

Natural Approaches to Stormwater Management



Low Impact Development in Puget Sound

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Clockwise from top: High Point Natural Drainage Systems study, page 29; rain garden installation, page 5 and pervious driveway, page 17.

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Puget Sound Action Team staff could not have produced this book without the cooperation of the landowners, developers, engineers and local government staff whose work and properties are featured in these examples. The Action Team extends its gratitude to them for their assistance and willingness to be innovative and to take risks that benefit us all as our region works to transform development practices in Puget Sound.

For more information on low impact development:
http://www.wa.gov/puget_sound/Programs/LID.htm

Introduction

Puget Sound planners, developers, engineers and others are in the early stages of transitioning to an innovative approach to land development and stormwater management. The innovative approach—low impact development (LID)—offers potential answers to the question: “How can we significantly reduce the harm from development to Puget Sound while accommodating the inevitable growth that is occurring throughout the region?” The Puget Sound Action Team produced this book to showcase early examples of this transition.

KEEPING IT NATURAL—AND MORE EFFECTIVE

LID is a more natural approach to land development and stormwater management. Conventional land development typically involves clearing and grading a site, resulting in the removal of all vegetation. The next development steps traditionally include paving areas for roads and parking, building structures and landscaping areas. Engineers then design stormwater facilities, such as ponds, to manage stormwater flow, remove pollutants, and infiltrate to recharge aquifers, streams and wetlands.

Research shows that these conventional techniques have not proven entirely effective at managing stormwater to prevent damage to water quality and natural resources. Conventional practices are especially inadequate at removing bacteria from stormwater runoff. Pavement and other impervious surfaces greatly limit or prevent infiltration. High stormwater flows cause flooding, damage public and private property, and destroy habitat for salmon and other fish and wildlife.

In contrast, LID design uses a site’s natural features and specially designed best management practices to manage stormwater. These principles include the following design steps:

- **Assess and understand the site.** Assess the site’s topography, soils, vegetation and natural drainages, and divide the site into protected and developable areas. Protected areas include streams, wetlands and other critical areas. Apply adequate buffers to protect these areas.

- **Protect native vegetation and soils.** Set aside a portion of the site’s native vegetation and areas with soils that have a high infiltration capacity. These natural areas are nature’s own excellent stormwater management systems and, if left undisturbed, will continue to manage runoff quite well. To protect native vegetation, cluster buildings in the area to be developed.
- **Minimize and manage stormwater at the source.** Minimize areas of impervious surfaces such as roads, rooftops and parking areas by designing shorter, more narrow roads, using various permeable pavements, and installing green roofs or rainwater catchment systems. Manage remaining runoff by disconnecting the impervious surfaces from one another, and directing runoff to bioretention areas (or rain gardens), amended soils, native vegetation or other types of infiltration areas. This can greatly reduce the need for pipes and other conveyance infrastructure.

The home, business or development that includes LID design practices causes less harm to area streams, wetlands and wildlife habitat. Rainwater can better infiltrate into the ground to recharge drinking water supplies, streams and wetlands. The site is greener and more attractive, with open spaces that appeal to potential buyers. The developer or municipality may save money because the overall infrastructure costs are often less.

A VARIETY OF APPROACHES

LID practices are appropriate for individual homes, residential subdivisions or businesses. LID works for new developments or as part of a retrofit project to fix existing drainage problems.

The examples highlighted in this publication reflect a broad range of LID applications—including local government ordinances, individual practices, entire residential subdivisions and new state highway designs. To date, developers and local governments have designed most of the projects in more urbanized areas. However, the projects are also applicable to rural areas, which often have more extensive stretches of undisturbed forest.

Introduction, *continued*

Specific practices highlighted in this publication include a broad range of LID techniques, including:

- Various types of permeable pavement.
- Rooftop rainwater collection systems.
- Bioretention areas.
- Soil amendments.
- Green roofs.
- Open road sections with vegetated swales.
- Innovative building foundations.
- Homemade bog garden.

Municipalities and developers choose LID techniques for a variety of reasons:

- To better protect streams, wildlife habitat, wetlands and other natural resources.
- To protect groundwater and drinking water supplies.
- To help communities grow more attractively.
- To manage stormwater in a more efficient, cost-effective manner.

Because LID is in the early stages in Puget Sound, many examples describe projects that use a single practice or technique rather than a complete LID design. This publication also features several projects from British Columbia, Canada to provide a broader view of the level of activity in the Puget Sound/Georgia Basin region.

A few examples feature practices that might be more accurately defined as “green building,” such as the use of recycled building materials or increased energy efficiency. Several examples also include land use elements of “smart growth,” such as mixed-use zoning and urban revitalization. LID-designed developments sometimes incorporate elements of each of these approaches.

LID is compatible with the sustainable approach of both green building and smart growth. As “green infrastructure,” LID is best distinguished by its central focus on stormwater management. LID does not replace local land use planning; rather, it is a set of tools to better manage stormwater from areas appropriately designated for growth.

BRINGING LID TO PRIME TIME

Despite the promise of LID, the vast majority of new development projects each year still rely on traditional stormwater management facilities without considering LID techniques. One reason is that most local government development regulations do not allow for certain LID practices, such as narrower roads or open road sections without curbs and gutters. Another reason is that many engineers and developers aren't familiar with LID techniques and continue to rely on better-known conventional practices.

To address these challenges, the *2000 Puget Sound Water Quality Management Plan* calls on every city and county in Puget Sound to revise existing ordinances or pass new ordinances that allow for and encourage LID practices. Several local governments have passed LID ordinances (see pages 39-49).

The Puget Sound Action Team has educated more than 800 planners, developers, engineers and others at LID conferences and regional workshops throughout Puget Sound. The Action Team has developed an assortment of educational materials on the subject, such as this publication. A number of other organizations now also offer training on LID. The Action Team posts these training opportunities and links to other resources on its website.

The Action Team hopes you enjoy reading *Natural Approaches to Stormwater Management: Low Impact Development in Puget Sound*. The goal of this publication is to provide you with ideas and inspiration to learn about and use low impact development practices in your community.

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Amended soils and bioretention

Amended Soils at Redmond Ridge King County

BACKGROUND

The Quadrant Corporation is developing Redmond Ridge as a mixed-use, fully contained community within the Novelty Hill Area of the Bear Creek Community in King County. The 1,046-acre site will include a full range of residential densities, employment, retail and business services, parks and public utilities. As mitigation for land clearing at the site, Quadrant is amending soils and revegetating landscaped areas with native plants. This will reduce stormwater runoff volumes and help maintain the water quality of the receiving native wetlands and forests.

DESCRIPTION

The development permits for Redmond Ridge describe a total water management program, from site clearing to educating residents about water conservation. Conserving native soils and restoring soils through amendment play an important part in the water management program.

After removing trees and stripping roadway corridors and development areas, the contractor will remove the top layer of forest duff, stockpiling it for use as amended soil material or to refill borrow areas. Plans call for all landscape soils to be amended to a depth of 12 inches to improve retention of stormwater. King County required Quadrant to use one of two guidelines when amending soils:

- Washington State Department of Ecology's On-Site Residential Stormwater Management Alternatives,

November 1995 Edition. If Quadrant uses this guideline, the soil-to-compost mix will have a ratio of 1 part compost to 2 parts soils. The topsoil product must be suitable for placement 12-inches deep in nonstructural fills and landscaped areas.

- King County Executive Proposed Site Alterations Code Ordinance (not yet adopted by the King County Council). This ordinance calls for adding nine inches depth of amended topsoil consisting of native soils mixed with organic matter (mixed at a content rate of eight to thirteen percent dry weight) over existing scarified till soils. (Although the ordinance calls for a depth of nine inches of amended soils, if Quadrant chooses to use this guideline they must still amend soils to a depth of 12 inches, using the content rate spelled out in the ordinance.)

A Water Conservation Plan will identify landscaped areas and uses, classify landscaped areas according to hydrozone and discuss soil preparation techniques, including soil amendments. Quadrant will educate all developers about soil amendment during the sale process. All lot purchase and sale documents will require land purchasers to comply with the soil amendment requirements.

To educate homeowners, Quadrant will prepare educational materials and



October 2002.
Aerial Photo of Redmond Ridge where landscaped areas will be amended to a depth of 12 inches to improve retention of stormwater.

Redmond Ridge, *continued*

programs on landscape management for water conservation, surface water management, water conservation and groundwater quality. Quadrant will also install a landscape plan for a single detached model home and a demonstration garden.

Quadrant is monitoring the erosion control measures related to site construction and the quality of the

receiving wetland waters. King County Water and Land Recourses Division is monitoring the function of the storm system and water quality of the native wetlands.

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Bog Garden City of Shoreline

BACKGROUND



Bog garden before

A homeowner in the city of Shoreline installed a bog garden to direct stormwater flows away from the foundation of his house. His objective was evapotranspiration and infiltration of rooftop drainage rather than discharging it to the

stormwater system. The bog garden serves as a model for other residential homeowners.

DESCRIPTION

The Bog Garden serves a 1/4-acre



Bog garden (after) handles approximately 10,800 gallons of rooftop runoff each year.

residential property and collects roof runoff for infiltration and evapotranspiration with wetland vegetation. The homeowner backfilled a lined retention pond (12-feet long by 8-feet wide by 3-feet deep) with three-way garden mix, coconut husk fiber and peat moss. He then

planted more than 30 species of native and non-native (to the Pacific Northwest) wetland facultative plants on the site. As the garden functions, there is no standing water, but the soils are saturated much of the time. Unlike many similar systems, this

one promotes evaporation and transpiration; the impermeable liner prevents infiltration. Excess water flows into a constructed dry streambed.

RESULTS

The Bog Garden is an aesthetically pleasing, affordable garden that provides an effective visual barrier to the street. The installation reduced impermeable lawn surface while directing water away from the house foundation. Very little excess flow discharges from the bog garden, and what does flow out quickly infiltrates within a few feet of its point of discharge.

The builder estimates that the Bog Garden will handle 10,800 gallons per year (based on 2,000 square feet of roof area divided by 4, times 36 inches per year precipitation = 10,800 gallons per year).

COSTS

The project cost approximately \$600. The homeowner could have used a traditional French drain for a similar cost, but it would not have been as aesthetically pleasing.

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Reining in the Rain: Parking Lot Rain Garden Bellingham City Hall

BACKGROUND

Whatcom Creek flows through the city of Bellingham (population 70,000) and eventually enters Bellingham Bay. Urban stormwater runoff entered the creek, causing high flows and degrading water quality. A catch basin in a parking lot



Installing first layer.

behind city hall was one of the sources of stormwater. The city decided to construct a rain garden (bioretention cell) that would treat runoff from the parking lot and also demonstrate the rain garden technology to businesses and property owners. Project funding came in part from the Public Involvement and Education (PIE) program administered by the Puget Sound Action Team.

DESCRIPTION

The city hall parking lot lies between Whatcom Creek on the north and city hall on the south. In creating the rain garden, the city gave up three of the 60 parking spaces in the rectangular lot.

Rain gardens involve layering different types of gravel, soils and mulch—much like layers in a cake. The top layer includes vegetation selected for filtration

of contaminants. The rain garden will clean the parking lot runoff by filtering some of the pollutants (such as oil drips from cars) and slowing down the rate at which it flows into the creek.

COSTS

Asphalt	.....	\$1,056
Concrete	.....	.800
Gravel	.....	.12
Labor	.....	1,690
Equipment	.....	.942
Total cost	.....	\$4,500

RESULTS

City staff report that the water appears less turbid than before the rain garden was built. The rain garden also performs a public education function as it is in a high profile location and includes educational signage about the water quality and habitat benefits.



CHALLENGES

City staff were reluctant to give up their coveted parking spaces behind city hall.

Vegetation laid out waiting to be planted.

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Planting rain garden.

Natural Drainage Systems

City of Seattle

BACKGROUND

The city of Seattle has a population of 516,259 and covers an area of 84 square miles. As the city's population grows, stormwater from impervious surfaces such as streets and rooftops speeds toward area creeks, causing floods and scoured habitat in the winter months, and inadequate creek flows in the dry, summer months. To address this, Seattle Public



Seattle SEA Streets Project. Graded swales with amended soils reduced stormwater volume by 97 percent for two consecutive years.

Utilities (SPU) staff are developing prototype "Natural Drainage System" projects to meet multiple goals within street right-of-ways. These goals include infiltrating and slowing stormwater flow, filtering pollutants by soils

and plants, reducing impervious surface, increasing tree cover and improving the safety of pedestrian paths. These projects use constructed features such as open, vegetated swales and stormwater cascades to mimic the functions of natural forests.

SEA STREETS PROJECT

Seattle's Street Edge Alternative (SEA) Streets Project manages stormwater and improves water quality drainage on individual blocks of low-traffic streets. The project reconfigures the street and right-of-way and uses swales on both sides of the street. SEA Streets began with a retrofit of an urban block in the Broadview section of Seattle in the Pipers Creek watershed. The specific objectives are to:

- Decrease runoff peak flow and volume.
- Minimize impervious area.
- Improve water quality.
- Document effects of alternative design.

- Minimize maintenance through design and stewardship.
- Design watershed and neighborhood friendly streets.
- Change the traditional view that curbs, gutters and sidewalks are necessary.

SPU staff selected the Broadview neighborhood through a process that considered community interest and technical feasibility. The site is on 2nd Ave. NW, between N. 117th and N. 120th streets. Key elements of the project include street improvements, drainage improvements, landscaping and neighborhood amenities. The new street design has a curvilinear form to allow more flexibility in designing the water quality improvements. The block has a sidewalk on just one side of the street. In addition to the water quality benefits, the design calms traffic and provides a more interesting streetscape. Neighbors were involved in the design process, from choosing the number of parking spaces to selecting and planting the trees and shrubs.

The graded swales direct and slow the flow of stormwater and provide detention during larger storms. Newly planted trees will eventually help to restore the evapotranspiration that was present before development. Amended soils in the landscaped areas have proved to be effective in retaining stormwater. The native wetland plants in the drainage swales also help filter and slow the flow of stormwater.

RESULTS

The SEA Street design resulted in reduced total volume of stormwater within its two-block, 2.3-acre area by 97 percent for two consecutive years. The project met its design goal of virtually eliminating stormwater for the level of storms that can

be expected to occur every two years. Residents of this neighborhood enjoy walking along SEA Streets because it is a natural, soft-edged environment, as opposed to the hard edges of traditional linear streets. More tree cover helps reduce summer heat while absorbing air pollutants and rainfall.

CHALLENGES

The street and sidewalk design required deviations from the city's building standards. The original design proposed to retain flows and allow infiltration into the native soils throughout the length of the block. This was not possible because part of the site had an existing problem with groundwater intrusion into basements. To limit the potential for stormwater to exacerbate these problems, some swales included an impermeable clay liner to divert stormwater away from problem areas.

COSTS

The budget for the project was \$800,000 and was funded by drainage fees. This included a more extensive design and communications budget due to the out-of-the-box nature of the project and the need to work closely with residents. The cost of future projects should compete favorably with the cost of traditional street improvement projects. City staff estimate the cost of future SEA Street prototype projects to be \$710,000, while an equivalent conventional drainage and street improvement project would cost approximately \$840,000. Staff are currently working on an improved SEA Street prototype design to lower construction costs.

CASCADE PROTOTYPE

SPU staff designed the Cascade Prototype to be used on steep, residential streets with high stormwater runoff from

watersheds of five to 50 acres in area. The design includes large cascading swales, sediment trap chambers and intensive vegetative cover. Traditional drainage infrastructure such as pipes, culverts and catch basins work in conjunction with more natural elements to create a balanced approach to drainage design.

Construction of the first Cascade project began in late 2002 on N. 110th, between Greenwood Ave. N. and 3rd Ave. NW. This project covers four blocks

and manages stormwater runoff from a 21-acre catchment area. The primary objectives of the Cascade prototype are to:

- Reduce the velocity of stormwater flow.
- Improve water quality.
- Decrease runoff peak flow and volume.
- Provide additional tree and vegetative cover.

SPU is moving forward with projects of both the SEA Street and Cascade type on 15 city blocks in 2003. These new projects will include a monitoring program for water quality and stormwater quantity and flow.

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Natural Drainage Systems website:
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The Cascade Prototype project at N. 110th St. after most of the construction has been completed and before planting.

Stormwater Treatment on Highway Slope Interstate 5 Tumwater to Maytown, Thurston County

BACKGROUND

Interstate 5 between Tumwater and Maytown in Thurston County originally had four lanes. By 1998, it was serving 50,000 vehicles per day and needed to be widened. Typically, such a project would require adding stormwater detention and treatment ponds. However, this section of I-5 runs through wetlands, and using additional wetland area for stormwater treatment would be problematic.

The Washington State Department of Transportation (WSDOT) and SCA Consulting Group solved this problem by developing a new stormwater management technique that treats stormwater on the side slope of the highway itself. The result is a low impact best management practice (BMP) that infiltrates the majority of the runoff from frequent storm events. This is a key principle of low impact development.

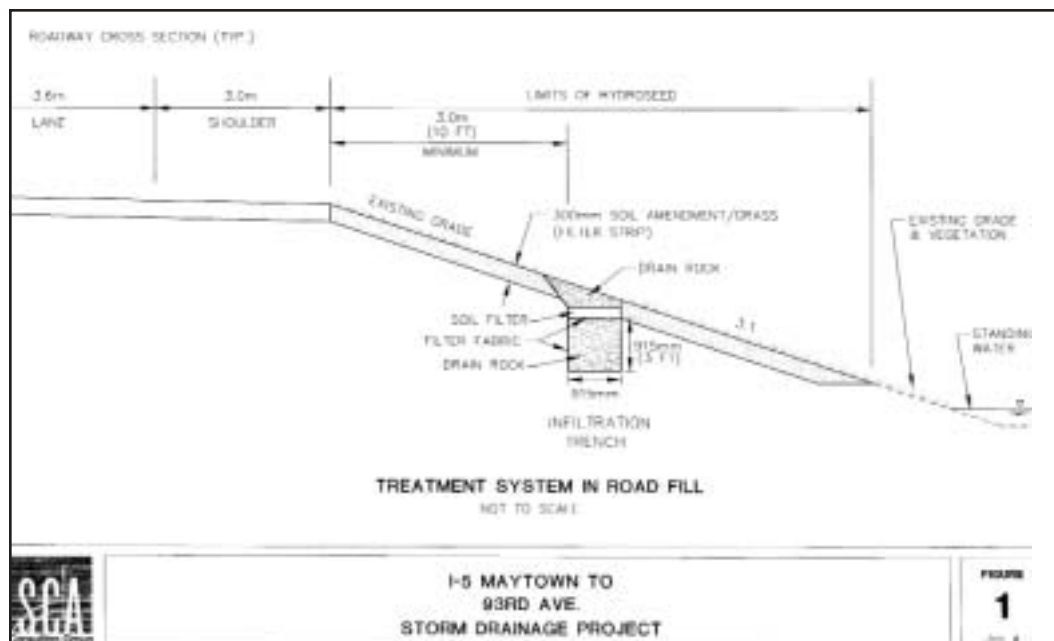
DESCRIPTION

The roadway for I-5 south of Tumwater runs through two miles of wetlands and is constructed on fill averaging about 6 feet. The widening project expanded the roadway into the existing median so it did not require additional right-of-way. However, the project still needed to provide stormwater treatment, and the adjacent wetlands limited available space.

Conventional alternatives would have involved expensive facilities such as pipe vaults or centrifuge manholes. These systems would require a lot of maintenance and closure of highway lanes for access. Furthermore, the data indicated that these devices would only be effective in treating runoff during low flow storm events.

To solve the problem, WSDOT and SCA Consulting Group created a new BMP using the highway side slope. The crew amended the soil on the slope with

Originally designed for water quality treatment, this system should also retain small storm events, according to SCA Consulting Group and the Washington State Department of Transportation.



compost and planted grass to provide pre-treatment of water leaving the road. Lower down near the toe of the slope, they constructed a shallow trench and filled it with a sand/gravel mix to provide final filtering. The existing fill slopes were about 1:6 (vertical: horizontal), making it difficult to keep the trench within the vertical limits of the fill, away from the shoulder and out of the wetlands. (Note: because steep saturated fill slopes can be unstable, the technique should not be used on slopes steeper than 1:3.)

RESULTS

WSDOT and SCA originally designed the new BMP as a water quality treatment system. However, the BMP has infiltrated nearly all the runoff for frequent small storm events. Because of the success on this site, WSDOT has adopted this BMP for use in future projects on state roadways that pass through wetlands. While there is no formal monitoring plan, WSDOT may perform monitoring in the future.

COSTS

Both the initial and maintenance costs should be significantly lower than for conventional systems. The system's designers hope that routine mowing will be the only maintenance required for the system.

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Tahoma Vista Ranch

Rainier, Thurston County

BACKGROUND

The Rainier Development Corporation is developing a large-lot residential subdivision called Tahoma Vista Ranch near the town of Rainier in Thurston County. Phase I of the project is under construction and contains nine 40-acre lots. Phase II will include 36 10-acre lots. Due to the large size of the lots, all runoff from structures can easily be infiltrated on-site. The remaining challenge is to design the access road for zero runoff.

DESCRIPTION

The Tahoma Vista site sits on a flat bluff overlooking the Deschutes River at 159th Ave SE and Vail Road. Design of the access road was a challenge because the site is very flat and mostly covered by shallow soils over hardpan (Class C, till soils). Several large wetlands on the site are not appropriate for discharge of stormwater. Traditional stormwater conveyance systems and ponds in this type of area with very flat gradients would require deep cuts into the hardpan.

SCA Consulting Group developed a low impact design road for the site that will feature bioretention swales on each side of the road. The treatment area of the swales will be 1.5 times the width of the road tributary to it. At the bottom of the swales, soil will be restored to a depth of 2 to 4 feet and planted with hydrophilic vegetation to treat stormwater runoff as it passes through the soil. Water reaching the till layer will infiltrate slowly through pockets or fissures in the till.

RESULTS

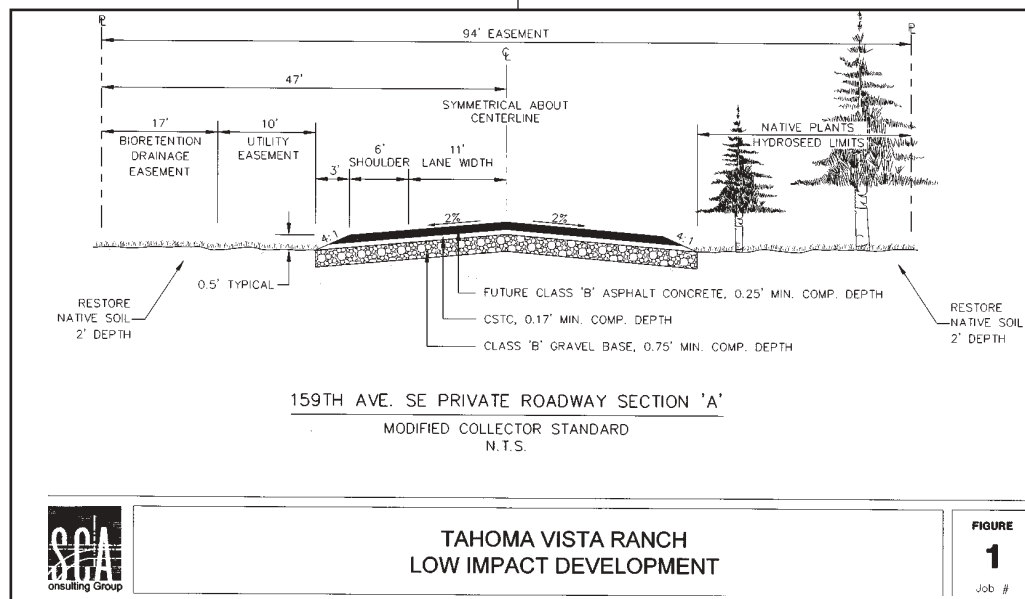
This best management practice should infiltrate 100 percent of all storm events up to the 100-year, 24-hour storm. Plans include beginning construction on the project in late 2002.

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SCA Consulting Group designed this system to infiltrate all storm events up to the 100-year, 24-hour storm.



Permeable pavement

Country Lanes Vancouver, B. C.

BACKGROUND

Alleys or back lanes in Vancouver, B.C. provide access to garages and are used for public services such as garbage pickup. Consequently, both passenger vehicles and heavy trucks frequently use these lanes. The city of Vancouver developed an environmentally sustainable "Country Lane" design that makes back lanes greener and more attractive. This alternative to paving asphalt lanes to full width is a response to the city's goal to reduce environmental impacts and to create a more livable community. The city also hopes to increase public awareness of stormwater issues.

DESCRIPTION

Country Lanes feature two narrow strips of concrete that provide a smooth driving surface. A plastic grid is placed between and beside these concrete strips and covered with topsoil and grass. This structural grass can support vehicles and prevents the grass roots from being compacted and creating ruts in the soil. The road base is a mixture of aggregate, which provides structural stability, and a sand/soil mixture that allows for drainage and provides the soil components required for grass growth.

RESULTS

Country Lanes provide several benefits:

- Controlling stormwater at the source means less change to stream hydrology.
- Surface water infiltration recharges groundwater.
- Topsoil filters pollutants naturally.
- Adding green space improves air quality.
- Replacing asphalt with grass reduces the "heat island effect," where warmer

temperatures occur due to pavement.

Vancouver is building three of these lanes as a demonstration project. With the success of these demonstration projects, this design will become available as a standard local improvement lane project.

COSTS

The costs are approximately 50 percent higher than conventional lane paving. However, as builders and regulators gain more experience with this approach, they will be able to refine the design and construction process and costs should drop.

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Preparing structural grass.



Vancouver Country Lane completed.

Pervious Paving Parking Lots Modification Project

The Evergreen State College, Olympia

*Zero Impact is a project that adheres to the 65/0 (65 percent forest cover preserved/zero effective impervious surface) development standard and is constrained by characteristics of a healthy watershed as described in the Salmon in the City Conference Abstracts.

BACKGROUND

New building construction at The Evergreen State College requires additional parking capacity. The philosophy of Evergreen is to reduce the impact of the campus on the environment with every maintenance or redevelopment project, wherever practical. In addition to reducing the environmental impact, "soft" drainage systems will provide monitoring and teaching opportunities for students in the college's environmental studies program. Based on a Zero Impact* Feasibility Study (see page 27), the college decided to intensify its use of existing parking areas rather than clearing more forest.

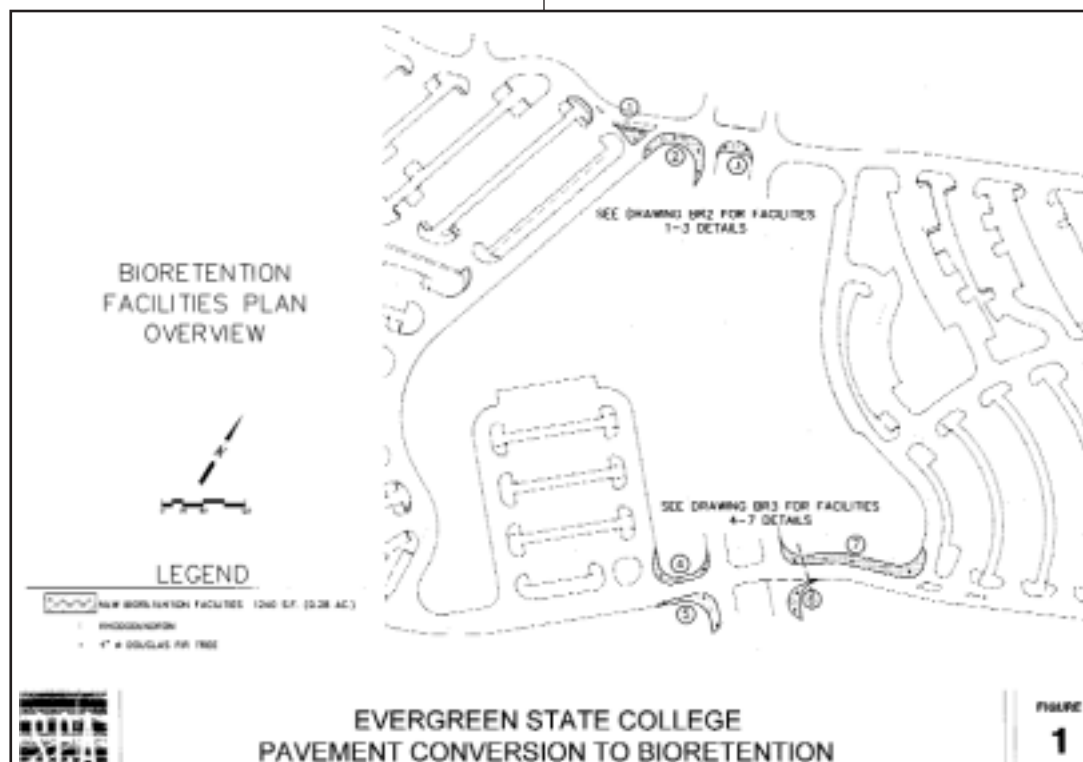
DESCRIPTION

The Parking Lots Modification Project will provide additional parking in lots B and C on either side of the main entrance to the campus. Runoff from the parking lots

currently discharges to the East Fork of Houston Creek without treatment or detention. The innovative design adds new parking by removing and reshaping planting islands and reorganizing lanes. Pervious paving systems will replace approximately 34,000 square feet of existing landscaping for new parking stalls. The combination of adding new pervious paving and converting existing paving to pervious surfaces will result in a net reduction of runoff to Houston Creek.

The paving bid package includes three alternative paving systems, including EcoStone® by UniGroup, Gravel Pave 2™, and a system of crushed rock with cellular confinement. The design for the pavement includes infiltration to the subgrade and storage in rock ballast under the pavement. The objective is to infiltrate the 100-year, 24-hour storm without surface

Approximately 9,000 square feet of impervious parking area at The Evergreen State College will be converted to bioretention areas (numbered in plan at right).



runoff. A sand filter providing water quality treatment is located directly below the paving system.

Approximately 9,000 square feet of parking lot access lanes will be converted to bioretention facilities. The design provides for soil restoration to a depth of two feet. The objective is to provide bioretention areas with sufficient surface and subsurface storage volume to infiltrate runoff from all events up to the 100-year, 24-hour storm.

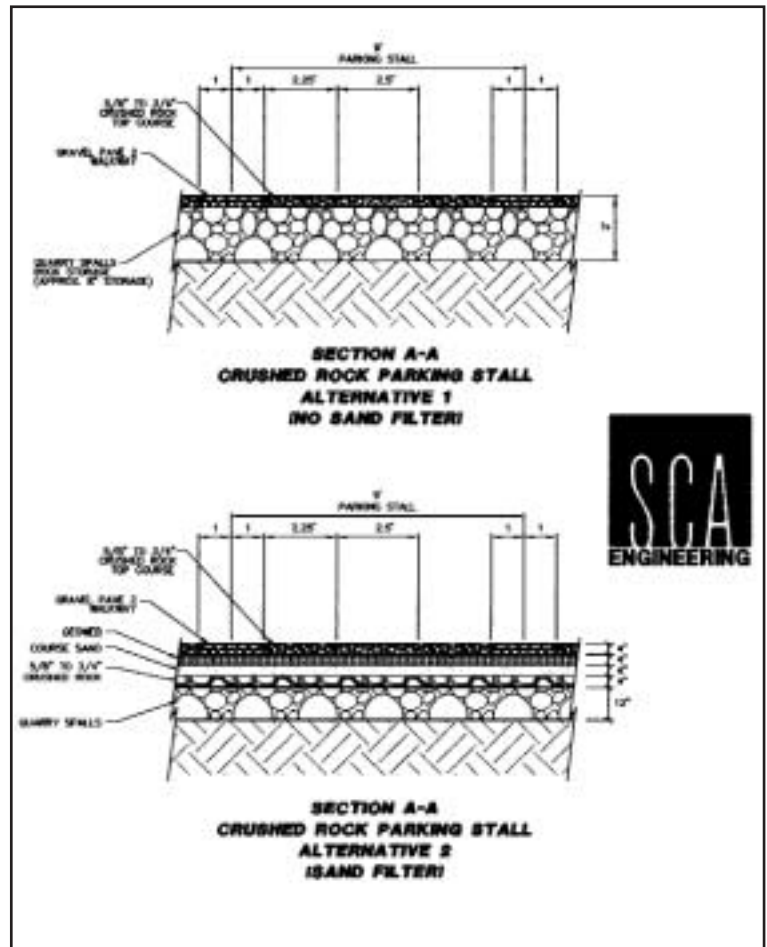
Evergreen may also build a motorcycle parking structure with a vegetated roof that will be a study focus for students in the environmental studies program. The motorcycle port will have approximately 6 inches of soil on the roof with plants selected for their tolerance to extreme wet and dry conditions.

CHALLENGES

One complication of the project was old fill material found under the existing pavement. Because it is unsuitable for pavers or bioretention facilities, contractors had to remove and dispose of it. This cost would not have occurred with the asphalt paving alternative.

COSTS

The cost of the zero discharge parking retrofits is the same as, or lower than, traditional alternatives using new treatment and detention systems. Costs for green roofing will be higher, but the increased life of the roof will help offset these costs. An important factor in choosing the pervious paving systems is that this approach negates the need to clear and grade surrounding forest areas for detention ponds.



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Pervious paving materials vary according to the intensity of use in parking lots. In the above diagram, a cellular confinement system stabilizes a parking surface of crushed rock.

Grass Parking Lot and Performance Area Whidbey Island and City of Bellingham

BACKGROUND

A farmers' market and community hall at Bayview Corner on Whidbey Island needed weekend parking. 2020 Engineering designed a reinforced grass pavement system that makes the area look like open space when not used for parking.

In Bellingham, the owner of the Boundary Bay Brewery wanted to expand the winter parking area and to provide a summer beer garden and performance area.

DESCRIPTION

The grass parking lots use an interlocking plastic grid (GeoBlock™ at Bayview Corner and Grassy Pavers™ at Boundary Bay Brewery). The grid was filled with a mixture of sand and chicken compost and planted with grass.

RESULTS

The parking lot designs meet standards for traditional traffic loading. The grass parking replicates natural conditions for slowing and infiltrating stormwater runoff and eliminates the need for conventional detention/treatment systems.

COSTS

The cost for both lots was \$3 to \$4 per square foot, installed.

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Grass parking lot design meets standards for traditional traffic loads and resembles open space when not used for parking.



Bayview corner, Whidbey Island. Top photo: after construction. Lower photo: during construction.



Boundary Bay Brewery, Bellingham. Top photo: during construction. Lower photo: after construction.



Pervious Concrete

Multiple Locations

BACKGROUND

Builders have used pervious concrete nationally for more than 20 years. In the 1980s, several projects used pervious concrete in the Puget Sound basin, including at Husky Stadium and at a park in Redmond. In recent years, builders have used pervious concrete in several new projects and more are planned.

DESCRIPTION

Pervious concrete is a special structural concrete with the fine particles removed. This creates 15 to 20 percent voids so the concrete looks like a giant rice cake. The pavement will support traffic and allow water to pass through to a gravel layer underneath. The strength of pervious concrete is about 85 percent of conventional concrete, making it suitable for sidewalks, driveways, alleys, parking lots and residential streets. Designers and installers need special training to ensure structural integrity and porosity. Post-placement testing is important.

Pervious concrete is much more porous than underlying soils. Typical infiltration rates are 250 to 300 inches per hour; typical installations require soils with percolation rates of more than 1/2-inch per hour. A gravel bed placed underneath the concrete stores water before it moves into the soil or can provide a channel for movement of water to stormwater channels. A 4-inch bed of rock or aggregate 3/4 inches or larger with 30 percent voids will store 1.2 inches of water. In addition to its water quantity benefits, pervious paving can remove some pollutants through absorption, straining and microbial decomposition.

Following are some of the locations of recent pervious concrete installations around Puget Sound:

- Four blocks of sidewalks on N. 145th Street, Seattle.
- 400 feet of sidewalks at 100th Ave., Marysville.
- Six parking lots at Fort Lewis.
- Sidewalk on North Street in Olympia.
- Plaza at Greenwood Park, Seattle.
- Alley in Bellingham.
- Parking lot for the Washington Aggregates & Concrete Association office, Des Moines.
- Nine parking spaces at Bayview Corner, Whidbey Island.

Planning is currently underway for a residential subdivision to demonstrate the usefulness of permeable concrete for residential streets, driveways and sidewalks.

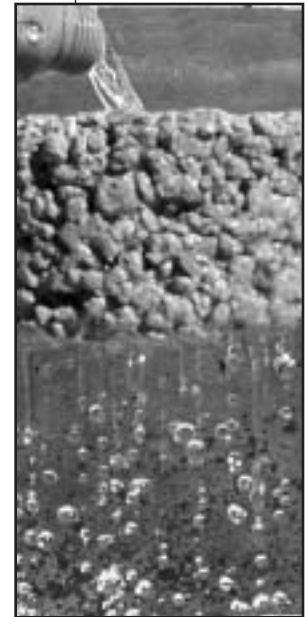
COSTS

The cost for pervious concrete is typically \$6 to 9 per square foot. This is comparable to conventional concrete.

CONTACTS

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(Photo courtesy of Greg McKinnon)

Pervious concrete infiltrates water extremely well—typically 250 to 300 inches per hour.

Pervious Concrete Alley

City of Bellingham

BACKGROUND

A residential homebuilder was interested in sustainable construction and decided to try pervious paving in an alley that provides access to homes. This was the first application of a pervious concrete roadway in a Whatcom County right-of-way.

DESCRIPTION

The alley provides access to two residential properties while minimizing environmental impacts. Porous concrete allows for the infiltration of stormwater runoff while providing the same structural capacity as conventional concrete. Engineers determined the depth of the crushed rock base material—used to support the concrete—based upon the

type of underlying soil conditions and amount of water storage area needed to accommodate storm events. No fine materials were used.

Since this project was the first of its kind, the city of Bellingham wanted to know about durability, load, treatment and maintenance requirements.

RESULTS

Stormwater treatment occurs as water flows through the pervious concrete road section and underlying soils. Other characteristics, such as maintenance issues, are comparable to conventional pavement systems. The engineer used the Department of Ecology's *Stormwater Management Manual for Western Washington* as one of the guides to document the stormwater infiltration benefits of the project.

COSTS

Materials cost approximately \$1.50 per square foot. Installation costs were similar to conventional paving.

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Pervious concrete alley, Bellingham.

Pervious Driveway

City of Bellingham

BACKGROUND

Stormwater runoff causes pollution in the Lake Whatcom watershed in Bellingham, as it does in many other developed areas. Because Lake Whatcom is the sole source of drinking water for the city of Bellingham, this can have serious consequences for the city's drinking water supply. A homeowner in the watershed wanted to demonstrate alternative sustainable building practices and decided to replace the existing impervious asphalt driveway with a pervious one.

DESCRIPTION

The homeowner installed a pervious paving system composed of individual interlocking paving blocks placed on a bed of fine gravel. The configuration of the pavement blocks provides a series of voids to allow stormwater to infiltrate.

RESULTS

The new driveway has better structural properties than the replaced asphalt surfaced driveway. The pervious paver system replicates natural conditions for stormwater infiltration, provides treatment, and eliminates the need for conventional detention/treatment systems. The homeowner reports a significant reduction in the volume of stormwater flowing down the driveway and into the lake.

COSTS

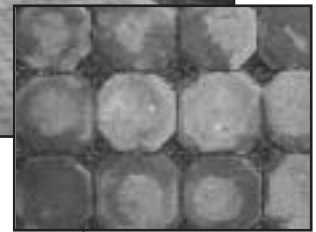
The cost was approximately \$5 per square foot installed.

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Pervious driveway,
Bellingham.



The pervious paver system replicates natural stormwater infiltration, provides treatment and eliminates the need for conventional detention/treatment systems.

Rooftop rainwater harvesting

King Street Center City of Seattle

BACKGROUND

King Street Center, at 201 S. Jackson Street, began as a typical office building project in downtown Seattle. However, the King County Department of Natural

Resources and Parks, a major tenant, asked that the building include environmentally friendly and sustainable approaches in its design, construction and operation.

Completed and occupied in

September 1999, the 327,000-square-foot building houses 1,600 employees of the county's Department of Natural Resources and Parks and Department of Transportation. The center serves as a model and testing ground for sustainable

practices and materials, including a system that collects stormwater and uses it within the building.

DESCRIPTION

In a first for a commercial building in Seattle, the King Street Center collects

rainwater to flush its 105 toilets throughout the year. The unique and innovative system is designed to collect

rainwater from the building's roof to fill each of three 5,400 gallon tanks. The water fills and passes through all three tanks and then small cylinders filter the water as it is pumped to toilets in the building through separate piping. If there is not enough rain to meet the building's flushing needs, the system automatically adds domestic water to the tanks. In addition, water diverted from the reclamation system fills much of the building's landscaping needs.

RESULTS

Since rainwater is dumped into the city sewer system, King County is capturing water that would otherwise be wasted and avoids significant loadings to the sewer system. The building uses approximately 2.2 million gallons of flushing water per year. The new system saves an estimated 1.4 million gallons of water per year, meeting over 60 percent of the building's estimated annual water needs.

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Take a virtual tour on King County's website: dnr.metrokc.gov/dnrp/ksc_tour/



Rainwater collection system saves an estimated 1.4 million gallons of water each year.



Collected rainwater irrigates landscaping and also flushes the building's toilets.

Residential Rainwater Collection and Use

San Juan Island

BACKGROUND

One method of reducing stormwater runoff and minimizing the strain on aquifers is collection and use of rooftop rainwater. Several major building projects in Puget Sound incorporate rainwater harvesting and use systems. (See King Street Center, opposite page, and Seattle Justice Center, page 24.) Some homeowners are also installing rainwater collection systems in residential homes, including using rainwater as a potable water supply, primarily in San Juan County where water shortages are a major concern.

DESCRIPTION

In the past four years, Northwest Water Source has installed 60 rainwater collection and use systems. Forty-eight of these provide drinking water and two serve homes that had access to community water supplies but chose not to connect to them. Northwest Water Source is also installing pilot systems in Seattle.

Depending on the design of a rainwater collection system, a variety of issues need to be resolved. These include: design of the collection and storage systems, disinfection, pumping, filtration, stormwater infiltration and groundwater recharge. Aboveground tanks can be made of polyethylene or galvanized steel with a polypropylene liner. Underground storage tanks can be made from polyethylene, fiberglass, or cement. Installers should choose roofing material based on how the rainwater will be used. Rainwater collected only for non-potable use such as irrigation, requires installers to avoid materials that can leach zinc or copper, which can damage landscape plants. Rainwater used for drinking purposes requires choosing roofing



material carefully. Vendors of catchment systems have information on the best materials to use for specific collection purposes.

Storage tanks installed.

One house on San Juan Island provides a typical example. The house sits on a small lot, and seawater has contaminated the site's water supply well. With desalinization, delivered water, and rainwater collection as the only available

Steel roof with drain to storage tanks under deck.



Residential Rainwater Collection, *continued*

alternatives, the homeowner chose rainwater collection. Northwest Water Source designed the system to provide for the water needs of two people at 60 gallons/day/person, with storage for the 90-day dry summer period. (Northwest Water Source has a spreadsheet available on request for calculating a home's water budget.) The system will produce excess water during the wet season.

Storage tanks with a total capacity of 10,000 gallons collect rainwater from a 1,300 square foot standing-steam, enameled steel roof. The water passes through a filtration system before entering the storage tanks. Water pumped out of the tanks flows through a final sediment filter and a carbon block filter before treatment by a NSF-approved ultraviolet disinfection system.

San Juan County required the developer to get a water availability permit to acquire a building permit. The designer submitted a design for the rainwater collection system to the county health department, which signed off on the system as meeting the guidelines for an alternative water system. However, the county doesn't want legal responsibility for ensuring that systems are operated properly so they don't inspect the installations. The county does require that a restrictive covenant be recorded on the property deed along with a system

diagram, water budget, maintenance and operations sheet, and list of materials used in construction. This ensures that potential buyers are fully informed about the system and know how to take care of it. Homeowners are solely responsible if systems are not maintained according to the guidelines and recorded documents.

COSTS

The cost of this system was \$10,000 and operating costs will be around \$500 per year for new filter cartridges and ultraviolet bulbs. Electricity costs will be the same as for a well pump. Northwest Water Source estimates the cost of an average-depth well in San Juan County to be 75 to 90 percent of the cost of a comparable catchment system, if the well water is not very hard or contaminated.

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Seattle Rainwater Resolution

Seattle

DESCRIPTION

In April 2002, the city of Seattle adopted Resolution 30454 on wastewater reuse and rainwater reclamation. While the major purpose for the resolution is to deal with water supplies, it provides additional benefits for reducing stormwater runoff. The resolution calls for addressing a number of issues relating to reuse of wastewater and rainwater, such as considering the full cost of reclaimed water, cost recovery, emerging state and national policy, and the effects on public health and the environment. The resolution also directs Seattle Public Utilities (SPU) to recommend changes to the city's land use and building codes that would encourage these programs and technologies.

City officials are considering several demonstration projects to test how to educate the public about water reuse and reclamation. City staff will survey near-term water reuse/reclamation opportunities and identify at least one rainwater reclamation demonstration project.

Several projects under consideration include a pilot program involving installing cisterns in up to 24 households to capture rooftop rainfall and slow its

release into the stormwater system during the winter. In late spring and early summer the cisterns would retain water for garden irrigation during the dry season. As many as half of these households may test toilet-flushing systems using the captured rainwater. SPU is also looking at larger-scale rainwater capture at Sand Point Magnuson Park where the water would be used for a community garden, and the utility is looking at possible rainwater harvesting for irrigation around multi-family projects.

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To view the entire text of the resolution, visit the city's web page at:

www.seattle.gov.

Under the "City Council" section on the right, select "Legislative Search." Then select "Resolutions" and enter the resolution number, 30454.

Low Impact Foundation Technology Multiple Locations

BACKGROUND

In 1992, Pin Foundations, Inc. built a boardwalk for the Hood Canal Wetlands Preserve that was supported on piers installed without digging or heavy equipment. Since that time, Pin Foundations has been developing and testing a residential construction system

DESCRIPTION

L.I.F.T. requires little or no excavation. Sections of foundation wall are poured at grade and “pinned” into the ground using heavy-duty steel pins that extend deep enough to support the structure and prevent uplift. Grading is left to smaller equipment that simply “feathers” the existing surface soils without having to strip them all away. Lot-by-lot compaction is all but eliminated.



Homeowners in Olympia install a Low Impact Foundation Technology (L.I.F.T.) system as an alternative to a conventional foundation.

based on the same low impact technology. Pierce County gave broad approval to the system in 2001. Builders are using this technology to install additions and detached single-family homes at Fox Island, Bainbridge Island, Olympia, Tacoma, Key Peninsula and Gig Harbor.

BuildingGreen, Inc., publisher of the *GreenSpec® Directory and Environmental Building News*, recently named Low Impact Foundation Technology (L.I.F.T.) as one of the top ten new green building products.

The advantage of the L.I.F.T. system for stormwater management is that the native soil structure continues to absorb and process rainwater. Runoff from roofs can be directed back into perimeter soils. Depending on the characteristics of the site, detention ponds, drywells and piping can be reduced in size. Less digging also reduces the size and impact of spoils piles and their contributions to erosion. Leaving healthy upper soil layers allows for better plant or sod growth that can also reduce the erosion potential of developed soils. Pin Foundations has created a mathematical model for civil engineers to use in calculating the volume of flows restrained in surface soils that are not compacted, and has conducted a case study to verify the values.

Homes built on L.I.F.T. foundations have conventional framing, floor plans and exterior styles. The framer works from a typical level concrete sill with familiar anchor bolting and earthquake strapping. Crawl spaces with standard plastic vapor barriers are vented in the typical manner,

and garage slabs are compacted and poured in the conventional way. The system is applicable for lot slopes up to 10 percent grade, and can be used in almost any penetrable soil.

Each building site has different conditions, so the specific configurations vary:

- **Gig Harbor:** A two-story home did not require grading or site manipulation, and builders poured the foundation to follow the grade of the site.
- **Key Peninsula:** Builders used a feathering approach where they bladed off surface sod. Soils shaped in benches and differing in height by just 4 inches were stepped down a 4-percent grade. Here the underlying soils were silts, which tend to be poor for conventional footings, especially when they become wet and soft.
- **Fox Island:** The goal on this low-bank beach was to avoid digging a conventional foundation pit that would trap water during flood tides.
- **Olympia:** Builders put in an addition to a home designed to minimize the disturbance to existing lawn, gardens and patio.

COSTS

L.I.F.T. is comparable in cost to conventional systems. L.I.F.T. systems use 20 to 30 percent less concrete, reduce the amount of site materials such as drain



pipe and imported gravels, and reduce trucking, excavator and bulldozer time. In one of the houses mentioned above, the L.I.F.T. system cost 5 percent more than the conventional system. Housing projects with 10 or more homes will realize the most substantial savings of the L.I.F.T. system.

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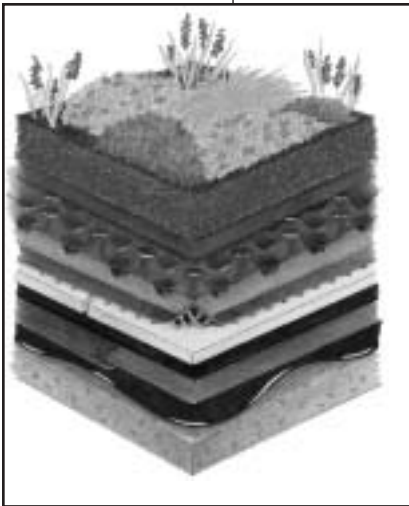
Website: www.pinfoundations.com

L.I.F.T. foundation installation at Habitat for Humanity on the Key Peninsula.

Justice Center Green Roof City of Seattle

BACKGROUND

The city of Seattle needed to replace the old Public Safety Building, which was seismically deficient and near the end of its useful life. Its replacement, the Justice Center, is one of the first city projects built to conform to the city's Sustainable Building Policy. To provide stormwater control and other benefits, a green roof—or living roof—was included in the design.



Graphic Courtesy of American Hydrotech

The green roof is made up of a multilayered waterproofing membrane that's integrated with a soil support system. The egg carton-shaped water retention liner helps retain moisture in the shallow soil between rainfalls.

DESCRIPTION

The Justice Center green roof consists of a multilayered waterproofing membrane integrated with a soil support system. The first layer in the system is the waterproofing component. Installed over a prepared roof surface, it is a

flexible monolithic membrane composed of refined asphalts and synthetic rubbers. An extra layer of fabric reinforcement is included between two membrane applications. Additional layers over the waterproofing form the integrated soil support system, which comprises the root barrier, insulation, water-retention liner, filter fabric and a lightweight planting soil.

The egg-carton-shaped water-retention liner helps to retain moisture between rainfalls. Shallow cups hold water and alleviate some of the harsh conditions of the rooftop environment that can quickly

dry because of the shallow soil profile. Rainwater not retained by the soil or water-retention liner flows through holes in the peaks of the liner cups, eventually making its way into subsoil runnels. The water then combines with runoff from the non-landscaped roof area and flows to a water-storage facility at street level. Captured rainwater irrigates landscaping at the base of the building.

The roof system plants will require little or no maintenance. The plants are drought resistant and do not require additional watering, fertilizing, mowing or pruning. With sustainability a top design criterion, designers rejected the idea of an irrigation system for the green roof. Hose bibs located nearby aid in establishing the plants for the first few years.

Green roof systems are generally divided into two categories: extensive and intensive. The Justice Center uses an extensive system, which is characterized by shallow soils typically 3- to 6-inches deep. The weight of an extensive system with saturated soils is not much heavier than that of conventional rooftop ballast applications, making additional structural support systems unnecessary.

An intensive green roof differs from an extensive green roof primarily in soil depth. Intensive green roof soils are deeper than 6 inches, allowing for larger plants. The additional soil produces a heavier roof load, which often requires additional structural support.

BENEFITS

The green roof's soil layer has a sponge-like quality. It will hold a significant quantity of water, as well as releasing water that it can't hold more slowly than a conventional roof. The slower release smooths out or attenuates peak stormwater rates. Evaporation from the soil surface and transpiration by the plants will further reduce the total volume of water that flows from the roof. In the case of the Justice Center, water that does flow from the roof will be stored for irrigation at street level, reducing the total load to the city stormwater/sewer system.

The green roof also provides benefit in energy savings. Thermal insulation provided by the soil layer slows heat transfer to the structure in the summer and reduces heat loss in the winter.

Life-cycle analysis suggests that the waterproofing for a green roof will last longer than that of a conventional roof. By protecting the waterproofing from ultraviolet degradation, mechanical puncture and temperature extremes, green roofs are less susceptible to heat damage and cracking.

The green roof also provides potential fly-over habitat for birds, and reduces localized heat gain caused by dark, heat-absorbing roof surfaces. The green space will be a welcome environment for staff, visitors, and jurors, turning a former stormwater problem into a building amenity.



Photo Courtesy of SvR Design Company

The Justice Center's 12th-floor plaza transforms what would have been a conventional flat roof into a living system that will absorb rain and provide a rooftop oasis.

CONTACTS

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New and redevelopment projects

Bayview Corner Whidbey Island

BACKGROUND

Goosefoot Community Fund is dedicated to preserving rural character and historic features and promoting sustainable development on Whidbey Island. To demonstrate non-traditional and sustainable development strategies, the fund developed a rural office and retail hub and learning center at Bayview Corner, on the southern part of the island.



The public restroom at Bayview Corner near Langley on Whidbey Island uses a number of cutting-edge sustainable design features.

DESCRIPTION

The fund constructed a public restroom facility from reclaimed and recycled materials to demonstrate cutting-edge sustainable building design. The building features solar panels, a 90-gallon rooftop water collection system, composting toilets, waterless urinals and gray water processing. Fund managers estimate that

these practices save 10,000 to 15,000 gallons of water each year.

A renovated 1914 Sears Kit House demonstrates innovative techniques such as a Rastra® foundation, which uses insulated concrete forms made from recycled Styrofoam; old-growth redwood wainscoting milled from a salvaged water tower; and pervious concrete parking for nine parking spaces. For the permeable parking lot, they used a mix similar to regular concrete, but without the sand. This leaves air spaces in the slab, allowing water to pass through to the soil below.

CHALLENGES

Part of the challenge in building these demonstration projects has been satisfying government permit requirements. Quite often, systems such as a septic system for the composting toilet building have been overbuilt to meet current building codes and have incorporated devices to monitor any usage. As a result, it is difficult to make any cost comparisons to traditional projects. As trust and relationships develops with regulators, projects will move more quickly and costs should decrease.

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The Evergreen State College Zero Impact Feasibility Study City of Olympia

BACKGROUND

The Evergreen State College on the outskirts of Olympia has 4,500 students on a 1,000-acre campus. The campus's storm drainage system—built before current standards—has no treatment or detention systems. In 1998, the college adopted a stormwater goal in the master plan: “For planning purposes the college should try to limit runoff on campus by minimizing hardened surfaces and maximizing undisturbed forest.”

Evergreen then obtained a grant from U.S. EPA Region 10 to study the feasibility of disconnecting the college's storm drains from the streams around the campus. The campus seemed a good candidate for this study because the campus has 70 percent forest cover area, which is greater than the recommended minimum for “zero impact”* projects.

Prior to the study, there was no visible damage to streams in the area, in spite of the lack of stormwater treatment or detention. However, part of the campus discharges to Green Cove Creek, which the city of Olympia and Thurston County have singled out for special protection. Part of the campus also discharges to Houston Creek, a productive salmon stream. College officials also wanted to do the study to foster sustainability, to provide an example for the community, and to provide a teaching opportunity.

DESCRIPTION

The college hired consultants to inventory stream conditions and review existing studies on fisheries and water quality. Consultants also reviewed the college's comprehensive plan and capital improvement program and engineering studies of campus soils, groundwater,

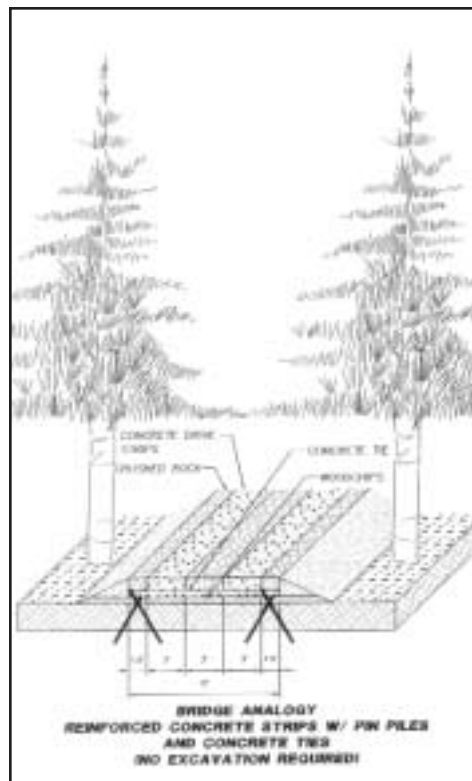
geology and infrastructure. They produced two kinds of analyses:

- How to introduce zero impact development design to new structures.
- How to retrofit existing development during the course of major redevelopment projects.

The study identified five areas for the use of low impact techniques: roofs, parking, roads, walkways and landscaping.

Recommendations include:

- **Roofs.** Use of infiltration, collection and green roof systems.
- **Parking.** Alternatives include adding stormwater storage under parking areas and in landscape strips, and reducing impervious surfaces through use of pervious paving.



***Zero Impact** means a project that adheres to the 65/0 (65 percent forest cover preserved/zero effective impervious surface) development standard and is constrained by characteristics of a healthy watershed as described in Salmon in the City Conference Abstracts.

Road design concept that requires no excavation.

Evergreen State Feasibility Study, *continued*

- **Roads.** Use of pervious pavement, directing drainage to adjacent forests, amending the soils of side slopes, and disconnecting drainage from streams. Recommendations included new road design concepts, some of which did not require excavation of existing soils for their construction.
- **Walkways.** Many campus walkways serve more as architectural statements than transportation. Alternatives include removal, replacement with pervious walks, placing pervious buffers around catch basins, expanding planters, and adding grass-roofed covered walkways.
- **Landscaping.** While there is comparatively little formal landscaping on campus, the study recommended that some landscaped areas could be converted back to natural forest, with amendment of soils to repair compacted areas.

RESULTS

The college has begun to implement the study by including a garden roof on its new Seminar 2 building (construction

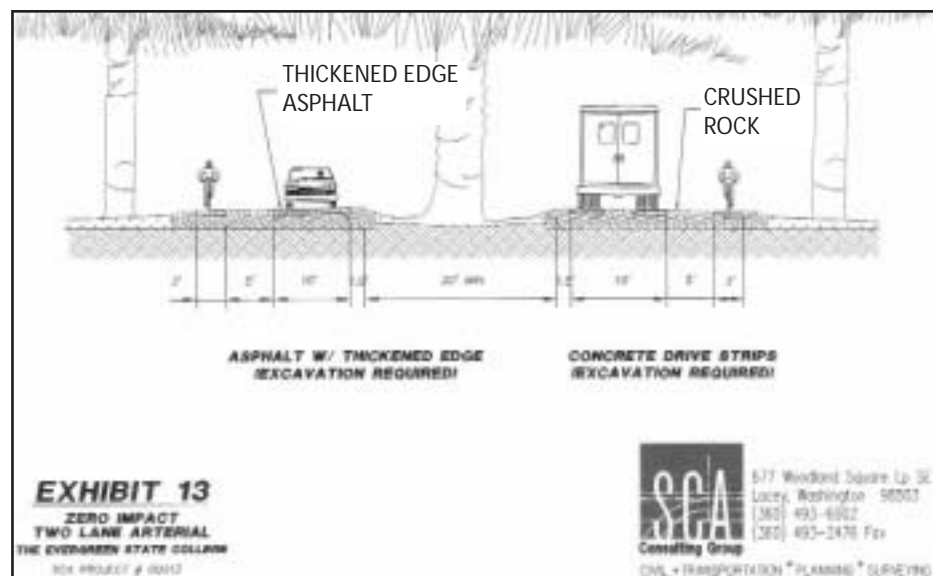
began in 2002). Soon, the college will rebuild portions of its parking lot using pervious pavement systems and may build a motorcycle parking structure with a vegetated roof. This would be a study focus for students in the environmental studies program.

COSTS

The study estimated that the costs of zero impact roads and stormwater systems would be as much as 60 percent lower than traditional high impact systems. Conversion of car parking to pervious pavers would be the same as or lower than traditional alternatives, which require expensive new treatment and detention systems. Green roofing would be more expensive, but the life-cycle cost might be lower.

An important factor in choosing the pervious paving systems is that this approach negates the need to clear and grade surrounding forest areas for detention ponds. Implementing the study's recommendations has an additional benefit to the public because the drainage system

New road design concept for arterial roads features narrow roads and permeable shoulders.



could eventually be disconnected from the local stream system.

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High Point Natural Drainage Systems Study City of Seattle

BACKGROUND

Starting in 2003, the Seattle Housing Authority (SHA) will begin construction of a 120-acre mixed-income housing development in West Seattle. The development will include a new street grid complete with new utilities, sidewalks, and trees. Plans call for a natural drainage system to be integrated into the new street layout, creating a network of connected, vegetated and grass-lined swales. The site comprises one-tenth of the Longfellow Creek watershed, and this project is a once-in-a-lifetime opportunity to provide neighborhood enhancements and improve the health of the creek.

DESCRIPTION

Longfellow Creek watershed started feeling the effects of development in the early 1900s. Physical barriers, piping of sections of the creek and pollution reduced the return of chum, coho and chinook salmon. In recent years, the removal of barriers and development of the Legacy Trail along the creek corridor increased fish and wildlife populations and promoted community stewardship of the creek.



Now SHA and Seattle Public Utilities (SPU) are going to the source of the problem by completely changing how they manage stormwater in the High Point neighborhood of West Seattle. Currently, a series of underground pipes collect stormwater and discharge it directly to Longfellow Creek, polluting its waters. SHA and SPU will redevelop the existing drainage system in this neighborhood with a new naturalistic approach. The approach to redeveloping the High Point neighborhood will provide guidelines for future construction of

A naturalistic approach to planning features a network of grass-lined and vegetated swales.

High Point Study, *continued*

publicly and privately funded homes. High Point will feature 1,600 primarily low-rise rentals and owner-occupied homes on 120 acres.

Throughout 2002, SvR Design Company worked with the city, SHA, SPU, the Seattle Department of Transportation, and the community to develop a menu of natural drainage system options tailored to the needs of each neighborhood block. These options balance “people space” (playable space and garden walks) with stormwater management (infiltration, filtering and flow control). A network of grass-lined and vegetated swales will filter and moderate water flows entering the creek. This will reduce discharge of pollutants, decrease erosion, stabilize the creek water temperature, and ultimately improve the habitat for salmon and other wildlife in Longfellow Creek.

EXPECTED RESULTS

This new drainage approach will function as a natural system by increasing infiltration, improving water quality, and decreasing the volume and rate of runoff from the development. Rain falling on pavement will flow into the swales where vegetation will slow the water. Soils, amended with organic material to mimic a

natural forest duff layer, will increase the rate of infiltration and water-holding capacity. Pollutants, pesticides and animal waste will be absorbed into vegetation and onto soil particles. Gravel under the modified soils will improve infiltration and increase water retention capacity. During smaller storms, rainwater will slowly infiltrate into the soils and eventually into the groundwater. During larger storms, water flow will be slowed before entering the creeks, thus reducing flooding and erosion of stream banks. SHA and SPU will also provide design guidance for amending the soils on homesites to reduce runoff from roofs and lots into the swale system.

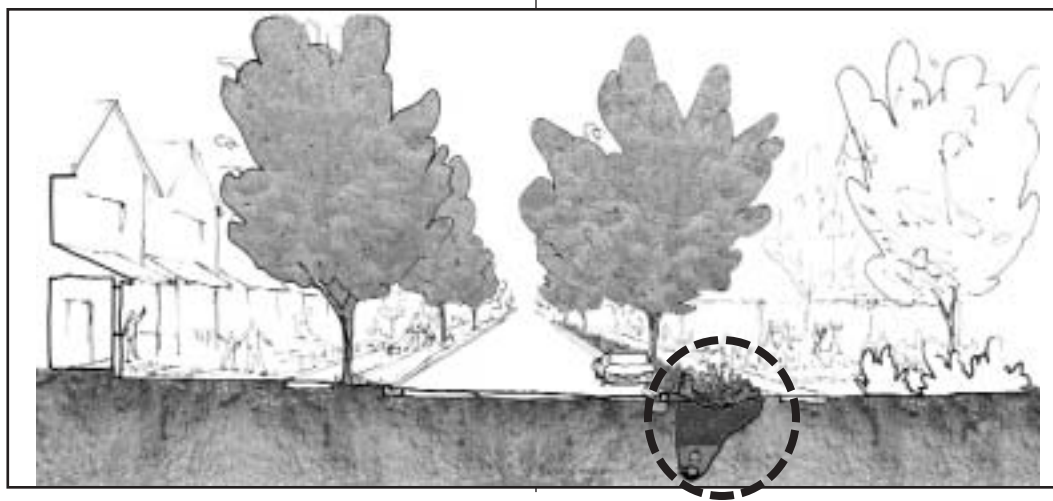
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Bioretention swales (circled) will treat, reduce and slow stormwater runoff from impervious surfaces and function as a natural system.



Low Impact Development Program

City of Chilliwack, British Columbia

BACKGROUND

The city of Chilliwack, east of Vancouver, British Columbia, has a population of 70,000 and covers 281 square kilometers (108.5 square miles) and nine watersheds that drain primarily to the Fraser River. Most of Chilliwack sits on the valley floor, but there is pressure to develop on the steep hillsides. The city decided to promote low impact development to address growing problems with flooding, and to protect habitat and water quality, enhance salmon streams, and recharge ground water.

DESCRIPTION

City officials adopted an integrated master drainage plan that incorporates a development philosophy and design standards based on LID technologies. One objective of the plan is to “manage development to maintain stormwater characteristics that mimic the peak flows, duration of flows and water quality in the pre-development watershed.”

City staff are working with developers to incorporate several low impact design principles, such as smaller lot sizes, narrower roads, and elimination of curbs, gutters, storm drains and sidewalks. Many developers are reluctant to use the principles for fear of not being able to market the lots. However, several developers have agreed to incorporate LID, and this experience will be instructive.

The developer built the **Peach Road Subdivision** with small lots, a narrow road and no storm drain for the street. Roof runoff goes into the yards and then drains to a surface swale for infiltration. The road has no storm drain; water runs down the road to an infiltration gallery. A major rainfall in January 2002

overwhelmed the capacity of the infiltration gallery, leading to some flooding and damage to a few houses. Although the developer remains committed to low impact development, he is building a detention pond on an adjacent subdivision to handle the largest storm events.

Suncor Developments is another residential development following LID principles. Twenty-two lots, built as of December 2002, feature narrow roads, no sidewalks, and no curb or gutter. Road runoff flows to an infiltration gallery.

The **Russel Heights Townhouse Project** is located on a challenging site with steep slopes. Runoff from the lots will be directed to a large green area for infiltration. Road runoff will be directed to an infiltration gallery that will provide detention for medium storms. Large storms will bypass the infiltration gallery.

The city plans to install monitoring stations at each of these residential housing projects to monitor both runoff volume and water quality chemistry. Chemical parameters will include temperature, turbidity, dissolved oxygen, and pH.

Monitoring for two other LID projects will also begin in the coming year. Stream International has an existing 800-stall parking lot that discharges into an adjacent stream. After negotiations with the city, Stream agreed to help build an



The Peach Road subdivision in Chilliwack, B.C. features small lots, a narrow road and no storm drains in the street.

Low Impact Development Program, *continued*

infiltration gallery on adjacent city property that will serve Stream as well as some other properties. At Village at Sardis Park a major green space will serve as an infiltration system and detention facility for road runoff.

COSTS

Development costs for the LID residential projects are approximately \$800 (Canadian) higher per lot than for

conventional systems. The higher costs are due to requirements for redundant stormwater facilities in case the LID facilities don't perform as expected.

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Meadow on the Hylebos Residential Subdivision Pierce County

BACKGROUND

Pierce County is working with a developer and AHBL Engineering to bring low impact development technologies to the Meadow on the Hylebos—a sensitive residential development site in north Pierce County.

The site is located on an important stream system—the Hylebos Waterway. The intent of the project is to use a variety of LID technologies to demonstrate the potential benefits to managing runoff volume and protecting water quality. Due to the proximity to the Hylebos Waterway, the technologies also offer the potential to enhance wildlife values by preserving and reintroducing native vegetation.

Another project objective is to deliver a housing product that is attractive and affordable. The Meadow on the Hylebos establishes a design process and forum through which the developer and Pierce County can cooperate, understand

challenges, and develop a design that meets the objectives of environmental protection and affordable housing.

DESCRIPTION

The Meadow on the Hylebos is an 8.9-acre site located between Milton and Fife in unincorporated Pierce County. The site is located at the intersection of SR 99 and 70th Street, at the geographic center of an urban growth area. It is well served by freeways and arterials. The site is highly visible, located on the hillside above the Puyallup Valley floor. With its relatively steep slopes, it offers panoramic views of the valley and Mt. Rainier. Soils on the site are primarily glacial till, offering a challenge for low impact design.

Construction on the project is due to begin in Spring 2004. The developer plans to build 35 residential units on the property. The drainage plan for the subdivision calls for the use of a variety of LID techniques, including narrower, open

road sections with swales; bioretention areas; pervious pavement; and low impact foundation technologies to reduce building excavation. The homes will incorporate a number of green building techniques as well.

Once completed, the Meadow on the Hylebos will be an important demonstration project for the application of LID technologies in an integrated site design. The project will be the first in Pierce County to fully illustrate the range of LID technologies in a typical residential subdivision.

A consortium of public and private sector organizations is monitoring the site for pre- and post-development runoff volume to evaluate the effectiveness of the LID practices. Depending on available funding, the group will monitor water quality as well. Washington State University Cooperative Extension is leading the effort, and is partnering with Pierce County, AHBL, the University of Washington, Pacific Rim Soil and Water, and the Puget Sound Action Team.

Costs

AHBL prepared a cost evaluation for the site for both the conventional design and LID preliminary plat design. The evaluation indicates a potential savings in construction costs of approximately 9 percent.

Kensington Estates

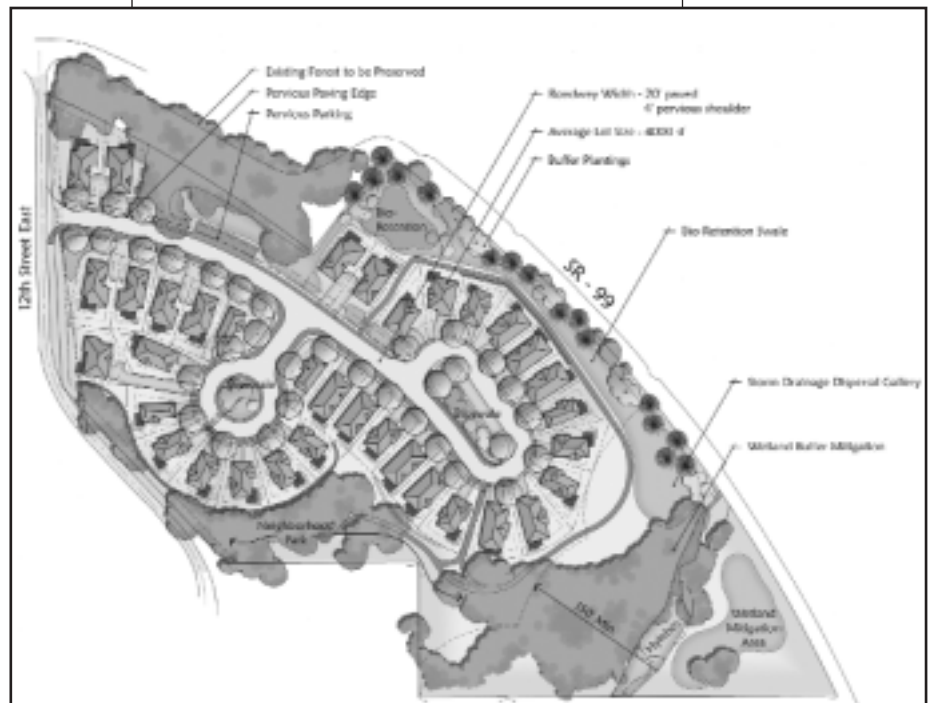
For another project in the county, AHBL analyzed a recently completed subdivision, Kensington Estates, to document the potential benefits that might have occurred if the

subdivision had incorporated LID technologies rather than conventional techniques. AHBL applied the new drainage model in the Department of Ecology’s *Stormwater Management Manual for Western Washington*, then outlined the LID process, chose appropriate control techniques, and conducted comparative cost analyses between LID and conventional stormwater management techniques. The resulting redesign of the project protected sensitive areas, provided additional green space, accommodated access for emergency vehicles, and maintained the same number of development lots. The results of the exercise showed an approximately 20 percent reduction in development costs.

EXPECTED RESULTS

The Meadow on the Hylebos project will demonstrate the benefits of using LID technologies in a residential subdivision. It will demonstrate individual techniques and show that the application of LID

The Meadow on the Hylebos design retains forests, clusters homes, uses bioretention swales and includes pervious parking.



Meadow on the Hylebos, *continued*

technologies in a residential setting results in attractive housing and green neighborhoods.

The Meadow on the Hylebos will provide the development community and Pierce County with a forum in which to explore the design and permitting process for an LID project. The project is a joint application between Pierce County and the developer. The project will improve protection of an important fish-bearing stream, deliver a housing product that is affordable, and establish a design process and forum through which the developer and jurisdiction can cooperate, understand challenges, and develop a design that meets the objectives of environmental protection and affordable housing.

In addition to potential construction cost savings, AHBL has found that application of LID technologies can help maintain project densities. Ecology's new drainage model can result in much larger detention ponds for conventional developments, reducing the number of buildable lots if developers don't incorporate LID practices. AHBL's design work indicates that projects could lose approximately 10 percent of their proposed net density if LID practices are not incorporated into new developments. The application of LID technologies thus gives communities a way to not only preserve the environment,

but also maintain densities as mandated in the Growth Management Act.

CHALLENGES

The first major challenge was to identify a potential piece of property and a willing developer to accomplish the demonstration project. The site's location on the Hylebos, within the geographic center of the urban growth area, and the interest of the developer to protect the environmental quality of the site all lent themselves to an LID project at this location.

The chief obstacle faced during project design was reconciling the many jurisdictional requirements while still maintaining the objectives of demonstrating LID technologies. For example, the Tacoma Fire Department insisted on a wider street profile to maneuver their emergency vehicles. AHBL modified the site plan to accommodate these concerns and still achieved the primary objectives of low impact design.

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Salishan Public Housing Project

Zero Impact Development Feasibility Study

City of Tacoma

BACKGROUND

The Tacoma Housing Authority plans to redevelop the 150-acre Salishan Public Housing Project. This will involve razing existing World War II vintage housing and replacing it with 1,200 new units for approximately 3,000 people.

In addition to the housing benefits, Tacoma Housing Authority's goal is to reduce or eliminate Salishan's impact on tributaries to the Puyallup River. Historically, Swan Creek supported chinook salmon and other fish species. As a first step, Tacoma Housing Authority commissioned a feasibility study to determine if the project could be redeveloped using zero impact development* (ZID) standards and remain within the guidelines and cost constraints from the U.S. Housing and Urban Development funding requirements.

DESCRIPTION

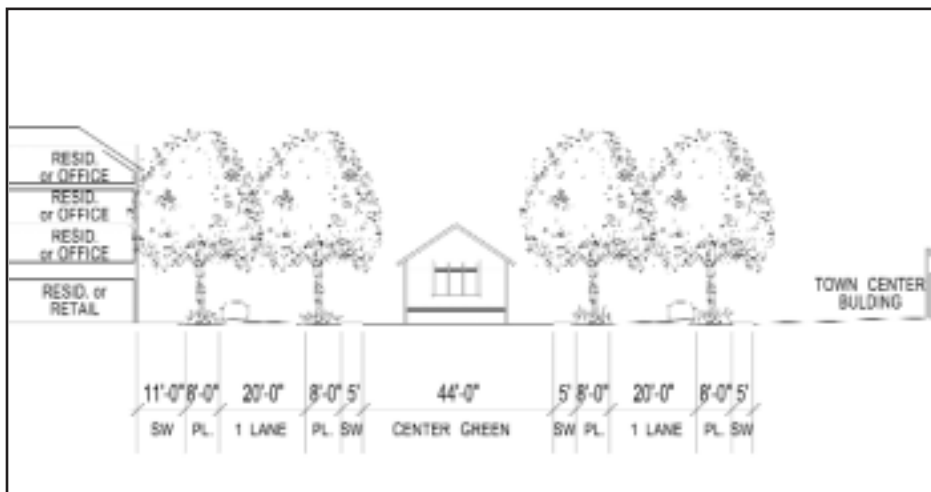
A team of consultants led by Torti Gallas and Partners performed the feasibility study. Washington Department of Ecology provided grant funding for the study. SCA Consulting Group wrote the grant proposal, and served as project

hydrologists, stormwater engineers, and road designers for the Torti Gallas study team. Consultants compiled ZID standards and design guidelines and compared these standards with existing city of Tacoma standards. This helped identify variances to existing development codes that would be needed to construct the project. One of the goals of the project was to retain 65 percent of the site in forest cover. The team considered every square foot of the project for retention, restoration and reforestation to meet the forest cover target.

The Salishan property straddles Swan Creek and T-Street Gulch canyons on Tacoma's Portland Avenue between 38th and 56th streets. These canyons provide a significant amount of forested area that could be preserved and counted toward the goal of 65 percent forest cover for the project.

Approximately 3.5 miles of new and existing streets will provide access to the project. Therefore, a major focus of the study was street design using pervious systems and roadside bioretention facilities. The consultants counted the bioretention facilities toward the forest

*** Zero Impact Development** means a project that adheres to the 65/0 development standard and is constrained by characteristics of a healthy watershed as described in the Salmon in the City Conference Abstracts. "65/0" means 65% forest cover preserved / zero effective impervious surface.



The Salishan design calls for wide planter strips and a bioretention area in a center green space.

Salishan Public Housing Project, *continued*



The feasibility study recommended California strips, such as those pictured above, for use in alleys at Salishan.

cover goal. They also investigated the benefits and costs of pervious paving systems for parking lots, rooftop rainwater collection systems, green roofs, wastewater recycling and reforestation of open spaces.

RESULTS

The study found that the cost of new street construction was lower than or comparable to conventional practices. However, soil restoration for the portions of the project that would be restored to

forest added considerable cost to the project. This may put low impact redevelopment for this site at a cost-disadvantage compared to traditional high impact development practices. The draft study, including cost comparisons, is now available.

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Vancouver Island Technology Park

Saanich Municipality

BACKGROUND

The British Columbia Buildings Corporation is redeveloping the former Glendale Lodge Hospital in the Municipality of Saanich. The goal is to convert the 165,000 square-foot hospital into the Vancouver Island Technology Park to provide space for high-technology research and development businesses.

Saanich has a bylaw requiring all new developments to provide a stormwater management facility to handle the change in post-development stormwater runoff. The Vancouver Island Technology Park proposal presented an opportunity to simultaneously restore stream and wetland function to many previously degraded freshwater systems. The design incorporated LID stormwater management practices to prevent water quality degradation during and after development and to protect and restore riparian function. Aquatic and terrestrial wildlife habitat have both improved as a side benefit of these activities.

The Vancouver Island Technology Park project received the LEED Gold certification (version 2.0) from the U.S. Green Building Council. This was the first project outside the U.S. and the first retrofit anywhere to get Gold certification.

DESCRIPTION

The project consultant, Aqua-Tex, designs and builds ecologically functional stormwater treatment facilities. Aqua-Tex looks for opportunities to work with the development community to find cost-effective stormwater solutions that not only deal with on-site stormwater, but also address stormwater problems from neighboring sites (stormwater run-on). Aqua-Tex also seeks to regenerate or rebuild riparian areas.



Project designs most closely resemble constructed wetlands, and are based on the Properly Functioning Condition criteria for streams and wetlands developed by the U.S. Department of Agriculture's Forest Service/Bureau of Land Management. The firm has adapted these criteria for urban use. Using these criteria in the design assures that the final project will function effectively over the long term without expensive maintenance. The criteria also serve as a checklist for addressing all critical aspects and avoid focusing on a single value such as fish habitat.

Aqua-Tex designed the stormwater management plan to deal with immediate redevelopment needs and a significant amount of run-on from adjacent properties. They created stormwater ponds and channels on two sides of the property to provide maximum detention and infiltration, and to capture runoff from adjacent parking areas at Camosun College and Layritz Park. Grassy swales and open channels, rather than piping, lengthened flow paths. Other practices

A newly constructed stormwater pond. Designs are intended to manage stormwater and protect and restore riparian habitat function.

Vancouver Island Technology Park, *continued*



Site design of the Vancouver Island Technology Park includes extensive open space.

included splitting stormwater flows so they were not concentrated in one location, reconfiguring and vegetating existing drainage ditches to slow flows and trap sediment, and amending soils around stormwater ponds to better establish new plantings, improve infiltration, and reduce surface runoff. In addition, the design included shallow stormwater ponds within the forested area to avoid tree root damage and soil compaction.

Other design features also minimized stormwater runoff and improved ecosystem function. GrassPave™ and GravelPave™ provided parking surface for approximately 170 cars. The parking lot will handle the stormwater volume from a 10-year storm event. Using rainwater on site wherever possible minimized runoff; for example, dual

plumbing allows collected rooftop rainwater to be used to flush the building's toilets. Though not currently in use, rainwater may in the future be used to flush toilets. Collaboration with the Horticulture Centre of the Pacific and Saanich Parks helped determine the location of walking trails outside the floodplain. The use of more natural materials in the stormwater facilities, such as large logs rather than concrete, helped restore Viaduct Creek.

CHALLENGES

Coordinating this "green" project required extra effort for all parties. Communicating the requirements of the stormwater bioswales, wetlands and ponds to the design team, particularly the engineers, was problematic as they were unfamiliar with this approach.

COSTS

Incorporating LID features into Vancouver Island Technology Park provided considerable cost savings. The LID approach cost \$150,000 while a conventional stormwater treatment system would have cost \$680,000. The savings are due to the pipes and excavation that are not needed in the LID approach.

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Island County Stormwater Code Low Impact Development Requirements

BACKGROUND

In December 1998, Island County adopted a stormwater ordinance that provides developers with the option of using low impact development practices. The design standards are based on *Low Impact Development Design Strategies—An Integrated Design Approach*, prepared by Prince Georges County, Maryland, January 2000.

DESCRIPTION

The Island County Stormwater and Surface Water Ordinance provides special performance requirements that developers must meet for their development proposals to qualify as LID. The code states:

A. Runoff Volume Control. The pre-development volume is maintained by a combination of minimizing the site disturbance from the pre-development to the post development condition and then providing distributed retention BMPs. Retention BMPs are structures that retain the runoff for the design storm event. A “customized” or detailed runoff curve number (CN) evaluation is required to determine the required runoff volume. The storage required to maintain the pre-development volume may also be sufficient to maintain the pre-development peak rate.

B. Peak Runoff Rate Control. Low-impact development is designed to maintain the pre-development peak runoff discharge rate for the selected design storm events. This is done by maintaining the pre-development time of concentration and then using retention and/or detention

BMPs (e.g., rain gardens, open drainage systems, etc.) that are distributed throughout the site. The goal is to use retention practices to control runoff volume and, if these retention practices are not sufficient to control the peak runoff rate, to use additional detention practices to control the peak runoff rate.

C. Flow Frequency Duration Control.

Since low-impact development is designed to emulate the pre-development hydrologic regime through both volume and peak runoff rate controls, the flow frequency and duration for the post development conditions will be almost identical to those for the pre-development conditions. The impacts on the sediment and erosion and stream habitat potential at downstream reaches can then be minimized.

D. Water Quality Control. Low-impact development is designed to provide water quality treatment control for the duration storm runoff from impervious areas using retention practices. The storage required for water quality control is compared to the storage required to control the increased runoff volume. The greater of the two volumes is the required retention storage. Low-impact development also provides pollution prevention by modifying human activities to reduce the introduction of pollutants into the environment. (Title 11.03)

The ordinance allows applicants who propose to use LID practices for development approvals a choice. Applicants of small development projects may accept permit conditions that fulfill

Island County Stormwater Code, *continued*

the best management practices for LID surface water rate control in lieu of submitting a drainage narrative. For major development activities and engineered grading projects, applicants who propose to use LID drainage controls may submit a drainage narrative instead of a preliminary drainage plan. The ordinance does not require a downstream analysis when the project design includes and is approved for using LID standards.

To date, LID practices have been partially applied in developments such as Bayview Corner (see page 26), but no major developments have used LID technologies in Island County.

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Stormwater Management Policy for Low Impact Development City of Issaquah

BACKGROUND

The city of Issaquah is growing rapidly. With annexations, the population could increase from 13,790 today to 47,000 by 2020. Two urban villages alone—Issaquah Highlands and Talus—could add more than 5,000 residential units, 3.5 million square feet of commercial and office space and 500,000 square feet of retail space. This growth will place heavy demands on already limited groundwater supplies, a congested road system and degraded stream ecosystems. Issaquah Creek is a regionally significant stream that provides habitat for the threatened Puget Sound chinook salmon. In 2000, the city of Issaquah adopted an update to the stormwater code (Title 13.28.055) that provides a process and criteria for evaluating low impact development proposals.

DESCRIPTION

The municipal code authorizes the Director of Public Works to authorize deviations from stormwater design standards to achieve “low impervious surface development.” The director also has the option of requiring evaluation and monitoring of project elements. The code language is on the Municipal Research Services Center website (www.mrsc.org). Go to “Legal Resources,” then “City and County Codes,” then “City Codes” to Issaquah City Code Title 13.28.055.

Authorizations for deviation from design standards are to be based on the following criteria. The policy states:

1. The deviations will produce a compensating or comparable result in stormwater flow control and treatment that is in the public interest;
2. The deviations contribute to and are consistent with the goal of achieving low

- effective impervious surface area within a development;
3. The proposed development project offers reasonable assurances that low impervious surfaces will be achieved and maintained;
 4. The deviations do not threaten public health or safety;
 5. The deviations are consistent with generally accepted engineering and design practices;
 6. The deviations promote one or more of the following:
 - a. Innovative site or housing design;
 - b. Increased on-site stormwater retention using native vegetation;
 - c. Retention of at least 60 percent of natural vegetation conditions over the site;
 - d. Improved on-site water quality beyond that required by current applicable regulations;
 - e. Retention or re-creation of pre-development and/or natural hydrologic conditions to the maximum extent possible;
 - f. The reduction of effective impervious surfaces to the maximum extent practicable;
 7. The deviations do not allow density greater than what would otherwise be allowed under city regulations then in effect;

8. The deviations do not present significantly greater maintenance requirements at facilities that will be eventually transferred to public ownership;
9. There shall be submitted in conjunction with each such project, covenants, conditions and restrictions which will be binding upon the property all necessary native growth protection easements, impervious surface restrictions and such other critical features as the Director may require.

The Issaquah Municipal Code (Title 13.30) also provides an incentive for projects that infiltrate stormwater. Projects that infiltrate 100 percent of the stormwater can receive up to a 50 percent reduction in the stormwater utility fee.

On other fronts, the city is considering a more comprehensive sustainable development program, including incentives. Some of these provisions relate directly to LID, such as green streets, green roofs, and pervious pavers.

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Zero Effect Drainage Discharge Ordinance

City of Lacey

BACKGROUND

In 1999, the Lacey city council enacted a “Zero Effect* Drainage Discharge” ordinance. Lacey, in Thurston County, has a population of 31,000 and an urban growth area of 31 square miles. City officials, understanding that even small increases in runoff can damage area streams, chose to encourage developers to achieve zero discharge of stormwater runoff. This could well be one of the very first ordinances of this kind passed in the nation.

DESCRIPTION

The goal of Lacey’s ordinance is to retain the critical functions of a forest including evapotranspiration and infiltration after site development such that near zero effective impervious surface is achieved. The purposes of the ordinance show that city planners saw this as a new concept that would go through trial and evolution.

The ordinance states:

- A. Provide those developing land the opportunity to demonstrate zero effective impervious surfaces.
- B. Improve the conditions of habitat and ground and surface waters within a watershed with innovative urban residential design and development techniques.
- C. Foster broad community acceptance of the use of significantly less impervious surface and greater natural habitat conservation on sites.
- D. Provide the opportunity to identify and evaluate potential substantive changes to land use development regulations which support and improve natural functions of watersheds.

The ordinance is flexible and establishes performance standards for development rather than specific design criteria. A

committee of Lacey staff has the authority to grant administrative variances from traditional standards to achieve the ordinance’s goal.

Projects must preserve 60 percent natural habitat area and achieve “near zero effective impervious surface.” A variety of practices can contribute to meeting the provisions of the ordinance, such as:

- Constructing narrower roads without curb and gutter.
- Using pervious paving systems.
- Using native forest as the stormwater management system.
- Avoiding discharges from impervious surfaces to surface streams.

EXPECTED RESULTS

The intent of the ordinance is that projects constructed under this ordinance will eliminate overland flow discharges and have no measurable impact on receiving waters and aquatic life. Such projects will be more aesthetically pleasing, require little or no erosion control during construction, and add value to the city.

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Website for Chapter 14.31 Zero Effect Ordinance:

www.wa.gov/lacey/lmc/lmc_main_page.html

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* Zero Effect (or Impact) Development (ZID) means a project that adheres to the 60/0 development standard and is constrained by characteristics of a healthy watershed as described in the Salmon in the City Conference Abstracts. “60/0” means 60 percent forest cover preserved /zero effective impervious surface.

Low Impact Development Strategy for Green Cove Basin

City Of Olympia

BACKGROUND

Olympia, with a population of 41,000, is a rapidly growing city in Thurston County. Despite a variety of measures enacted in the 1980s and 1990s to increase density and protect environmental quality, the quality and diversity of aquatic habitat in the city continued to decline.

In 1998, Olympia undertook a process to “define the balance between human activities and protecting habitat” in its streams and watersheds. After reviewing all city watersheds, the city council decided to focus on the 2,600-acre Green Cove Creek watershed in west Olympia. In October 2001 the Olympia City Council adopted a unique set of mandatory low impact development regulations to prevent further damage to aquatic habitat from urban development in the Green Cove Basin.

DESCRIPTION

Olympia elected officials and staff went through a three-year process of research, analysis and peer review in designing the program for Green Cove Basin. Following is a summary of the major steps:

- Consultants developed criteria for evaluating the viability of aquatic habitat in Olympia’s eight watersheds and recommended goals for growth and habitat based on the habitat potential of each basin.
- A team of scientists, including hydrologists and biologists, reviewed and concurred with the consultant’s recommendations.
- The city council agreed to use the recommended approach in the Green Cove Basin as a pilot project and adopted interim standards for zoning

density, stormwater management, timing of clearing and grading, and tree removal.

- Consultants developed alternate site plans for two proposed developments in the basin to determine whether they could achieve low impact objectives. The city also consulted with realtors, development engineers, bankers, and developers on the site plans.
- The science team reviewed the standards and proposed designs and confirmed that the proposed subdivision designs were generally consistent with scientific findings and that implementation would have the potential to maintain habitat conditions equivalent to the present.

Based on the above process, the Olympia City Council completed a comprehensive policy revision covering development density, impervious surface coverage, lot size, open space/tree retention, street design, street width, block sizes, parking, sidewalks, and stormwater management requirements. The following is an outline of key policy changes for the Green Cove Basin.

Comprehensive Plan Amendments

- Designate Green Cove Creek as a sensitive drainage basin.
- Avoid high-density development where new development would have a significant adverse impact upon the habitat within designated sensitive drainage basins.
- Administer development regulations that protect critical areas and designated sensitive drainage basins.
- Adopt low impact development regulations within designated sensitive drainage basins that may include

LID Strategy—Green Cove Basin, *continued*

stormwater standards, critical area regulations, zoning designations and other development standards.

- Establish street designs that minimize impacts to the natural environment especially within a designated sensitive drainage basin.

Olympia Municipal Code

- Establish a new zoning district with increased tree protection and replacement requirements.
- Establish residential densities of two to four units per acre; allow duplexes, townhouses, and multifamily uses.
- Reduce lot widths and rear setbacks and increase maximum building heights compared to other residential districts.
- Limit maximum impervious surface coverage per lot to 2,500 square feet.
- Allow several land uses, including duplexes and parking lots that are not typically permitted in single-family residential developments.
- Require a minimum tree density of 220 trees per acre (approximately 55 percent tree cover in any given development).

Development Guidelines and Public Works Standards

- Residential block perimeters cannot exceed 1,700 feet.
- Driveways and sidewalks can be constructed of pervious surfaces with city approval.
- Sidewalks are required on one side of local access streets.
- Sidewalk planter widths can be increased from the required eight feet to an optional 25 feet.
- Additional parking within low impact developments can be provided by the construction of pervious surface lots subject to city approval.
- A rock infiltration gallery/conveyance system is to be constructed when street slopes are 5 percent or less.

- Neighborhood collector streets are to be 25 feet wide, with parking provided on alternating sides of the street.
- Local access streets are to be 18 feet wide, with similar parking arrangements.

Drainage Design and Erosion Control Manual

- Stormwater discharge must be controlled by matching developed discharge durations to pre-developed durations, for the range of pre-developed discharge rates from 50 percent of the two-year peak flow to the 50-year peak flow.
- The city will allow clearing and grading within the basin only between May 1 and October 1 of any given year.

Since part of the Green Cove Basin is in Thurston County, the county adopted policy and regulatory changes to complement Olympia's program. This included changes to the county's comprehensive plan, zoning, and open space program.

Unlike LID ordinances in Lacey and Tumwater that are voluntary, Olympia's Green Cove regulations are mandatory. As of October 2002, the city has received two subdivision projects for development under the new policies.

CHALLENGES

Several questions remain unresolved in the Green Cove basin process. The extra costs of non-standard development techniques have not been defined. One question is whether home buyers will buy homes in a "low impact" neighborhood with narrower streets, less parking, smaller home footprints, and regulatory limits to additions that would increase impervious surfaces. Finally, there are still questions about the environmental

benefits of the development restrictions, given the overall pattern of development and previous disruption of the natural hydrology.

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For a more detailed case study and a CD-ROM containing project reports and ordinances, contact the City of Olympia.

Low Impact Development Regulations Pierce County

BACKGROUND

Unincorporated Pierce County has a population of 330,000 and a land area of 1,790 square miles. The county is exploring the use of low impact development techniques as a method to maintain natural hydrologic functions during the land development process and reduce impacts associated with conventional stormwater management methods. County staff is evaluating various LID methods for quality of performance and applicability. Development of an LID chapter within the county's Stormwater and Site Development Regulations will clarify what LID techniques are acceptable and will establish a performance goal and objectives. This chapter will also provide certainty to land developers and federal and state agencies in terms of performance measures and compliance with National Pollutant Discharge Elimination System requirements.

DESCRIPTION

Pierce County, in cooperation with Washington State University Cooperative

Extension, is currently developing an LID chapter for the Stormwater Management and Site Development Regulations. A committee review of the proposal was underway at the time of this writing in late 2002.

The following draft chapter establishes a performance goal and objectives and prescriptive standards for LID.

The goal of Low Impact Development is to manage stormwater generated from new development and redevelopment so there will be no negative impacts to adjacent and/or downstream property owners and no degradation to groundwater or surface waters such as but not limited to streams, ravines, wetlands, potholes, and rivers.

The Low Impact Development goal shall be achieved through adherence to the following objectives:

- Maintain and/or restore the pre-developed, undisturbed stormwater flow volumes, flow frequencies and durations, and water quality from a developed site. In the Puget Sound lowlands, the predeveloped hydrologic condition is near

LID Regulations—Pierce County, *continued*

zero overland flow runoff. (Note: To provide a quantifiable and measurable standard for flow control, minimum requirement #7 Flow Control of the Department of *Ecology Stormwater Management Manual for Western Washington*, will be adhered to in addition to meeting the other objectives listed below. It states that stormwater discharges shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50 year peak flow.)

- Establish the pre-developed condition of a site used for hydrologic modeling as the native vegetation and soils that existed on the site prior to 1800 A.D., which shall be a forested land cover unless reasonable, historic information indicates the site was prairie prior to settlement (modeled as “pasture” in the Western Washington Hydrology Model.)
- Retain or restore native soils and vegetation on 65% of the site area. Where 65% is not achieved the applicant will demonstrate how the combined use

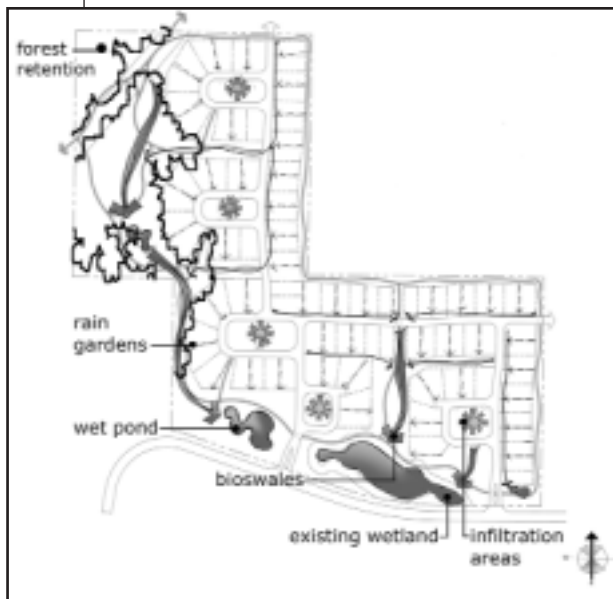
of other LID techniques will achieve the overall goal.

- Limit the effective impervious area of the site to no more than 10%.
- Retain and incorporate natural site features that promote infiltration of stormwater on a developed site.
- The use of traditional conveyance and pond technologies to manage stormwater quality and quantity should only be considered after all other LID techniques have been considered and used to the greatest extent possible.
- Use bioretention, pervious surfaces, open space surface water dispersion, soil restoration, and other dispersed facilities to control stormwater as close to the origin as possible.

To meet the goal and objectives, the draft chapter discusses how LID can be considered at each phase of development including: site planning; vegetation retention and reforestation; site clearing and grading; roads, parking and sidewalks; and building design. It also provides best management practices and monitoring requirements. In addition, the chapter will address ongoing management and maintenance needs, and education of homeowners.

Pierce County, in cooperation with Washington State Cooperative Extension, has entered into a partnership with a private developer to develop an LID pilot project. For more information on this project, see Meadow on the Hylebos, page 32, or call Len Zickler, AHBL, at (253) 383-2422.

Example of a site design using LID techniques.



CONTACTS

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 Water Programs
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www.co.pierce.wa.us/pc/services/home/property/pals/landuse/esa.htm
 (see Title 17A amendments)

Reduced Discharge Housing Demonstration Program Snohomish County

BACKGROUND

In the 1990s, Snohomish County, with a population of 628,000, established a program to introduce different development schemes, such as mixed use, affordable housing and innovative designs. As part of this effort, the county adopted the Reduced Discharge Housing Demonstration Program (Ordinance 00-004) in April 2000. This program provides a three-year trial period for selecting and overseeing demonstration low impact development projects.

DESCRIPTION

The reduced discharge ordinance has five purposes:

1. Demonstrate the benefits of alternative development practices that reduce offsite discharge.
2. Improve the conditions of habitat, ground and surface waters.
3. Foster community acceptance of housing that conserves habitat and uses less impervious surface.
4. Allow flexibility in the development standards.

5. Identify and evaluate desirable changes to the land use code.

Requirements and guidelines in the ordinance provide for a variety of LID concepts, such as infiltration, tree retention, density bonuses, smaller footprints/taller house designs, permeable pavements, grass pavers, and minimizing grading and site disturbance.

The county established a special committee to oversee the program, select demonstration sites and recommend changes to the land use code. The committee includes representatives of county departments, environmental organizations, university faculty, and the development community. The committee began its work with a tour of low and reduced impact development sites in Snohomish and King counties. Snohomish County sites included the Canyon Park Business Center (which uses bioswales for water quality treatment and groundwater recharge) and the Harbor Point Master Planned Community (which recharges groundwater through a wetland).

Reduced Discharge Housing, *continued*

To guide submittal of development proposals, the committee developed an outline of minimum requirements and a project review checklist (available from the county on request). By the end of 2002, developers had proposed six project design concepts. The county accepted three of these projects into the system. The project rating system evaluates tree retention (minimum 60 percent of the site); impervious surfaces; infiltration (minimum 70 percent); visual impact; innovation; and the reputation of the developer.

One project proposal is for higher-end fourplex condominiums. The site is heavily forested with steep slopes and outwash soils. A vertical design with underground parking and narrower roads will save tree cover and reduce runoff. Permeable pavement will reduce impervious cover and soils will be amended with compost. The county will need to modify the zoning code from the current single-family classification to allow for this type of development in this area.

The second proposal, Wandering Creek, is for lower cost single-family housing. The site is bounded by wetlands on three sides. The upland area is on outwash soils and will drain to a wetland buffer. LID features include preserving overstory vegetation, working with topography, narrowing the road section, using permeable pavers, and reducing building footprints to 1,000 square feet.

A third proposal is in an existing plat where the developer proposes to revegetate a pasture area with trees.

County staff and the developers will jointly monitor each of the development projects for stormwater flows. Results will be available to the public once construction begins.

CHALLENGES

The county's demonstration program has faced several challenges in implementation. Developers and engineers have proven reluctant to try new approaches and techniques. They also state that the Department of Ecology's *Stormwater Management Manual for Western Washington* limits the use of wetlands for infiltration.

COSTS

Cost estimates for these LID projects are highly variable and site-dependent. The fourplex project on a steep slope will be expensive due to the vertical design and underground parking, but the site would be difficult to develop without the flexibility provided under the LID program. The single-family housing project is expected to be less expensive than a traditional development because of reduced road width and sidewalks on one side of roads. The developer is also receiving a density bonus, which allows him to add several housing units on the site.

CONTACT

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Development Services
(425) 388-3424 extension 2014
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Zero Effect Development Ordinance

City of Tumwater

BACKGROUND

The city of Tumwater in Thurston County has a population of 12,730 and an area of 10.7 square miles. Several years ago, city officials and staff recognized the relationship between traditional development practices and stream degradation, and established alternative development standards to protect aquatic life in receiving waters.

DESCRIPTION

In 2000, Tumwater enacted the Zero Effect Drainage Ordinance (Title 13, Chapter 13.22). The city found that typical site development hinders stormwater retention, that stormwater discharges offsite adversely affect stream habitat, and that retaining forest canopy aids evapotranspiration and infiltration of stormwater runoff. The ordinance provides developers with the option of using zero impact development* practices in residential and commercial projects. A set of performance guidelines indicates the characteristics of an acceptable project.

While the ordinance contains design guidance it also allows design creativity. A committee reviews project proposals and can approve variances to the city's development code to accommodate nontraditional construction techniques. Projects approved under the ordinance must preserve 65 percent of forest area on the development site. Runoff must not be collected or discharged to surface water (thus achieving zero effective impervious

area). The guidelines encourage looped one-way streets; narrow pervious driveways; small, pervious garage aprons; and small home footprints. Roof runoff must be infiltrated or mitigated. To compensate for narrower roads and reduced access for emergency vehicles, structures are required to meet more rigorous fire standards.

COSTS

There is the potential for substantial cost savings for projects that might be approved under this ordinance, however no cost analysis was performed.

CONTACTS

Michael Matlock
City of Tumwater
(360) 754-4210

Website:

www.ci.tumwater.wa.us/
Follow the link to City Departments,
then Planning and Facilities.

Thomas W. Holz
SCA Consulting Group
(360) 493-6002
tholz@scaconsultinggroup.com

***Zero Impact Development** means a project that adheres to the 65/0 (65 percent forest cover preserved / zero effective impervious surface) development standard and is constrained by characteristics of a healthy watershed as described in the Salmon in the City Conference Abstracts.

Low Impact Development in the Highway Runoff Manual

Washington State Department of Transportation

DESCRIPTION

The Washington State Department of Transportation is currently revising its 1995 *Highway Runoff Manual*. As part of this revision, the department will develop and reference three low impact development elements in the revised manual:

1. Permeable paving at park and rides, pedestrian paths, and lower speed roadways.
2. Bioretention along roadways.
3. Constructed wetlands for stormwater treatment.

The LID portion of the revised manual should be available for use by the end of September 2003 and will include plans, specifications, methodology for estimating costs, and a hydraulic design process.

CONTACTS

Rick Johnson
Washington State Department of Transportation
(260) 440-4642
johnsor@wsdot.wa.gov

Larry Schaffner
Washington State Department of Transportation
(360) 570-6657
schaffl@wsdot.wa.gov

Website:

www.wsdot.wa.gov/fasc/

Follow the links to:

- >Engineering Publications
- >On-Line Technical Manual Library
- >Highway Runoff Manual

Workers install Eco-Stone® permeable pavers at a municipal park and ride in Marysville. The Washington State Department of Transportation is considering using permeable pavement, such as Eco-Stone®, at its park and rides and on pedestrian paths.



Eco-stone detail.

Green Building: Built Green™ and LEED™

BACKGROUND

Green building refers to a series of practices and use of materials that result in a construction process and finished product that causes less harm to the environment, is more resource and energy efficient, and provides a healthier environment for its occupants. One way that the building industry and local governments are promoting green building is through green rating systems. In the Puget Sound Basin, two green rating systems are most prevalent:

- BUILT GREEN™ for residential developments, multifamily, and single family new construction and remodeling
- Leadership in Energy and Environmental Design (LEED™) for commercial projects.

Both programs are included here because each contains site design elements of low impact development.

BUILT GREEN™

BUILT GREEN™ programs are market-based (what the consumer will pay) approaches to promoting green building practices. Architects, builders, developers, subcontractors, suppliers, lenders, and real estate agents use a rating system of environmentally friendly practices to certify that their homes offer reduced impact on the environment and human health. Because each program sponsor develops checklists, considerable variability can occur between certification requirements.

BUILT GREEN™ programs are located in Denver, Vermont and in King, Snohomish, Kitsap and Clark counties in Washington. Denver's program began in 1995 and includes more than 4,000 environmentally friendly homes. The Master Builders Association (MBA) of King and Snohomish Counties launched their program in 2000, and it already includes 1,753 new and remodeled homes. The association expanded its program to include multi-family residences and has certified more than 247 to date. Kitsap County's program, BUILT GREEN™/Build a Better Kitsap, started in 1997 and features 100 homes. Clark County began its Build a Better Clark program in 1998 and has certified more than 60 homes.

The Master Builders Association of King and Snohomish Counties launched its BUILT GREEN™ program in partnership with King County, Snohomish County and other government agencies.

Building projects are qualified using a BUILT GREEN™ checklist organized into six categories of regionally appropriate, environmentally friendly action items. One of the categories—"Site and Water"—includes elements of low impact development:

- Limiting heavy equipment to avoid compaction of soils.
- Preserving trees and existing vegetation.
- Protecting wetlands and other critical areas.
- Setting aside a portion of the site to be left undisturbed.

Built Green™ and LEED™, *continued*

- Amending soils with compost to a depth of 8 to 10 inches.
- Managing water so that groundwater will be recharged.
- Limiting effective impervious surface area to 0 percent for projects of five acres or more and less than 10 percent for projects less than five acres.
- Using pervious materials for at least one-third of all driveways, walkways and patios.
- Using green roofs.
- Avoiding impervious surfaces outside the building footprint.

Builders use this checklist prior to construction to determine which features to include in the home. When a builder completes construction, he or she sends a signed copy of the checklist to the MBA, certifying that the home contains the identified features. Based upon that builder certification and after reviewing the application, MBA will award the appropriate Certificate of Merit indicating that the home has received a 1-, 2-, or 3-star rating.

The city of Seattle and King County promote the use of the BUILT GREEN™ rating system by sponsoring exhibits and promoting the program through print, radio and TV media. In addition, Seattle City Light and Seattle Public Utilities sponsor a BUILT GREEN™ Incentive Program for multifamily projects. The program provides financial assistance to building owners and developers that incorporate sustainable building goals early in building, programming, and design decisions. Incentive funding is limited to covering incremental design costs, such as rating system documentation or hiring professionals for design input or process facilitation, and may not be used to cover construction costs. As part of this program, the city

helps identify sustainable building services to offer to the private sector. BUILT GREEN™/Build A Better Kitsap grew out of a partnership between the Home Builders Association of Kitsap County and Kitsap County Public Works. Kitsap County Public Works and the Washington Department of Ecology provided financial support. BUILT GREEN™/Build A Better Kitsap addresses energy efficiency, indoor air quality, health and sustainable construction practices. There are separate checklists for homebuilders, remodelers, developers and light commercial. Each checklist has sections that relate to stormwater and include some low impact development practices, such as:

- Limiting impervious surfaces to 3,000 feet.
- Protecting 20 percent of the site from clearing and grading.
- Using permeable pavement for driveways, walkways and patios.
- Providing infiltration for rooftop runoff.
- Preserving existing native vegetation.

BUILT GREEN™/Build a Better Kitsap also produced brochures for homeowners on “How to Shop for a Fish Friendly Home” and “How to Maintain a Fish Friendly Home.” The items listed in these brochures are different from those included on the BUILT GREEN™/Build A Better Kitsap certification checklist.

BUILT GREEN™ CONTACTS:

King/Snohomish Counties

General BUILT GREEN™ information:

www.builtgreen.net

Master Builders Association
of King and Snohomish Counties
Robin Rogers
(425) 451-7920 or (800) 522-2209
builtgreen@mba-ks.com

Website: www.mba-ks.com

Home Builders Association
of Kitsap County
Art Castle
(360) 479-5778
info@kitsaphba.com

Website: www.kitsaphba.com/bbk.html

Leadership in Energy and Environmental Design (LEED™)

LEED™ is a national rating system for commercial building projects sponsored by the U.S. Green Building Council. Projects achieve LEED™ Certified Silver, Gold or Platinum rating levels based on the number of points achieved in five different areas:

- Sustainable sites.
- Water efficiency.
- Energy and atmosphere.
- Materials and resources.
- Indoor environmental quality.

Version 2.1 (November 2002) contains elements of low impact development under the sustainable sites and water efficiency categories and includes: protecting open space, reducing the development footprint, exterior landscaping to reduce heat islands (such as a green roof), and use of water efficient landscaping (native plants). However, unlike many elements in other categories, the program does not require performance targets (such as protecting 50 percent of open space, or limiting impervious surface to by 10 percent) for these practices.

Certification is currently available for commercial projects, but the U.S. Green Building Council is developing rating systems for residential, commercial interior redesigns, and operations applications.

King County recently adopted the LEED™ Rating System as a standard for all buildings that the county constructs, remodels, and renovates. The city of Seattle's Sustainable Building Policy states that all new city-financed buildings and major remodels with more than 5,000 square feet of occupied space shall achieve the Silver Level using the LEED™ Rating System. Seattle City Light and Seattle Public Utilities also operate a LEED™ Incentive Program to encourage use of LEED™ in the private sector. Incentive funding is limited to covering incremental design costs, such as rating system documentation or hiring professionals for design input or process facilitation, and may not be used to cover construction costs. Buildings within City Light's service territory are eligible to apply.

LEED™ CONTACTS:

U.S. Green Building Council Website:
www.usgbc.org
Select the link to "LEED"

Peter Dobrovolny
City of Seattle
Peter.Dobrovolny@seattle.gov

Website:
[www.cityofseattle.net/
sustainablebuilding](http://www.cityofseattle.net/sustainablebuilding)

Karen Price
Business and Industry Resource Venture
(within Seattle)
kareng@resourceventure.org

website: www.resourceventure.org

King County website:
dnr.metrokc.gov/swd/bizprog/
Follow the link under Construction Recycling/Green Building to "Green Building Techniques."

Glossary

amended soil	Soil with compost tilled in to restore natural capacities to treat, store and infiltrate water. Amending soil reduces runoff, promotes plant health and reduces needs for watering and application of fertilizers and herbicides. The <i>Stormwater Management Manual for Western Washington</i> (Best Management Practice T5.13) recommends tilling in 10 percent dry weight of compost into the top 8 inches of topsoil and breaking up at least 4 inches of subsoil below this.
bioretention	A vegetated depression located on the site that is designed to collect, store and infiltrate runoff. Typically includes a mix of amended soils and vegetation.
curvilinear	A curving street design that provides room for bioretention areas or other treatment systems, slows traffic and creates a more attractive street.
detention system	Temporary storage of stormwater to control the rate of release, allow for infiltration and provide treatment.
evapotranspiration	A process where vegetation absorbs, uses and releases water.
facultative plants	Plants capable of adapting to varying environments.
filtration	A process in which filtering, or treatment, takes place.
hydrology	Scientific study of the properties, distribution and effects of water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere.
hydrophilic plants	Vegetation adapted to wet conditions.
impervious surfaces	Hard surfaces, such as rooftops, roads and parking areas, that prevent or slow infiltration of water. Lawns with underlying soils compacted by heavy machinery are considered impervious.
infiltration	Downward movement of water from land surfaces into the soil.
pervious or permeable surfaces	Soil or other material that allows infiltration or passage of water or other liquids.
Salmon in the City Conference	Conference sponsored by the American Public Works Association, Washington Chapter, in 1998 that featured presentations addressing the intersections of salmon, salmon habitat and urban development. Abstracts from this conference are available at: http://depts.washington.edu/cwws/Research/Reports/salmoninthecity.pdf .
Smart Growth	Collection of land use planning techniques that features compact, mixed-use, transit-oriented development with the objective of creating more attractive, livable, economically strong communities while protecting natural resources.
swales	Open, vegetated drainage channel designed to detain, treat and/or infiltrate stormwater.
turbid or turbidity	Sediment, organic matter or other particles that reduce the clarity of water. Excessive turbidity in streams and other surface waters can directly impair the growth of aquatic vegetation, and indirectly lead to degraded fish and wildlife habitat and decreased oxygen in waters.

