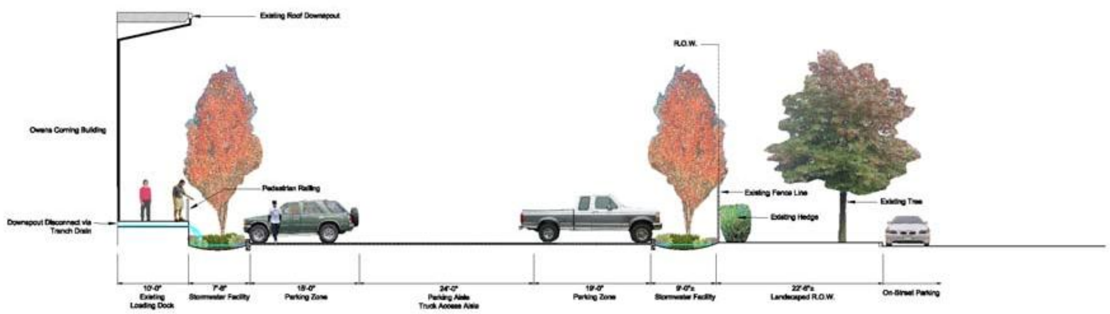
Positive project example:
The facilities got their first test in June 2008. Runoff from the roof and parking lot entered the facilities and infiltrated into the ground. There was no overflow. Success!

Public private partnership:
One of the most significant successes of the project was the positive partnership between BES and Owens Corning. Through all the decisions, hard work, and impacts to Owens Corning employees (their parking lot was torn up for two months), each partner worked cooperatively to resolve issues and get the project done.

Sustainable, creative, cost effective approach:
In addition to the stormwater planters and vegetated swales, Owens Corning constructed a water reuse and recovery system to filter and reuse a large portion of their water. Since the installation of the water reuse system, Owens Corning has been able to decrease average water use by approximately 25% or, 400 gallons/production hour.

Stormwater reduction rate: Under Portland's Clean River Rewards program, the onsite stormwater management measures will earn the property owner a stormwater management charge discount.





TYPICAL CROSS SECTION THROUGH PARKING LOT

FINAL CONCEPT PLAN

November 3, 2006

OWENS CORNING
INNOVATIONS FOR LIVING™

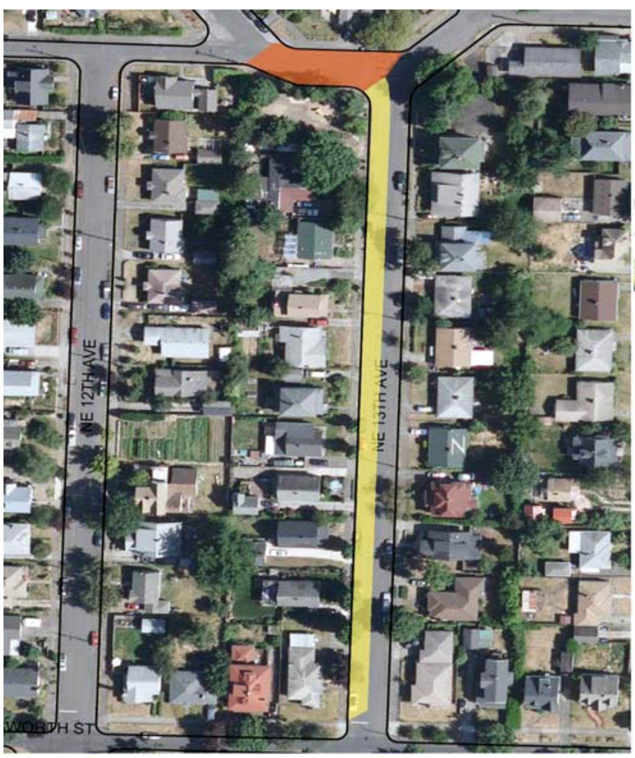
Landscape Architecture
Nevue Ngan Associates

Holman Pocket Park and Green Street Bike Boulevard Project

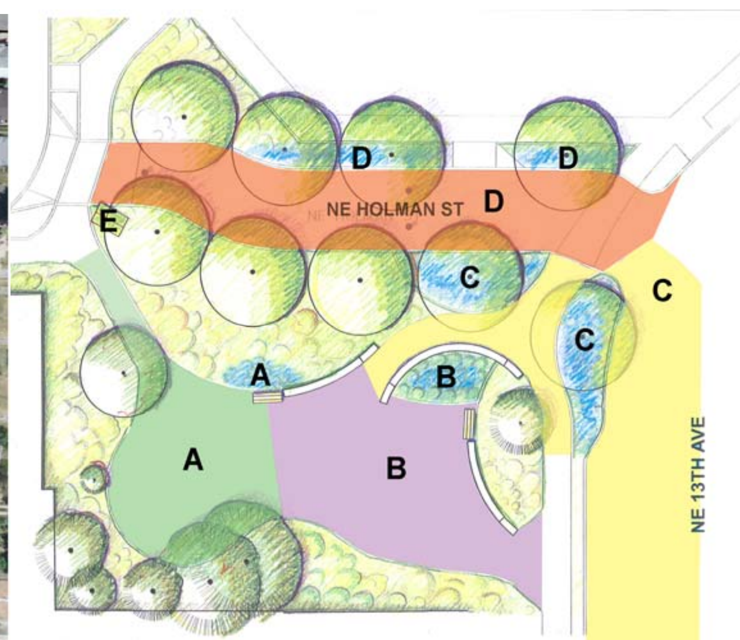
NE Holman St. at NE 13th Ave.

Project Summary	
Project Type	Neighborhood Bikeway with green streets and stormwater retrofit in adjacent public park
Technology	Infiltration planter, infiltration basin, landscape filter strip, green streets, ecoroof, street trees
Benefits	-The 6 facilities (excluding the ecoroof), totaling 1,113 ft^2, manage runoff from 16,100 ft^2 of concrete and asphalt. -Most of the flow captured infiltrates, treating for water quality before going to a sump. -The re-design decreased the impervious surface in the area. -Neighborhood destination, meeting space and public education
Notable Features	-Seat walls were added to allow for better community gathering opportunites. -The underlying soils have an infiltration rate of 18” per hour. -Multiple types of stormwater management facilities -Holman Street adjacent to the park was closed to car traffic, allowing for the narrowing of travel lanes, creating more pervious landscape area.
Cost	The cost of design and construction was $368,813 with $62,953 paid for by EPA funds.
Construction	The Bureau of Maintenance constructed the project from August-October 2011.
Ownership	The Parks Burea owns and maintains the park. They will also maintain the expanded landscape area adjacent to the park. BES will maintain the green streets.

Collaboration: This project was made possible by a special collaboration between the U.S. Environmental Protection Agency, Portland Bureau of Environmental Services, Portland Parks & Recreation, Portland Bureau of Transportation, and Portland Water Bureau. The work in the ROW was designed and constructed by PBOT and BES. BES and Parks designed the park improvements.



Holman ROW stormwater facility catchment areas extend from NE Holman St. in the north to NE Ainsworth St. in the south. The yellow catchment area is managed by green street facilities in the ROW adjacent to the park, while the orange catchment area is managed by landscape facilities in the ROW to the north.



Plan shows both Holman Park and Holman ROW stormwater management facilities. There are 4 major catchment areas, shown in different colors. Each catchment is labeled A-D to correspond with the facility type into which it flows. The facility types are as follows: A) infiltration basin, B) infiltration planter, C) green streets, D) landscape filter strips, E) ecoroof. The ecoroof accepts rain that falls on it.

Project Inception: The project meets a number of complementary objectives. PBOT proposed traffic diversion at this block to enhance the Holman Bike Boulevard. The neighborhood had a longstanding interest in making park improvements. Moving the curb line 14 feet north created an opportunity to expand the landscape area and decrease the paved area. Environmental Services had an interest in decreasing unnecessary impervious surfaces and enhancing opportunities for stormwater management. The park improvements were funded through the EPA Innovative Wet Weather Program (IWWP) administered by the Bureau of Environmental Services.

Community Involvement: Woodlawn area neighbors participated in the design process expressing significant ownership in the project. The existing park conditions included an outdated play structure, two benches in disrepair and one picnic table for seating. The community's desire for the removal of the play structure and addition of more seating areas and a kiosk were incorporated into the design. The closure of Holman Street emerged as a suggestion from the community involvement process as an enhancement for both bike and pedestrian safety.

Catchment Area: The stormwater catchment areas draining to the park and street facilities total 16,100 ft^2.

The infiltration basin accepts runoff from the plaza inside Holman Park. It has a 3:1 slope on all sides and a ponding depth of 6". In an overflow situation, water spills into the landscape area north of the facility.

The infiltration planter also accepts runoff from the plaza inside Holman Park. It has a flat bottom and a ponding depth of 6". The site has extremely high infiltration rates. An emergency overflow pipe was installed, but has been left capped.

Two green streets in the ROW adjacent to the park accept runoff from the street. They are flat bottom infiltration facilities with a ponding depth of 6”. Water enters the first facility (left), ponds to 6”, then enters the second facility (right) by way of a trench grate. An emergency overflow beehive inlet in the second facility directs water to a sedimentation manhole and sump.

Two filter strips were constructed in the ROW north of the park. They are flat bottom infiltration facilities with a 3” ponding depth. Water enters from the street over the flush curb. The emergency overflow runs back into the street and to a catch basin east of the site where the water previously drained.

Landscaping: The largely native plant palette includes Kelsey dogwood, tufted hair grass, slough s edge, camas and lilyturf. Neighborhood volunteers helped plant the surrounding landscape outside the stormwater facilities as part of the overall site construction.

Budget:

Bureau of Maintenance-construction: $239,300
Parks Horticulture Services-construction (irrigation, grading, stormwater plantings): $38,659
Parks-project management and review: $15,586
Parks-plant material: $2,200
Water Bureau-drinking fountain design and installation: $4,800
Bureau of Environmental Services-design and project management: $66,505
Permit Fees: $1,763

Lessons Learned:

Although bollards were placed in the bike route in the street to prevent vehicular through-traffic, cars continued to drive around the bollards, damaging the adjacent landscape. Temporary posts with reflectors were installed to address the problem until the landscape plants fill in enough to deter vehicles.

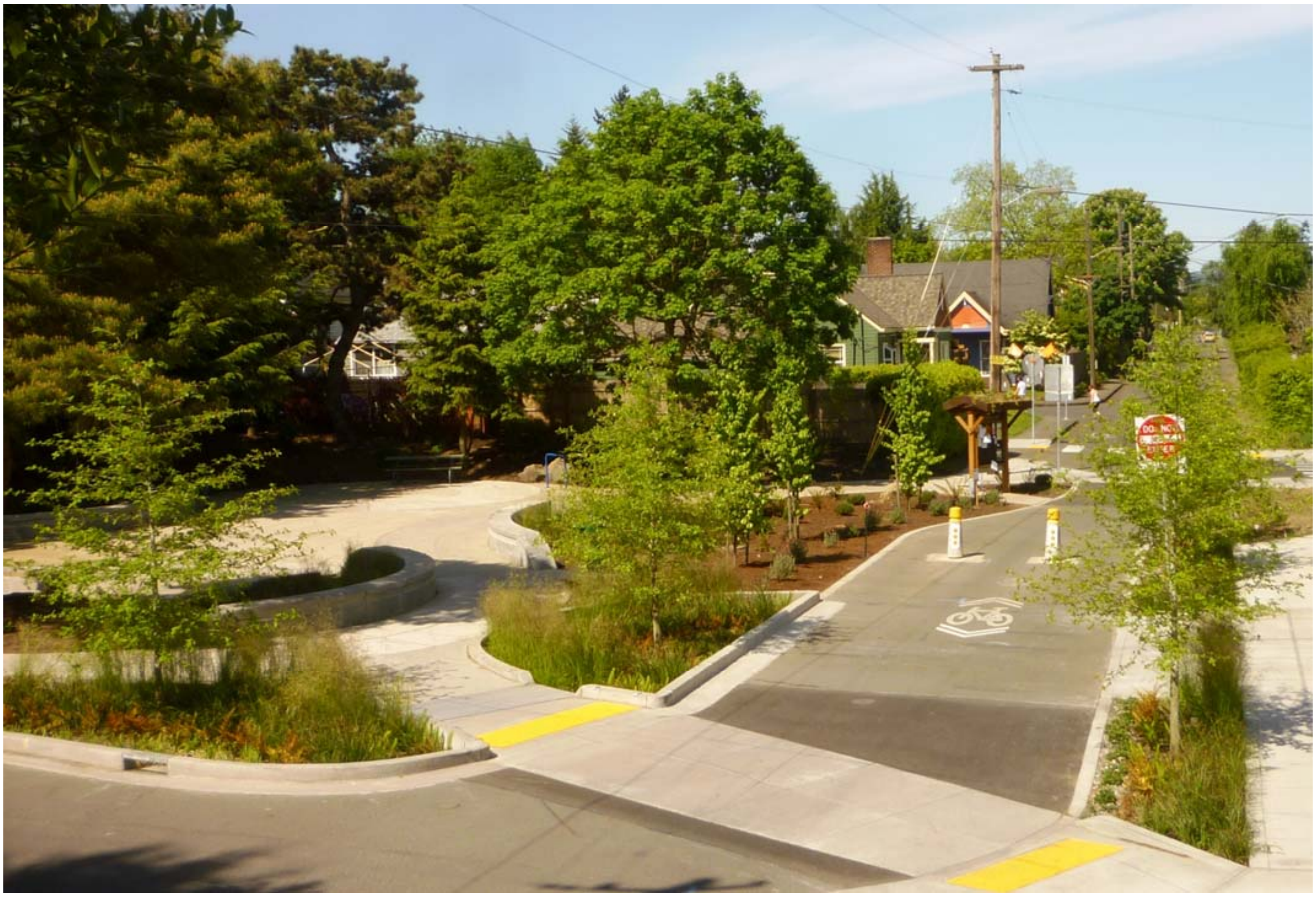
The landscape filter strips were filled with too much soil in anticipation of settling. The soil did not settle, and the ponding volume was greatly reduced. To regain volume, some soil was removed and a layer of river rock was added to the finished surface of the soil in certain areas.

NE corner of the park before construction

NE corner of the park after construction

Looking east before construction

Looking east after construction



Overview of park and ROW work looking west after construction

Curvilinear seating walls were added

A kiosk for neighborhood news was added. Community members added an ecoroof to the structure in May 2012.

Stormwater runoff can impact water quality in rivers and streams. Portland uses green streets, ecoroofs, trees and other green infrastructure to increase sewer system efficiency, and protect water quality, public health, and the environment. Green infrastructure keeps stormwater out of the sewer system, filters pollutants, provides habitat and increases neighborhood green space for healthier watersheds.

working for clean rivers

Portland Community College Stormwater Education Plaza

The PCC Stormwater Education Plaza's (above) sustainable stormwater management features include the kiosk's ecoroof and disconnected downspout that allows roof runoff to cascade over a concrete and steel slab waterfall into a rain garden (below).

Portland Community College (PCC) worked with Environmental Services to create an educational stormwater project at PCC's Central Campus, the CLIMB Center. Stormwater runoff from the CLIMB Center's 5,200-square-foot roof cascades over a concrete and steel slab waterfall into a rain garden.

Runoff from 3,000 square feet of the adjacent street enters the rain garden after flowing under a steel grate that crosses the sidewalk. Stormwater that enters the rain garden soaks into the ground. In a very large rainstorm, excess water flows back into a catch basin in the street.

The kiosk in the plaza describes methods of sustainably managing stormwater runoff. The kiosk is covered with an

Environmental Services
City of Portland
working for clean rivers

Historic log dog

ecoroof, a vegetated roof system that absorbs rain and reduces stormwater runoff.

Portland artist Linda Wysong created the six-foot steel sculpture titled ***Eye River***. The historic log dogs, six-inch steel spikes used by the lumber industry to bind log rafts together, inspire the design.

TS Construction Management donated labor to construct the kiosk. Students from Portland Community College constructed and welded the steel base of the kiosk as part of their curriculum. Builders used wood that Beam Development salvaged and donated from the redevelopment of several 100-year-old warehouses in the Central Eastside Industrial District for benches along the kiosk. Teufel Landscape and Tremco Roofing donated materials used to construct the kiosk ecoroof.

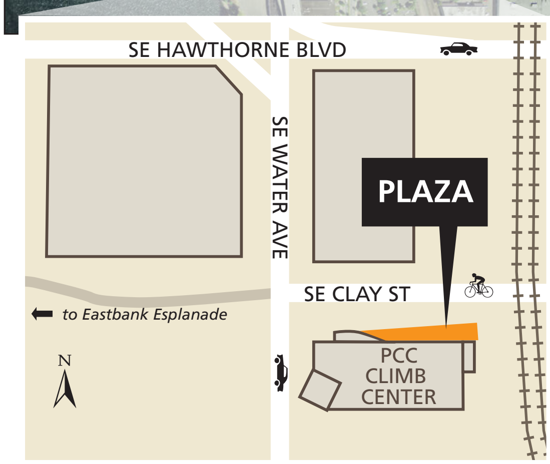
Partial funding for the project came from an Environmental Protection Agency Innovative Wet Weather Program grant.

***Eye River** by Portland artist Linda Wysong was inspired by log dogs once used to bind log rafts together.*

FOR MORE INFORMATION

Contact Alice Coker at 503-823-7914 or ***alice.coker@portlandoregon.gov.***

SE Clay Green Street Project – Route to the River



The PCC rain garden and stormwater plaza are part of the SE Clay Green Street Project – Route to the River. The Clay green street project has several benefits:

- Enhances Clay Street from SE 12th Avenue to SE Water Avenue with stormwater management and improved pedestrian, bicycle and motorist safety
- Creates an urban greenway that connects business districts, neighborhoods and parks
- Provides a safer connection between Portland's inner east side neighborhoods and the Willamette River

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