Green Parking Lots

September 30, 2005

WHO SHOULD CONSIDER GREEN PARKING LOTS?

If you're looking for a cost-effective option for meeting landscaping and water quality requirements when building or redeveloping a parking lot, consider "going green."

WHAT ARE GREEN PARKING LOTS?

Green parking lots reduce runoff that is discharged into local water bodies by using permeable paving and natural drainage landscapes.

Alone or together, these two strategies can be used to meet water quality and landscape requirements and provide credit toward flow control requirements for parking lots.

Permeable Paving

Permeable pavements include pavers, grid systems, porous asphalt and porous concrete. Pavers may be pre-cast sections or individual units that fit together. They are available in a variety of patterns and colors and can be used to enhance the project's aesthetic. Grid or lattice systems are rigid plastic forms that are filled with gravel or soil and vegetation. Porous asphalt and porous concrete are similar to conventional asphalt and concrete in structure and form except that the fines (sand and finer material) have been removed.

When installed over a drainage storage bed, these permeable pavements allow rain to infiltrate through the voids of the permeable surface. Beneath the permeable surface, runoff storage is achieved and/or infiltration occurs where soil permits. Surfaces that infiltrate 100% of the six-month storm runoff may be eligible to be removed from area calculations for water quality requirements. See attached handout for more information on different types of permeable paving.

Natural Drainage Landscapes

Natural drainage landscapes include bio-swales, rain gardens, and bioengineered planting strips that can improve water quality and reduce runoff.

Bio-swales are open, linear channels that filter stormwater as the water flows through vegetation to the discharge point. Although their width and length vary as needed to achieve function, at a minimum they are two feet wide at the bottom and have a maximum slope of 2.5:1.

Rain gardens are shallow depressions in the landscape and are designed to hold and infiltrate runoff. They are amended with bioengineered soil and vegetated with plants that are adapted to both wet and dry conditions.

Bioengineered planting strips are similar to bio-swales but they include an infiltration component. As with rain gardens, native soil below the swale is excavated and backfilled with gravel and loamy sand and planted with shrubs and groundcover.

All systems include an overflow system such as a perforated pipe or a raised overflow device to convey excess drainage to another system or discharge point. These natural drainage landscapes can help reduce the volume of runoff generated from parking lots and filter, infiltrate and store runoff for slower discharge. Existing landscape features such as planters and landscape strips can be converted to natural drainage landscapes.

HOW DO GREEN PARKING LOTS MEET REQUIREMENTS?

The green parking lot strategies described above may help meet requirements for several City codes, including:

- Seattle Municipal Code (SMC) Ch.22.800, Stormwater, Grading, and Drainage Control Code
- SMC 23.47.016, Screening and Landscape Standards
- SDCI Director's Rule (DR) 26-2000, Volume 3, Flow Control Technical Requirements Manual

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- SDCI DR 27-2000, Volume 4, Stormwater Treatment Technical Requirements Manual
- SDCI DR 13-92, Landscape Standards for Compliance with the Land Use Code and SEPA Requirements

Stormwater Treatment Technical Requirements

Depending on the site, SMC 22.800-22.808 and SDCI DR 27-2000 require new and redeveloped parking lots to meet water quality treatment requirements.

Landscaping Requirements

SMC 23.47.016 specifies landscaping requirements for parking lots. These requirements are articulated further in SDCI DR 13-92.

Water Quality Treatment Requirements

Permeable paving can reduce the size of engineered stormwater treatment facilities by reducing the amount of runoff needing treatment. If designed to infiltrate the six-month storm, permeable pavement can be used to get a one-to-one impervious surface reduction credit for water quality treatment requirements.

Credit Toward Flow Control Requirements

Seattle DCI DR 26-2000 specifies how credit toward flow control requirements can be achieved.

Natural drainage landscapes may be used to meet both landscaping and water quality requirements. Parking lot areas that direct runoff to natural drainage landscapes may be eligible for water quality credit if they are sized to filter or infiltrate the six-month storm event. Permeable paving can be designed to meet water treatment requirements and provide credit toward flow control requirements. Refer to the codes and manuals listed above for design requirements.

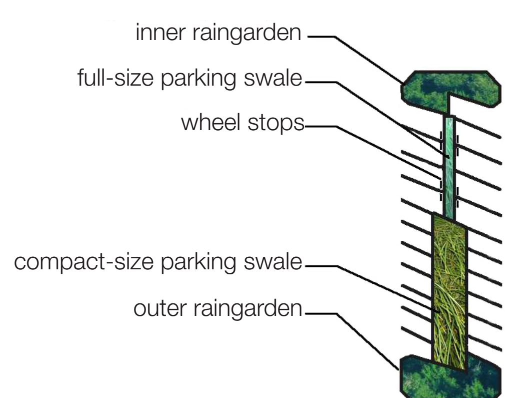
ADDITIONAL BENEFITS FROM GREEN PARKING LOTS

In addition to achieving landscaping, water quality treatment and flow control requirements, green parking lots may reduce capital costs and overall facility maintenance costs. Green parking lots also enhance the pedestrian experience for clients and customers by providing green islands in a sea of asphalt. Additional benefits include an increase in the amount of infiltration surfaces that filter and attenuate stormwater runoff flows, which can enhance the protection of nearby water bodies. The next section illustrates how these benefits can be achieved.

GREEN PARKING LOT DESIGN OPTIONS

Three innovative design options were developed for an existing 15-acre commercial parking lot to evaluate the feasibility and cost-effectiveness of green parking lots. Each of the three options uses permeable pavements and/or natural drainage landscapes. These options demonstrate that parking lots can achieve water quality treatment requirements using green strategies. Although unquantified for this project, the use of a natural drainage landscape is anticipated to reduce the total volume of stormwater from the site through some infiltration. For this case study, each green parking lot design option was compared to a conventional parking lot design that was being considered. A long-term economic analysis of the capital and maintenance costs found the green parking lot design options to be equal to or less expensive than the conventional parking lot design.

The green parking lot design options demonstrate that different combinations of porous asphalt, unit pavers, rain gardens and telescope swales can be used to meet the water quality treatment requirement. With the exception of the telescope swale, each of these elements has specific technical requirements for their design and construction that can be found in SDCI DR 26-2000. The telescope swales are a strategy specifically designed to integrate into parking lots. Telescope swales are designed to have multiple sections that vary in width over the length of the swale to accommodate both compact and standard size parking spaces (see figure).



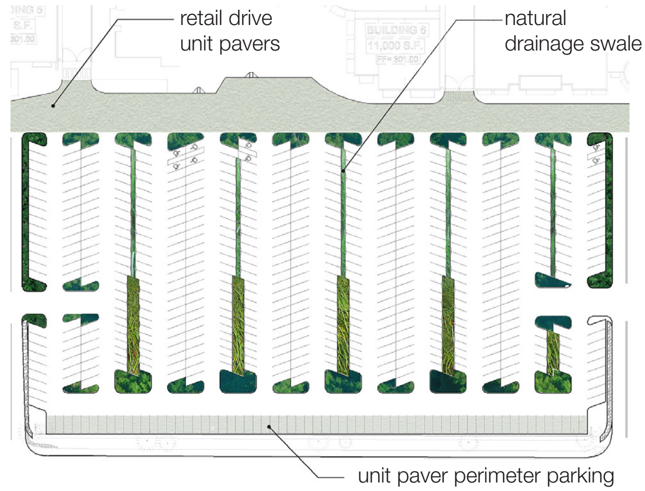
Telescope swale
Image courtesy of SvR Design Company

Option one is the conventional parking lot design to which the three green parking lot design options were compared. The conventional parking lot proposed to use detention vaults with water quality treatment filters to manage stormwater runoff.

Option two combines three strategies: telescope swales, unit pavers and porous asphalt. Telescope swales are distributed throughout the main parking lot. Unit pavers are used along the "retail drive" and in the perimeter parking spaces. Porous asphalt is proposed for the lower-use parking lot. This option enhances water quality, allows partial infiltration, attenuates very small storms, and contributes to the aesthetics of the parking lot design.

Option three also uses the telescope swales throughout the main parking lot and unit pavers along the retail drive and in the perimeter parking spaces. However, telescope swales replace the porous asphalt in the lower-use parking lot. The stormwater benefits of option three include enhanced water quality and attenuation of very small storms, but there is less infiltration than with option two.

Option four uses only telescope swales, which are used throughout the main parking lot and replace the porous asphalt in the lower-use parking lot. Catch basin filters replace the unit pavers along the perimeter of the parking lot. Since the entire permeable pavement area is replaced in this option, stormwater infiltration is less than that estimated for options two and three. Although not as effective as options two and three, this option is



Green parking lot design options
Image courtesy of SvR Design Company

Cost Comparison of Conventional and Green Parking Lot Designs*

	Option 1: Conventional Design w/ Water Quality Filters	Option 2: Pavers Porous Asphalt Telescoping Swales	Option 3: Pavers Telescoping Swales Water Quality Filters	Option 4: Telescoping Swales Water Quality Filters
Total Capital Costs ($ Mil.)	$6.60	$6.37	$6.10	$5.73
Maintenance Costs ($/yr.)				
Sweeping**	$35,040	$35,040	$35,040	$35,040
Landscaping	$20,000	$24,000	$24,000	$24,000
Water Quality	$14,000	$ 2,000	$ 4,000	$ 6,000
Total	$69,040	$61,040	$63,040	$65,040

*planning level estimates

**The Low Impact Development Technical Guidance Manual for Puget Sound recommends maintaining permeable pavements with high-efficiency or vacuum sweeping twice per year. Preferably, sweeping would occur once in the autumn after leaf fall, and again in early spring. For porous asphalt, high pressure hosing should follow sweeping once per year. The standard maintenance procedures for this commercial parking lot include vacuum sweeping, therefore the use of permeable pavement did not add an additional vacuum sweeping cost.

anticipated to enhance water quality and increase infiltration when compared to standard technologies.

The estimated total capital costs of construction for the green parking lot design options are less than the conventional parking lot design option. Additionally, the estimated maintenance costs for the green parking lot design options are less than the maintenance costs for the conventional parking lot design. Replacement of the water quality filters for the conventional parking lot design option is estimated at $14,000 per year. The estimated maintenance costs for the green parking lot design options are estimated to be $2,000-$6,000 when water quality filters are replaced with telescope swales.

GREEN PARKING LOT DESIGN CONSIDERATIONS

What is the native soil infiltration rate?

Since infiltration is one function of green parking lots, understanding the infiltration rate will help determine which strategies are appropriate and how they need to be designed. Greater infiltration rates can reduce the size and the cost of the facilities. Keep in mind that the low infiltration rates found in Seattle's typical glacial till soils can be significant enough to provide water quality benefit. Rates greater than or equal to 0.5 inch/hour are acceptable for designing an infiltration facility. See SDCI DR 26-2000 for guidance on determining soil infiltration rates.

If the 0.5 inch/hour infiltration rate threshold is not achieved, please see SDCI DR 26-2000 for additional flow control design guidance.

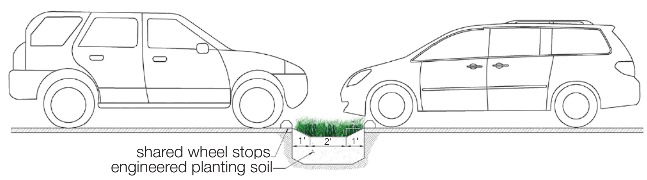
What is the minimum number of parking spaces required?

In addition to stormwater and landscaping requirements, there may be minimum requirements for the number and size of parking spaces. The dimensions and shape of natural drainage landscapes can be modified to fit adjacent to parking spaces.

Consider directing drainage flows to natural drainage landscapes along the perimeter, to swales between parking rows, and to rain gardens at the end of parking bays. Swales can be designed to accommodate the number and size of parking spaces desired.

Can wheel stops or curbs with curb cuts be positioned to allow vehicle bumpers to overhang natural drainage landscapes to economize space?

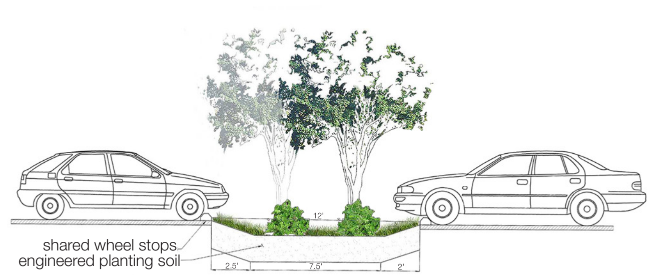
Yes. The image below illustrates this feature.



Full size swale
Image courtesy of SvR Design Company

Can compact spaces be located adjacent to larger natural drainage landscapes?

Yes. The image below illustrates this feature.



Compact size swale
Image courtesy of SvR Design Company

How much space is available for green parking lot strategies and what is the minimum dimension for the natural drainage landscape?

Each strategy should be sized to filter or infiltrate the six-month storm from the adjacent drainage area.

FIVE STEPS TOWARD A GREEN PARKING LOT

1. Determine native soil infiltration rate.
2. Determine the direction of stormwater flow and where it needs to be collected.
3. Determine opportunities for incorporating permeable pavement and natural drainage landscapes.

- Calculate the drainage area being directed to each natural drainage landscape area. Try to distribute flows to multiple landscaped areas.
- Incorporate permeable pavement in areas where appropriate, especially in over-flow parking areas, fire

lanes and other lower use areas. Determine impervious surface reduction credits and adjust the total area required for flow control and stormwater treatment. This can significantly reduce additional facility needs.

4. Determine the required dimensions for natural drainage landscape areas and ensure that the receiving area is sufficient and practical.

- For sizing bio-swales, refer to the continuous inflow biofiltration swale sizing method in SDCI DR 27-2000. For calculating size, width can be the average width of the swale area. The following modifications to the standard biofiltration swale sizing can be made: Flow rate can be modified to account for water infiltrated into the native soil; and vegetation type can be substituted with native plantings with non-woody, high stem density. If vegetation used is over 18 inches high, the maximum water quality treatment depth can be increased to 6 inches.

- For sizing rain gardens and bioengineered planters, refer to the sand filter sizing method in SDCI DR 27-2000. Maximum depth of surface ponding is 10 inches. Soil used in rain gardens should meet City of Seattle Specification 09-14.1(3)C, Bioretention Soil Type 2, and should be modeled using a hydraulic conductivity of 1 inch/hour maximum in areas not anticipated to have pedestrian traffic through the rain garden, and 0.5 inch/hour maximum in areas that do anticipate pedestrian traffic.

5. Identify location of overflow structure and where the structure is to be connected to the storm sewer.

One or more green parking lot strategies can provide multiple benefits. A green parking lot can prevent pollution at the source, remove pollutants before runoff is discharged, control discharge rates of stormwater runoff, and provide a pleasant experience for clients and customers. Green parking lots may save capital and maintenance costs and will enhance creek protection. For your next parking lot project, consider the benefits of a green parking lot.

Access to Information

Links to electronic versions of SDCI Tips and Director's Rules are available on the Resources page of our website at **www.seattle.gov/sdci**. Paper copies of these documents, as well as additional regulations mentioned in this Tip, are available from our Public Resource Center, located on the 20th floor of Seattle Municipal Tower at 700 Fifth Ave. in downtown Seattle, (206) 684-8467.

Page intentionally left blank. See Permeable Pavements attachment on subsequent pages.

WHAT ARE PERMEABLE PAVEMENTS?

Permeable pavements are surfaces that allow water to pass through voids in the paving material and/or between paving units while providing a stable, load-bearing surface. An important component to permeable pavements is the reservoir base course, which provides stability for load-bearing surfaces and underground storage for runoff.

What are the benefits of using permeable pavements?

Permeable pavements reduce impervious surfaces and can be used to achieve City of Seattle water quality requirements and credit toward flow control requirements. The capital and maintenance costs of permeable pavements can be less than conventional pavement materials if stormwater detention and/or water quality treatment is required.

What permeable pavements meet the City of Seattle standards?

When properly designed, porous concrete, porous asphalt, plastic grid systems and interlocking pavers meet the City of Seattle standards for pedestrian and/or vehicular use. A comparison of porous concrete, porous asphalt, plastic grid systems and interlocking pavers is presented in Table 1 (see reverse side).

What are some general design standards for permeable pavements?

- Use surface material that allows infiltration.
- Place a minimum 6-inch depth of aggregate base/storage bed below the permeable pavement surface.
- Provide positive drainage from the permeable surface (slope surface at 1% to 2%).
- Provide surface conveyance system as if material was impervious. Drain stormwater to a designed discharge point.
- Evaluate the need of perforated overflow pipe with project engineer or geotechnical engineer.
- Provide cleanouts when a perforated pipe is installed.

What are some general limitations of permeable pavements?

- Achieve a 2% slope or flatter. The maximum slope for any permeable pavement is 5%.
- Locate permeable pavements 300 feet away from steep slopes.
- Avoid use at high-use sites, commercial services for autos, i.e., gas stations, auto repair, auto wash, commercial truck parking areas, heavy industrial activity areas and areas with high pesticide use.
- Avoid use where seasonal high groundwater is at or near ground surface.
- Avoid use in areas subject to heavy, routine sanding for traction during snow and ice accumulation.
- Separate permeable pavements from arterial streets with a minimum 5-foot width-planting strip.
- Eliminate or minimize sediment from adjacent areas onto the permeable surface.
- Maintain a minimum 5-foot setback between any part of the permeable paving and any structure or property line.
- Avoid run-on from adjacent surfaces. If runoff comes from minor or incidental pervious areas, those areas must be fully stabilized.
- Avoid use on USDA Type D soil, or soils with a design infiltration rate of less than 0.5 inch per hour, unless a professional engineer submits design.
- Surface material cannot be treated with top-coat or slurry seal as this will clog the pores.

See Table 1. Permeable Paving Materials on reverse side.

Table 1. Permeable Paving Materials

Permeable Paving	Description/Design Considerations	Limitations	Maintenance	Cost[1]
Porous Concrete  *Image ©2020 Enginerring*	Porous Concrete is similar to standard pavement in aesthetics and load-bearing capacity, but the fine material (sand and finer) has been reduced or eliminated in the mix. As a result, channels form between the aggregate in the pavement surface to allow water to infiltrate. Acceptable porous concrete materials have a minimum of 15% voids and a minimum design infiltration rate of 200 inches/hour. Properly installed and maintained porous concrete is expected to have a service life that is longer than conventional asphalt, but shorter than conventional concrete.	■ Application must be large enough to be cost effective for supplier to mix material. ■ System must be designed with an overflow or lateral release from the storage bed.	■ Annual vacuum sweeping or high pressure hosing required to maintain function.	\$3 to \$5 per square foot. Costs are comparable to conventional concrete.
Porous Asphalt  *Image courtesy Cahill & Associates*	Porous Asphalt looks like conventional asphalt and it provides a load-bearing surface for low-traffic areas and pedestrians. The elimination of fines and the mix of stone aggregate and asphalt binder results in voids that allow water to infiltrate. Acceptable porous asphalt materials have a minimum of 15% voids and a minimum design infiltration rate of 200 inches/hour. Properly installed and maintained porous asphalt has a service life that is comparable or longer than conventional asphalt.	■ Application must be large enough to be cost effective for supplier to mix material. ■ System must be designed with an overflow or lateral release from the storage bed.	■ Annual vacuum sweeping or high pressure hosing required to maintain function.	Approximately \$1 per square foot. Application needs to be minimum size due to manufacturing requirements.
Grid/Lattice Systems Image  *Image courtesy Invisible Structures, Inc.*	Plastic Grid Systems are rigid, plastic cells that are filled with gravel or soil and grass. The cells allow water to infiltrate. The grid sections interlock and are pinned in place. Acceptable grid/lattice systems (filled with soil or sand medium) materials have a design infiltration rate of 10 inches/hour. Properly installed and maintained, plastic lattice systems have an expected service life of approximately 20 years.	■ Typical uses include alleys, driveways, utility access, loading areas, trails, and parking lots with relatively low traffic speeds (15-20 mph maximum).	Vegetated Systems: ■ May need occasional reseeding ■ Requires mowing and irrigation. Non-Vegetated Systems: ■ May need occasional refilling of crushed rock or gravel.	\$3 to \$4 per square foot.
Interlocking Pavers  *Image courtesy City of Seattle—Thor Peterson*	Interlocking Pavers are cast-in-place systems or modular pre-cast blocks that have wide joints or openings that are filled with gravel or soil and grass. They are available in a variety of materials, colors, and shapes. Acceptable interlocking pavers have a minimuim of 12% open space, and a minimum design infiltration rate of 10 inches/hour (when filled with soil or sand medium).	■ System must be designed with an overflow or lateral release from the storage bed.	■ Periodically add joint material (sand) to replace material that has been moved/worn by traffic or weather. ■ Easy to repair, since units are easily lifted and reset.	Approximately \$2.50 to \$4.50 per square foot.

[1] Cost for aggregate base/storage bed varies with depth and are not included in cost estimate. Costs and the majority of the design guidance in this document has been obtained from the Puget Sound Low Impact Design Manual.