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Terms used:

Permeable/Porous/Pervious - essentially same term, allows water to filter through
Impervious - not allowing something to pass through; not penetrable
Stormwater runoff - Rain water that runs off surfaces such as rooftops, paved streets, highways, and parking lots.

Introduction

The gravel parking lots on Western Washington University are an aesthetic and environmental issue on campus. These parking lots become uncontrollably muddy and leak harmful sediments into our local streams when it rains. Conversely, when the weather is dry, dust clouds roll off the lots. This is a problem that needs to be fixed if Western wants to continue purporting an image of excellence as an environmental university.

The involved parties include Western's Facilities Management, Parking Services, Washington Department of Ecology and students that pay for parking permits to use the lots. They all agree that something must be done to address these issues.

The purpose of this report is to present an alternative pavement solution to these issues, one that is more environmentally sensitive than traditional pavement. This alternative is pervious pavement.

Environmental issues

The gravel parking lots represent a large array of environmental problems as they are a source of sediments and pollution. When rainwater washes urban streets and parking lots, it collects a

wide variety of pollutants from the surface of the land and carries them into streams, lakes, and estuaries. Runoff from developed areas, construction sites, rooftops, roads, and highways is categorized as urban stormwater runoff. Rain that would have been absorbed by plants or filtered into groundwater aquifers instead flows into storm drains. Though many people believe that storm drains carry water from streets to waste water treatment plants, these drains usually carry runoff directly to nearby streams, rivers, lakes, or coastal waters. Extensive network of parking lots, rooftops, and especially roads, creates a stormwater superhighway that carries polluted water quickly into the aquatic environment.

Because there is no opportunity for plants to absorb the moisture that falls on pavement, a much larger volume of storm water drains into streams than flow from urban areas. This large quantity of water reaches streams too quickly, flowing across roads and through pipes that do not offer the same resistance to surface flow that the natural vegetation of meadows and forests would. During dry periods, stream base flow is substantially reduced. Because none of the past rains were able to saturate the ground, shallow groundwater storage is diminished. As a result, less water is available to gradually flow into streams.

Pollutants accumulate on impervious surfaces during dry weather. When the first drops of rain fall, this pollution is quickly collected in stormwater runoff. The initial volume of stormwater with high concentrations of pollutants is often called the ‘first flush.’ Since about 90% of pollutant loading is thought to occur within a storm’s first flush, controlling the initial surge of runoff can drastically reduce transport of contaminants to water bodies. (Schueler 1994)

Stormwater laden with sediments flows into water bodies as a large plume of cloudy water. Suspended sediments prevent submerged plants from photosynthesizing by limiting the amount of light that can pass through water, depleting food sources and habitat for other aquatic life. Fine sediments can also suffocate salmon eggs in local streams and impair juvenile salmon sight based feeding behaviors (Sigler J. 1984). The parking lots cause this by moving fine sediments off the lots and into streams. Bruce Chattin, of Washington Aggregates stated that gravel parking lots are expensive to maintain. The source of this economic problem is because the gravel needs to be replaced every time it rains because so much is lost down storm drains.

This problem on the gravel lots has been noted by Christina Maginnis, Municipal Stormwater specialist at DOE, and stated that Western needs a capital funding project to fix these problems. This money from legislature is needed to support Westerns Storm water management program.

Governmental Regulations on Stormwater

Western Washington University is permitted under the National Pollutant Discharge Elimination System (NPDES) permit program that is authorized by Clean Water Act (CWA) section 402. Western is classified as a Regulated Small Municipal Separate Storm Sewer Systems (MS4s) and is a secondary permitee with the City of Bellingham (CoB) being the primary. (DOE) An MS4 is a conveyance or system of conveyances that is:

- Owned by a state, city, town, or other public entity that discharges to waters of the U.S.;

- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches,)
- Not a combined sewer; and
- Not part of a Publicly Owned Treatment Works (sewage treatment plant).

Phase II NPDES permits, issued in 1999, require regulated small MS4s in urbanized areas, as well as small MS4s outside the urbanized areas that are designated by the permitting authority, to obtain NPDES permit coverage for their stormwater discharges.

Beginning in 2007, Western Washington University has worked with the Washington State Department of Ecology (DOE) to implement a Storm Water Management Program (SWMP), with the expressed purpose of reducing the discharge of pollutants from Western's storm water system to the maximum extent practicable and to protect the water quality of out-flowing waterways. The SWMP is accessible at http://www.wwu.edu/depts/fm/Services/StormWaterMgmt/index.html. As part of the program they must submit annual report to the DOE to confirm that appropriate actions are being taken as stipulated by the permit agreement.

As a part of the SWMP, Western releases annual Planned Program Activities. Included in the 2011 plan are plans to initiate a request for funding through the state Legislature to replace the gravels lots on campus and provide a maintainable surface where WWU can meet the requirements of its secondary MS4 permit with the CoB. Coordination for funding requests will be through the University's EHS office and Facilities Management.

Pervious Pavement: a maintainable surface

What it is/does

Porous asphalt and porous concrete are similar to conventional asphalt and concrete in structure and form except that they allow water to pass though their surface.When installed over a gravel drainage storage bed which is several feet thick, water can be stored and infiltration into ground water can occur where soil permits. This creates a pavement type surface that, unlike impervious conventional pavement, doesn't have stormwater runoff.

The top layer of aggregate mix in a porous system is made without 'fine' particles that would usually function to fill void space between the larger aggregates. Also, the amount of binding substance used is less than that used in non-porous systems. What results is a pavement surface similar to traditional pavement that is smooth enough to meet requirements of the Americans with Disabilities Act but is also noticeably porous. A less visible structural difference is the depth of the base material under the pavement. The depth of the stone recharge bed can be several feet deep, allowing for a significant amount of water holding capacity.

Different forms of pervious pavement

Permeable pavements include pavers, porous asphalt and porous concrete. Pavers may be pre-cast sections or individual units that fit together. 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, leaving 15%-25% void space for water to flow through it.

Maintenance of pervious pavements

General Maintenance

Sediment removal for porous asphalt and concrete may become necessary within the life of the parking lot because porous services can become clogged otherwise. Vacuum sweeping annually or more frequently depending upon sediment loading. Preventative measure help by stabilizing adjacent areas, removing leaves and large debris after they fall and proper training for maintenance crews working around site.

Several studies were done to assess the success of cleaning clogged pavements. First tested a permeable paver grocery store parking lot fifteen years after construction and it had remained permeable and filtered pollutants. Another tested a schoolyard paving system and after six years the pavement had become clogged. But was cleaned by a “geoCLEANING” machine, the pavement exceeded infiltration capacity requirements. Under winter weather, one is advised to avoid sanding the site and adjacent streets if possible since tires will track it onto the porous pavement and clog the pores.

Under a DOE grant the city of Bellingham received $233,000 Shared Sweeping for Whatcom County NPDES Permittees. Using the money Bellingham purchased a regenerative air vacuum street sweeper and will share its use during the next 10 years with partners Ferndale, Whatcom County and Port of Bellingham. Enhanced street sweeping will help all four municipalities meet water quality standards, as well as local water cleanup goals in several watersheds. This specialized machine could be used on permeable pavements to eliminate clogs. If Western could work out a way to use this sweeper it would eliminate the cost of having to hire a private contractor to do the work.

WWU Parking Services currently has a portion of their budget for maintenance of the lots including gravel replacement and sandbagging of stormwater flow. These problems would be eliminated by a paved surface and reallocated to the less frequent maintenance of permeable pavements.

General Concerns about the use of permeable pavement

There is a common misconception of permeable pavements ability to survive cold weather freeze thaw conditions without damage. The idea is that when water freezes it expands and can break its container, much like a soda can in the freezer. The misconception is that because permeable pavements have such large pores that water can flow into, it allows an opportunity for frozen water to destroy the pavement. However many studies have been done by professionals to show that porous pavement installations can withstand freeze-thaw conditions. The following study was done in Sweden, where the winter weather is more extreme than more temperate Washington winters.

“Porous pavement was more resistant to freezing than a conventional impermeable pavement due to higher water content in the underlying soil which increased the ground’s latent heat.” (Blackstrom 1999)

Permeable pavement is actually safer for cars and pedestrians in the winter because it does not accumulate icy buildup. Typical pavement puddles when snow melts, the puddles then freeze again. With permeable pavement, the periodic melt enters the pavement and underlying drainage system and is not able to refreeze on the surface. A properly designed and constructed permeable pavement will withstand winter weather much better than conventional pavement. Although conventional pavement is termed impervious it still allows some water into tiny pores and cracks in its surface. Conventional pavement is at a much higher risk of freeze-thaw damage than permeable pavement because the water allowed into the small pores has nowhere to go and will go through many freeze thaw cycles.

Because of the climate in Bellingham, we do not experience frost heave or an upward pressure from ice forming deep underground, but even if we did, porous pavement experiences less effects from frost heave than impermeable pavement - due to water's ability to retain heat more than soil and the storage of warmer water in the gravel storage bed.

The Importance of the completion of this project

Everyday students and visitors park in the lots. For many people, the uneven, muddy or dusty parking lots is the first impression of the university. And for others it is a constant irritant as they drive over mud puddles and potholes every day. Additionally for people with previous knowledge of storm water and sediment loading in our local water ways, including government inspectors, the lots appear inadequate at addressing environmental concerns. If Western wants to give the impression of an environmental college it needs to address the environmental impacts on its own campus. and if Western is being contacted by the Department of Ecology to fix similar stormwater issues then Western is not performing adequately in this respect.

President Shepard stated in his email budget update that Western wants to "continue the excellence that, we know, attracts the very best undergraduates in Washington." Then environmental issues on campus like this one need to be addressed, if Western wants to continue giving the impression of excellence as a "University of the Environment," as stated in another budget document.

Case Studies

Evergreen State College:

Evergreen is well known for its environmentally sustainable practices. Due to unsustainable stormwater management, the school planned for the implementation of permeable pavements to ultimately reduce stromwater runoff into their local streams but also successfully infiltrate the 100-year, 24-hour storm without surface runoff. Both permeable

pavers and permeable asphalt have been installed on campus thus far, about 10 years ago and 2 years ago respectively. The water quality was tested and they found that Total Suspended Solids, Total Phosphorous, Total Nitrogen, and Heavy Metals all had at least an 65% reduction and at most 98%. These projects were capitally funded and are still effective methods of stormwater management for the campus today.

Results:

- Replaced 34,000 square feet (over 250 parking spaces) of traditional asphalt to permeable pavers
- About 10 parking spaces worth of permeable asphalt
- Great success with the permeable asphalt - very low maintenance, even being placed beneath a pine tree, it only requires sweeping/vacuuming 3 times a year
- Permeable pavers are a lot of maintenance (weeding, unwanted materials difficult to extract, etc) and are incompatible with some disabled people.
- A net reduction of stormwater runoff to Houston Creek.

Quil Ceda Casino:

This is the largest pervious concrete parking lot in the state of WA. This 200,000 square foot (22,200 square yard) parking lot expanded the parking at the Quil Ceda Casio owned by the Tulalip Tribe in Tulalip, WA. It provided the needed additional parking capacity while protecting the adjacent Quil Ceda Creek and the Puget Sound into which it drains.

Results:

- Provides additional parking capacity
- Protects Quil Ceda Creek as well as Puget Sound
- Enhances the success of their Casino enterprise

Cost Benefit Analysis of different forms of pervious pavement and conventional pavement

Pervious pavement costs depend highly on a multitude of site specific parameters. Conventional concrete costs on average $55 per square yard (8” thick of concrete, with base). Right now, pervious concrete is about 15%-20% more expensive, so some companies may ask for $65 per square yard (8” thick of concrete, with 12” of drain rock beneath). The gravel lots on south campus, the C-lots and 12A lot together, are roughly 43,000 square yards in size. 43,000 square yards at $65 per square yard is roughly $2.8 million - just for materials. This does not include the cost of labor or any other costs. As a proposed pilot program, paving just the west C-lot (about 19,000 square yards), the cost of this project would be similar to the Quil Ceda Casino project due to its size - about $1.2 million for the pavement.

	lifespan	cost (per sq yard)	maintenance

Pervious concrete	20-40 years	~$65	● vacuum 2-3 times per year ● pressure wash every 5 yrs
Traditional concrete	30+ years	~$55	● little to none ● pressure wash every 5 yrs ● stormwater drainage system

Recommendation for lots

Pervious concrete is the best alternative we have found for paving the lots. After analyzing our case studies, we have concluded that for the size and purpose of the lots, pervious concrete succeeds in all aspects. It has a long lifespan, is durable, is easily and cheaply maintainable, environmentally friendly, very visually appealing (it is possible to color the concrete any color without reducing its effectiveness), vehicle and pedestrian friendly, and rids the need for externalities such as additional water use to wash cars after using the lots.

Other future works

- Conduct a geo-tech analysis of the lots in multiple (roughly 6 scattered about per lot) areas: drill 6 feet down into the soil and test to find if soils are the correct hydrologic rating for pervious concrete to be on top of. The better the hydrologic rating, the better suited the soil is for the concrete.
- Conduct an actual cost estimate of the lots by a professional engineer (perhaps contact Freeman “Fritz” Anthony from City of Bellingham).
- Further in depth analysis of hazardous runoff into wetland/rest of Taylor stream. Which contaminants have been found? Any close to the maximum levels on a consistent basis?
- Additional case studies for further understanding of environmental effectiveness of pervious concrete.
- Continuation with student/community outreach - facebook profile, student surveys, etc. http://www.facebook.com/#!/pages/WWU-Pave-the-Lots/117793588303929

Conclusion of why project is important

When traditional concrete is compared to pervious concrete across criteria of cost, and future outcomes such as durability, maintenance, and long term savings, pervious concrete is clearly equal to traditional concrete where it is appropriate to be used. In many situations, it comes out ahead.

When factors such as long-term impact on the environment are considered, pervious concrete proves superior. The infiltration properties of the material -- the ability to remove pollutants from storm water – show far greater effectiveness than some of the most popular storm water

management systems. This demonstrates that a paving system which is nearly equal in cost to traditional concrete actually pays for itself over the long term, with a more effective storm water infiltration system than commonly used traditional storm water systems. It is therefore possible to employ an environmentally sound pavement solution while saving money.

This project will also improve the university's excellence as environmental university. It will not only exemplify but expand upon the momentum behind Western's sustainability movement and make Western a leader in low impact development in Washington State.