Washington State Department of Transportation

Office of Research and Library Services
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research notes

Low Impact Development Methods for Stormwater Management

The Problem

Many research efforts have been undertaken in recent years to determine the characteristics of stormwater impacts on the natural environment and it has generally concluded that stormwater from impervious surfaces (i.e., roads) must be mitigated to ensure that the quantity and quality of that runoff will not degrade environmental conditions. Traditional methods of stormwater runoff treatment have involved detention ponds which collect highway runoff in a central location. Recent studies have shown that centralizing highway water runoff may inhibit the natural recharge of groundwater. These methods are also very susceptible to maintenance problems. Also, centralized detention facilities, such as detention ponds and constructed wetlands, are difficult and costly to build in rural areas where the long, straight stretches of the highway system make it difficult to collect runoff.

A new method using existing vegetated right of way to treat highway stormwater has been tested. Generally referred to as "low impact development" (LID), it shows promise as being a cost effective and efficient way to deal with the "quality" of highway stormwater runoff — particularly in rural areas. However, there has been little documented evidence as to its ability to mitigate the total volume (quantity) of stormwater. The use of the LID design in lieu of traditional stormwater treatment might be more beneficial, but more information to determine this was needed.

This wet pond is a traditional highway stormwater runoff quantity control facility. It requires conveyance systems and valuable right of way property. It also requires ongoing maintenance and can have performance issues.

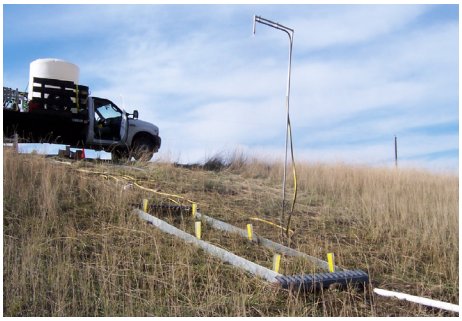
Above are two examples of Urban Local Impact Development (LID) stormwater designs. They treat runoff at or near the source to avoid concentrating stormwater runoff in pipes or ditches. They work by using natural systems such as infiltration and retention that uses sheet flow across permeable surfaces adjacent to impervious areas without the use of conveyance systems.

What We Did

This research evaluated how stormwater naturally disperses and infiltrates by using rainfall/runoff data collected primarily in eastern Washington. This information was coupled with a numerical model. The study looked at the effects of slope, length, and amount of impervious coverage in the runoff area on natural dispersion applications. A simplified equation was established, termed the LID Design Equation, to analyze natural dispersion performance. The equation can be used with inputs from site specific conditions, allowing highway engineers to tailor natural dispersion requirements for various locations throughout eastern Washington.

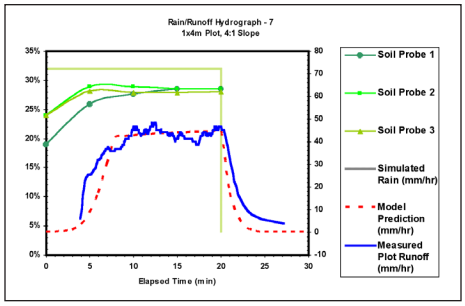
What We Learned

Low impact development may be a viable solution for dealing with the quantity of highway stormwater runoff in areas of Washington State, particularly where the slope of the drainage area is not as steep as the current design guideline requiring a 7:1 slope. The field research did not



A mobile rainfall simulator was invented for this research and used for field testing in a number of locations with variable, but controlled water flows.

Numerical Modeling Compared With Field Tests



Numerical modeling is used to compare and analyze the field data.

Comparing Results

Highway Location	Roadway Width (m)	Embankment K_{sat} Value (mm/hr)	Current WSDOT LID Length Guidance (m)	Equation 3 LID Length Requirement (m)
Stevens Pass	14.0	152	5.0	4.7
Stevens Pass	14.0	102	5.0	6.0
Stevens Pass	6.1	102	3.0	2.6
Wenatchee	14.0	152	5.0	2.7
Wenatchee	14.0	75	N/A	4.5
Wenatchee	6.1	75	N/A	2.0
Moses Lake	14.0	152	5.0	2.4
Moses Lake	14.0	102	5.0	3.2
Moses Lake	6.1	50	N/A	2.3
Spokane	14.0	152	5.0	2.8
Spokane	14.0	102	5.0	3.8
Spokane	6.1	102	3.0	1.7

This chart shows a comparison of the Current Natural Dispersion Guidance vs. the Simplified Design Equation.

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observe more runoff on steeper slopes. This means that LID design and applications may be an effective treatment method at more locations along the highways, particularly in eastern Washington.

This research also developed a new method for analyzing whether low impact development methods are appropriate at certain locations. Both field experiments and numerical modeling were used to develop a design equation. The modeling identifies the relationship between measurable design variables such as saturated hydraulic conductivity, roadway width, rainfall intensity, and roadway embankment. The field test data was compared to the numeric model output to develop a simplified design equation for highway engineers to use.

What the Researchers Recommend

New concepts in stormwater treatment such as low impact development, which focus on decentralized strategies such as natural dispersion may be a viable solution to the management of highway stormwater in some circumstances. Natural dispersion allows non-concentrated flows to infiltrate into roadside areas without the need for capturing the runoff. This is particularly relevant to many multi-lane highways in eastern Washington, as well as most rural arterials throughout the state.

The recommended changes to existing natural dispersion evaluation guidelines includes revising LID slope requirements to include up to 3:1 slopes and to use a LID Design Equation that incorporates roadway width, measured conductivity values, and climate specific design rainfall intensities when considering applications.

Summary of Implementation

The results of this research clearly produced a reliable method of natural dispersion analysis that should be incorporated into stormwater design procedures in lieu of current natural dispersion guidelines in Washington State. However, further work remains to determine the saturated hydraulic conductively related to the LID areas. Current methods of measurement involve the use of soil sieve analysis based on regression data for western Washington soils. While this method is a widely accepted practice for infiltration pond design, its correlation with surface infiltration values is highly variable and partially dependent on soil sampling procedures and compaction. Further study on alternative methods to determine the important saturated conductivity parameter, such as direct measurement procedures like the Guelph Permeater, should therefore be pursued. WSDOT also continues to work with the Department of Ecology on the research findings related to steeper slopes.

Report Title and Number

Application of a Simplified Analysis Method for Natural Dispersion of Highway Stormwater Runoff WA-RD 618.1

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