Barriers to Implementing Low Impact Development Approaches in Washington State Roadways and Highways

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16. ABSTRACT

Low impact development (LID) is an approach to stormwater management that seeks to mimic the natural hydrologic functions of stormwater runoff prior to development. In general, LID techniques emphasize infiltration and evapotranspiration to remove pollutants and attenuate flows from urban runoff. As the largest land developer in Washington State, the Washington State Department of Transportation (WSDOT) is interested in better understanding the challenges of applying LID techniques to a highway setting and learning ways to address those challenges. This report identifies barriers to implementing LID approaches in a state roadway setting and provides recommendations on how WSDOT can overcome those barriers. This research question stems from a National Pollutant Discharge Elimination System municipal stormwater permit issued by the Washington State Department of Ecology (Ecology) to WSDOT in February 2009. Barriers were identified through a literature review, Ecology LID advisory committee meeting discussions, and interviews with people who are involved in stormwater management in a variety of capacities throughout Washington State.

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Barriers to Implementing Low Impact Development Approaches in Washington State Roadways and Highways

by

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Executive Summary

Stormwater runoff is one of the most urgent environmental issues in Washington State. Low impact development (LID) is an approach to stormwater management that seeks to mimic the natural hydrologic functions of stormwater runoff prior to development. In general, LID techniques emphasize infiltration and evapotranspiration to remove pollutants and attenuate flows from urban runoff. More conventional or "end-of-pipe" stormwater management systems channel runoff from development into detention ponds, combined sewer-stormwater systems and treatment facilities, or nearby bodies of water.

At its core, LID is a land use management philosophy that seeks to protect natural resources, prevent pollution, minimize adverse environmental impacts, and improve quality of life through green infrastructure and sustainable development. LID practices can be applied to a variety of development types, including residential, commercial, industrial, and recreational development. The use of the term LID in the realm of stormwater management, however, is a more recent application.

The Washington State Department of Transportation (WSDOT) is the largest land developer in Washington State. It ensures that people and goods can travel safely and efficiently throughout the state. In addition to providing mobility, WSDOT is committed to being an environmental steward and declares environmental quality as one of its five transportation policy goals. To fulfill this goal and its regulatory requirements, WSDOT is interested in better understanding the challenges of applying LID techniques to a highway setting and learning ways to address those challenges.

This report identifies barriers to implementing LID approaches in a state roadway setting and provides recommendations on how WSDOT can overcome those barriers. This research question stems from a National Pollutant Discharge Elimination System municipal stormwater permit issued by the Washington State Department of Ecology (Ecology) to WSDOT in February 2009. The permit covers discharges from municipal separate storm sewers owned or operated by WSDOT. This report concentrates on roadway and highway settings and does not address LID implementation in WSDOT owned parking lots, ferry terminal facilities, park-and-ride lots, rest areas, or maintenance yards.

Barriers were identified through a literature review, Ecology LID advisory committee meeting discussions, and interviews with people who are involved in stormwater management in a variety of capacities throughout Washington State.

Barriers to LID Implementation

Category of Barrier	Barrier	Barrier Description
Physical	Site infeasibility	Right-of-way space limitations; soil suitability; high groundwater; steep slopes; floodplains; proximity to wetlands; contaminated soils
	Studded tires	Damage from studs limits permeable paving applications
Technical	Inconsistent definitions	Disagreement on the greater meaning of LID and the techniques that have been identified as LID
	Unknown life cycle costs	Lack of understanding about what LID will cost to design, construct, and maintain in comparison to conventional stormwater approaches for each possible combination of soil, climate, and grade
	Unknown risks	Lack of long-term performance data
Institutional	Risk aversion	Conservative design criteria
	Stormwater is an afterthought	Stormwater missing from outset of the design process
	Lack of incentives from Ecology	Not enough reward to offset the risks of using unconventional stormwater approaches
	Lack of WSDOT management support	Current system does not encourage unconventional approaches
	Lack of education and training	LID is not a part of engineering culture
	Competing agency missions	Environmental priorities challenge priorities of safety and provision
	One-size fits all standard	LID applications limited to Ecology-approved toolbox

Recommendations

Based on the barriers identified, it is recommended that WSDOT:

- Research and test new LID techniques in sites traditionally considered infeasible
- Build consensus around definitions and characteristics of LID
- Prioritize LID lifecycle cost data collection
- Aggressively educate engineers about LID opportunities
- Bring together engineers and water-quality managers
- Develop a stronger vision for LID in highways with specific goals and targets
- Bring stormwater to the beginning of the design process
- Absorb the risk of trying new things

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Section 1: Introduction

Stormwater runoff is one of the most urgent environmental issues in Washington State. Stormwater is a leading contributor to water quality pollution in Puget Sound and is a serious threat to many waterways throughout our region.[1] As urban growth and land development increase the amount of impervious surface in our state, understanding how to best manage stormwater runoff has become a serious challenge for state agencies and municipalities.

Low impact development (LID) is an approach to stormwater management that seeks to mimic the natural hydrologic functions of stormwater runoff prior to development. In general, LID techniques emphasize infiltration and evapotranspiration to remove pollutants and attenuate flows from urban runoff.

The Washington State Department of Transportation (WSDOT) is the largest land developer in Washington State. It has built over 20,000 lane miles of highway and ensures that people and goods can travel safely and efficiently throughout the state. In addition to providing mobility, WSDOT is committed to being an environmental steward and declares environmental quality as one of its five transportation policy goals. To fulfill this goal and its regulatory requirements, WSDOT is interested in better understanding the challenges of applying LID techniques to a highway setting and learning ways to address those challenges.

This report investigates barriers to implementing LID approaches in a state roadway setting and provides recommendations on how WSDOT can overcome those barriers to not only meet regulatory requirements, but also to meet broader environmental protection goals that will improve air and water quality throughout Washington State. This report concentrates on roadway and highway settings and does not address LID implementation in WSDOT owned parking lots, ferry terminal facilities, park-and-ride lots, rest areas, or maintenance yards.

1.1 Research Question

This paper specifically addresses the following research questions:

1. **What are the barriers to implementing low impact development approaches in state roadway and highway settings?**

[1] Puget Sound Partnership (n.d.). *Stormwater and Low Impact Development (LID)*. Retrieved February 10, 2010, from http://www.psp.wa.gov/stormwater.php

2. What actions can WSDOT take to remove those barriers?

This research question stems from a National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit issued by the Washington State Department of Ecology (Ecology) to WSDOT in February 2009. The permit covers discharges from municipal separate storm sewers owned or operated by WSDOT.

The permit states that: "WSDOT's Stormwater Management Plan shall require non-structural preventative actions and source reduction approaches including Low Impact Development Techniques (LID), to minimize the creation of impervious surfaces, and measures to minimize the disturbance of soils and vegetation where feasible." The permit goes on to require that: "WSDOT shall identify barriers to implementation of LID and, in each annual report, identify actions taken to remove barriers identified."

The permit defines "low impact development" as "a stormwater management and land development strategy applied at a project scale that emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic pre-development hydrologic functions."

1.2 Methodology

There is no one definition of LID that applies to all development. The design and scale of LID depends on the context of the development to which it is applied. To assess the barriers to implementing LID in a highway setting this report uses the following three-step methodology:

Literature Review

The literature review establishes LID techniques currently used in stormwater management for state highways and explores some of the documented barriers to their implementation. The literature review covers regions outside of Washington State; however, because WSDOT is often considered at the forefront of stormwater technology and is subject to stricter environmental regulations than most U.S. states, there is little literature to evaluate.

Technical and Implementation Advisory Committee Tracking

To better understand the environmental regulations and community context shaping stormwater management, meetings of the Washington State Department of Ecology (Ecology) Technical Advisory Committee and the Implementation Advisory Committee in developing LID standards were regularly attended. The discussions at these meetings demonstrated the difficulties of defining new regulatory requirements and helped in the formulation of interview questions and recommendations for this report. More information on the committees and their role in shaping LID standards is located in Section Two: Background.

Interviews with Technical Specialists and Stakeholders

This report analyzes information gathered from semi-structured interviews with engineers, researchers, planners, and environmental specialists from municipalities, state agencies, and state universities. Main findings from the interviews demonstrate the challenges of utilizing LID approaches in Washington State highways and roadways. Other states and municipalities may find this report's findings useful in evaluating their own experience with LID, as the obstacles WSDOT currently faces may be similar to other agencies looking to increase their use of LID.

1.3 Interview Design and Analysis

As described in the previous subsection, research for this report was conducted through interviews, Ecology's technical and implementation advisory committee tracking, and a literature review. This subsection details how interviews were designed, conducted, and analyzed.

Interview Design and Data Collection

Semi-structured interviews were used to give both the interviewer and the respondents flexibility and to encourage more open, conversational, two-way communication. Interviews lasted about one hour and were conducted either in person or over the phone. An interview guide (See Appendix B) was prepared in advance of each interview, to help focus the conversation around topics relevant to LID implementation in a highway setting.

A total of 15 interviews (See Appendix C) were conducted with the following stakeholders from WSDOT, Ecology, Washington State University, and various municipalities in the Puget Sound region:

- Environmental and maintenance specialists
- Hydraulics/Stormwater engineers
- Hydraulics/Stormwater researchers

To ensure that a wide range of viewpoints are heard, all interviewees were asked to recommend other stakeholders involved in LID implementation that they think should be interviewed too.

Data Analysis

Interviews were summarized and analyzed using techniques outlined in *Qualitative Data Analysis* by Matthew B. Miles and Michael Huberman. Interviews responses were recorded in writing, along with field notes and questions raised by the subject, during the interview. Following the interview, responses were analyzed for common themes. Those themes were then listed into specific categories and responses were sorted out for analysis.

Using marginal notes as a coding aid, the following sequential analysis was applied to each interview:

1. Underline key terms.
2. Restate key phrases.
3. Create clusters related to key terms and phrases.
4. Make generalizations about ideas within each cluster.
5. Construct categories for each cluster based off of generalizations.
6. Integrate categories into policy implementation frameworks to make relevant recommendations.

1.4 Methodology Limitations

This report relies solely on qualitative data and could benefit from quantitative research. If there were more time and funding available, a structured interview or a survey questionnaire could be constructed to gather data for quantitative analysis. Having quantitative data would be helpful for strengthening findings and comparing results across different groups of respondents. It would also allow for WSDOT to learn how different stakeholders rank and rate different barriers to LID in relation to one another. Data that would permit WSDOT to systematically prioritize current barriers to LID was not collected for this report, but should be collected in the future.

Another limitation to this report is the interview design. Because interviews were not recorded, they could not be transcribed verbatim. Therefore, some of the data surrounding a respondent’s experience with LID was possibly lost or misinterpreted during note taking. Given the constraints of the interview design, it was sometimes challenging to capture wording accurately.

Section 2: The Context of Low Impact Development

2.1 Background

Stormwater discharges were added to the National Pollutant Discharge Elimination System (NPDES) in 1987 following amendments to the Clean Water Act (CWA). The Environmental Protection Agency (EPA) uses the NPDES permit program to verify stormwater discharge compliance with the terms of the CWA. EPA requires NPDES permits for discharges from four types of stormwater discharges:

- Municipal separate storm sewer systems (MS4s)
- Construction activity
- Industrial activity
- Sand and gravel activity

WSDOT has permit coverage for all four types of stormwater discharge. Ecology issues permit coverage to WSDOT.

As part of a larger movement in the late 1980s to protect water quality of the Puget Sound basin, the Washington State Legislature enacted the Puget Sound Highway Runoff Program. The Puget Sound Highway Runoff Program established controls for state highway runoff into state waterways.[2] It applied new stormwater rules to WSDOT regarding:

- best management practices (BMPs),
- new construction,
- inventorying
- retrofitting existing facilities
- vegetation management
- monitoring,
- reporting.

The legislation provided for discussion between WSDOT and any municipalities, tribes and organized parties affected by WSDOT's stormwater practices. WSDOT was also required to adopt an approved highway stormwater management manual.

[2] Washington Administrative Code tit. 173, 270 W.A.C. tit. § 270 (1991).

The Puget Sound Highway Runoff Program required WSDOT to develop its own Highway Runoff Manual and submit it to Ecology for approval.[3] The WSDOT Highway Runoff Manual established standards for stormwater runoff management from transportation infrastructure and by law, is required to be consistent with Ecology's Stormwater Management Manual. Much of Washington State's transportation infrastructure was built before passage of the CWA. Prior to CWA, most state roadways did not knowingly integrate low-impact development (LID) with stormwater management. Many roadside features were LID in nature (e.g., swales); however this was not understood to be LID at the time. Since then, WSDOT has worked to include many other LID techniques into its BMPs for controlling stormwater and preventing pollution from entering Washington State's waterways.

In 2008, the Pollution Control Hearings Board (PCHB) ordered Ecology to incorporate LID implementation language into its Phase I Municipal Stormwater General Permits. Phase I permits regulates stormwater discharges from municipalities with populations of more than 100,000, including the cities of Seattle and Tacoma, and the counties of Clark, King, Pierce and Snohomish. For Phase II, Ecology extended NPDES permit coverage across Washington State to include small MS4s. They issued two Phase II permits, one for Eastern Washington and one for Western Washington. Together the Phase II permits cover 100 cities and portions of 13 counties in Washington State.

WSDOT has been a Phase I permittee since 1995, when the first round of municipal permits were issued by Ecology. Upon permit reissuance, WSDOT, in agreement with Ecology, decided to apply for its own permit, covering Phase I and Phase II designated areas. WSDOT chose to apply for its own permit, rather than continue coverage under the general municipal stormwater permits because the general permits are written primarily for urban land use and are not well fit to a highway setting.

Ecology issued the NPDES Municipal Stormwater Permit to WSDOT in 2009. The permit regulates stormwater discharges from state highways and WSDOT facilities and requires compliance with all relevant EPA and Washington State water quality regulations. The permit also orders for nonstructural preventative actions and stormwater source reduction approaches, including LID approaches where feasible. However, the permit does not include specific language for LID standards or enforcement particular to a transportation setting. In addition, the permit requires WSDOT to identify barriers to LID and describe actions taken to remove those barriers.

[3] Washington Administrative Code tit. 173, 270 W.A.C. tit. § 270-030 (1991).

Ecology's municipal permit for WSDOT raised stakeholder concern.[4] In March 2009, Earthjustice, an environmental law firm, challenged the permit on behalf of the Puget Soundkeeper Alliance, a nonprofit environmental advocacy organization. The group alleged that the permit was inadequate because it lacked standards consistent with CWA requirements and it did not require for upgrades to existing roads to meet updated water quality standards. In January 2010, Ecology, WSDOT and the Puget Soundkeeper Alliance reached a settlement. In the settlement, Ecology agreed to modify the WSDOT permit[5] and WSDOT agreed, within the Puget Sound basin, to spend up to 20% of a highway project's stormwater management cost to retrofit an existing highway for stormwater pollution control.[6] For any highway areas where it is deemed infeasible or not cost-effective to retrofit, WSDOT must now provide cost information to document its decision. In addition, WSDOT agreed to list all projects that add impervious surface and are unable to meet stormwater requirements. This listing will also describe the BMPs used for each project. In short, WSDOT consented to put more resources into meeting stormwater management requirements for existing highways in the Puget Sound basin and increased transparency for any new project that does not meet current stormwater standards.[7]

In early 2009, the PCHB ruled that Ecology must work to prepare Phase II permittees in Western Washington for future implementation of LID. PCHB gave Ecology time and flexibility to figure out the best way to move forward with LID implementation in the form of:

- Performance standards,
- Permit modification, and
- Technical guidance documents for implementation.

By direction of PCHB, Ecology is focusing its efforts first at the site and subdivision scale.

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[4] Puget Soundkeeper Alliance vs. Washington State Department of Ecology and Washington State Department of Transportation. (2009). Appeal to the Pollution Control Hearings Board for the State of Washington.
[5] The permit was last modified May 5, 2010.
[6] Puget Soundkeeper Alliance. (January 26, 2010). *Deal Announced to Cut Stormwater Pollution in Washington State* [Press release]. Retrieved from: http://pugetsoundkeeper.org/press-room/press-releases/deal-announced-to-cut-stormwater-pollution-in-washington-state.
[7] Puget Soundkeeper Alliance v. Washington State Department of Ecology and Washington Department of Transportation, PCHB Nos. 09-203. Pollution Control Hearings Board Settlement, Stipulation and Joint Motion to Stay (January 2010).

In October 2009, Ecology began to convene implementation and technical advisory committees meetings to help inform the process of changing permit standards and defining feasibility. The Puget Sound Partnership (PSP), a state agency established to protect and restore the Puget Sound called for the development of new permit standards in their 2008 Puget Sound Action Agenda. The advisory committee meetings will continue through June 2010.

The implementation and technical advisory committees are a group of stakeholders that include selected Phase I and II permittees, environmentalists, developers, planners, and engineers (See Appendix, Part D). The workgroup is charged with determining technically feasible LID practices and developing a performance standard for project design and evaluation.
These meetings aim to help Ecology better define:

- The scope of LID techniques
- The criteria of feasibility techniques, and
- Specific LID performance standards.

Like many other stakeholders, WSDOT was invited to attend open meetings associated for this process, but was not granted a place in either the technical or implementation advisory committees. At the end of the process, Ecology will consider the input it received and decide on what LID-related permit requirements to include when the Phase I and II Permits are reissued. Ecology will also incorporate these requirements into the Stormwater Management Manual for Western Washington. However, the extent to which this process will explore LID techniques in the road and highway setting is unclear.

2.2 Definitions

LID in the context of land use planning has a long history. At its core, LID is a land use management philosophy that seeks to protect natural resources, prevent pollution, minimize adverse environmental impacts, and improve quality of life through green infrastructure and sustainable development. LID practices can be applied to a variety of development types, including residential, commercial, industrial, and recreational development.

The use of the term LID in the realm of stormwater management, however, is a more recent application. LID in stormwater management strives for specific water protection goals.

Low-impact development has many names. Here are a few common terms used to describe LID in stormwater management:

- Sustainable Stormwater Management
- Natural Drainage
- Stormwater Best Management Practices
- Green Infrastructure
- Green Engineering
- Water-Sensitive Urban Design
- Context Sensitive Design
- Flow control BMPs

According to Ecology, LID is "a stormwater management and land development strategy applied at a project scale that emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic pre-development hydrologic functions."[8] WSDOT uses a suite of LID techniques such as compost amended vegetative strips, media filter drains, and dispersion from its HRM's BMPs, approaches that "prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State."[9]

Seattle Public Utilities defines LID as "a stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning and distributed stormwater management practices that are integrated into a project design." Furthermore, Seattle labels LID-based stormwater management practices as "Green stormwater infrastructure" or GSI.[10]

The National Cooperative Highway Research Program defines LID as "a decentralized source and treatment control strategy for stormwater management." LID design "integrates natural hydrologic functions into the design to replicate the process of storage, detention, infiltration, evaporation and transpiration, or uptake by plants in order to

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[8] Washington State Department of Transportation. Municipal Stormwater Permit, page 43. May 2010.
[9] Ibid.
[10] Seattle Public Utilities, 2010.
http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/index.htm

reduce runoff volumes, attenuate peak runoff rates, and filter and remove pollutants from runoff."[11]

More conventional or "end-of-pipe" stormwater management systems channel runoff from development into detention ponds, combined sewer-stormwater systems and treatment facilities, or nearby bodies of water.

BMPs are structural or operational. Structural BMPs are usually constructed on-site for stormwater flow control treatment. For example, rain gardens and vegetative filter strips qualify as structural BMPs. Operational BMPs, also called nonstructural BMPs, relate to the maintenance of the development or facility. Examples of operational practices include street sweeping, catch basin cleaning, and illegal dumping control. In general, they are activities aimed at reducing pollution at a local or regional level (See Appendix, Part E).

LID is a category of BMPs. Some structural BMPs can take a LID approach; these are sometimes called LID BMPs. Conventional BMPs follow a more traditional approach to stormwater management. They typically collect and convey runoff through pipes or ditches to a stormwater facility such as a stormwater pond or vault and then an outfall to a surface water body, are sometimes referred to as an "end-of-pipe" solution.

2.3 A Working Definition of LID

For the purposes of this report, I have created a working definition of LID in the context of a highway setting:

> ***LID is an approach to stormwater management that uses a site's natural features and specially designed BMPs to minimize and manage stormwater at the source. The goal of LID in the highway setting is to mimic pre-development hydrologic functions and to minimize the negative environmental impacts of post-construction usage.***

[11] National Cooperative Highway Research Program, 2006. *Report 565: Evaluation of Best Management Practices for Highway Runoff Control* (prepared for Transportation Research Board of the National Academies). Page 22.

Section 3: LID Techniques in Stormwater Management for State Highways

The following are examples of LID techniques for state roadways. These examples were identified through both stakeholder interviews and a literature review. Interviewees mentioned these techniques because they are Ecology approved and appear in the WSDOT Highway Runoff Manual.

Dispersion: using existing or engineered natural area to remove pollutants from sheetflow stormwater runoff through a combination of vegetative and surface infiltration. Dispersion techniques include:

- Natural dispersion
    - Unconcentrated stormwater runoff sheetflows from the highway into a natural vegetative area. Natural dispersion often involves little or no construction activity, but can incur capital costs for right-of-way or easement land acquisition.

- Engineered dispersion
    - Concentrated stormwater runoff flows are dispersed via sheetflow with a flow spreader or energy dissipating device into a natural or engineered dispersion area (e.g., amended with compost and vegetation). Engineered dispersion requires construction activity and can also incur require right-of-way or easement land acquisition costs.

Biofiltration: using vegetation to filter and remove pollutants from stormwater runoff. Biofiltration also recharges groundwater. Biofiltration techniques include:

- Grass buffer or vegetated filter strip
    - Vegetated filter strips use vegetation and flat cross-slopes to maintain water flows. They reduce runoff speeds, trap sediment and filter pollutants. Grass buffers and vegetated filter strips are less expensive to install than average stormwater ponds.
- Compost Amended Vegetative Filter Strip (CAVFS)
    - A variation of the vegetated filter strip that incorporates compost into the soils of the roadside embankment.
    - CAVFS provides greater surface roughness, retention, and infiltration capacity. It is less expensive to install than average stormwater ponds.
- Bioinfiltration swale
    - Basic bioinfiltration swale: Roadside swale filled with vegetation, compost or porous mix, reduce runoff velocities and capture pollutants.

- Wet bioinfiltration swale: Variation on the basic infiltration swale to be used where site conditions cause soils to be saturated.
    - Continuous inflow bioinfiltration swale: Variation on the basic infiltration swale for sites where water enters swale continuously along the slide slope, instead of in concentration at an end upstream.
- Vegetation conservation
    - Native vegetation including, plants, trees, moss, grass, herbs, and wildflowers filter and break down pollutants, evapotranspires runoff, and provides oxygen
    - Soils surrounding development maintain stability, decreasing chance of erosion
- Vegetation planting
    - Vegetation filters and break downs pollutants, evapotranspires runoff, and provides oxygen
- Amending compost to soils
    - Compost increases infiltration capacity of soil
    - Compost increases spacing between soil particles, allowing soil to absorb more water
- Media filter drains (MFD)
    - A multi-component or "treatment train" stormwater runoff treatment device that runoff flows through in areas where right-of-way is limited. Media filter drains are installed along highway shoulders and medians to collect sheet flow. MDFs consist of a no-vegetation zone, a vegetated filter strip, a mixed media bed, and in the event of poor draining soils, a gravel-filled trench and drainpipe are added beneath the mixed media bed.

Infiltration: using a site's natural features or designed techniques to allow runoff to enter and absorb into the soil. Infiltration treats stormwater through settling, biological action, and filtration. Infiltration also recharges groundwater. LID infiltration techniques include:

- Permeable paving (limited application to highway settings)
    - Porous asphalt or concrete that allows stormwater to penetrate into the soil below.
- Infiltration trenches
    - Linear, stone-filled trenches used to collect, temporarily store, and infiltrate highway runoff.

Section 4: LID Implementation in Stormwater Management – Opportunities and Barriers

This section is a summary of barriers to and opportunities for implementing LID in highway stormwater management. These barriers and opportunities were identified through a literature review[12], Ecology LID advisory committee meeting discussions, and interviews with people who are involved in stormwater management in a variety of capacities throughout Washington State (see Appendix A).

Interviews took place February 2010 through April 2010 and were conducted either in person or over the phone. The statements given in support of the themes are simplistic; they summarize from the complexity of LID implementation, but in turn offer a clear picture about the attitudes and challenges facing LID implementation at WSDOT.

Interviews centered on the following topics, set in the highway environment:

1. Definition(s) of LID
2. Role of LID
3. Experiences with LID implementation
4. Benefits of LID
5. Opportunities for LID
6. Limitations of LID
7. Ideas for improving LID implementation

To facilitate understanding and organization, implementation barriers have been categorized as physical, technical, and institutional barriers. These categories were then further subdivided into themes. Recommendations for addressing the barriers are provided in the next section.

[12] There is a dearth of literature on barriers to LID in the realm of highway stormwater management. Studies documenting the barriers to implementing LID concentrate on residential or ultra-urban settings. The results of these studies are not often useful for understanding barriers to LID in a state highway setting that often presents different physical constraints as well as opportunities.

4.1 Opportunities for LID Implementation

Theme: LID has a place in the highway setting

There are unique opportunities for LID in a highway setting
Depending on the location and site constraints, large right-of-way (ROW) tracts give WSDOT unique opportunities to implement LID. These sorts of open spaces are hard to come by in tight, urban settings—for WSDOT as well. However, in some sites ROW is wide and long and ideal for biofiltration techniques. ROW in highways and roadways tends to be continuous and uninterrupted, meaning there aren't jurisdictional breakups and property setbacks to contend with. Having a large amount of land to work with for LID approaches is a privilege. LID allows for a more distributed approach to stormwater management, rather than a large, regional facility located at the end of a highway or outside of a watershed.

Controlled access is another opportunity for WSDOT. WSDOT has the advantage of being the developer, owner, and operator of its LID facilities. With controlled access, WSDOT does not have to be concerned about another party's failure to maintain the facilities or follow implementation rules.

Permeable paving on shoulders is also a possible opportunity for LID in a highway setting. There are limitations to permeable paving on driving lanes, but it could have the strength and longevity to be used adjacent to driving lanes. More research and testing on different types of permeable paving and its applications before it can be implemented widely.

According to stormwater engineers LID BMPs at WSDOT have largely focused on biofiltration and ignored evapotranspiration. This is primarily because WSDOT, like others in Washington, are required to use Ecology approved BMPs. There are unique opportunities for using evapotranspiration techniques as LID in parts of Washington. More testing and pilot projects would help evapotranspiration become a more common approach that is acceptable by Ecology's standards.

LID should be prioritized where it will provide the greatest environmental benefit
Some engineers felt strongly that LID should not be used solely for the sake of using LID. LID should be used when it is feasible and in sites where it will provide environmental benefit. Rural highways and roadways are less traveled and often are surrounded by undeveloped or forested land. Some engineers felt LID was not as high of priority in rural areas. They did not consider it worthwhile to spend a lot of money to implement LID in certain rural settings as it is in urban settings where traffic is greater and there is a much greater amount of impervious surface abutting ROWs.

4.2 Physical Barriers to LID Implementation

Theme: LID can't be implemented everywhere

Site infeasibility
LID cannot be implemented due to site limitations that are either impossible or impractical to overcome.

Examples of site infeasibility include:

- ROW space limitations: sometimes there is not enough space to meet the needs of both transportation and LID infrastructure. ROW limitations often occur in:
  - An urbanized setting,
  - Roads sited alongside rivers,
  - Bridges.

- Soil suitability: well-drained soils are vital to LID infiltration techniques. LID is infeasible in sites where soils do not have the capacity to store and release water.

- High groundwater: Water beneath the ground surface in soil spaces and rock formation fractures. Regions that experience heavy or frequent rainfall tend to have high groundwater.
  - High groundwater is a common limitation in Western Washington because roads and communities were sited in floodplains.

- Steep slopes: infiltration into steep slopes can cause instability, resulting in landslides or erosion.

- Proximity to wetlands and water bodies

- Contaminated soils: infiltration of stormwater will cause contamination in soils to spread and possibly enter waterways or groundwater

Studded tires limit permeable paving applications
Studded tires are small metal juts inserted into winter tires to provide greater traction in snow and ice conditions. Studded tires damage permeable pavement, making it costly and unsafe to implement. Studded tires damage regular pavement too; it creates ruts in roadways that fill with ice or water and cause drivers to slip or hydroplane. Some U.S.

states have banned studded tires. Washington State has not banned studded tires, but has restrictions on the times of year in which they can be used.

4.3 Technical Barriers to LID Implementation

Theme: Inconsistent Definitions

LID is big; LID is small

Most interviewees described LID as both a macro-level environmental goal to minimize negative environmental impacts and micro-level techniques to mimic pre-existing hydrology. Some also described it as an environmental position or philosophy. Some interviewees felt that there is some argument between the greater meaning of LID and the techniques that have been identified as LID. There are conventional/tradition techniques that aren't strictly LID by definition that achieve the larger goal of LID. An example of this is an infiltration pond.

LID goes by many names

Different stakeholders call LID different things across Washington State and the United States. A few interviewees felt that an abundance of terms can cause confusion working across jurisdictions and poses a challenge to bringing in the public to the discussion of LID use in their region.

Theme: Uncertainty around LID

The lifecycle costs of LID are unclear

The construction and maintenance costs of LID are important factors in their implementation. In some sites, LID is a less expensive method of stormwater management, while in other sites, LID is more expensive to implement and maintain than traditional end-of-pipe systems. There is not enough understanding about what LID will cost to design, construct, and maintain in comparison to traditional/conventional stormwater approaches for each possible combination of soil, climate, and grade throughout Washington State. These uncertainties can make planners and engineers reluctant to use LID.

Risks of LID are not entirely known

There are questions about the efficacy of LID in a highway setting that have not yet been answered by pilot projects and research. It is unclear how some LID BMPs will perform in the long-term, especially across different climates and soil types. This characteristic of LID can make planners and engineers reluctant to use it. Three examples of risks cited by engineers were lack of spill containment, vegetation's susceptibility to toxic spills, and the cost-effectiveness of permeable paving. They wondered how permeable pavement would endure a chemical spill and if the soil beneath the pavement would become contaminated and require removal.

4.5 Institutional Barriers to Implementation

Theme: Uncertainty around LID

WSDOT takes a conservative approach to LID

WSDOT is a risk-averse organization. Public safety comes first and in issues of stormwater management, its foremost goal is to maintain the structural integrity of the road so that people and goods can travel safely and efficiently. WSDOT's design criteria is conservative and favors BMPs that are proven techniques to remove runoff from the surface of the road so as not to compromise safety or the integrity of the transportation infrastructure. Water quality managers held that in certain sites, LID BMPs could perform the same or better than conventional stormwater techniques, but they do not yet have the years of applied use to demonstrate effectiveness and durability behind them. This means LID is not used as often as it could be.

Theme: LID needs a greater push from WSDOT and Ecology

Stormwater design is often an afterthought

Neither stormwater nor LID is a part of the WSDOT Design Manual; it is discussed separately in the Highway Runoff Manual. Water quality and stormwater managers felt that LID use could improve if stormwater design was considered at the outset of the project in the early design phases, rather than in the later phases of project development. Transportation engineers and stormwater engineers don't often come together at the beginning of a project or before right-of-way is purchased to think through stormwater design and LID opportunities in for drainage.

LID needs more incentives from Ecology

Ecology-approved stormwater guidance manuals and modeling tools do not take into account the actual benefits of using LID approaches compared to more conventional BMPs. Thus, project engineers tend to rely on traditional stormwater approaches because there isn't a big enough incentive for using these alternative approaches.

LID needs more management support

Project engineers who do choose to implement LID don't receive enough ongoing support from management at WSDOT. LID can face a long review process or unexpected site infeasibility challenges. This can create frustration, especially if there is pressure to keep the project on schedule and on budget. Project engineers feel they are taking a risk when they implement LID and WSDOT lacks an administrative support system for people willing to try new ideas. They would like to see a management system that doesn't penalize them for taking more time and resources to experiment with an unconventional approach.

Engineers need more LID education and training

Nearly all interviewees—including engineers—stated that project engineers need to have a better understanding of LID and how to implement it. LID isn't yet a part of engineering culture, but increased training and education will allow project engineers to feel confident in implementing LID into typical transportation projects.

Theme: LID requirements pose challenges

There are competing agency missions

WSDOT's core mission is to "keep people and businesses moving;" Ecology's core mission is to "protect, preserve, and enhance Washington's environment." Deciding which mission to prioritize is a matter of public policy and civic engagement. Environmental planners and stormwater engineers alike feel that sometimes priorities of environmental protection outweigh those of improved transportation provision and safety; sometimes they do not.

All interviewees stated that LID techniques are not always possible for state transportation development. For example, Federal Highway Administration (FHWA) requires certain lane widths and clear zones for safety. These requirements can diverge from LID techniques that would require native vegetation and reduced pervious surface. Critical habitats for the protection of ESA listed species such as salmon and steelhead, might also limit the space needed for LID techniques.

According to stormwater program managers, stormwater regulations are also not well understood throughout all WSDOT staff. Stormwater regulations are understood by staff who work on stormwater, but not those in different areas of transportation design and engineering. This feature, coupled with a quickly shifting regulatory landscape, makes implementation difficult. If there is uncertainty around regulation, planners and engineers will continue to approach stormwater with the traditional methods they know to work.

A one-size-fits-all standard does not work

To meet both conservative performance standards and LID goals, WSDOT needs a diverse set of tools. If WSDOT is limited to the tools used in urban or residential development, it will not succeed in using LID.

Section 5: Recommendations

The following section gives recommendations for how WSDOT can address the barriers identified and described in Section 4. These recommendations were devised using established public management, policy analysis and consensus building frameworks.[13]

5.1 Physical Barriers: Recommendations

Research and test new LID techniques in sites traditionally considered infeasible

New techniques may work differently than anticipated and lead to changes in design criteria for stormwater management. Contract out third-party evaluations of new LID stormwater treatment techniques and technologies. Third-party evaluations may develop the basis to help LID techniques gain acceptance as reliable stormwater treatment to WSDOT engineering and maintenance staff and regulatory authorities.

5.2 Technical Barriers: Recommendations

Build consensus around definitions and characteristics of LID

Some LID techniques are based upon established civil engineering principles, but how they are being applied to transportation today is still relatively new. In short, the LID lexicon is still being established and the definition of what LID is and isn't, particularly in the realm of state roadways, is not well understood. These differences of opinion can make it difficult to implement LID strategies because there will not be buy-in from all different groups of WSDOT staff and its regulators. If there are LID strategies that WSDOT considers applicable to transportation development but other agencies do not consider applicable, those differences need to be aired and worked out in order for LID to be more broadly implemented and accepted.

Prioritize LID lifecycle cost data collection

Engineers may know how LID works, but they do not know for how long it will function properly. Long-term performance data of LID is needed to make technical staff more comfortable with using new approaches to managing stormwater. Lifecycle costs, including operation and maintenance, need to be calculated so that engineers and project planners can make accurate cost-benefit decisions. Unknown costs of inspections,

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[13] Bardach (2009), Brinkerhoff and Crosby (2002), and Weimer (2005). See Section 8: References for full entries.

maintenance, and installation and maintenance equipment for LID projects make it difficult for managers to estimate for lifecycle costs.

Some BMPs cost more to maintain and inspect than others. The costs of LID BMPs, including scheduled maintenance and failure rates, should be made clear to project engineers. Costs should be compiled into a common metric with other BMPs so that the decision is easier to make. If there is a common cost metric, engineers might be able to see how implementing LID will reduce the costs of other infrastructure needs. Not having lifecycle cost data is a risk to managers and engineers and gives them good reason to be reluctant to implement LID widely.

5.3 Institutional Barriers: Recommendations

Aggressively educate engineers about LID opportunities

Education is crucial to LID implementation. As one engineer describes it, "Opportunities for LID are created, capitalized upon, or lost by the engineers associated with a project."[14] Many interviewees cited the inertia of engineering culture as a reason why LID did not yet have broad acceptance. Because engineers are trained to notice all the ways things can go wrong, they are reluctant to accept new applications. The best way to overcome this barrier is to acknowledge and understand their reasons for resistance, and then to educate and train them in new stormwater approaches. Therefore, WSDOT should develop an initiative that aims to help WSDOT staff work through the stages of LID implementation and permit changes to come. An initiative would require a dedication of resources to education, research, training, and inspection. Through this initiative, WSDOT could take bold steps such as requiring LID knowledge for all contractors and could work towards requiring LID training for all contractors and subcontractors hired for a project.

Admittedly, it is difficult to teach people about LID standards when they are not yet set or are changing. But once the standards are set, it will be easier to bring engineers to action if they don't feel the approaches they are being asked to use are risky.

Bring together engineers and water-quality managers

WSDOT needs to bring together engineers and water-quality managers to share ideas and communicate experiences. For LID to have broader acceptance, professionals from different parts of the design and post-construction process need to come together to

[14] Matel, Larry John. *Creating an LID Environment in an Ultra Urban Setting, Part One*. Conference Paper at the 2008 International LID Conference, Seattle, Washington.

discuss and learn about LID in highways. For LID implementation to work, WSDOT needs buy-in from its engineers. Therefore, engineers' voices need to be heard and their expertise needs to be a part of the discussion in wider application of LID.

Develop a stronger vision for LID in highways with specific goals and targets

To do this, WSDOT should develop an initiative that aims to help WSDOT staff work through the stages of LID implementation and permit changes to come. An initiative would require a dedication of resources to education, research, training, and inspection. Through this initiative, WSDOT could take bold steps such as requiring LID knowledge for all contractors and could work towards requiring LID training for all contractors and subcontractors hired for a project.

Bring stormwater to the beginning of design

A paradigmatic change is needed for long-term success of LID implementation. If stormwater has long been an afterthought of highway design and construction, there needs to be a strong effort to bring LID to the forefront of a project. To be considered at the outset of design, LID should be included in the Design Manual, in addition to the Highway Runoff Manual. For LID to be successful, both hydraulic engineers and construction engineers need to be sharing the same information. If stormwater needs are considered at the start of the project, then LID can be more efficiently incorporated into projects.

Absorb the risk of trying new things

Liability and public disclosure of mistakes are two reasons cited by engineers for why they are reluctant to try LID BMPs. For many, the level of comfort with LID BMPs is still low, and the risks are still high. If WSDOT wants to encourage LID implementation, it needs to shoulder some of that risk so that smaller, private contractors can be more innovative. Ecology also has a role to play in absorbing risk and fostering innovation. As a stormwater regulator, Ecology should facilitate the LID learning process by being flexible and communicative with WSDOT. Encouraging change will be difficult, as WSDOT itself is risk averse, but meaningful support from WSDOT and Ecology is necessary if WSDOT staff is to move through the LID learning curve.

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Appendix

A. Interviews

Name	Title	Organization	Date
Steve Foley	Senior Engineer	Regulations and Compliance Unit, King County	May 4, 2010
Dick Gersib	Stormwater and Watersheds Program Manager	Environmental Services Office, WSDOT	April 21, 2010
Liv Hasselbach	Associate Professor	Civil and Environmental Engineering, Washington State University	April 28, 2010
Greg Lahti	Hydraulics Engineer	Eastern Region, WSDOT	March 10, 2010
Larry Matel	Managing Engineer	City of Bremerton, Department of Public Works and Transportation	May 10, 2010
Mark Maurer	Highway Runoff Program Manager	Environmental Services Office, WSDOT	February 25, 2010
Mike Misiak	Hydraulics Engineer	Southwest Region, WSDOT	April 8, 2010
Aimee Navickis-Brasch	Hydraulics Engineer	Headquarters, WSDOT	February 24, 2010
Alex Nguyen	Hydraulics Engineer	Headquarters, WSDOT	February 25, 2010
Robert Nolan	Stormwater Engineer	Multi-Agency Permitting, Ecology	April 8, 2010
Norm Payton	Maintenance Water Quality Manager	Headquarters, WSDOT	April 6, 2010
Larry Schaffner	Municipal Stormwater Permit Coordinator	Environmental Service, WSDOT	January 28, 2010
Tracy Tackett	LID Program Manager, Engineer	Seattle Public Utilities	April 27, 2010
Bruce Wulkan	Stormwater Program Manager	Partnership for Puget Sound	May 7, 2010
Jane Zimmerman	Senior Engineer	City of Everett Public Works Department	April 21, 2010

B. Semi-Structured Interview Guide

<u>Before Interview:</u>

1. Explain who I am, what my project is, and how it will be used.

- My name is Claire Miccio and I am a graduate intern working with Larry Schaffner on identifying barriers to implementing LID approaches in the highway setting. My work will help WSDOT meet its regulatory obligations for stormwater permit compliance.

2. Ask if they have any questions about what I've explained.

3. Make clear that I am discussing LID approaches in a highway setting.

<u>Interview Questions:</u>

1. What is your position at (agency or organization name)? Tell me about your role there.
2. Based on your knowledge of LID, how would you define or describe LID within a highway setting?
3. What do you consider the benefits or opportunities of utilizing LID approaches in the highway setting?
4. What do you consider the limitations of utilizing LID approaches in the highway setting?
5. In your experience, what are some challenges with implementing LID in a highway setting?
6. What do you think are some good ways that WSDOT could address these challenges of LID implementation?
7. (Optional) Would it be okay if I contacted you later for any follow-up?
8. (Optional) Do you have any suggestions for someone I could talk to regarding LID implementation?

<u>Follow-up Prompts:</u>

1. Can you describe a specific example? If no answer, prompt: technical problems, institutional problems, or physical problems.

2. In your experience, did you encounter region or site specific challenges?
3. Do you feel this way from experience? Could you illustrate this with a specific problem?
4. What is your experience with LID and WSDOT?
5. What are your thoughts on how WSDOT has implemented LID in the past?
6. Do you have any additional comments about LID you would like to share?

C. Alphabetical List of Abbreviations

BMP – Best management practice

CAVFS – Compost Amended Vegetated Filter Strip

CWA - Clean Water Act

Ecology – Washington State Department of Ecology

EPA – United States Environmental Protection Agency

FHWA – Federal Highway Administration

GSI – Green Stormwater Infrastructure

HRM – Highway Runoff Manual

LID – Low impact development

MFD – Media Filter Drain

MS4 - Municipal separate storm sewer systems

NPDES – National Pollutant Discharge Elimination System

PCHB – Pollution Control Hearings Board

PSP – Puget Sound Partnership

ROW – Right-of-way

WSDOT – Washington Department of Transportation

D. LID Advisory Committee Members

LID Technical Advisory Committee

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E. Nonstructural BMP Chart

Source: NCHRP Report 565, 2006

Nonstructural BMP	Type
Source Control/Maintenance	Street sweeping
	Catch basin cleaning
	Good housekeeping practices, e.g., covering of stockpiled materials, washing of construction vehicles before leaving construction sites
	Safer alternative products, e.g., highway construction materials, herbicides, road salts
	Material storage control
	Reduction in vehicle use
	Household hazardous waste collection*
	Used oil recycling
	Vehicle spill control
	Above-ground tank spill control
	Illegal dumping control
	Vegetation control
	Storm drain flushing
	Roadway and bridge maintenance
	Detention and infiltration device maintenance
	Litter control
	Litter pickup
Public Education and Participation	Education, e.g., newspapers, brochures, K-12
	Land use planning and management
	Adopt-a-Highway
	Integrated pest management
	Storm drain system signs (stenciling)
Other	Curb elimination
	Reduction of runoff velocity

* Unlikely to be applicable to highways.