Residential Application of Permeable Pavement Within the City of Oshkosh

Steve Freund

Burgundy Pendragon

Olivia Hauser

Austin Hanson

Executive Summary

Stormwater management has become an issue of increasing concern for municipalities across the United States, including the City of Oshkosh. Many technologies have been developed specifically to address these concerns. One such technology is permeable pavement. Permeable pavement systems have many different benefits. However, the main benefits stem from their ability to filter stormwater runoff. This ultimately leads to the reduction of things such as heavy metals, mineral oils, hydrocarbons, total nitrogen, and total phosphorus ending up in our waterways. The reduction of algal bloom-causing phosphorus and nitrogen, and the reduction in heavy metals entering waterways are of particular interest due to the problems that the Winnebago watershed has had with these issues in the past.

Although the City of Oshkosh has allowed the use of permeable pavement in several commercial applications around town, current Oshkosh municipal code does not allow the use of permeable pavement for residential driveways. We are proposing a change to the City of Oshkosh's municipal codes that would explicitly allow residents to use permeable pavement systems on their driveways. By implementing code that allows for the residential use of permeable pavement systems, Oshkosh is giving its citizens the freedom to choose to be able to help reduce stormwater runoff and water pollution. This action directly aligns with the city's sustainability goals. It also continues the city's push toward addressing stormwater issues in a similar manner as other best management practices already implemented such as the permeable pavement parking lots around the city and the city's rain barrel credit program.

Background

The City of Oshkosh lies in the heart of the Winnebago watershed on the shore of Lake Winnebago itself. These surrounding waterways provide both municipal services such as drinking water, as well as recreational opportunities for citizens of the surrounding communities. However, DNR monitoring shows that Lake Winnebago is eutrophic, meaning that the lake is "characterized by large nutrient concentrations such as nitrogen and phosphorus and resulting in high productivity" (Wisconsin DNR, 2004). One of the more significant sources of these nutrients is stormwater runoff from rain water washing over the large amounts of pavement found in urban areas such as Oshkosh. The United States Department of Agriculture's Natural Resources Conservation Service lists urban stormwater runoff as one of the most significant non-agricultural resource concerns for the Winnebago watershed (USDA NRCS, 2007). Because of its reliance on the surrounding waterways for both health and recreation, the City of Oshkosh has a vested interest in mitigating stormwater runoff as much as possible.

With an increase in awareness of environmental issues such as the ones impacting the waterways surrounding Oshkosh, the category of building technologies known as “Green Infrastructure” is gaining popularity. The Water Infrastructure Flexibility Act, an amendment to Section 402 of the US Clean Water Act, defines green infrastructure as “the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters” (S. 692, 2017). One example of such a technology is known as “permeable pavement”. In general, permeable pavement is any pavement system that allows water to soak through the pavement and into the ground underneath. As this happens, impurities are filtered out and prevented from flowing into nearby waterways. (For more information regarding water quality issues and how permeable pavement systems can help, see the ***Significance for Sustainability*** section).

The City of Oshkosh is already somewhat familiar with permeable pavement systems. Notably, Oshkosh currently has parking lots that use permeable pavement at Fire Station 16, the Senior Center, the public parking lots at CP and Otter, and the YMCA downtown. However, residents are not currently allowed to use permeable pavement systems for their own driveways. Through our stakeholder interviews, we know that at least some residents are quite interested in using permeable pavement at their homes. While stakeholders did raise some concerns regarding the residential implementation of permeable pavement systems (see the ***Barriers*** and ***Stakeholders*** sections for more details), none of the problems or concerns that we encountered throughout our research make the use of permeable pavement within the city of Oshkosh unreasonable. Furthermore, many other cities have allowed for the residential use of permeable pavement with great success (for detailed examples, see the ***Benchmarking*** section along with ***Appendices B and C***).

Currently, Oshkosh’s municipal codes allow for the use of permeable pavement on patios [see Chapter 30, Article VIII, Section 30-241(C)(4)(a) and Chapter 30, Article VI, Section 30-161(E)(4)(f)], and in Chapter 30, Article VI, Section 30-241(J)(1), the use of permeable pavement is explicitly allowed in the Traditional Neighborhood Development Overlay Zoning District.

Recommendation

Our recommendation is that the City of Oshkosh allow for the residential use of permeable pavement by amending Oshkosh's municipal code so that permeable pavement is explicitly permitted for use in residential driveways. Because multiple sections of Oshkosh's municipal code address driveways and relevant aspects of construction, adoption of the proposed changes may require multiple sections of municipal code to be altered. However, the proposed code presented below seems like it would fit well in Chapter 30, Article VII, Section 30-175(R) which addresses surfacing.

Proposed code

Section 30-175 (R) (1) (a): Permeable pavement that is capable of carrying a wheel load of four thousand (4,000) pounds is permitted. Gravel, turf, or other materials that are not part of a structured system designed to manage stormwater shall not be considered permeable pavement. Permeable pavement shall meet the following conditions:

(1) All materials shall be installed per industry standards and follow the Wisconsin Department of Natural Resources Technical Standards for Permeable Pavement. Appropriate soils and site conditions shall exist for the pervious pavement or pervious pavement system to function properly. If clay soils excessively prohibit the timely infiltration of water into the soil, underdrains and storage reservoirs may be required.

(2) All materials shall be maintained per industry and city standards. Areas damaged by snow plows or other vehicles shall be promptly repaired. Gravel that has migrated from the pervious pavement systems onto adjacent areas shall be swept and removed regularly.

(3) Permeable pavement that allows turf grass to penetrate to the surface shall be limited to overflow parking spaces that are not utilized for required parking and that are not occupied on a daily or regular basis.

While public education regarding permeable pavement systems may be beneficial, such an endeavor is not necessary to implement these changes into the code. However, we have also provided an example of some educational material designed to inform the public about permeable pavement that could be used to help model any educational materials that Oshkosh may decide to put together in the future. (See ***Appendix F*** for educational material.)

Stakeholders

James Rabe - Director of Public Works, City of Oshkosh

The overall goal of the Department of Public Works is to ensure that infrastructure throughout the city of Oshkosh is dependable. As the Director of Public Works, James is in charge of multiple departments working toward this goal, including the Stormwater Utility. His position gives him a direct interest in whether or not the residential use of permeable pavement might be a beneficial addition to Oshkosh's municipal code. James also has previous experience with permeable pavement. Because of this, James is considered a key primary stakeholder and expert.

One of the first things that James stressed was the importance of education with new technologies such as permeable pavement. He used the example of how the Stormwater Utility in Oshkosh recently allowed for a reduction on homeowners' stormwater utility bills if they used rain barrels. However, few people have taken advantage of these opportunities, most likely due to a lack of knowledge and education surrounding the programs. He also discussed how when recycling programs first began, education programs were needed in order to inform the public about what can and cannot be recycled. These examples highlight the potential need for an education program or campaign to accompany the implementation of the new technology of permeable pavement. However, although education is surely important, it will not be a main focus of this proposal.

Todd Meuhrer - Zoning Administrator, City of Oshkosh

As a zoning administrator, Todd has some important insights into the potential issues surrounding the residential implementation of permeable pavement and is considered a secondary stakeholder. Throughout the interview, Todd made it clear that the specific details of any proposed change to the municipal code will be of utmost importance. Todd emphasized that the code should be explicit and thorough in order to ensure that as few problems arise as possible once the code is actually implemented. He strongly believes that in developing any new code, worst case scenarios should be taken into consideration as much as possible.

Doug Bush - President, Pave Drain

A stakeholder that our group was interested in contacting was Pave Drain due to the multiple projects implemented in Oshkosh already. Here we were able to get in contact with Doug Bush, the president of Pave Drain. Getting a hold of Mr. Bush about the company's opinions on permeable pavers gave our group the chance to discuss barriers. Mr. Bush had multiple years of experience in construction projects where some projects pertained to the implementation of permeable pavers which was able to help give us important insight on the concerns in the paving industry about permeable pavers. One of the critical topics Doug Bush addressed is its stress on sustainability as sustainability is key to the development and success of permeable pavers. If no one is interested in being sustainable on their land, installing their complex and expensive pavers is a massive waste of resources and money.

In Oshkosh, a concern with permeable pavers is the installation and maintenance involved. In our discussion we asked Mr. Bush about the maintenance of permeable pavement and the results that he has seen. Mr. Bush emphasized the importance of building permeable pavement due to the complexity compared to typical pavement. In the projects in Oshkosh that Pave Drain has had a hand in, he has found no problems with the draining and very little maintenance has had to be done. Mr. Bush also addressed other concerns about the impacts of road salt, cost, and the difficulty of implementing due to lack of guidance (more information on this topic can be found in the ***Barriers*** section.)

Anonymous Company

Another stakeholder that our group was interested in contacting was someone from Fox Valley Region due to its similar demographics to Oshkosh. For the project, the company requested to remain anonymous. We were able to get in contact with the owner of a company who plays a vital role in advocating green infrastructure and promoting the use of permeable pavers and their benefits. The company does multiple different types of jobs surrounding landscaping. They have also completed projects that included permeable pavers on lakeshore houses.

Due to the distance between the Fox Valley and Oshkosh, getting in contact with the company seemed like a good idea because of the similar communities, populations, ethnic groups, and climate. Due to the group's primary research being on permeable pavement for residential areas, we wanted to focus mainly on that idea in our discussion. During the conversation with the anonymous owner, the main questions that came up were about installation, promoting permeable pavers, and the owner's personal thoughts. The company's owner showed great eagerness to share his thoughts on permeable pavers in general due to the many benefits which are listed under ***Significance for Sustainability***.

Dr. Misty McPhee - Private Citizen, City of Oshkosh

Dr. Misty McPhee is a citizen of Oshkosh, who wished to have her driveway be made up of permeable pavements. She wants to have a net positive house, meaning she wants to create more energy than she uses.This makes her a primary stakeholder for this permeable pavement project because she is directly impacted by a decision to disallow permeable pavements. A permeable pavement driveway will help her reduce the amount of concrete to build her house. Her interest level in this topic is high, but because of city codes, she wasn't allowed to have a permeable driveway. She had numerous email exchanges with various people from the city, and the conclusion was, there were concerns regarding the engineering of the driveway, along with some uncertainty about what exactly is going to be used. With multiple people from the city being involved in this one project, information maybe wasn't relayed resulting into many concerns to allow the project to continue.She had someone from TrueGrid (a contractor company that installs permeable pavement), email her designs of driveways and how this type of permeable pavement works better in all climates and soils. There are many benefits of including Misty's perspective in planning. She knows how the hydrologic cycle works, the value of permeable pavement, and has a decent understanding of city codes. By providing Misty's perspective on permeable pavement, it shows that people want other options for residential driveways, especially ones that help the environment, not hurt it. It's a matter of finding a product that works, and can be maintained properly to ensure maximum efficiency. While addressing any concerns from the city, because they have the ultimate say.

Justin Gierach - Engineering Division Manager, City of Oshkosh

Justin Gierach works for the city in a few different areas. He is the Engineering Division Manager, an Engineer, and is involved in the city's Public Works Department. He has experience in dealing with contractors, private citizens, and other city officials on many different issues. In talking with Justin he expressed that Oshkosh does have a few places around the city that allow for permeable pavements; they include the senior center, a fire station, and Menominee Arena. These places can use permeable pavements because redevelopment of larger areas must account for TSS (Total Suspended Solids).

His interest in the topic lies in trying to improve Oshkosh's stormwater quality, and properly manage stormwater runoff. Permeable pavements are a good alternative, but the city has concerns about the residential application concerning drainage and runoff, and it's important to note moving forward, so we can find a model that addresses these concerns. Overall, talking with Justin will help our group better understand the current situation in Oshkosh regarding permeable pavement. Even though there are concerns about permeable pavement driveways, now we know what they are. Justin seemed to have a positive view of permeable pavements and said if someone can show how the water will be drained, then he doesn't see the city having an issue with allowing it. Another benefit of including his perspective is that there are permeable pavements applications around the city that work that the city maintains. They are vacuumed a few times a year to remove debris from the cracks, this shows that Oshkosh trusts permeable pavements, just not in the residential application. Drainage and clogging are real concerns that must be addressed, but there are options available that decrease the chances of that happening. The better educated we are as citizens, the better chance we have to implement things that we want. As a city official he has to abide by city regulations on projects, so currently permeable pavements aren't allowed for driveways, but with a change in the city ordinance they can be incorporated for residential applications in the future.

Fox-Wolf Watershed Alliance (FWWA) Kelly Reyer

Kelly Reyer graduated from UW Oshkosh with a degree in Environmental Studies in 2012. She works for the Fox-Wolf Watershed Alliance as the Outreach Coordinator. The organization works to protect, restore, and sustain the water resources of Wisconsin's Fox-Wolf River Basin. Her role as Outreach Coordinator has her performing many duties, including event planning, working with the media, developing educational documents, designing documents and educational signs, creating lesson plans, and providing outreach and education in schools and at community events. She coordinates Fox-Wolf's largest event, the Fox-Wolf Watershed Cleanup.

In our interview with Reyer, we asked her about water conservation issues facing the Fox-Wolf watershed. She explained by saying that nonpoint stormwater runoff is the biggest issue impacting the quality of our waterways. While it's debatable which pollutants are worse in our water, phosphorus and sediment are the biggest runoff concerns given that there are Total Maximum Daily Load standards set for these pollutants in the Fox-Wolf River Basin. She went on to talk about how the FWWA has been working with agricultural producers for years with grant funding to install conservation practices, like treatment wetlands, cover crops, buffer strips, etc., on their lands. In a similar vein, she talked about how urban municipalities are concerned about the types of pollutants running off in our cities because they have MS4 permit requirements that they must meet. Her outreach and educational efforts are ways that FWWA aids in these conservation efforts. We then asked her about ways that locals can reduce polluted stormwater runoff, she provided many examples, including the reduction of impermeable surfaces, picking up after pets, sweeping up grass clippings, keeping leaves off our streets, washing vehicles on a grassy area or at a carwash, and much more.

Northeast Wisconsin Stormwater Consortium (NEWSC)- Anna Bartsch

NEWSC is a membership-based organization branched out of FWWA that is meant specifically for municipalities, counties, and institutions (such as the University of Wisconsin Oshkosh) who have Municipal Separate Storm Sewer System (MS4) permits from the Wisconsin Department of Natural Resources (DNR). The organization helps members maintain the legal requirements of the MS4 permits by providing expert resources and guidance to its members, effectively doing the hard work of understanding the legal nuances, the data, and providing design plans. Anna Bartsch's job as the NEWSC Coordinator is to manage the program by planning, budgeting for, and implementing the activities described above.

When we asked Bartsch for what she believed to be the most prevalent issues facing our waterways, she answered with erosion control, getting creative with green infrastructure (including permeable pavements), reducing chloride (salt) pollution, preventing the spread of invasive species, and encouraging and incentivizing sustainable farming practices. We then asked her what she thought was the best practices for reducing stormwater pollution. Bartsch had this to say, "first and foremost, education and altering public perception is what everything comes back to. Most people don't consider that runoff doesn't get treated the way water inside houses and businesses do. The water running down your street and into the storm drain ends up in a water body along with everything it picks up on the way, and there are things everyone can do to improve the quality of that water. It's important for people to see the connection between their inability to enjoy lakes and rivers due toxic algae blooms and what is coming off of their very own yards (raked leaves and grass clippings left in the street, pet waste left to deteriorate and enter groundwater)."

Benchmarking

Olympia, Washington

Olympia, Washington is a city that is similar in size to Oshkosh. They have been using permeable pavement in multiple different projects for over 15 years (Tosomeen, 2007). They started off using permeable pavement on sidewalks in order to assess the utility and public reaction to permeable pavement in general. After constructing permeable pavement sidewalks, Olympia city officials took a survey to understand the public's perception of those sidewalks. The vast majority of those surveyed enjoyed the looks of the sidewalks, perceived them to be less slippery than traditional sidewalks, wanted to see builders encouraged to use more permeable pavement, and would have liked to be able to use permeable pavement for their homes. This experience has led the city to refine its municipal codes to where they currently allow the residential use of permeable pavement for driveways (Tosomeen, 2007).

Minneapolis, Minnesota

Although Minneapolis is a much larger city than Oshkosh, the climate is very similar. This provides a great test case for any issues that harsh winter weather may present with the use of permeable pavement. Originally, Minneapolis began investigating permeable pavement as a means to address multiple water quality issues. Since then, Minneapolis has become a leader in the implementation of permeable pavement. They have used permeable pavement at their university, at city buildings, on city roads, in parking lots, and many other places. Because of this intense interest in permeable pavement, the surrounding communities are also embracing permeable pavement. Shoreview, a community north east of Minneapolis, has the longest stretch of permeable pavement in North America (Janzer, 2020).

One thing that Minneapolis has done to help address the education concerns that some of our stakeholders have mentioned is they have plenty of resources available to those who are interested in using permeable pavement. Also, their municipal code is well-written, covering all important aspects of the implementation of permeable pavement while not being overly difficult to understand. See ***Appendix B*** for a copy of the Minneapolis municipal code concerning permeable pavement.

Menasha, Wisconsin

Menasha is a community that is very similar to that of Oshkosh in demographics. Both Menasha and Oshkosh also face similar water quality and water runoff related issues due to the closeness of many waterways and have tried multiple solutions to fix the problem. Lakeshore residential homes in Menasha have led the way for residential installations of permeable pavement. Menasha's recent work is a great example of a small city embracing sustainable development, including implementing permeable pavement. In Menasha, their current ordinances highly encourage permeable pavement usage for stormwater best management practices through a Driveway Installation Policy which can be found in ***Appendix C***.

One example of a permeable pavement project in Menasha is a residential lakeshore home completed in 2015. The project was a 1,150-square-foot driveway installed at a residence on Firelane Road. The driveway took approximately one week and the cost came out to approximately $16,000 (County Materials, 2016). Hanging over the project was a requirement by the Wisconsin Department of Natural Resources (DNR) through Wisconsin Department of Natural Resources Technical Standards. See ***Appendix E*** for a copy of the Technical Standards dealing with permeable pavement. In the Standards it states that no runoff could exit the property, either onto adjacent lots or directly into Lake Winnebago. The agency's involvement was fairly minimal as the county really oversaw the enforcement of the regulation so there was no water issue. This project was important to the development of a policy for permeable pavement to be available to be used by the residents.

Keshena, Wisconsin

Another Wisconsin community that has a similar climate to Oshkosh is Keshena located in Menominee County. Just like Menasha, Keshena is a great example of implementing permeable pavement in residential areas to overcome stormwater management issues. In Keshena, residential homeowners contacted Menominee County for a new development project. The homeowners wanted a new driveway that was environmentally friendly but also functional. Similar to locations near waterways like Oshkosh, Keshena is located near Blacksmith Lake causing trouble for residents due to runoff into the lake.

Menominee County's lakeshore zoning regulations specifically limit the amount of impermeable surface that can be used on lakeshore lots (Menominee County, 2021). Permeable pavement played an important role in this project, as the residents were already at their limit for the amount of impervious asphalt and concrete allowed. Menominee County officials wanted a larger low-impact improvement project to help educate the public and demonstrate the success to potential permittees especially for stormwater runoff. For this project, an important part of the system was the base below the permeable pavers which acts as a temporary storage area. The main function is to allow the runoff enough time to seep into the ground but also not collect above the surface of the pavement. By using a base under the permeable pavement, the system was able to reduce the peak stormwater runoff flow rate to the lake.

Isanti, Minnesota

In Isanti, Minnesota, a small town with a population a little more than 5,000 and near the Wisconsin border, a couple named Shelly and Jason Dailey purchased lakeside property with the intention of developing a new building in the footprint of an old structure. Unfortunately, the Dailey's were faced with the Isanti County Zoning regulations, which only allow up to 25% impervious surfaces on lake property. This regulation is in place in order to protect local waterways. The house by itself would fill the 25% impervious surface quota, and the Dailey's still needed a driveway and patio. Seeking a way to meet the water conservation purposes of the Isanti County Zoning regulations, the Dailey's consulted Jim Wanserski for help, who is a seasoned landscaping contractor and the developer of the Vistas at Greenwood Hills in Wausau, Wisconsin. Together with the permeable pavement supplier County Materials, they came up with a win-win solution: the implementation of a permeable pavement system. Isanti County needed evidence for the effectiveness of permeable pavement. The team did just that when they prepared themselves with extensive knowledge with the expertise of County Materials and Wanserski. This preparation was vital to winning over Isanti County and obtaining their permit. In addition, the plan achieved two goals: (1) infiltrating stormwater via the pavers, and (2) providing a structurally sound, low-maintenance, reliable, and durable surface for the Dailey's new driveway and patio. In fact, the system works very well to capture and filter stormwater runoff. Since installation in 2010, the pavement has survived midwest winters with minimal maintenance. This example is relevant because Oshkosh also has engaged citizens who want permeable pavement driveways, and this demonstrates that not only is there precedent for this, but permeable pavement systems also allow residents to help meet the city's stormwater management goals.

Village of Egg Harbor, Wisconsin

In 2008, the Village of Egg Harbor in Door County, Wisconsin underwent a redevelopment project at its local Beach Park, located along the waters between Green Bay and Lake Michigan. As a lakeside town, water conservation is a major concern for them, especially since Beach Park was plagued by geese, seagulls, and their waste. Facing water pollution of a different variety, the Village of Egg Harbor needed to drastically reduce *E. coli* contamination in its sensitive waterway. Originally, the solution was to build retention basins, but the improved water quality brought additional tourism which presented a new problem: a need for more parking space. However, the Village of Egg Harbor was constrained by the intersecting needs to reduce water pollution, an inability to purchase more land, and the need to provide more parking. The solution was to use permeable pavement. With the help of the businesses Edgewater Landscaping and County Materials, as well as assistance from Door County, they implemented a permeable pavement system utilizing concrete bricks that allows rainwater to percolate around the bricks and infiltrate through the ground (Stormwater Management Best Practices).

Rockville, Maryland

This example from Rockville, Maryland is good in the sense that it has guidelines laid out that citizens must follow if they wish to have a permeable pavement driveway. In ***Appendix D*** there is an example of what is required for a permeable pavement driveway, which can be useful for the City of Oshkosh so they can see what other cities have done to allow this type of pavement. Applications in Rockville must have a reservoir of ten inches, and this is ultimately where the infiltrated water is temporarily stored. There is also an overflow pipe recommendation that will allow water to leave the system when there is too much, returning it to the hydrologic cycle. Additionally, there are rules in place to protect utilities such as sewer lines, tree roots, and septic systems. This example also takes into consideration soil type and infiltration rates. Although it doesn't rule out any soil type, all permeable pavements are designed to withstand one to two and a half inches of rain at a time. If there are concerns, the issue can be looked into further, but this is the standard baseline.

Durham, New Hampshire

New Hampshire is a place that experiences a similar climate as Wisconsin, in that they experience around six months of below freezing temperatures. This case study looked at the impacts of permeable pavements in an environment that experiences a freeze-thaw cycle similar to Oshkosh. This study used porous asphalt, and found that it performed well as a stormwater management system under harsh weather conditions. Porous pavements thawed and refroze throughout the winter, because with permeable pavement, not as much water is on the surface so there's less ice forming on the surface as well. They also found that permeable pavements completely thawed nearly thirty days earlier than the reference site. This implies that less winter maintenance for areas with permeable pavements is needed. Lag time increased by 1,275 minutes for a two year storm. These porous pavements also fared well in terms of water quality performance; effluent pH was higher (7.1) compared to influent pH (6.1). This means the water is less acidic which helps protect the aquatic species native to the area. Only one rain event from the study indicated high levels of Total Suspended Solids (TSS). Zinc was detected 66% of the time, while nitrate and chloride levels showed no statistical difference between the test sites. This study was conducted between 2004 and 2008, and through this study the researchers figured the average lifespan of permeable pavements is around fifteen years. However, with proper maintenance, these systems can last much longer. Because of freeze-thaw conditions, permeable pavements can deteriorate, but because permeable pavements allow water to infiltrate through the soil, some of the freeze-thaw susceptibility is reduced.

Costs

One important aspect of permeable pavements is the expenses associated with their implementation. Exact costs for permeable pavements have many contributing factors including the specific type of permeable pavement used, its maintenance, installation, the climate, and soil type. For soil type, if the soil does not drain well, then underdrains and storage reservoirs may be needed. This is typically the case in places where the soil contains high amounts of clay. Because Oshkosh has a significant amount of clay soil, this could raise the cost of permeable pavement systems. However, this increased cost would not fall on the city, for it would simply be a factor that the resident would need to take into consideration when deciding whether or not they want to implement a permeable pavement for their driveway.

Due to the multiple different types of permeable pavement systems and varying installation factors, the cost for installing permeable pavement fluctuates. However, the benefits that permeable pavements contribute will return those costs to the community and help with costs in other areas of concern including stormwater management plans. In ***Appendix A*** we have provided a chart listing different installation costs of different types of pavers for residential use. An important thing to keep in mind is that costs for residential driveways were hard to come across as the field is smaller than the field of standard concrete or asphalt parking lot construction.

According to a study performed at the University of California-Davis, the average cost of a square foot of permeable pavement ranges from one dollar to eleven dollars. This difference is due to the drastically different materials and designs utilized in the ten different permeable pavers (Drake, Bradford, & Marsalek, 2013). The researchers also found the individual average costs for each type of pavement: Porous asphalt was around 1.11 dollars/square foot, pervious concrete came out to 6.66 dollars per square foot, and concrete pavers cost the most at 11.10 dollars per square foot (Terhell et al. 2015). These results were accrued over a 25 year period. In this study, porous asphalt had a life expectancy of 17.5 years, pervious concrete had a life expectancy of 25 years, and concrete pavers had a life expectancy of 25-30 years. To put things into a larger perspective, the researchers at UC Davis also gathered data on the overall costs of entire parking lots. After factoring in installation and maintenance costs, the total price of a half-acre standard asphalt lot came out to $371,356.28. Compare this to the total cost of a permeable parking lot, which was only $306,706.62 (Terhell et al. 2015).

There are some additional factors to consider as a consumer who is looking to redo their driveway. The main costs associated with permeable pavements consist of refreshing the base and vacuum sweeping or other maintenance to help restore permeability. Standard pavements, on the other hand, have seal coating, crack sealing, patching, stripping, and resurfacing. Each type of surface includes costs that the other will not have based on the features that need tending to over the years. All these factors lead to permeable pavements being more expensive when looking at the initial costs of purchase and the installation labor costs. The high initial cost associated with permeable pavement can be seen as the price paid for the added function of filtering stormwater. Even though there are higher installation costs at the beginning, the maintenance costs over time are less expensive compared to traditional asphalt. After dissecting each feature of the two surfaces and estimating maintenance intervals, Terhell et al. came to the conclusion that “permeable pavement will be more cost-effective in the long run” (2015).

For the city, the only potential direct costs that might need to be considered would stem from any decision to implement an educational campaign. Otherwise, costs are simply the time and effort needed to figure out the details of and write the code itself.

Barriers

Our proposal does face some barriers. However, most of these barriers are manageable and simply require adequate planning or incur additional costs to the homeowner. One potential barrier that was discussed with both Director of Public Works James Rabe and Engineering Division Manager Justin Gierach was the previously mentioned issue with the clay content of the soils in Oshkosh. Permeable pavement systems work best when the soil underneath the pavement is capable of absorbing water fairly quickly. Since high clay content can make soil less permeable, the high clay content in the soil in and around Oshkosh means that permeable pavement systems may not be appropriate in many places around the city. However, in these cases, it is also possible to construct underdrainage and storage systems that either drain or store the water away. Though these systems do incur additional costs to the homeowner, they also make it possible to still use permeable pavement systems where the clay would normally prohibit the use of such pavement systems.

James Rabe also brought up concerns regarding the particular type of permeable pavement systems used and their associated maintenance requirements. Some types of permeable pavement can clog easily and require periodic maintenance. These facts would need to be taken into consideration when designing the permeable pavement system for any particular application and would need to be understood by the homeowner.

Todd Meuhrer had concerns regarding maintenance. Specifically, Todd was concerned that if a house that has permeable pavement is later sold, the new owners may not abide by appropriate maintenance practices and allow the permeable pavement to degrade and lose its permeability. One proposed solution to this problem that Todd brought up was the idea of some sort of maintenance agreement that could be written into the homebuying contract. Also, similar to James Rabe, Todd mentioned the need to ensure that the appropriate type of permeable pavement system is being used for any particular situation.

When interviewing Doug Bush, president of Pave Drain, and Charlie Siver, Internal operations manager of Wolf Paving, both shared concerns regarding the construction aspects of permeable pavement. Doug Bush stressed that a considerable concern in the industry is that even though permeable pavement, in general, is becoming more popular, many businesses don't have enough knowledge on permeable pavement. Another concern that they raised was that different cities have different ordinances pertaining to permeable pavement. This makes it difficult for them to keep track of what is and is not allowed in different locations.

Although it would mostly impact the homeowner, cost could also be a barrier. The average cost of a permeable pavement system is about three times as expensive as regular pavement. However, as stated previously, if the homeowner is willing to pay for the system, they should be allowed to, and thus this wouldn't end up being a barrier. Since this doesn't necessarily impact the city, it shouldn't stop the city from adopting code that permits the use of permeable pavement. Furthermore, the benefits of a permeable pavement system will be reaped by the city because the city will have less stormwater to manage.

Oshkosh currently has permeable pavement applications across the city including the senior center, Fire Station 16, and Menominee Arena. These applications are maintained by the city where they vacuum the surfaces multiple times a year to ensure proper drainage. Residential applications will have to be maintained by the homeowner and the concern is that over time they won’t keep up with the maintenance and the cracks will be clogged with rocks and sand. To clean the system, a high power vacuum is used to clear all sand, gravel and other debris from the cracks. This can be seen as a barrier for the homeowner. If the resident doesn’t continue maintenance on their permeable pavement system, the driveway will act as an impervious surface. However, there is no real damage or cost to the city if the resident falls behind on maintenance. Therefore, this barrier ultimately has minimal impact.

Finally, from our interviews, it seems that the overall perceptions of permeable pavements are positive. In our interviews with both city officials and Dr. McPhee, they all had positive things to say about permeable pavement. Dr. McPhee was exuberant about the topic. City officials understand the benefits of permeable pavement, but are concerned about other barriers such as the previously mentioned clay soils and maintenance. These concerns are understandable but manageable. Furthermore, many of our benchmarking examples provide evidence that suggests that, while clay soils and maintenance are important to take into consideration, they aren't determining factors in whether or not a permeable pavement system should be implemented.

Significance for Sustainability

The Fox-Wolf-Winnebago watershed has a long history of water pollution that leads to our modern day issue, having an impaired waterway. Stormwater runoff causes pollutants to flow directly into our damaged waterways, such as phosphorus and organic nitrogens from animal feces, grass clippings, fertilizers—which lead to toxic algal blooms in the summer that kill dogs, poison people and especially children, and close down beaches—as well as salts, pesticides, motor oil, and heavy metals. Beyond water pollution, large amounts of storm runoff also lead to issues such as shoreline erosion, flooding, loss of biodiversity, and poor refilling of groundwater supplies. Conservation of our impaired waterway is a priority for the city.

Permeable pavements help protect our waterways (Drake, Bradford, & Marsalek, 2013). There are ten different types of permeable paver systems, which each range in their environmental impacts throughout their life cycle (Drake, Bradford, & Marsalek, 2013). These are:

- porous aggregate
- porous turf
- plastic geocells
- open-jointed paving blocks/permeable interlocking concrete pavers
- open-celled paving grids
- porous concrete
- porous asphalt
- soft paving materials
- decks
- epoxy-bonded porous materials

These environmental impacts include differences in filtration of heavy metals, salts, total nitrogen, total phosphorus, hydrocarbons, mineral oils, and so forth. It also includes their carbon footprints during manufacturing and transportation, which any pavement is going to have, permeable or impermeable. If the permeable pavement is composed of concrete (which includes asphalt), then it is going to have a very high carbon cost both during the manufacturing process and the transportation (Yuan et al., 2018), but non-concrete/asphalt based pavers, such as gravel-filled plastic geocells (which is what our own resident, Dr. Misty McPhee, wanted for her driveway) have a significantly lower carbon footprint than concrete, nor do they experience the same maintenance costs as concretes do.

The ability for permeable pavements to filter out pollutants is vital for the protection of the Fox River and Lake Winnebago. Stormwater runoff picks up these pollutants from lawn fertilizers, grass clippings, animal waste, as well as motor oil from cars, mineral oil, heavy metals, salts, and pesticides. This water then flows directly into our impaired waterways, directly contributing to our need for costly cleaning projects, poisonous algal blooms in the summer, and the ecological destruction of our beloved Fox-Wolf watershed—which also flows directly into Lake Michigan through Green Bay. But when permeable pavements substitute for the impervious pavements of urban areas, the stormwater instead flows through the pavement material and gets filtered and purified by the soil's natural biological processes.

The most immediate environmental benefit from allowing the construction of permeable pavement driveways would be <u>the filtration of total nitrogen, total phosphorus,</u>

and total suspended solids from entering the waterway. We have a small sample of that literature provided in the list below:

- A study by Liu et al. (2020) found that in water filtered by permeable pavements, nitrogen levels reduced by 47.4%, phosphorus at 42.1%, and the average removal rate of total suspended solids was 69.3%.
- An Ontario study (Drake, Bradford, & Van Seters, 2014) from 2010-2012 compared two interlocking permeable concrete pavers (IPCP) to an asphalt control, and it found that the IPCPs demonstrated great runoff filtration for suspended solids, metals (copper, iron, manganese, zinc), hydrocarbons, and nutrients (including nitrogens, phosphorus). The same study also found that the IPCPs all-butt eliminated oils and grease from stormwater runoff, and that overall, the IPCPs were better for stormwater management and water quality than their impervious asphalt counterpart under similar conditions.
- A study out of Hong Kong (Liu, Fong, & Chui, 2017) showed that permeable pavements reduced runoff by nearly 90% in drier climates and 70% in wetter climates. In addition, they found that impervious surfaces lead to flooding, riverbank, and water quality degradation.
- A 2007 review by Scholz and Grabowiecki found that permeable pavement systems are far and beyond better at reducing stormwater runoff than impervious asphalt. Additionally, permeable pavements are especially effective at filtering hydrocarbons and mineral oil pollutants.
- A cradle-to-grave life cycle assessment (LCA) of low-impact-development (LID) technologies in Ontario (Bhatt, Bradford, & Abbassi, 2019), which compared the LIDs (including permeable pavements) against traditional stormwater management practices, such as detention ponds, and found that LIDs have ~20% lower cradle-to-grave environmental impact than the detention ponds, and the benefits accrued by the LIDs are ~300% higher than the traditional detention pond.
- A study in Washington (Brattebo & Booth, 2003) found that permeable pavements decreased motor oil concentrations dramatically.
- A 2013 literature review (Drake, Bradford, & Marsalek) found that there is an overwhelming body of literature articulating the costs and overwhelming benefits of LIDs, especially permeable pavements. It also found that LIDs are better at water infiltration across the board, and that permeable pavement treated water can improve the quality of groundwater supplies.

In relation to the filtration of nutrients from stormwater comes another benefit with certain permeable pavements, and that is the ability to inoculate them with beneficial bacteria that perform denitrification and other biological processes that purify stormwater before it enters the groundwater supply. This benefit mostly applies to porous asphalt and porous concrete (Drake, Bradford, & Marsalek, 2013).

- The same 2013 literature review found that certain types of permeable pavements, particularly porous asphalts and porous concretes, can be inoculated with microbes that improve the biodegradation of nitrogen (denitrification)—which is important for minimizing the effects of excess nutrients from entering our waterways, thus helping to prevent toxic algal blooms.
- This ability to inoculate porous concretes with beneficial bacteria is also evidenced in Scholz & Grabowiecki (2007).
- Drake, Bradford, & Van Seters (2014) says that the aggregate bases beneath permeable pavers may fill with water after especially heavy rainfalls, but that this saturation could be used to foster beneficial bacteria within the aggregate base.

With porosity and permeability of surfaces also comes the absorption of other substances, such as winter road salt. This is an aspect of permeable pavements that varies considerably from system to system.

- A 2019 paper (Selbig, Buer, & Danz) tested a permeable interlocking concrete paver, porous concrete, and porous asphalt against traditional concrete pavement for water pollution filtration properties. Chloride loads in groundwater increase with the three permeable pavements tested, a byproduct of being permeable. However, the paper proposes that reduced road salt usage in cold climate areas, where salting is the primary form of de-icing, would balance out these concerns.
- The 2014 Ontario paper by Drake, Bradford, & Van Seters found that while, yes, road salt was more present in the permeable pavement during mid-winter than the traditional asphalt, the effect was minimal, and the salt concentrations were still well below tolerable thresholds.
- The 2013 literature review by Drake, Bradford, & Marsalek, found that while road salts are a concern with permeable pavements, it is more so an issue with the pressing need to instigate better deicing practices that do not involve oversalting our roads. For a more in-depth proposal on better winter

salting practices, please read the report by our classmates who presented on more sustainable winter road salt additives.

There is also the fact that heavy metals are another pollutant concern addressed by permeable pavements.

- Based on a study in Madison, Wisconsin (Selbig, Buer, & Danz, 2019) that compared interlocking permeable concrete pavers, porous concrete, and porous asphalt, against traditional pavement, it found that porous asphalt was the best filtrater of metals.

- The 2010-2012 Ontario study found that interlocking permeable concrete pavers were highly effective at filtrating the metals copper, iron, zinc, and manganese from stormwater (Drake, Bradford, & Van Seters, 2014). The 2013 literature review found that permeable pavements were good at capturing metals from stormwater runoff, amongst their other numerous benefits.

- Additionally, while the initial usage of some concrete permeable pavements will temporarily increase the acidity of stormwater runoff, this effect lasts only for the first handful of rainfall events, and it quickly tapers off to a level that becomes much lower than traditional pavement (Drake, Bradford, & Van Seters, 2014). This effect is no different than how some tools need to be “broken in” with a couple of uses before they reach peak functionality.

- A study in Washington (>Brattebo and Booth, ???<) found that permeable pavements decreased copper levels by 74% below minimum detection levels, zinc by 22% below minimum detection levels.

As for the design of permeable pavements themselves, as with all pavements there is a gravel aggregate base for structure, support, and as a reservoir for the rainwater as it gets filtered through the soil. In traditional concrete pavements, the gravel aggregate base is only for support, but because of the impervious surface the stormwater has nowhere to go, which during heavy rainfalls can lead to flooding of streets (Drake, Bradford, & Marsalek, 2013) (Liu, Fong, & Chui, 2017) (Drake, Bradford, & Marsalek, 2013). When the rainwater has a place to go that isn’t the streets, such as the gravel aggregate base of a permeable pavement system, this reduces street flooding in that area. Though, building owners are encouraged to work closely with professionals to build the best permeable pavement system plausible within the confines of their local geography. Additionally, a case study from New Zealand (Fassman, 2010) looked at how long it took for impervious pavement and permeable pavements to begin the runoff stage of a rain event, and the impervious pavement averaged at 12 minutes while the permeable pavements averaged at an hour. The researchers noted that with deeper gravel aggregate basins, such as would be necessary in places with poor soil drainage or that experience more frequent or unpredictable precipitation patterns, the time the gravel basins took to fill extended into the three and six hour range. Thus, this drastically decreased peak flow rates during rain events by about 90%, a significant difference for any city or municipality that deals with flooding issues, such as in Wisconsin.

Beyond the ability for permeable pavements to improve stormwater filtration, is also the added benefit that some of them utilize grass as part of the permeable paver system, usually in cellular grid systems. These cellular grid systems, generally built with either plastic geocells, interlocking concrete pavers, and open-celled paving grids, can be reinforced with grass, dirt, sand, or gravel, with the specifics of the pavement's design based on its intended function and environment. The grid design helps to minimize the effects of dirt compaction, the roots from grass strengthen the soil and prevent erosion and improve gravel retention, the gravel fill is not susceptible to ecological or clogging problems of concretes nor does the gravel readily escape its geocell containers, and sand cannot be clogged by itself (Drake, Bradford, & Marselek, 2013). These types of permeable paver systems and their non-concrete inclusions are the best options for preserving our waterways, minimizing erosion, and allowing residents an opportunity to drastically reduce their own carbon footprints.

Summary

We are proposing a small legislative change to our residential development codes, that residents may be permitted to build permeable paver system driveways in addition to the pre-existing ability to build them for patios. The City of Oshkosh is concerned with water conservation of the Fox River and Lake Winnebago, and allowing residents to have permeable pavers developed on private land as part of a personal effort to minimize water pollution should be encouraged in our city codes.

Permeable pavement systems are a great benefit to water conservation. Benefits include: the infiltration of stormwater runoff, which leads to the reduction of heavy metals, mineral oils, hydrocarbons, total nitrogen, and total phosphorus in our waterways; reduction in phosphorus and nitrogen helps minimize noxious algal blooms in the summer; and heavy metals are a well-known pollutant to the Fox River. While the types of systems vary wildly, from porous asphalts and porous concretes, to bricks arranged neatly with spaces in between to allow water to percolate between bricks, to less conventional systems such as gravel-aggregates; thus their benefits and costs do range, that is a matter for the private citizen to decide for themselves. By legalizing the implementation of permeable paver systems in driveways for private citizens, it is giving citizens the freedom to choose to be able to reduce water pollution, and it would be in-line with the already existing permeable pavement systems around the city, such as the University of Wisconsin Oshkosh and the Menominee Nation Arena.

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Appendix A - Costs of Different Types and Installation of Permeable Pavement

Permeable Pavement Costs: Here are the costs for the different types of permeable pavement for 2015 (Terhell).

Surface Type	**Limitations/Application**	**Material average cost/ft^2**	**Average Life span**
Porous Asphalt	Low weight capacity	$1.11	17.5

Pervious Concrete	Small to large projects	$6.66	25
Concrete Pavers	Small to large projects	$11.10	25-30

Permeable Pavers vs. Asphalt Parking Lot Construction/Maintenance: (Terhell, 2015)

1/2 Acre Parking Lot Costs over 25 Years				
	Frequency in 25 Years	Permeable Pavements	Frequency in 25 Years	Asphalt
Installation	1	$165,350.00	1	$109,000.00
Detention	1	$15,000.00	0	$0.00
Vaccum Sweep	25	$400.00	0	$0.00
Restore Permeability	5	$1,750.00	0	$0.00
Refresh Base	1	$8,100.00	0	$0.00
Crack Sealing	0	$0.00	25	$250.00
Seal Coat	0	$0.00	5	$20,000.00
Stripping	0	$0.00	1	$3,125.00
Patching	0	$0.00	5	$100.00
Replace Surface		$0.00	1	$32,000.00
	Total for 2003	*$207,200.00*	**Total for 2003**	*$250,875.00*
	Total for 2015	*$306,706.62*	**Total for 2015**	*$371,356.28*
	2015 Cost per Square Foot	*$14.08*	Cost per Square Foot	*$17.05*
	2015 Cost per Acre	*$613,413.23*	Cost per Acre	*$742,712.57*

Although our project focuses on residential areas, the above table gives a good visualization of the costs associated with the process of permeable pavers being installed and maintained. The amount saved is around $64,649.66 over 25 years for ½ acre of land by installing permeable pavement instead of standard asphalt. However, these costs will decrease regarding driveways as they are a smaller project.

Looking at the analysis of permeable pavements compared to regular asphalt, various costs are associated with them. The initial costs (money and labor) for permeable pavers required for standard asphalt installation are higher. The high initial cost associated with permeable surfaces is due to the design and infrastructure necessary to let surface water permeate the underlying soil properly.

On the other side, due to the lack of base layers needed to install, standard asphalt has a low installation cost. The lower installation cost of regular asphalt is followed by high upkeep/maintenance costs throughout its lifetime. These upkeep costs are related to the cracking and patching of worn-out surfaces due to the high surface tensions in asphalt affected by weathering, environmental impacts, and temperature increases.

Appendix B - Example of Municipal Code From Minneapolis, MN

The following is the section of Minneapolis' municipal code dealing with permeable pavement. Their implementation provides an example of code that is both detailed and simple and served as the template for our code recommendation.

541.305. - Pervious pavement or pervious pavement systems.

(a) *In general.* Pervious pavement or pervious pavement systems, capable of carrying a wheel load of four thousand (4,000) pounds, including pervious asphalt, pervious concrete, modular pavers designed to funnel water between blocks, lattice or honeycomb shaped concrete grids with turf grass or gravel filled voids to funnel water, plastic geocells with turf grass or gravel, reinforced turf grass or gravel with overlaid or embedded meshes, or similar structured and durable systems are permitted. Gravel, turf, or other materials that are not part of a structured system designed to manage stormwater shall not be considered pervious pavement or a pervious pavement system. Pervious pavement and pervious pavement systems shall meet the following conditions:

(4) All materials shall be installed per industry standards. Appropriate soils and site conditions shall exist for the pervious pavement or pervious pavement system to function. For parking lots of ten (10) spaces or more documentation that verifies appropriate soils and site conditions shall be provided.

(5) All materials shall be maintained per industry and city standards. Areas damaged by snow plows or other vehicles shall be promptly repaired. Gravel that has migrated from the pervious pavement systems onto adjacent areas shall be swept and removed regularly.

(6) Pervious pavement or pervious pavement systems, except for pervious asphalt or pervious concrete, shall not be used for accessible parking spaces or the accessible route from the accessible space to the principal structure or use served.

(7) Pervious pavement or pervious pavement systems shall be prohibited in areas used for the dispensing of gasoline or other engine fuels or where hazardous liquids could be absorbed into the soil through the pervious pavement or pervious pavement system.

(8) Pervious pavement or pervious pavement systems, except for pervious asphalt, pervious concrete, or modular pavers shall not be used for drive aisles or driveways.

(9) Pervious pavement or pervious pavement systems that utilize turf grass shall be limited to overflow parking spaces that are not utilized for required parking and that are not occupied on a daily or regular basis.

(10) Pervious pavement or pervious pavement systems that utilize gravel with overlaid or embedded mesh or geocells shall be limited to industrial districts and shall not be used for drive aisles or driveways, except as otherwise allowed by this chapter, and in no case shall be used for drive aisles or driveways less than a minimum of twenty (20) feet from the curbline.

(11) Pervious pavement or pervious pavement systems used for parking or associated drive aisles or driveways shall count as impervious surface for the purposes of impervious surface coverage in any zoning district that has a maximum impervious surface limit or percentage, except where a pervious pavement system utilizing turf grass is provided for a fire access lane that is independent of a parking lot.

(12) Pervious pavement or pervious pavement systems shall not count as required landscaping except as allowed by alternative compliance as a part of Chapter 530, Site Plan Review.

(13) Pervious pavement or pervious pavement systems shall not allow parking spaces, drive aisles, or driveways to be located anywhere not otherwise permitted by the regulations of this zoning ordinance and the district in which it is located.

(14) Parking areas shall have the parking spaces marked as required by this chapter except that pervious pavement systems that utilize gravel or turf may use alternative marking to indicate the location of the parking space, including, but not limited to, markings at the end of spaces on the drive aisle or curbing, wheel stops, or concrete or paver strips in lieu of painted lines.

(b) *Off-street parking areas and driveways accessory to single-, two-, and three-family dwellings.* Notwithstanding the provisions of subdivision (a), off-street parking areas and driveways accessory to a single-family dwelling may be surfaced with pervious paving systems that utilize gravel installed and maintained per industry standards. Off-street parking areas and driveways accessory to single-, two-, or three-family dwellings may be surfaced with pervious paving systems that utilize turf with plastic geocells or open-celled paving grids installed and maintained per industry standards and designed so that the parking of vehicles does not kill the turf.

Appendix C - Driveway Installation Policy, Menasha, WI

The following is the City of Menasha's Driveway Installation Policy.

1. This Driveway Installation Policy has been adopted by the Common Council as a supplement to Section 13-1-51(b)(1) of the Municipal Code and applies to R-1, R-2, and R-2A zoning districts. It is intended to assist with interpretation and application of the section but may not cover all situations encountered.

2. A Driveway Permit and Zoning Permit from the Building Inspection Office and a Grade Request from the Department of Public Works shall be obtained prior to installation of any driveway, driveway extension, or parking area. Permit applications shall include a site plan drawn to scale showing the location and dimensions of the driveway or parking area in relation to all property lines, structures, service walks, sidewalks, and street rights of way along with specifications showing the proposed materials and cross sectional dimensions.

3. The following standards shall apply:

a. All driveways, driveway extensions, parking areas, and driveway aprons shall be surfaced ("paved") with a durable dust-free material acceptable to the Department of Public Works. Alternative materials shall be approved prior to installation by the Director of Public Works as part of the Driveway Permit application. This paving requirement shall not apply to parking areas utilized solely for storage of recreational vehicles in compliance with Sec. 13-1-52.

b. Approved paving materials include concrete, asphalt, brick, and similar durable, dust free materials acceptable to the Department of Public Works. Durable, dust free pervious paving materials specifically designed to reduce stormwater runoff are encouraged and may be utilized upon approval by the Director of Public Works.

c. The minimum width of any paved driveway or parking area shall be nine (9) feet. If a property does not have a garage, carport, or rear yard parking area, the property owner shall be required to have a minimum area of 320 square feet of paved area per dwelling unit. The minimum paved area shall be adjacent to the driveway apron.

d. The following minimum installation standards shall apply:

   i. Concrete shall be finished to a minimum thickness of 4" and installed on a minimum 4" base of 3⁄4' crushed aggregate;

   ii. Asphalt shall be finished to a minimum thickness of 2 1⁄2" and installed on a minimum 6" base of 3⁄4" crushed aggregate;

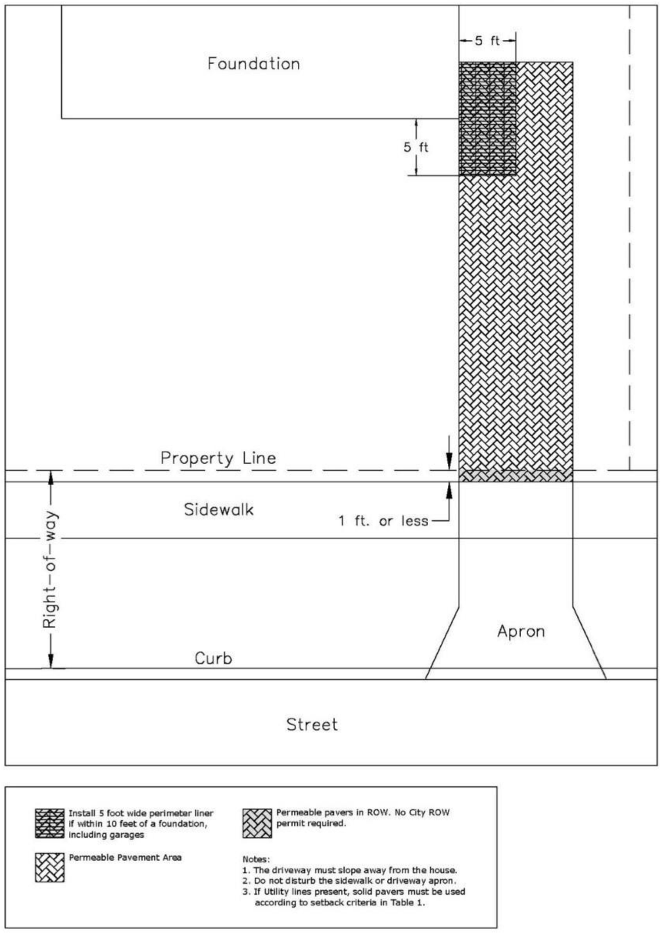
   iii. Paving bricks shall be no less than 2 1⁄4" thick and installed on a minimum 4" base of approved granular material.

   iv. Similar durable, dust-free materials approved by the Department of Public Works shall be installed in a manner that is consistent with professional installation standards.

Appendix D - Example application of Permeable Pavement

The following is an example application of permeable pavement.

Figure 1a. Plan view of permeable pavement driveway installation (sidewalk present)



Appendix E - DNR Technical Bulletin on Permeable Pavement Implementation

The Wisconsin DNR has already put together a technical standard regarding the implementation of permeable pavement. Below is a link to that technical standard, and we will also be forwarding a copy of them along with this proposal.

https://dnr.wi.gov/topic/stormwater/documents/1008PermeablePavement.pdf

Appendix F - Example of Educational Material from Laurel, MD

Should the City of Oshkosh want to engage in an educational campaign for permeable pavement, we have provided a sample of literature that other municipalities have used to spread awareness of permeable pavement. The following is a copy of a permeable pavement handout put together by the city of Laurel, Maryland and found here: www.cityoflaurel.org/system/files/files/permeable20pavement20guidelines20pdf.pdf.

Rushern L. Baker, III
County Executive

Department of Environmental Resources
Adam Ortiz
Director

Guidelines for

Permeable Pavement

What is permeable pavement?

When rainwater falls on conventional pavement, such as concrete, it accumulates and then flows across and off of this impervious surface as stormwater runoff. Permeable pavement allows stormwater to slowly seep through (infiltrate), reaching the soil and groundwater below the surface.

A variety of permeable pavement materials are available, such as interlocking pavers, porous asphalt, pervious concrete, and manufactured grass pavers. Interlocking pavers consist of precast blocks (primarily brick or concrete) that are aligned in such a way that water is able to pass between the blocks into the soil below. Grass pavers are a type of open-cell paver made of concrete or plastic, in which the cells are filled with soil and planted with turf.

While the specific designs vary, all permeable pavements have a similar structure, consisting of a surface pavement layer, an underlying crushed stone reservoir layer, and a filter or fabric layer installed on the bottom. The size and extent of the crushed stone layer depends on a variety of factors, such as the amount of precipitation and the capacity of the soil to soak up rainwater.

The installation of permeable pavement is a robust approach to stormwater management and environmental stewardship with a wide range of residential and commercial applications. Permeable pavements can be installed on walkways, patios, plazas, driveways, and parking areas. Because it does not require additional land, permeable paving is an excellent technique for urban areas.

What are the benefits to property owners and communities?

Throughout a typical community, paved surfaces—such as driveways, sidewalks, patios, parking lots, and roadways—are primarily composed of asphalt and concrete. The stormwater that flows across these surfaces is directed toward storm drains, inlets, streams, and ponds. In many locations, the quantity of runoff generated from the impervious surfaces is so large that it can exceed the capacity of storm drains, resulting in localized flooding. In addition, stormwater runoff contributes to sewer overflows, poor water quality and stream erosion. The replacement of conventional concrete or asphalt with porous pavements or permeable pavers helps to reduce these impacts by allowing precipitation to infiltrate into the soil below. This results in a direct reduction to peak stream flows during storms, which can help reduce erosion as well as the frequency and severity of flooding in downstream locations. Water that infiltrates into the soil replenishes groundwater, ensuring productive aquifers within the community.

To be eligible for a rebate under the Rain Check Rebates Program, an individual residence must install a minimum of 100 square feet of permeable pavement while multi-family residences, commercial properties, and projects completed by nonprofit or not-for-profit organizations must install a minimum of 350 square feet of permeable pavement.

An added benefit to permeable surfaces is that pollutants slowly permeate through the crushed stone and soil layers, allowing natural filtration processes to improve water quality by retaining some pollutants that would otherwise enter streams and rivers with runoff. With proper maintenance, the longevity of permeable pavements typically exceeds that of conventional systems. Grass pavers can improve site appearance by providing vegetation where there would otherwise be only pavement.

rain check

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How can your permeable pavement project qualify for a rebate?

To be eligible for a rebate through the Rain Check Rebate Program, the area on which you install permeable pavement must be at least 100 square feet in residential applications and 350 square feet for multi-family, commercial, nonprofit, or not-for-profit uses.

How can you determine if your property is suitable for permeable pavement?

Permeable paving is well suited for many residential and commercial applications. However, because it's load-bearing capacity is lower than that of conventional pavement, permeable paving should not be used in areas subject to excessive loads or high-speed traffic. Permeable paving is most appropriate for pedestrian-only areas and for very low-volume, low-speed vehicle areas such as overflow parking areas, residential driveways, alleyways, and parking stalls. It should not be used in areas with high pollutant loads because the stormwater is not pre-treated before infiltration.

To determine the suitability of areas on your property, first identify your existing impervious surfaces or areas that you intend to pave. Most properties have driveways, sidewalks, or patios—these are prime locations that can often be replaced with permeable pavement to improve rainwater infiltration and visual appeal. Or, if you want to pave an area that is not currently paved, you may want to choose permeable pavement. Exclude any surfaces that accumulate a lot of sediment and debris as this can clog the surface and reduce the effectiveness of the system. Only include areas that have a gradient, or slope, that will direct water away from the foundation of your home or other nearby structures, and include only those areas with a slope of less than 5%. Think about the project size that will best fit within your budget; smaller projects are more affordable and can offer a wide degree of flexibility, particularly at the residential level. Consider the landscaping requirements of the project; some types of permeable pavement, such as interlocking pavement, can be decorative as well as functional. Once you have identified the locations on which you would like to replace impervious surfaces with permeable pavement, measure the total area to be sure it is at least 100 square feet (for residential properties) or 350 square feet (for other types of properties).

The type of soil found on your property is an important consideration. Soil conditions do not constrain the use of permeable pavement, although they do determine whether an underdrain is needed. Soils such as sand and loam are permeable and allow water to infiltrate fairly rapidly. In contrast, clay soils can be impermeable and will probably require an underdrain system to prevent ponding. Professional designers and contractors will be able to help determine the infiltration capacity of the soils on your property.

How can you determine what kind of permeable pavement to use and where?

Once you have selected the location, decide what type of system will be the most effective and visually pleasing. A wide variety of permeable pavements are available. For residential properties, permeable interlocking pavers are commonly used because property owners can customize their shape, size, color, and layout to meet their individual needs. Permeable interlocking pavers are not restricted to residential applications; they have also been successfully implemented in walkways, plazas, and parking areas for larger-scale projects. Pervious concrete and porous asphalt are versatile and can be used in a wide variety of applications, including the resurfacing of sidewalks, driveways, and parking areas. For aesthetic reasons, asphalt is not typically used for patios or sidewalks. Manufactured grass pavers are a good option for driveways or overflow parking. Grass pavers are not suitable for everyday, all-day parking because the grass will not receive sufficient sunlight.

Which other techniques work well with permeable pavement?

Permeable pavement can replace a conventional asphalt driveway and therefore works well with pavement removal. In some permeable paving applications, you may be able to incorporate the overflow from a rain barrel or cistern.

What are the costs?

On most sites, permeable paving costs more than conventional asphalt or concrete paving. In the case of pervious concrete or porous asphalt, construction costs may be 50% more than their conventional counterparts, and are typically in the $7 to $15 per square foot range. For a typical 10 foot by 20 foot single car driveway this would amount to between $1,400 and $3,000. For a 5,000 square foot parking lot, costs can be expected to range between $3,500 and $7,500. Construction costs of paving stones and manufactured grass pavers vary considerably but generally cost about 20% more than traditional concrete pavers. Annual maintenance generally costs about 1% to 2% of the construction cost. The use of permeable pavement reduces the amount of land needed for stormwater management and may satisfy requirements for green space, allowing more development on a site.

To alleviate costs, the Rain Check Rebate Program provides a rebate of $1,200 (100-square-foot minimum) for residential properties and $5,000 (350-square-foot minimum) for commercial properties, multi-family dwellings, and projects undertaken by nonprofit and not-for-profit organizations.

Can you do this project yourself?

No. The installation of any type permeable pavement should be completed by a qualified contractor. Specialized equipment, such as excavators and pavement machinery, are required. Various landscaping, soil type, and drainage issues must be considered as they can affect the stability of the surface and rainwater infiltration. Your certified contractor can help you select a system that works best for your needs.

How should you choose a contractor?

You will need to hire a qualified contractor who is licensed and bonded to install porous asphalt, pervious concrete, and other types of permeable pavement. Find out what type of system will work (and look) best in your situation. Ask potential contractors what their experience is in soil testing, amending soils, and soil reinforcement or stabilization techniques and be sure that they are experienced with the specific type of permeable pavement you are considering. Ask whether they hold certifications from nationally recognized organizations, such as the National Ready Mix Concrete Association, the Interlocking Concrete Pavement Institute, or the National Asphalt Pavement Association. Find out if they can supply references and past project experience in the area. Ask potential contractors how much the project will cost, what is included in their services, and whether any additional fees are associated with the disposal of removed materials. Ask what type of equipment will be needed, whether any subcontractors will be used, how long the project should take, and whether the work will be guaranteed.

What kinds of permits are required?

A permit is not required for most permeable pavement projects. However, if installing your permeable pavement (on its own or in combination with a concurrent project on your property) exceeds 5,000 square feet and/or 100 cubic yards of earth-moving disturbance (such as grading, cutting, and filling), or a change in grade of +/- 12" a permit is required. Contact the County's Department of Permits, Inspection and Enforcement (DPIE) for more information: (301) 636-2000 or www.princegeorgescountymd.gov/sites/dpie.

What maintenance will be required?

As with any structural feature, permeable pavement requires maintenance to ensure that the system continues to function properly. The most common problem impacting permeable pavement is clogging, which occurs when sediment and other material obstructs pores, reducing infiltration. To help prevent these problems, keep landscaped areas well maintained and prevent soil from being transported onto the pavement. The most effective preventive maintenance for permeable pavement is yearly dry weather vacuum sweeping. Brooms, hoses, and pressure washers can compromise the system's integrity and should not be used for cleaning and clearing. For paving stones, periodically add joint materials (sand) to replace material that has been transported away. Inspect your permeable pavement each year to check for and repair cracking, splitting, or other damage to the pavement surface. Do not reseal or repave with impermeable materials. Grass pavers may require periodic reseeding to fill in bare spots. In winter, salt can be used in moderation to melt ice, but never use sand unless you have paving stones. Pervious concrete works well in cold climates as the rapid drainage of the surface reduces the occurrence of freezing puddles and black ice. Melting snow and ice infiltrates directly into the pavement, facilitating faster melting. Snow plows can catch the edge of grass pavers and some paving stones. Rollers should be attached to the bottom edge of a snowplow to prevent this problem.

MAINTENANCE SCHEDULE FOR PERMEABLE PAVEMENT

		Spring			Summer			Fall			Winter		
Interlocking Pavers	Inspection	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
	Cleaning and sweeping		Required at Low Frequency	Required at Low Frequency	Required at Low Frequency	Required at Low Frequency	Required at Low Frequency	Required at Low Frequency	Required at Low Frequency	Required at Low Frequency			
	Replacement of filler material	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary
Grass Pavers	Inspection	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
	Reseeding of bare spots		Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary	Required As Necessary				

Required · Required at Low Frequency · Required As Necessary

For more information

While Prince George's County does not endorse any one method or vendor for permeable pavement projects, the following information is provided for your consideration.

General Information

Metropolitan Area Planning Council, Massachusetts Low Impact Development Toolkit
www.mapc.org/sites/default/files/LID_Fact_Sheet_-_Permeable_Paving.pdf

Paver Search (a comprehensive list of national paver products and contractors)
www.paversearch.com/index.htm

Interlocking Concrete Pavement Institute, Low Impact Development Center, and North Carolina State University, Permeable Interlocking Concrete Pavements
www.ncsu.edu/picp/

Interlocking Concrete Pavement Institute, Carving a new path in town?
www.icpi.org/

Low Impact Development Center, Permeable Interlocking Concrete Pavement Specification
www.lowimpactdevelopment.org/epa03/pavespec.htm

New Jersey Stormwater Best Management Practices Manual, Standard for Pervious Paving Systems
www.njstormwater.org/tier_A/pdf/NJ_SWBMP_9.7.pdf

Chesapeake Stormwater Network, Permeable Pavement Design Specification
http://chesapeakestormwater.net/2009/11/permeable-pavement-design-specification/

Maryland Ready Mix Concrete Association Inc. (pervious concrete information and pervious pavement contractor certification)
www.marylandconcrete.com/

Low Impact Development Center, Permeable Pavers: Watershed Benefits
www.lid-stormwater.net/permpavers_benefits.htm

National Asphalt Pavement Association, Porous Asphalt Pavements for Stormwater Management
http://store.asphaltpavement.org/index.php?productID=179