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Natural Drainage Systems Overview

Natural drainage systems (NDS) are an innovative alternative to traditional stormwater management systems. The pipes and ditches of traditional drainage systems carry runoff with traces of everyday contaminants such as oil, paint, fertilizer, and heavy metals directly into creeks, lakes, and Puget Sound. The speed and volume of water coming out of pipes erodes stream channels. These problems decrease water quality, disrupt marine food chains, and negatively impact wildlife habitat.

Natural drainage systems limit the negative impacts of stormwater runoff by redesigning residential streets to take advantage of plants, trees, and soils to clean runoff and manage stormwater flows. Vegetated swales, stormwater cascades, and small wetland ponds allow soils to absorb water, slowing flows and filtering out many contaminants.

Natural Drainage Projects

Street Edge Alternatives (SEA Streets)
This natural drainage pilot project was the first natural drainage system constructed by the City of Seattle. It was completed in the spring of 2001.

110th Cascade
110th Cascade was completed in the spring of 2003. It is a series of stair-stepped natural pools that slow the flow of stormwater, reduce flooding, and filter pollutants before they reach Pipers Creek.

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Broadview Green Grid

This ambitious natural drainage system project provides stormwater improvements to almost the entire sub-basin of Piper's Creek watershed. Broadview Green Grid was completed in the spring of 2005.

High Point

High Point is one of the largest redevelopment projects in Seattle's recent history. The High Point NDS is the largest the City has undertaken and is the first natural drainage system to be used in a high density urban setting. The first phase of the High Point NDS was completed in the fall of 2005.

Pinehurst Green Grid

This project covers 12 city blocks and combines neighborhood enhancements with a new stormwater system that improves the quality of runoff to Thornton Creek. Landscaping was completed in the spring of 2007.

More Information

If you have questions after viewing this site, contact Drena Donofrio at drena.donofrio@seattle.gov.

Links to other sites

Low Impact Development - Learn how Puget Sound planners, developers, engineers and others are transitioning to an innovative approach to land development and stormwater management

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Program Information

Natural drainage systems (NDS) are an innovative approach to street design in the United States. Learn more about:

• The Story of the Natural Drainage Systems Program
Learn about the problems threatening our waterways and how NDS have proved an effective part of the solution.

• Goals and Objectives
Natural drainage systems are designed to meet certain goals and objectives.

• Benefits and Challenges
Natural drainage systems offer many benefits to homeowners, municipalities, and the environment. There are also a few risks and challenges.

• Frequently Asked Questions
How are NDS sites selected? How are projects funded? How much do NDS cost? These and other questions are answered on the Frequently Asked Questions page.

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The Story of Natural Drainage Systems

The Problem

Prior to development, present-day Seattle was covered by forests and grasslands that acted like a sponge, absorbing rainfall into the ground and letting it seep into creeks and rivers. Today, the rooftops, streets, and parking lots that cover much of the land in Seattle prevent rain from moving through the soil. Instead, water is carried away from these hard surfaces through pipes and ditches to our waterways.

This can lead to two problems:

- Runoff carries everyday contaminants, such as oil, paint, fertilizer, and heavy metals directly into creeks, lakes, and Puget sound, impacting the food chain that supports fish and other wildlife
- The speed and volume of stormwater coming out of pipes erodes stream channels, impacting wildlife habitat

Toxic runoff in Puget Sound waterways has likely caused high numbers of mortalities of the endangered Coho salmon. Chinook salmon, which are listed as threatened under the Endangered Species Act, are also in dramatic decline.

An Innovative Solution

In response to the threats to habitat, Seattle Public Utilities began programs such as the Urban Creeks Legacy projects to actively promote citizen stewardship and restoration of local creek habitat.

However, in-stream restorations alone are not enough. In 1999, SPU initiated the natural drainage systems (NDS) program, an innovative approach to stormwater management that protects the fragile ecosystems in Seattle's water bodies.

In pristine forest conditions, creeks maintain a dynamic equilibrium with storm cycles, allowing for aquatic

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organisms to adjust to changing creek conditions. NDS mimics natural forested conditions to limit the impacts of urban development on Seattle's water bodies.

SPU redesigns residential streets to include vegetated swales, stormwater cascades, and small wetland ponds. These features slow stormwater flows and allow soils to absorb water and filter out many contaminants. The system relies on plants, trees, and the deep, healthy soils that support them. If maintained properly, the plants and soils combine to form a living infrastructure that, unlike pipes and vaults, improves in function over time.

Achieving Positive Results

The first natural drainage project, Street Edge Alternatives (SEA Streets), was implemented in a single residential block in a low-density neighborhood in Piper's Creek watershed in northwest Seattle. The project combined swales with traditional drainage infrastructure (such as catch basins and culverts) and decreased the watertight surface area of the site's streets by 11 percent.

Two years of monitoring show that SEA Streets reduced the total volume of wet season runoff by 99 percent.

Natural Drainage System Evolution

The success of SEA Streets enabled the NDS projects to grow and diversify. The High Point project features the largest natural drainage project that the City has undertaken and protects 10 percent of the Longfellow Creek watershed. The Capitol Hill Water Quality Improvement project will redesign the drainage system in one of Seattle's densest neighborhoods.

For more information about specific natural drainage projects, visit the Natural Drainage Systems Program Overview page.

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Goals and Objectives

The natural drainage systems (NDS) program has two goals:

1. Slow the flow and reduce the volume of stormwater runoff. Retrofit and redevelop public right-of-ways to improve water quality and imitate hydrologic processes that existed before development
2. Use a state-of-the-science approach to apply existing and new data in adjusting technical stormwater management design objectives.

NDS has three objectives for management of urban stormwater in areas of the city draining into creeks:

1. Protect Aquatic Organisms: Minimize the fluctuation of stream levels and disturbance of creek beds during storms that account for up to 90 percent of the total volume of rainfall in a given year.

Why? Creeks within urban areas receive too much stormwater flow too often, completely altering the sensitive equilibrium between storms and creek organisms.

How? Stormwater volumes entering our creeks as surface water will decrease by letting stormwater infiltrate into soils. Stormwater turns into ground water that seeps into creeks and keeps water at a level that is habitable for fish and other aquatic organisms.

2. Protect Creek Channels: Where possible, NDS will be used to reduce the disturbance of creek channels to pre-development levels.

Why? Prior to development, large rainstorms significantly changed the physical form of creek channels only once a year or less. The use of traditional drainage systems in developed areas increases the speed and volume of stormwater flows. Subsequently, the physical form of creek channels

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changes more frequently. This leads to the damage of wildlife habitat.

How? By infiltrating into soils, stormwater flows and volumes entering our creeks will decrease and the physical form of creek channels will change less frequently.

3. Improve Water Quality: Reduce pollutants reaching water bodies.

Why? Urban environments generate pollutants that are transported to creek systems by stormwater, impacting creek life and the food chain that includes humans.

How? Soils and vegetation absorb water and filter out or chemically break down many contaminants.

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Benefits and Challenges

Benefits

Natural drainage systems (NDS) offer a number of benefits to homeowners, municipalities, and the environment:

- Reduce stormwater volumes, and thereby decrease flooding.
- Improve water quality because plants and other natural organisms remove or neutralize contaminants.
- Reduce peak flow volumes and provide more stability for our creek flows.
- Incorporate more trees and green space into our neighborhoods.
- Involve neighbors in planning and implementation.
- Increase pedestrian and traffic safety by reducing average auto speeds.
- Rather than deteriorating over time like piped systems, NDS become more effective as plants and trees grow.
- NDS can easily integrated into the landscape and appear more natural than traditional drainage systems.
- One or more of the swales, cascades, or other components of the system can fail without undermining the integrity of the system as a whole.
- Controlling runoff at the source eliminates the need for more costly conveyance systems, regional detention facilities, and mitigation for toxic buildups in water bodies.
- The reduction of impervious surfaces (such as roadways and sidewalks) and use of aboveground

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swales rather than underground vaults significantly reduce costs of new street and drainage improvements in residential areas of low to medium density.

Challenges

In addition to the benefits associated with NDS, there are also risks and uncertainties:

- The possible failure of infiltration, resulting in standing water within the swale. Mosquitoes require at least six days of standing water to breed. Therefore, all swales are designed to drain completely within three to five days.

- The possibility of infiltration causing slope instability. SPU has a policy of not placing infiltration facilities within one block of a steep slope at minimum and further if a geotechnical survey shows higher risk.

- Uncertainty regarding long-term impact on aquatic species in Seattle's creeks, lakes, and bays.

- Safety of car traffic on non-standard design streets.

- The reduction of available parking.

For municipalities, NDS may be difficult to implement due to institutional barriers:

- Traditional land use code standards may impede implementation of NDS. Traditional land use codes require wide street widths, curb and gutter, and piped stormwater infrastructure.

- Street design mangers often prefer to uphold existing national street standards they feel are necessary for car mobility and pedestrian safety.

- Fire response officials often assume the need for wider streets for emergency vehicle access.The High Point project required a city executive directive to secure street widths that were less than redevelopment code required. Once built, the established rules of standard street design can more easily be questioned as emergency vehicles navigate the new street without difficulty.

Although there can be significant hurdles to overcome, SPU found that the impact on our region's receiving waters is too high to forgo the study and implementation of natural

drainage systems.

Seattle develops at a slow rate (less than one percent per year); therefore new regulatory requirements in the state stormwater manual will take hundreds of years to be fully implemented. Taking a proactive retrofitting approach to improving receiving waters' health is a priority for the City.

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Frequently Asked Questions

Why is Seattle doing this program?
Urban activities such as landscaping, transportation, and business generate pollutants which are carried through creeks into nearby lakes and Puget Sound – impacting our local marine life food chain.

Traditional stormwater management, focusing on pipes to move stormwater from one area to another, serves worthy goals of flood reduction and public safety. Unfortunately, this type of management negatively impacts our creeks and the larger receiving water ecosystems they flow into.

Natural drainage systems (NDS) are a response to the public call to develop drainage projects that sustain high quality water bodies and species diversity. In addition, emerging federal and state environmental regulations clearly indicate that efforts to protect and enhance the state's receiving waters will be mandatory.

How are these projects funded?
Seattle property owners pay a drainage fee based on impervious surface coverage. The drainage fee supports many different drainage projects and programs at Seattle Public Utilities.

What are the benefits of using natural drainage systems?
Natural drainage systems

- Improve water quality through filtering out or chemically breaking down pollutants
- Slow the flow and reduce the volume of stormwater
- Incorporate more trees and green space into our neighborhoods
- Involve neighbors in planning, implementation, and maintenance
- Increase pedestrian and traffic safety by reducing average auto speeds
- Become more effective as plants and trees grow

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What are the drawbacks?
Because of the participatory and comprehensive nature of the projects, NDS can take more time than traditional systems in the planning and design phase. It may also be necessary, and difficult, to change street standards.

How much more do they cost than "traditional" systems?
NDS cost about 10 to 20 percent less than traditional street redevelopment with curb, gutter, catch basins, asphalt, and sidewalks.

How do they relate to work done in support of compliance with the Endangered Species Act?
NDS are an important element of Seattle's Endangered Species Act response. They are a key strategy to protect water bodies with all types of salmon and other aquatic life.

How do these systems perform over time?
From October of 2000 through September of 2003, the University of Washington monitored the stormwater flow of the SEA Streets project and found that the project prevented 99 percent of the wet season runoff from flowing directly into Piper's Creek.

SPU is monitoring the flow and water quality of the Broadview Green Grid and High Point.

How are sites selected?
Streets are selected based on the following criteria:

- The proposed project streets are residential streets.
- Each project street has or could have (by diverting flow from an adjacent ditch) a minimum of five acres of upstream drainage area directed to it.
- The majority of the project streets have no existing local drainage infrastructure.
- The potential project blocks have no existing formal street improvements, such as sidewalks and asphalt or concrete streets.
- All potential project streets are a minimum of 300 feet from a critical slope area (as defined by the Department of Planning and Development) so that infiltration technologies can be used.
- Existing soil maps do not indicate clay in the area.
- The longitudinal slope of project streets is less than eight percent. Larger longitudinal slopes may limit infiltration capacity or drive up project costs by requiring earth stabilization walls and fences.
- Potential project streets do not have a bus route on

them.

If any potential funding partnering is desired from Seattle Public Utilities, the proposed project streets must be in an area prioritized for one of our business area needs. These areas include creek basins, combined sewer overflow problem areas, and prioritized water quality basin areas. No funding mechanism is currently in place for partnering on these types of projects; this process will be initiated in 2008. Due to intensive time commitment for City staff to evaluate and develop a partnering strategy, the minimum project area that SPU can consider for partnership is a 600-foot project length.

Related links
Be a Creek Steward
Creek Restoration Projects
Charting Common Ground for Salmon and Buildings

Links to other sites
Low Impact Development - Learn how Puget Sound planners, developers, engineers and others are transitioning to an innovative approach to land development and stormwater management

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Technical Resources

Seattle Public Utilities offers an array of technical resources for other municipalities that have an interest in implementing natural drainage systems (NDS). Learn more about:

Measuring the Success of Natural Drainage Systems
The NDS program monitors water quality and surface runoff volumes at some NDS sites.

Cost Analysis (PDF)
A cost comparison of SPU's natural drainage system program and traditional street and drainage improvements.

Plant Palette, 2000-2006 (PDF)
Compilation of planting lists from SEA Streets and Broadview Green Grid.

Soil Specifications (PDF)
Soil mix requirements for High Point Phase I.

High Point Landscape Maintenance Guidelines (PDF)
Written to guide maintenance professionals at High Point, this manual is a good example of a landscape maintenance plan for any project. It has many practical methods and resources for landscapers and project managers.

Seattle Natural Drainage Systems Program Presentation (PDF)
Overview of NDS presented at the Second National Low Impact Development Conference.

Stormwater Design Seminars
2006 professional seminars highlighting design and construction lessons learned from NDS and Low Impact Development projects around the Northwest.

Practically Easy Landscape Manual: A Care Manual for Natural Drainage Systems, Fall 2006 Edition (PDF)
This manual outlines the responsibilities of the City and of residents in maintaining natural drainage systems. It also

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includes helpful tips for major landscape maintenance tasks needed to establish and nurture NDS plantings, or to maintain any residential yard.

Plant Identification (PDF) - Provides color photos, special needs, and environmental requirements of NDS plants.

Learn more about Project specific technical resources:

- Street Edge Alternatives (SEA Streets)
- Broadview Green Grid
- Pinehurst Green Grid
- 110th Cascade Project
- High Point Project

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Measuring Success of Natural Drainage Systems

From October of 2000 through September of 2003, the University of Washington's Department of Civil and Environmental Engineering monitored the stormwater flow of the Street Edge Alternatives project (SEA Streets). The Hydrologic Monitoring Report (pdf) was produced and found that the SEA Streets project:

- Prevented 99 percent of the wet season runoff from flowing directly into Pipers Creek between 2000 and 2003.
- Discharges much less runoff to Pipers Creek than a traditional system. A drainage system that adheres to City of Seattle conventions would have discharged almost 100 times more runoff to Pipers Creek as the SEA Streets system.
- Prevents more runoff from flowing directly into Pipe's Creek as time passes. As vegetation matures, more water is absorbed through the soil.

Seattle Public Utilities is monitoring the water quality of Broadview Green Grid. A report will be available at the end of 2007.

Seattle Public Utilities began monitoring the first phase of the High Point natural drainage system in January of 2007. Data will be available in three years.

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Seattle Public Utilities – Natural Drainage System Program

Problem Statement: Seattle's receiving waters and aquatic life have been significantly impaired by the negative impacts of urban stormwater runoff. Increasing volumes of runoff also cause flooding of roadways and property. Traditional methods of stormwater management and street design have proven to be ineffective at countering the impacts of current and future development on receiving waters.

Natural Drainage Systems (NDS) is an alternative stormwater management approach that delivers higher levels of environmental protection for receiving waters at a lower cost than traditional street and drainage improvements.

- NDS targets areas of the city draining to creek watersheds that do not currently have formal drainage or street improvements.
- NDS design is based on technology that emphasizes infiltration and decentralized treatment of stormwater to reduce the total volume of runoff reaching creek systems.
- The goal of NDS is to more closely match the hydrologic function of natural forests that existed prior to development, thereby creating stable creek systems and clean water.
- NDS designs cost less than traditional drainage and street designs.

Cost Analysis of Natural vs. Traditional Drainage Systems Meeting NDS Stormwater Goals

Street Type	***Local street*** **SEA Street**	***Local street*** **Traditional**	***Collector street*** **Cascade**	***Collector street*** **Traditional**	**Broadview Green Grid** 15 block area
Community Benefits	▪ one sidewalk per block ▪ new street paving ▪ traffic calming ▪ high neighborhood aesthetic	▪ two sidewalks per block ▪ new street paving ▪ no traffic calming ▪ no neighborhood aesthetic	▪ no street improvement ▪ moderate neighborhood aesthetic	▪ no street improvement ▪ no neighborhood aesthetic	▪ both 'SEA Street' and 'Cascade' types ▪ one sidewalk per block ▪ new paving ▪ high neighborhood aesthetic
Ecological Benefits	▪ high protection for aquatic biota ▪ mimics natural process ▪ bio-remediate pollutants	▪ high protection from flooding ▪ some water quality	▪ high water quality protection ▪ some flood protection	▪ high protection from flooding ▪ some water quality	▪ high water quality & aquatic biota protection ▪ some flood protection ▪ excellent monitoring opportunity
% impervious area	35%	35%	35%	35%	35%
Cost per block (330 linear feet)	$325,000	$425,000	$285,000	$520,400	Average per block: $280,000

SPU Natural Drainage Systems Plant Palette 2000-2006

A DRAFT compilation of planting lists from SEA Streets and the Broadview Green Grid.

Scientific Name	Common Name	Sun	Shade	Water	Native Notes
Emergent/Wetland Plants					
Carex obnupta	slough sedge	●		wet-moist	Y
Carex rostrata	beaked sedge	●		wet-moist	Y
Sagittaria latifolia	broadleaf arrowhead	●		wet-moist	Y
Scirpus acutus	hard stem bulrush	●		wet-moist	Y
Scirpus microcarpus	small fruit bulrush	●		wet-moist	Y
Evergreen Groundcover					
Arctostaphylos uva-ursi	kinnikinnick	●		dry	Y
Rubus calycinoides	creeping bramble	●		moist-dry	N
Ferns/Perennials/Herbs					
Athyrium filix-femina	lady fern	●	●	moist	Y
Asarum caudatum	wild ginger		●	moist	Y
Cornus canadensis	bunchberry		●	wet-moist	Y
Epimedium	epimedium		●	moist-dry	N
Gaura	gaura	●		moist-dry	N
Geranium sanguinium	cranesbill geranium	●	●	moist-dry	N
Helianthemum nummularium	sunrose	●		moist-dry	N
Hemerocallis spp.	day lily	●		moist-dry	N
Heuchera micrantha	purple palace heuchera		●	moist	N
Heuchera sanguinea	coral bells		●	moist	N
Iris douglasiana	Pacific coast iris	●		wet-moist	Y
Iris foetidissima	Gladwin iris	●	●	wet-moist	N
Lavandula spp.	lavender	●		dry	N
Lupinus spp.	lupine	●		dry	N/Y
Maianthemum dilatatum	false lily of the valley	●	●	wet-moist	Y
Polystichum munitum	sword fern		●	moist	Y
Smilacina racemosa	false solomon's seal		●	wet-moist	Y
Tolmiea menziesii	youth-on-age		●	wet-moist	Y
Evergreen Small Shrubs (12-30" Height)					
Gaultheria shallon	salal		●	moist-dry	Y
Mahonia nervosa	longleaf mahonia		●	moist-dry	Y
Mahonia repens	creeping mahonia	●		moist-dry	Y

Scientific Name	Common Name	Sun	Shade	Water	Native Notes
Deciduous Small Shrubs (12-30" Height)					
Cornus stolonifera 'Kelseyi'	dwarf redtwig dogwood	●	●	wet-moist	N
Potentilla fruticosa	bush cinquefoil	●		wet-moist	Y
Rosa spp.	dwarf wild rose	●		moist-dry	N
Symphoricarpos albus	snowberry	●	●	moist-dry	Y
Evergreen Shrubs (>48" Height)					
Arbutus unedo 'compacta'	compact strawberry tree	●		moist-dry	N
Myrica californica	California myrtle	●		wet-moist	Y
Vaccinium ovatum	evergreen huckleberry		●	moist-dry	Y
Deciduous Shrubs (>48" Height)					
Cornus stolonifera (& cultivars)	redtwig dogwood	●	●	wet-moist	Y
Hydrangea quercifolia	oak-leaf hydrangea	●	●	moist	N
Lonicera involucrata	twinberry	●	●	wet-moist	Y
Philadelphus lewisii	mock-orange	●		moist	N
Ribes sanguineum	red flowering currant	●		moist-dry	Y
Rosa nutkana	nootka rose	●		moist-dry	Y
Rosa rugosa	rugosa rose	●		moist-dry	N
Rosa woodsii	woods rose	●		moist-dry	Y
Rubus parviflora	thimbleberry	●	●	moist-dry	Y
Rubus spectabilis	salmonberry	●	●	moist-dry	Y
Vaccinium spp.	blueberry		●	moist-dry	Y/N
Evergreen Small Trees (16-20' Height)					
Arbutus unedo	strawberry tree	●		dry	N
Deciduous Small Trees (16-20' Height)					
Acer circinatum	vine maple		●	wet-moist	Y
Amelanchier alnifolia	Western serviceberry	●	●	dry	Y
Corylus cornuta	Western hazelnut	●	●	moist-dry	Y
Evergreen Medium Trees (20-30' Height)					
Chamaecyparis obtusa	Hinoki cypress	●		moist-dry	N
Pinus contorta	shore pine	●		wet-dry	Y
Deciduous Medium Trees (20-30' Height)					
Acer campestre	hedge maple	●		moist-dry	N
Cornus nuttallii	Western dogwood		●	moist-dry	Y
Crataegus spp.	hawthorn	●		wet-moist	Y/N
Magnolia 'Ballerina'	ballerina magnolia	●		moist-dry	N
Magnolia 'Galaxy'	galaxy magnolia	●		moist-dry	N
Sorbus spp.	mountain-ash	●		moist-dry	N

Scientific Name	Common Name	Sun	Shade	Water	Native Notes
Evergreen Large Trees (>30' Height)					
Pinus nigra	Austrian pine	●		moist-dry	N
Pinus thunbergii	Japanese black pine	●		moist-dry	N
Pseudotsuga menziesii	Douglas-fir	●		moist-dry	Y
Thuja plicata	Western redcedar		●	moist-wet	Y
Tsuga heterophylla	Western hemlock		●	moist-wet	Y
Deciduous Large Trees (>30' Height)					
Acer 'Norwegian sunset'	Norwegian sunset maple	●		moist-dry	N
Acer 'Pacific sunset'	Pacific sunset maple	●		moist-dry	N
Betula jacquemontii	Jackmonti birch	●	●	moist-dry	N
Cercidiphyllum japonicum	katsura tree			moist-dry	N
Fraxinus latifolia	oregon ash	●		wet-moist	Y
Fraxinus ornus	flowering ash	●		wet-moist	N
Fraxinus oxicarpa	flame ash	●		wet-moist	N

HIGH POINT PHASE I – GRADING AND INFRASTRUCTURE
SEATTLE, WASHINGTON
SECTION 02310
NATURAL DRAINAGE SYSTEM SOIL MIX

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. Work includes but is not limited to the following:
   1. Natural Drainage System (NDS) soil mixes.

1.2 SUBMITTALS

A. Submit the following in accordance with Section 01300 – Submittals:
   1. Manufacturer certification that the organic compost material meets the specifications in Part 2.1, including certified laboratory test results dated within 60 days of placement of material.
   2. As construction progresses, resubmit every 60 days manufacturer certification that the organic compost material meets the specifications in Part 2.1, including certified laboratory test results dated within 60 days of placement of material.
   3. A grain-size analysis per ASTM Designation D 422 (Standard Test Method for Particle-Size Analysis of Soils) from a representative sample of the gravelly sand material, demonstrating that it meets the specifications in Part 2.2.
   4. Organic content and permeability test results demonstrating the organic soil mixture meets the requirements specified in Parts 3.1.A.1 and 3.1.A.2.

B. Submit the following test results prior to mixing of compost with other specified materials in accordance with Section 01300 – Submittals:
   1. Solvita Compost Maturity Test of Organic Compost: Test results of Organic Compost shall be submitted one (1) working day prior to mixing Organic Compost with other NDS soil materials specified in Part 2. Organic Compost material that does not meet specifications noted in Part 2 shall not be mixed as NDS soil nor delivered to the site. Organic Compost material to be used in following day mixing operation shall be tested each day prior to mixing operation (i.e. this will be a continuous, at times daily, submittal process).

PART 2 – PRODUCTS

2.1 MATERIALS

A. Organic Compost: derive from a Type 1 feedstock and produced by a facility in compliance with WAC Chapter 173-350 (Solid Waste Handling Standards), Section 220 (Composting Facilities).
   1. Meet Grade AA Compost as defined by the Washington State Department of Ecology's Interim Guidelines for Compost Quality (Publication #94-38, Revised November 1994).
   2. Meet Grading Criteria: 100 percent passing a ½-inch screen.
   3. Decomposed Organic Compost shall be mature as US Composting Council stability test ratings referred to in the WAC 173-350.
   4. Meet Sovita Compost Maturity Test Score: 6 or above. Solvita Compost Maturity Test is available from Woods End Research Laboratory, phone (207) 293-2457 or 1(800) 451-0337, or website address: www.woodsend.org .

B. Gravelly sand: conform to the following gradation:

U.S. Sieve Size	Percent Passing
2-inch	100
¾-inch	70-100
¼-inch	50-80
No. 40	15-40
No. 200	0-3

C. Crushed Rock: use 5/8-inch clear crushed rock with no more than a trace of sand and silt.

D. Fill Sand: use slightly gravelly sand that meets the following gradation:

U.S. Sieve Size	Percent Passing
No. 4	95
No. 10	70-75
No. 20	58-62
No. 40	38-42
No. 60	12-16
No. 200	< 3

E. Provide gravelly sand free of organic material, contaminants, and hazardous materials.

PART 3– EXECUTION

3.1 MIXING

A. NDS Soil Mix #1:
   1. Mix 30 to 35 percent by volume organic compost with the remaining volume being gravelly sand to provide an organic soil mix with the following properties.
      a. Organic content between 4 and 8 percent by dry weight per ASTM D 2974.
      b. Minimum hydraulic conductivity rate of 4 inches per hour per ASTM Designation D 2434 when compacted to 80 percent of maximum dry density per ASTM Designation D 1557.

B. NDS Soil Mix #2:
   1. Mix three parts organic compost with one part fill sand by volume. Mix shall have an average organic content of 5 percent and be within a range of 4 to 8 percent as measured by ASTM D 2974.
   2. Mix 78 percent crushed rock to 22 percent organic mix by dry weight.

C. Mix each NDS Soil Mix uniformly to a homogeneous consistency.
   1. Do not mix in the rain or wet conditions.

3.2 STORAGE

A. Store stockpiles of organic soil mix in a manner that prevents them from becoming wet from rain, stormwater runoff, or other sources of water or contaminated by fine soil or other undesirable materials.

B. All stockpiles of mixed and pre-mixed NDS soil material shall be protected and covered in accordance with Contract Documents.

3.3 PLACEMENT

A. Moisture condition the organic soil mixes as needed for suitable placement and compaction and at the locations shown on the Drawings.

B. Place in lifts not exceeding 6 inches in loose thickness.

C. Compaction
   1. NDS Soil Mix #1: compact lightly organic soil mixes to not less than 70 percent and not more than 80 percent of the maximum dry density per ASTM Designation D 1557.
   2. NDS Soil Mix #2: compact to 95%.

D. Do not drive or park equipment on the NDS soil mix once placed.

E. Coordinate construction scheduling so that sediment laden water does not enter NDS soil mix once placed.

END OF SECTION 02310

News
Careers
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Garbage System
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Water System
>> Drainage & Sewer System

Project Photos

These photos can be used by government agencies, educational groups and individuals. Please reference Seattle Public Utilities as the source.

SEA Street before

SEA Street after

Natural Drainage Overview Home
Program Information
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» Project Photos
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SEA Street aerial view

SEA Street swale detail

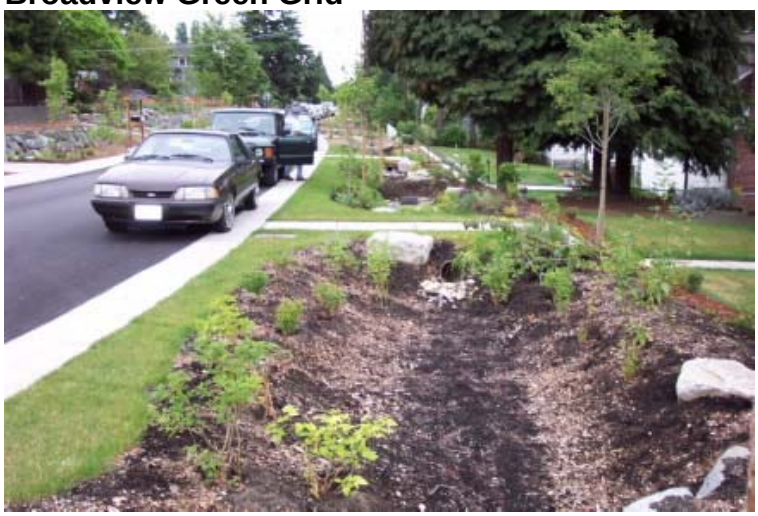
Planted swales on SEA Street

110th Street excavation, Summer 2003

110th Street planting, Winter 2003

Cascade in a storm, Broadview Green Grid

New grass, plants and swales on the street edge, Broadview Green Grid



New pavement in rain, Broadview Green Grid

New swale in rain, Broadview Green Grid

New curvy streets and sidewalks, Broadview Green

Grid

Pinehurst Swale

Pinehurst Street View

High Point Swales

Related links

Street Edge Alternatives (SEA Streets)
Broadview Green Grid Project
High Point Project
110th Cascade Project

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