Decatur Street Selected for Stormwater Low Impact Development Project

Two blocks of Decatur Street, SW from 9th to 11th Avenues will be re-constructed during the summer 2007 to be a demonstration site for three different methods to clean and infiltrate stormwater runoff next to and under the road. After the construction is complete, none of the stormwater runoff from these two blocks will enter the traditional stormwater system which currently pipes the runoff to Schneider Creek and into Puget Sound.

This new way of treating and infiltrating stormwater runoff on-site is called Low Impact Development (LID). The finished road will look similar to other roads, because the technologies used for stormwater treatment and infiltration will be mostly underground.

The low impact development portion of the road reconstruction is funded through a Washington State Department of Ecology grant to test and monitor new LID methods. Twenty-eight project applications from around Puget Sound were submitted to a competitive grant process for $2.6 million appropriated by the legislature. The City of Olympia’s Decatur Street project was selected and tied for 4th in overall scoring and received the third largest grant award of $352,000.

Continued on next page.

Schneider Creek Watershed

Stormwater from these two blocks of Decatur Street and much of the surrounding neighborhood is piped north to Schneider Creek. Prior to development, this area was a large headwater wetland for Schneider Creek. The neighborhood was built with no stormwater treatment. The lack of available land to build large stormwater ponds had limited the options for conventional stormwater treatment in this basin.

Learn how each of these systems deals with stormwater runoff in an innovative way.
Decatur Street Selected for Stormwater Low Impact Development Project - Continued

Construction is expected to begin in August and last for four weeks. The construction will begin with removal of the existing road bed and traffic calming device followed by installation of the three different stormwater systems.

The three systems are:

**System A**  
Regular asphalt pavement with cartridge filter for treatment and under the road infiltration.

**System B**  
Porous asphalt pavement with under the road infiltration. (Cleaning of the pavement is the water quality treatment of the system.)

**System C**  
Regular asphalt pavement with rain garden for treatment and under the road infiltration.

See the diagrams on the next page for a more detailed explanation of each system.

All three treatments will be monitored for performance in the following areas:

- Amount of water soaking into the ground onsite (100% required).
- Amount of pollutants removed from the stormwater runoff by onsite treatment before the water enters the subsoil and groundwater.
- Amount of runoff receiving water quality treatment will be at least 91% of the annual rain that falls on these sections of roadway.
- Durability and ongoing maintenance required to keep systems functioning at optimum levels.
- Total construction cost (and long-term maintenance cost) related to performance of each treatment method.
How The Decatur St. Low Impact Systems Work

The three stormwater treatment systems use innovative techniques to limit their environmental impact. These diagrams illustrate how each system cleans and infiltrates stormwater runoff next to and under the road.

After the construction is complete, none of the stormwater runoff from these two blocks will enter the traditional stormwater system which currently pipes the runoff to Schneider Creek and into Puget Sound.

The map on the top of the previous page indicates the location of each system on Decatur Street.
What is Low Impact Development?

As the name implies, this type of land development uses the best available methods and technologies to reduce the impacts of development on the land. Currently, the methods of constructing buildings, roads, and parking lots on the land drastically changes the way rain interacts with the land. A typical land development is constructed with a storm drain system to prevent flooding. The storm drains are connected to underground pipes that transport the rain runoff somewhere else – usually to a nearby stream or other body of water.

Recent research has shown that when a stream basin or watershed has at least 10% of the land covered in impervious surfaces significant damage is done to fish and wildlife habitat in the streams by stormwater. The stormwater carries pollutants to the stream and erodes the stream bank and bottom. More impervious surfaces on the land means less water is being soaked back into the ground naturally and more is running off. Low impact development uses engineered technologies and methods to keep 100% of the stormwater on-site to naturally infiltrate into the ground, instead of allowing the runoff to leave the property through storm drains.

Low impact development uses site-specific engineered systems that will mimic pre-development conditions when it rains. Many factors, such as soil type and drainage, storm events, and the type of development are evaluated to determine the best systems to use to infiltrate and clean the water. For more information on low impact development visit the Puget Sound Action Team’s web site at http://www.psat.wa.gov/Programs/LID.htm.

Two systems (the filtered catch basin system and the system using the natural filtration of a rain garden) use perforated pipe to allow runoff to be released into subsoil beneath the road surface.

Catch basins will be fitted with cartridge filters that will clean the captured runoff.

A rain garden installed at 11th Street SW shows the sequence of making a rain garden. The original soil is dug out and mixed with compost to make a soil that soaks up and infiltrates the water. Then the garden is planted.
Abstract

The City of Olympia has built a demonstration low impact development (LID) roadway that uses traditional pavement materials and infiltrates runoff under the roadway. Our transportation needs prompt extensive amounts of pavement with inadequate right-of-way area for onsite stormwater management. Current roadway designs conflict with the LID goal of dispersing and managing stormwater near its source. The Decatur Street LID Roadway Project is an innovative design that meets LID goals and manages its stormwater within the existing right-of-way.

Under-pavement infiltration is advantageous because traditional water quality treatment and pavement construction materials can be used. This accommodates traditional maintenance and life cycle cost expectations for the above-ground roadway features. Utilizing the entire roadway area for infiltration provides designs suitable for poorly drained soils and for use with various roadway widths.

This paper presents the design and construction aspects of the Decatur Street LID Roadway Project. The paper describes the three different stormwater management techniques utilized in the project. Roadway structural design is presented, including the use of geogrids for structural stability of the roadway over a subgrade of uncompacted soil. The bid prices, cost comparisons to traditional construction, and lessons learned are provided.

Introduction

The City of Olympia, Washington is actively pursuing the use of permeable pavements as a stormwater management tool. For example, the City routinely builds sidewalks out of pervious concrete and has allowed the use of porous asphalt in parking lots. Additionally, the City has built a major roadway reconstruction project with a traditional asphalt roadway draining to a pervious concrete bicycle lane. To date, we have not built porous asphalt roadways.
While porous or pervious asphalt appears to be a good LID roadway strategy, there are concerns about the durability of the porous asphalt, especially in hot weather and under heavy loads. Porous asphalt is harder to maintain than traditional roadways and stormwater facilities and cannot be chip sealed to extend the pavement life.

The stormwater functions of a porous asphalt roadway rely on the surface pores remaining free-draining. Olympia’s experience with large void pavement materials is that they clog easily with leaf litter and sediment and are difficult to clean. Currently the City does not own a high-powered vacuum street sweeper which could clean the pores of porous asphalt. There is a real concern that a porous asphalt roadway would clog before the end of its structural life and hence would cease to function for stormwater mitigation. While not overwhelming, these concerns are appreciable.

In response, the Decatur Street project is a side-by-side trial of a porous asphalt roadway and two traditional roadway sections that incorporate underground infiltrations systems. These infiltration systems may provide all the benefits of permeable pavements but with traditional pavement durability and maintenance. Short- and long-term performance of the three are being tracked and compared.

The goal of the project is for each of the street designs to meet the water quality treatment and flow control requirements of Washington State Department of Ecology’s 2005 Stormwater Manual for Western Washington within the existing roadway right-of-way. The Decatur Street project is funded in part by the Washington State Department of Ecology 2007 Low Impact Development – Stormwater Management Grant Program.

**Decatur Street - Three Stormwater Management Roadway Designs**

The three low impact development (LID) roadway designs for Decatur Street all utilize under-pavement infiltration. By using the roadway footprint to infiltrate the rainfall, the LID goal of managing and infiltrating rainfall as close to the source as possible is fulfilled. Each roadway section utilizes a different water quality treatment technique of catch basin filters, porous asphalt cleaning, and a rain garden. Each section of the roadway uses the same under-pavement infiltration system to meet flow control requirements.

Soils under the roadway are challenging. The under-pavement infiltration system is designed with an infiltration rate of 0.15 inches per hour. This design infiltration rate was determined from the soils at the site and the depth to the seasonally high groundwater elevation. Olympia typically has poorly infiltrating soils. If the Decatur Street under-pavement infiltration system proves to be effective in Olympia’s soils, it could be easily replicated in areas of better infiltrating soils. LID designs are easier to achieve in soils that infiltrate well.
The three roadway sections are reflected below in Figure 1.

A) Regular asphalt pavement overlying an under-pavement infiltration system with catch basin stormwater filtration units.

B) Porous asphalt pavement overlying an under-pavement infiltration system.

C) Regular asphalt pavement overlying an under-pavement infiltration system with a planter strip rain garden for stormwater treatment.

Each roadway section is about 200 feet long with the entire project encompassing a two block section of Decatur Street.

The adjacency of the roadway sections provides a good comparison between designs through the monitoring portion of the project. Details for each of the three roadway designs are presented in Figures 3, 4, and 5 on the following figures.
Figure 2. Section A - Asphalt with Catch Basin Filter

Figure 3. Section B - Porous Asphalt
Roadway Drainage Design

All roadway sections have a design infiltration rate of 0.15 inch per hour. The native soils have a high percent of fine aggregate with some portions overlaying weakly cemented till. The depth to the shallow groundwater is minimal.

The drainage layer in permeable pavements needs to be designed for both short-duration and long-duration storm events. The Washington Department of Ecology Stormwater Manual requires flow control up to the 50-year event. For this project, long-duration event sizing was performed with the Western Washington Hydrologic Model (WWHM). The model uses 34 years of rainfall data with 1-hour time steps.

The long-duration WWHM drainage analysis generated the need for a drainage rock thickness of 12 inches. The short-duration analysis was performed using intensity duration frequency curves for Olympia. This analysis yielded a necessary drainage layer thickness of 7 inches. In general, soils with high infiltration rates are dictated by the storage needs of short-duration events, while lower infiltration rates are dictated by storage needs of long-duration events.
The water quality design flow rate needs to captures 91% of the average annual runoff. For the 200 feet of pavement for each section, a rate of 13.6 gallons per minutes (gpm) is needed. Each stormwater filter used in the traditional pavement design can accommodate 7.5 gpm. Conversely, the porous asphalt roadway section is not sized for a treatment flow rate. Typically, porous asphas are 15 to 20% void which results in sufficient infiltration capacity.

Little technical design guidance is available for rain gardens in this application. The rain garden area passes the runoff through at least 18 inches of soil/compost media. Standing water should drain within 24 hours of the conclusion of a storm event. The project’s design discharges water onto the surface of a swale. Compost/soil media is provided below the swale. The media is in a gravel envelope with perforated pipe used to capture the treated water. An overflow is located at the downstream end of the swale that directs excessive flows directly into the under-pavement infiltration system.

Roadway Structural Design

Decatur Street is classified as a major collector roadway with an expected average daily traffic (ADT) of between 3,000 to 14,000 vehicles. The equivalent single axial load (ESAL’s) for the expected life of the pavement is 2.4 million (Craig---units?).

The experimental pavement design is based on a 12 inch thick drainage layer topped with 6 inches of aggregate base coarse. Asphalt thickness is 4 inches. The roadway subgrade is assumed to be completely saturated and of very little support. In order for the section to meet design requirements, a geogrid was installed to help support the subgrade. Contech Earth Stabilization Solutions determined that the geogrid and roadway would continue to be stable with a subgrade support value as low as 1.2. Without the geogrid, the life of the pavement would be reduced to 500,000 ESAL’s, a reduction of 80%.

The geogrid compensates for the saturation of the subgrade material by the runoff stored in the drainage layer of the roadway section. Traditional pavement designs strive to keep moisture out of the subgrade, thereby maintaining the strength of the native material. Under-pavement infiltration systems weaken the subgrade necessitating the use of additional structural reinforcement.

The drainage layer contains a high percentage of voids (30 to 40% by volume). The native soils also contain a significant amount of voids and fine materials. There is the potential for the fines in the subgrade to migrate into the drainage layer. A geotextile allows water to move between the drainage layer and subgrade while preventing the fines from migrating back into the drainage layer. Additionally, the geogrid must be in contact with the drainage layer in order to resist loading forces. Given these constraints, the sequence of the pavement section is uncompacted native subgrade, a geotextile for separation, the geogrid, and the drainage layer.

Cost Comparison to Traditional Roadway Projects

It is difficult to compare costs between two entirely different approaches to stormwater management. Traditional stormwater facilities require land, the cost of which is highly variable
depending on zoning, availability and willingness of sellers. For the following analysis a variety of land acquisitions costs are assumed.

The contractor bid prices for the Decatur Street project ranged from $383,000 to $632,000 with an average bid of $506,000. The original City Engineer’s estimate for the project was $409,000. These bids encompass only the roadway portion of the work, curb to curb including the rain garden and the under-pavement infiltration system. Sidewalks are not included. The project is approximately 600 feet long.

The cost per foot of roadway is:

- Original estimate = $680/ft
- Low bidder = $640/ft
- Average bid = $843/ft

The following costs were estimated for the same roadway project built with traditional pavement and stormwater management. Land purchase and stormwater pond construction would be needed.

**Table 1: Estimated Cost of an Equivalent Traditional Roadway Construction.**

<table>
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<tr>
<th>Roadway cost, $/foot</th>
<th>Estimated construction cost, $</th>
<th>Cost of land, $/Acre</th>
<th>Cost of land, $/square foot</th>
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All costs given do not include engineering and contingencies. Total project costs are significantly higher due to these factors.

As can be seen, there is a great deal of potential variation in project costs depending on the bidding environment and the cost of land. The cost of land varies significantly with the zoning and the cost to develop the parcel to its highest and best use. Unfortunately, roadway reconstruction projects in Olympia are commonly major thoroughfares within fully developed areas. These roadways have high density or commercial zoning adjacent to them. Land is often not available for stormwater ponds and what is available is expensive. A recent appraisal of a potential stormwater pond property on a commercial corridor estimated the value of the land at between $10 to $15 per square foot.

We find that if land is relatively inexpensive, traditional roadway and stormwater designs are less costly. However, if land is expensive, permeable pavement projects are less costly.

The above cost comparisons are for the initial construction of the roadway and stormwater management system. In order to perform a thorough cost evaluation between different roadway designs, a complete life cycle cost analysis should be completed. However, since the life expectancy of porous asphalt and the under-pavement infiltration systems is currently unknown, life cycle cost analysis falls apart.
It is evident that under-pavement infiltration systems utilizing treatment filters and porous pavement will have higher ongoing maintenance costs than a traditional pavement and stormwater pond design. Additionally, stormwater ponds do not depreciate to zero. While an under-pavement infiltration will slowly lose its effectiveness and eventually have to be totally rebuilt, a stormwater pond can be effectively rehabilitated with the relatively simple removal of sediment. The stormwater pond never loses its ability to store runoff and thus always has value.

Lessons Learned

Evaluation and monitoring of the Decatur Street LID roadway design will begin in fall 2008. At this time the project is complete. While we feel that the project will adequately test the alternative stormwater management techniques, we do not feel that the design is highly efficient.

The design requires moving water underground against the natural slope of the roadway. This requires that a deeper than needed drainage layer be installed. An improved design would infiltrate the runoff from one section of roadway under the pavement of the immediately down gradient section of roadway. In this way, water would only need to be moved down gradient. In long roadways, the initial section of roadway would not have an under-pavement infiltration system. The last section would need either a traditional pond or some other form of stormwater management. This more efficient layout will be considered in future projects.

Under-pavement infiltration systems require deeper excavation and under-pavement sections than do traditional roadway designs. The extra depth of the roadway system can conflict with utilities under the pavement. The Decatur Street project required relocation of a water main. If the under-pavement infiltration systems are adopted as a standard, the depth of utilities should be increased. Another concern with the under-pavement infiltration system is the potential need to repair existing utilities under the drainage layer. Repairs could be completed through the geo-grid and geotextile, but only with additional excavation, care, and cost.

A three-year monitoring plan will be implemented to measure the performance of the Decatur Street LID demonstration project. Monitoring for stormwater pollutants (total suspended solids, dissolved metals, and nutrients) will be conducted from sampling ports integrated into the street section design. The monitoring will evaluate samples before and after each treatment method in order to determine the effectiveness of the various systems. Water level monitoring will be performed in the drainage layer to determine the site infiltration rate. In turn, the infiltration rate will be used to determine if the design is meeting the flow control requirements for the stormwater manual and its LID design.

More information and the results of the performance monitoring of the Decatur Street project will be posted on the City of Olympia web site as they become available: http://www.olympiawa.gov/cityutilities/stormwater/scienceandinnovations/porouspavement.htm
UNDER PAVEMENT INFILTRATION DEMONSTRATION
The Question

- This project is a consequence of not being able to answer the question: *How long will the pervious pavement last?*

- This project is demonstrating an alternative that shares the benefits of pervious pavements but avoids the question of pavement life.
Decatur Street LID Roadway Project

A = Catch basin filter and under-pavement infiltration

B = Porous asphalt and under-pavement infiltration

C = Rain garden and under-pavement infiltration
Asphalt with Catch Basin Filter

A graded road surface directs stormwater runoff to a catch basin filter. The filtered water is then piped to a perforated pipe running the length of the road surface. Water is released into the rock aggregate and percolates into the ground.

Catch Basins with Filtration

Two catch basins are fitted with cartridge filters to clean the runoff.

System A Layers

- Asphalt
- Aggregate Base Course
- Geogrid
- 12" Drain Rock
- Subgrade

Geogrid

The grid structure grips and stabilizes the rock in the aggregate base, effectively distributing weight from the road surface and vehicles, while using less rock aggregate base.

Perforated Pipe

The perforated pipe has small holes in the pipe that allow the water to trickle into the surrounding aggregate and down into the subsoil.
Porous Asphalt

A porous asphalt surface covers the entire road surface, allowing the stormwater to pass directly through the surface into the drain rock below the road. The stormwater is cleaned as it filters through the pore space in the asphalt. The asphalt needs periodic cleaning to remove these particles and pollutants.

Porous Asphalt

Specially engineered asphalt creates a porous surface which allows water to quickly pass directly through the road surface, while providing the strength and hardness required for heavy vehicles.

System B Layers

- Porous Asphalt
- 2" Leveling Course
- 12" Drain Rock
- Geogrid
- Subgrade

Curb

Water flow diagram:

- Water flows through the porous asphalt layer.
- Water passes through the drain rock layer.
- Water is directed towards the subgrade.
Asphalt with Rain Garden Treatment

A graded road surface directs stormwater runoff to the rain garden which provides natural filtration. Water is then directed to a perforated pipe below the road surface and released into the aggregate.

Rain Garden Filtration System

The stormwater runoff is naturally filtered in the rain garden by a deep soil-compost mixture and the plants. The special soil mixture holds the water like a sponge and allows slow movement through the soil into the subsoil and to the drain pipe.

System C Layers

- Asphalt
- Aggregate Base Course
- Geogrid
- 12” Drain Rock
- Subgrade

Geogrid

The grid structure grips and stabilizes the rock in the aggregate base, effectively distributing weight from the road surface and vehicles, while using less rock aggregate base.

Collection Trench/Pipe

Perforated Pipe

After flowing through the rain garden, the excess water is collected in a catch basin that directs the water to the perforated pipe under the road surface. The perforated pipe runs the length of the road and releases the water into the surrounding aggregate and down into the subsoil.
• Traditional pavement designs seek to avoid saturation of the subgrade.
  ▪ Saturation = Reduced Support
  ▪ Geo-grid = Enhanced Support
How Geo-grids Work
## Decatur LID Construction Cost

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Average bid = $843/ft

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Pervious Pavers
Strong and Porous
Pervious Paver Sidewalk Installation
Pervious Paver Edging
Questions?

FIGURE 1—WATER QUALITY SAMPLING LOCATIONS
Decatur Street LID Demonstration Project
Performance Monitoring Quality Assurance Project Plan