

Improving Stormwater Management in Oshkosh Through Green Infrastructure

Environmental Studies Senior Seminar

University of Oshkosh Wisconsin

Landscaping Group

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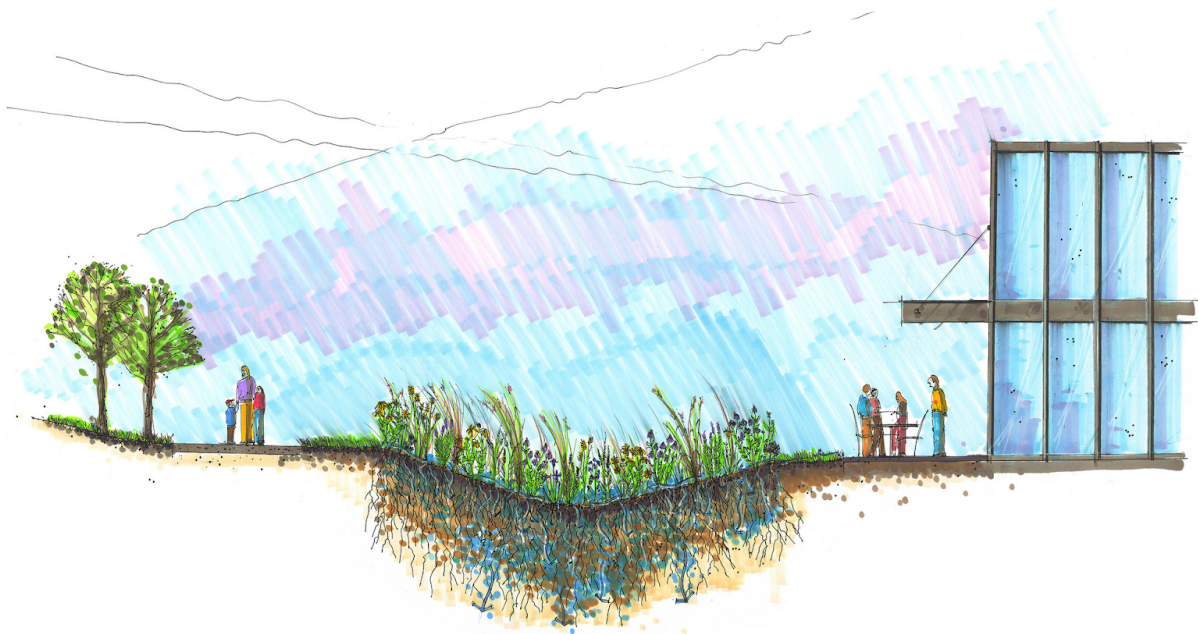


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Executive summary:

The landscaping techniques we propose involve different levels of difficulty, costs, and their own individual barriers. The techniques we want to implement are rain gardens, bioswales, green roofs, and vertical plantings. Behind all of these techniques is a dependence on soil series which determine the different beneficial qualities for the area. Each soil series contains a different amount of silt, sand, and clay which affects the type of landscaping and materials that can be placed in the area. The basis of these ideas comes from the city of Oshkosh Sustainability Plan, the Green Tier Community document, and extensive research on the use of green infrastructure. Oshkosh is a certified Green tier Community, a part of Tree City USA, and has high flyer status through Bird City. This shows how Oshkosh is dedicated to being sustainable and how implementing the landscaping methods we are recommending are a feasible change for the city. We talked to several stakeholders to gauge their opinion on the ideas we are proposing and to see how viable these ideas are. A large portion of the following report is spent explaining each landscaping technique and where these methods will be best utilized. Before moving forward, it is also important to address what barriers and costs we may encounter and how to overcome them. Through our research and audit of the city of Oshkosh, we would like to propose numerous landscaping techniques to implement, especially in parking lot design, to improve stormwater management, reduce runoff, and improve water quality.

Introduction:

Within the city of Oshkosh there is a need for more green infrastructure. As a community that is a Tree and Bird City, and a Green Tier Community, we must uphold this prestige by maintaining and improving our green infrastructure. We find the issue of green infrastructure relevant to the issue of stormwater management and relevant to parking. Through our research, we find that different techniques of landscaping can aid in trapping and filtering stormwater before entering the sewer systems and groundwater. These landscaping techniques include bioswales, rain gardens, native plants, and vertical plantings. By implementing our recommendation of how to manage stormwater, we will see improved water quality, reduced runoff, less flooding, and lower stress on sewer systems.

Identification of the Problem:

Stormwater drainage issues are seen mostly in parking lots with impervious surfaces. Stormwater runs off of impervious surfaces and into water bodies. There are very high rates of eutrophication in Lake Winnebago and the Fox River. These water bodies around Oshkosh have increasingly high levels of limiting nutrients like nitrogen and phosphorus; causing algal blooms and accelerating the lifetime of the lakes. Additionally, the water running off of impervious surfaces and the low absorbance of water in turf grass around the city causes flooding in yards, streets, and basements.

Local pollution from brownfield sites pollutes the soil and groundwater. Brownfields are areas that are contaminated with various pollutants that impact public health and prevent or

slow development (Mikkelsen et. al 1994). It is important to prevent contamination of water that originates from runoff of these sites because many of these contaminants will persist in the water and soil for very long periods of time and cause a variety of negative health impacts to humans and the ecosystem.

Background:

Soil varies greatly depending on different factors such as climate, moisture regime, and geological history. Each soil series and type of soil varies in composition of sand, silt, and clay. These three components and the composition percentages create the different types of soil.



Figure 1.1: City map of Oshkosh map with NRCS data overlay

Figure 1 shows a map of the city of Oshkosh with an overlay of NRCS soil data. The yellow lines depict the borders for different soil series in the area. For the city of Oshkosh there are many different soil series each with a different soil profile and description with qualities that

determine the types of plants that can grow in that area or the amount of infiltration. It determines the depth to the water table and within the different soil types are variations amongst the availability of water intake and the amount of water that stays within the top soil layers. Depending on soil composition and the amount of air space between each aggregate, the water will trickle and slowly filter toxins out before entering the water table. At the base of any landscaping technique implementation, there needs to be a qualitative analysis of the soil underneath the area along with an accurate site label, such as brown, etc. At the corner of Butler and Snell there is a designated brown site, which means that this area is polluted and therefore compromised and in need of restoration (Soil management plan, 2012). This area is contaminated by petroleum. The basis of soil health and contamination is something that is required to know before trying to remediate the area. For example, certain native plants will be able to hold up to pollution better than others and eventually filter those toxins out of the soil through uptake from the soil. The importance of soil and knowing the condition of the soil can make a restoration process go much smoother and therefore lead to the success of landscaping techniques in the system.

Native plants with deep roots hold the soil together, prevent erosion and runoff, do not require the use of pesticides and fertilizers, and overall do not require much maintenance (Hefland et. al 2006). Additionally, they increase biodiversity which benefits the environment in a number of ways as well as provides beauty and brings a natural sense of place and belonging to this area. The ecotone in Oshkosh is traditionally oak savanna which contains many deep rooted grasses. These grasses grow a complex root systems that hold the soil together and soak up water from the surface. Along shorelines, a buffer of deep rooted native plants will prevent

soil erosion which causes turbidity and poor water quality. Using native grasses in all parts of city, in addition to along water bodies, is beneficial and helps to conserve the quality of an important natural resource - water. Native plants have evolved with other species in the ecosystem which means they are better suited to handle the different climate events in this area. Hasselkus, E. R. (2012) is a good reference for what types of plants are native to Oshkosh, what their different benefits entail, and where to place them based on the habitat and soil type. This will not only guide the city on how to better understand the ecosystem and types of plants, but also residents who want to implement native plants on their own property. The benefits of native plants outweigh non-native plants. They provide structure for the soil and they are adapted to this ecosystem so they are better suited for the climate and therefore require less maintenance and resources.

Rain gardens are a sufficient solution for stormwater best management practices (BMPS). A rain garden is a depressed area that collects water from runoff (Asleson, 2009). They are planted with grasses and flowering plants. Some of the major benefits include being cost effective, aesthetically pleasing, reducing runoff, filtering pollutants, and creating habitat for wildlife (Asleson, 2009). Bioswales achieve the same goals as rain gardens but are designed to manage a specified amount of runoff from a large impervious area, such as a parking lot or highway. Bioswales often deeper than rain gardens but use the same native plants to withstand both heavy rains and drought (Soil Science Society of America, 2018). The use of rain gardens and bioswales will provide useful bioretention for positive drainage. Rain gardens and bioswales are a great step toward introducing green infrastructure. We need to first implement sustainable stormwater infrastructure. Then, begin planning and policy to connect ecological

aspects. These bioretention methods will also feature native plantings that will create habitat and be aesthetically pleasing to the citizens of Oshkosh. We can also work with large corporations to implement rain gardens and bioswales on commercial property. For example, Oshkosh truck is building their new headquarters in Oshkosh and by using green infrastructure on their property, they can be a leading example in the city for other businesses. Oshkosh Truck is especially significant because their new headquarters will be positioned on two bodies of water. Rain gardens and bioswales are effective at capturing water that typically runs off of the land and into the water. Working with businesses around the city to implement rain gardens and bioswales on their properties is an effective stormwater management practice.

Preserving what we already have, the City of Oshkosh Sustainability Plan outlines that the retention of existing trees and other vegetation is a goal for the city now and in the future. We would like to reiterate the importance of maintaining that vegetation within Oshkosh and ensuring that any new developments that take place in the city are mindful of Oshkosh's commitment to retaining native vegetation. Ensuring that new developments are following recommendations and guidelines will help Oshkosh maintain its Tree City USA status along with making it a healthier and more sustainable city. The benefit of retaining our Tree City USA status requires us to maintain the trees we already have, but we recommend these trees are native and have the deep rooted systems made for this environment and climate so they will benefit the other species in the ecosystem and maintain a clean environment (Berland et. al 2017). Native trees placed along our street frontages will help increase infiltration. Placing native trees along street frontages will reduce soil compaction from the impervious surfaces and increase infiltration during rain events. (Bartens et. al 2008). Combining all of the landscaping methods

mentioned will create the best stormwater management practice and greatest benefit for the environment.

Proposed Action:

In order to protect our water resources, reduce runoff, and prevent flooding within the city, we recommend three changes to the landscaping ordinance. In Article IX, Chapter 30 of the city of Oshkosh ordinances describes a point system that requires public and commercial land to meet a certain number of points which are assigned to different landscaping features. Currently, the point system is not used directly to manage stormwater and residential areas are excluded. We have also found that there are more parking lots than are being utilized in Oshkosh which contributes to more runoff into the waterways. When rain gardens, bioswales, and other landscaping features are added to parking lots, streetscapes, and other areas of the city, the amount of runoff is reduced. The amount varies depending on how much landscaping is added to an area, considering flow rate, slope of incline, soil type, and the severity of the rain event, but green infrastructure and sustainable landscaping will have a positive impact on stormwater management within the city. Overall, Oshkosh needs to implement a more developed point system which favors green infrastructure in order to strengthen stormwater management to be the best management strategies.

As the landscaping team for the University of Wisconsin-Oshkosh Environmental Studies Senior Seminar capstone we suggest the city implement an extension of the point system found

in Article IX, Chapter 30 of the Oshkosh Municipal Code. The city of Oshkosh Municipal Code states that the purpose of the Landscaping Requirements chapter is to “establish landscaping requirements and other regulations intended to preserve and maintain vegetation within in a manner that promotes the natural resource protection, aesthetic, and public health goals of the City.” The point system is used as a way to enforce specific landscaping techniques on commercial and public lands in Oshkosh. Reaching a certain amount of points per area (which differs depending on the land use) is required under the Landscaping Requirements ordinance. The ordinance lays out how to reach the minimum amount of points required by assigning points to different types of plants, shrubs, trees, fencing, and more. To further align with the mission of Oshkosh and promote ecosystem health, these are the potential changes we propose be made to the Landscaping Requirements:

We request that the city implement within article IX section 30-253, item (2) paved areas. For paved areas we want to alter the current plan from 40% of shrubbery requirements to 40% native shrubs only. Second to that, we want article IX section 30-255 item (3) street frontages. Within street frontages the minimum of 50% of all points are devoted to decorative and medium trees and we want to change this to be 30% native trees and a minimum of 30% must be deep rooted native grasses. We believe that native plants are better to manage stormwater than trees. Article IX section 30-255 item (2) requirements part (A): currently bioswales and rain gardens get 20 points per 20 square ft. area and cannot exceed 100 points. We are requiring this be changed to 30 points per 20 square ft. area with no point limit.

We would also like to see changes to Section 30-251: Applicability (B). This section asserts that any expansion of existing buildings exceeding 50% of the current building’s floor

area are required to follow the landscaping requirements listed in Chapter 30 - Article IX. We recommend that this figure be reduced to 25% of the current building's floor area. This means that if the expansion of the existing building exceeds one quarter of the the building's current floor area, the owner(s) will be required to adhere to the requirements listed in Chapter 30 - Article IX.

Finally, we recommend an amendment to Section 30-251: Applicability (E) Exemptions. This section has exempted single family and two family dwellings from meeting landscaping requirements. We propose that newly developed single and two family dwellings be included in the landscaping requirements upon construction.

Stakeholders:

We met with a variety of people in Oshkosh and the surrounding communities to gain insight into their perspectives on various parts of the community in order to better understand how they perceive the landscaping ideas we are proposing. In addition, we desired to discover how viable these options are by gauging community acceptance.

I. Steven Wiley, Assistant Planner of the City of Oshkosh

One of the primary stakeholders we interviewed was Steven Wiley, who is the assistant planner for the City of Oshkosh. Mr. Wiley is an important stakeholder for the Landscaping group because he is knowledgeable about how different parts of Oshkosh are implementing green infrastructure, where improvement needs to happen, and how feasible some of our ideas are in regards to current regulations. He had a lot of really great things to say that were very helpful in creating our recommendation for the city. The topics we focused on from his

interview are community planning, natural assets in Oshkosh, hazards, stormwater regulation, current green infrastructure usage, how willing the community is to accept those features in the City, and how everything ties into community identity and character.

Mr. Wiley discussed that there was a comprehensive plan in place that is currently being updated. It addresses Oshkosh's natural resources as important for agriculture, nature, and culture. The plan outlines a need for green infrastructure through conservation of resources, with special attention to our water supply (i.e. watersheds, runoff issues, navigable waters and erosion from wake, groundwater, drinking water, and floodplain and wetland zoning districts). Although there have not been any formal wetland restoration projects that have taken place in Oshkosh (to the best of Mr. Wiley's knowledge), the comprehensive plan does give suggestions on how to do so were one to be undertaken.

Oshkosh has many resources including rivers, streams, lakes, property on the water, and other natural areas such as Sawyer Creek and Miller's Bay. As Mr. Wiley mentioned previously, Oshkosh's resources bring a sense of culture to the city. Volunteers from all over Oshkosh came together to help restore the Miller's Bay Mainly through native plantings with the goal to maintain a healthy environment and an attractive appearance. Steven also suggested that the Pioneer site in Oshkosh would be a suitable site for restoration and implementation of green infrastructure. Another initiative that has brought together the community is implementation of a stormwater medallion near stormwater drains that educates the community on what should not be dumped into those stormwater drains that run directly into local bodies of water.

An unfortunate topic that has to be brought up when discussing stormwater drainage, is hazards. Oshkosh has had many flooding issues including basements backups, wet basements in

homes, street flooding, and flooding in yards and other green spaces. Steven was not sure that there have ever been beach closures because of high levels of bacteria, but it is not necessarily always safe to swim in the water. In Lake Winnebago, there are high levels of phosphorus, PCBs, and suspended sediment. The Fox River is in slightly better shape with low levels of PCBs and aquatic toxicity.

Perhaps the most important part of the interview with Mr. Wiley in relation to this project, was of discussion of stormwater regulations. The stormwater ordinance is up to date and does offer some incentives for green infrastructure. Examples of these incentives include credit given to property owners who have city-approved rain barrels and rain gardens (and an extra credit given for property on the water), a best management practice credit, and a credit given to those who improve the quality of the runoff from their land. Native plants and rain gardens are noted in the stormwater ordinance, but there is little to no mention of green roofs and permeable pavers - both of which are important to groups in this class. Overall, Steven said that using green infrastructure to reduce infrastructure is not discouraged, but it is definitely not as encouraged as it perhaps should be. In all of these categories, Oshkosh is doing a fair job at focusing on environmental impact, but there remains room for improvement.

It is important to consider what has already been implemented in and around the City of Oshkosh when planning what we would like to propose to the City for our portion of the final project. Two of the most noteworthy green infrastructure features that were discussed in our interview with Mr. Wiley were rain barrels and rain gardens. Perhaps due to the simplicity of installation and their low maintenance requirements, rain barrels seem to be the more prevalent feature implemented by residents. Such features do not require a permit to be

installed, but in order to obtain the stormwater utility credit that the City offers, a permit must be submitted by those seeking the credit. Along with rain gardens and rain barrels, Mr. Wiley noted some of the other green infrastructure features that can be found in the City of Oshkosh including, bioretention areas, green roofs, permeable surfaces, bioswales, and native plantings.

Overall, residents have been fairly accepting of green infrastructure features in the City of Oshkosh. However, it was discussed that concerns related to such projects usually arise around their cost. For the most part, residents are open to green infrastructure projects so long as they are not overly expensive. Additionally, there has been some controversy surrounding the Friends of Menominee Park Shoreland restoration project. The dominant issue with this project has not been the cost, rather it has been that the native plants that have been planted are supposedly blocking some residents' view of Lake Winnebago and therefore some want to see those plants either removed, trimmed, or replaced with shorter vegetation.

Although there is acceptance of some of the most common green infrastructure features in the City of Oshkosh, it was discussed that the community's identity and character do not necessarily reflect green infrastructure and landscaping. There is a small portion of the population of Oshkosh that is interested in taking on such projects; however, there appears to be a much larger portion that simply is unaware of such issues and projects. Steven also noted that developers may be aware of such features but typically stick to what they are used to, which does not usually involve green infrastructure. Even though there may not be widespread interest, Oshkosh seems to be changing for the better. Part of this change comes in the form of Oshkosh being designated a Tree City USA, receiving High-Flyer statues through Bird City, and being a Green Tier Legacy Community. There are also various allies to green infrastructure and

environmental initiatives including Silverstar Brands, the Southwest Rotary Club, Oshkosh Corp., the Oshkosh Public Library, Friends of the Menominee Park Shoreland, and others.

II. Margy Davey, Head of the Sustainability Board for the City of Oshkosh

Along with Steven Wiley, Margy Davey is a primary stakeholder. Margy is a primary stakeholder to the landscaping group because she works directly with the city of Oshkosh on the Sustainability Advisory Board. Margy showed concern that although the community's natural resources are addressed in the comprehensive plan, they are not given as much attention as they should be getting. She states that the city could be doing a lot better with specific attention to the community's water resources in the comprehensive plan. In relation to stormwater, she mentioned that although inflow and infiltration has improved, many residents of Oshkosh still struggle with flooding. She mentioned that a major issue with the landscaping point system, is how it is set up. Currently, trees gets more points than native plants even though native plants would help mitigate stormwater runoff better because of their deep root systems and coevolution with other species in the ecosystem.

Ms. Davis stated that the main problem is that other departments do not realize that there is a Sustainability Advisory Board which will do research for them. The Sustainability Advisory Board and Parks Department do not have a close relationship, but Ms. Davis believes that if they could work together, they would get a lot more accomplished. On a more positive note, she acknowledged that the community is very involved with the Sustainability Advisory Board by asking questions and demanding that more be done.

Since the community seems to be engaged with the board, we asked her if being “green” is attractive to new people moving into the area. Ms. Davis said that, that was a good question, and that she does not know. What she does know is that the board has spent months on green events that provide information for people that want to be green. She once again voiced her concern and frustration that they do not get any recognition from the city for holding such events.

Specific environmental initiatives that have been started in the community that relate to the green events are rain gardens and rain barrel workshops. Fox-Wolf River Shed Rain Barrel workshops are more popular than the rain gardens. Ms. Davis is happy that there is a workshop for people to attend but she wishes that they either they make it shorter and more concise or make it long and go into greater detail. The workshop provides barrels, kits, and information on how to set everything up. The issue she discussed is that there is confusion with the stormwater credit that is in place. She is pretty certain that participants have to fill out paperwork to have the rain barrels on their property to get the stormwater credit but no one keeps track of whether they actually set up and are using it. In addition to the rain gardens and rain barrel workshops in the community, there may be some community gardens but she is unsure of where the water comes from to maintain the gardens.

Ms. Davis brought up that she has contacted hotels in the area to see which hotels claim to be “green” and what makes them green. What makes the hotels green include, asking guest their if they want their sheets washed everyday during their stay. Another way they are being green is by the landscaping techniques they are implementing. She wanted to put hotels and restaurants that are “green” in a brochure for tourists. Her logic was that by promoting “green”

companies, they would be rewarded with an increase of tourists going there.

Another issue she discussed in the city is shoreline preservation. Ms. Davis would like to see more native vegetation buffers planted in Menomonee Park. There is terrible algae in Miller's Bay and as a way to combat this, a restoration project was completed to implement native vegetation.

We asked if residents of the City of Oshkosh like a homogeneous appearance to their neighborhoods or if individual residents' preferences are tolerated or are celebrated. Ms. Davis noted that a majority of Oshkosh looks similar and most have short turf grass which have very short root systems. However, there are some residents that have native plants and keep up with them. She wishes that there was more education for citizens so they could realize the importance of native plants - especially those that have property on the water. She believes that they should take more initiative and learn about such plants. Even if they used a "soft" buffer zone, it would be better than nothing.

Overall, issues that she voiced revolve around people not understanding the advantages of green infrastructure and other environmental initiatives, along with the fact that politics complicates things and slow down the process. In future, she hopes the community will become more informed about such issues. In order to educate citizens, she offered a few methods. First, she mentioned a cellphone app called POLCO which can be used to ask questions about anything environmental. Another way she noted on how to reach and educate people is through the mail and social media sites, like Facebook. She wanted to voice special concern that it is important to take into consideration the fact that there are 78 different languages spoken in the Oshkosh area and it is a necessity to make all of this information accessible to all of the

residents in Oshkosh. Interviewing Ms. Davis was valuable for this project because she gave us insight into how the community reacts to native landscaping, if residents are implementing these practices already, and noted how education, communication, and accessibility is key to being successful.

III. Bruce Bartel, District Director at Northeast Wisconsin Water

Bruce Bartel is the District Director/ Treatment Manager for Northeast Wisconsin Water (N.E.W Water). Interviewing him gave us insight into what activities are occurring downstream of the Fox River to better the watershed. N.E.W Water is a Metropolitan Sewerage District but they also clean water from the bay of Green Bay that they use for their drinking water. Because the Fox River flows north, Green Bay receives the effluent from Oshkosh and other cities downstream so it is important that we work to better our water quality in the watershed as a whole.

Mr. Bartel talked about how Oshkosh wastewater had been hit with a high demand for phosphorus reduction from their effluent flow. The consequences of not reducing meant they will not be permitted by the Wisconsin Department of Natural Resources (WDNR) anymore. In order to combat this, N.E.W Water has been undergoing several large scale renovations on their campus that Mr. Bartel was excited to tell us about. When the plans were being drawn up, there were some intense negotiations going on about which route to take. The two choices were to focus more on the campus, expand and buy new technology, or to place money into the community and work on adaptive management through the introductions of new green infrastructure to their campus and new technology. The adaptive management route was

chosen. They are currently working on restoring Silver Creek and implementing rain gardens all throughout the city of Green Bay. Additionally, they are pushing for larger buffer zones along shorelines and want to lay down permeable pavements. This will help filter water that runs off of their campus which tends to be especially polluted due to wastes that are dropped off and they do not want to risk contamination of the groundwater supply. Overall, N.E.W Water is setting a great example and have high standards for the rest of the watershed. Mr. Bartel said they are seeing significant benefits from the adaptive management approach and hope to see Oshkosh start implementing some of these techniques to better the watershed as a whole.

Although N.E.W. water is a secondary stakeholder, we can learn a lot from their own decision to implement adaptive management and community involvement with green infrastructure as a method to better manage their stormwater runoff problem. Overall, this interview provided us with a local example of a city and company that is affluent enough to implement change in their city to better handle stormwater runoff. They have taken on huge projects and said they are still working to better green infrastructure and stormwater management in the city.

IV. Brian M. Helminger, Heart of the Valley - District Director (Kaukauna)

The next stakeholder we met with was the district director at Heart of the Valley, Brian M. Helminger. The main goal of this interview was to get a better understanding of how different areas of the same watershed are influenced by the actions of others. We asked about the current methods that Heart of the Valley is using to reduce stormwater runoff, examined landscaping alternatives, and discussed potential barriers.

We first discussed how pollution multiplies as water heads downstream. Whatever happens upstream will impact what goes on downstream. Oshkosh is upstream of Kaukauna and Kaukauna is upstream of N.E.W Water in Green Bay so we met Mr. Helminger to further explore this trend and how it affects Oshkosh. Mr. Helminger explained that total suspended solids or (TSS) is the biggest issue that the plant faces. The Department of Natural Resources (DNR) sets various water quality standards such as TSS. We asked Mr. Helminger if his plant was conducting any adaptive management methods to reduce stormwater runoff and he told us that the only method they used was water retention ponds. He admitted that the community does not favor having retention ponds near their property and it actually brings down their property value. This makes sense because a large concrete hole with dirty standing water is not exactly aesthetically pleasing. As an alternative, we asked about the use of rain gardens. He agreed that rain gardens are a good idea that the community would be more willing to accept, but his main concerns with rain gardens were the continued maintenance and initial cost associated with them. This was a notable point that we revisited when forming our recommendation for Oshkosh and overcoming our barriers.

A main barrier for small towns like Kaukauna to invest in green infrastructure is the cost of doing so. Mr. Helminger said that “Europe is more willing to roll the dice on green infrastructure” because of their larger budget. This is true, however we came to the conclusion that cities would ultimately be paying less if they worked in tandem with natural processes. The hardest part of implementing green infrastructure is the initial cost, but after doing so, it will start to pay off both monetarily and environmentally. When cities utilize natural processes and ecosystem services, they do not have to pay as much for water treatment, fixing the damage

from erosion, and more. This is one of the main driving points that we want the city of Oshkosh to receive and utilize.

Case Studies:

Examining the implementation of green infrastructure and landscape techniques for stormwater management in places around the world is important to understand how viable these methods will be in Oshkosh. The four cities we studied were Prairie Crossing, Illinois, Seattle, Washington, Milwaukee, Wisconsin, and New York, New York and the country of Singapore. Each of these locations have used their resources to manage stormwater in a natural way that improves water quality, reduces runoff, helps the ecosystem, and is aesthetically pleasing.

The first city we examined was Prairie Crossing, Illinois. We chose this city because it is close to home - meaning they have a similar ecosystem, weather patterns, soil types, and plant and animal species. Additionally, the community size is roughly the same as Oshkosh and it has similar landmarks and land usage (i.e. agriculture, a lake, and natural spaces). Prairie Crossing introduced their “stormwater treatment train system” which has successfully reduced peak runoff by more than 60 percent and has reduced annual runoff up to 75 percent by using different types of green infrastructure within the city (Buranen 2014). They restored 165 acres of prairie and 20 acres of wetland using native plants. They also planted deep-rooted native plant species throughout the city which holds the soil together, prevents erosion, absorbs water that would normally run off, and maintains good water quality. Using native plants also benefited the city because they did not require fertilizers, pesticides, and do not need to be watered in comparison to non-native species. Native plants evolved with the soil type, amount

of water, and amount of sunlight in its natural habitat, so maintenance after initial planting is very minimal. Prairie Crossing also used bioswales filled with native plants along streets to collect and infiltrate polluted runoff coming off the roads. To further protect the quality of the lake, they created wetland buffer zones using native plants which acted as a biological water treatment and detention to the lake. The final aspect of the stormwater treatment train system took into consideration the social aspect of sustainability in managing stormwater: education. Educational events are put on about how to plant effective bioswales, what native plants should be used and how to arrange them, and more. The city has adopted an atmosphere of environmental care - their lake which holds endangered fish is named "Aldo Leopold" and there street signs reflect other environmentalists and plant species. New home owners and prospective builders in the city are given a pamphlet about how build "green" houses and grow a native yard. We know transforming Oshkosh to adopt this environmental culture and changing the physical state of our yards may take many years, but it is possible. Prairie Crossing, Illinois is a great example of how a city can significantly reduce stormwater runoff (among many benefits) through natural landscaping and we know that Oshkosh can do the same.

The second location we examined was Singapore. This is an international example that can show how a new leader and collective effort can entirely revamp an urban environment. Singapore's Prime Minister urged the city to move forward with Green in mind and launched a campaign in the early 2000's. The purpose of the campaign was to become the world's leader in knowledge and implication of green infrastructure at the city-state's center. They successfully implemented vertical planting, rain gardens, and overall worked to improve soil health. Singapore took the initiative to rebrand their city-state to bring in tourism and to better their

city-state for their residents. Singapore can provide us with an example of how anywhere can transform from a gray infrastructural “concrete jungle” to green infrastructure (Karlenzig, 2018). The associated benefits we have discussed thus far in this report were seen as a result of Singapore’s actions towards using sustainable green infrastructure.

Another city we examined is Seattle, Washington which has taken a slightly different approach in the landscaping of its city. Seattle aims to accomplish many of the same things that we do here in Oshkosh, such as improving stormwater management, maintaining the aesthetic appeal of the city, and improving the health of its residents and the environment. However, one thing that Seattle is doing different is that they are planting species of vegetation within the city that can be harvested and used by the residents. This activity, known as urban foraging, is slowly becoming more popular in major metropolitan areas around the world. Essentially, the city plants or maintains vegetation that can be harvested by residents and used for food, medicine, crafts, recreation, and cultural and spiritual practices. By supporting urban foraging in the city, Seattle is not only being environmentally sustainable by planting vegetation throughout the city, but it is also be socially sustainable. Just as diverse as the uses of the foragable urban landscape, are the people who engage in urban foraging. The range of urban foragers can go from hobbyists who might forage to maintain a connection to nature while in the city, to lower-income residents who rely on urban foraging to supplement a portion of their income. Whatever the reason for participating in urban foraging, the practice is a unique way to assist a city in being socially sustainable, creating and maintaining the social cohesiveness and inclusion that is a part of being a truly sustainable city (Poe 2014).

Our last case study comes from New York, New York. In this case study we were able to delve into bioswales and the mean retention that they offer. Bioswales are able to fit into tight spaces within city blocks and they are also able to be implemented into parking lots. When they are implemented into parking lots, they serve as collection for runoff and filter the small particulates out before entering the ground water. Bioswales also allow for recharge of the groundwater. They studied ten bioswales during 185 rain events from Spring 2011 through Summer 2011 (McLaughlin,2012) . They found that the mean capture rate between ten bioswales when below one inch of rain fell was 73%. When there was 1.00-2.00 inches of rainfall, the mean capture rate was 25%. Lastly, when over 2 inches of rain fell, the mean capture rate was 14%. That makes more a total average of 59% capture rate.

Cost:

The costs associated with implementing green infrastructure will come from installation, operation, and maintenance within the city of Oshkosh. In this section, we will also explain the differences in the effectiveness of best management practices (BMPs) versus conventional systems and the environmental and economic benefits that BMPs and low-impact development can provide for stormwater management. It is important to look at more than just the up front installation cost when practicing low-impact development due to the fact that many of these investments into infrastructure will provide long-term benefits for the city of Oshkosh. Overall, cost considerations vary greatly based on the user and the project for the per-unit area in square feet. The cost of building a rain garden will vary based on the size, complexity of the

design, surface area, soil quality, and slope of ground (Rain garden alliance, 2018). The estimated cost for bioretention (rain gardens/ bioswales) was estimated at \$1-\$5 per square foot average for “do-it-yourself” prices and \$10- \$40 per square foot average for professional prices (Rain garden alliance, 2018). For example, a parking lot with 250 and 125 square foot planter islands is replaced utilizing professional average installation pricing. Both maximums and minimums for 250 square foot and 125 square foot planter islands are used. To replace the planter islands with bioretention areas, the 250 square foot area will cost from \$2,500 to \$10,000 dollars. For the smaller 125 square foot planter island, it will cost from \$1,250 to \$5,000 dollars. It is important to note that these prices are high and low averages. Surveys will be needed to get an approximate price for areas within the city of Oshkosh.

Benefits:

The benefits of these best management practices often go ignored as policy makers only focus on up-front cost. Best management practices are proven to manage stormwater quantity and quality more effectively than conventional approaches (Coffman et. al., 1999). Examples include filtering more pollutants, reducing flooding, improving water quality, increasing ground water recharge, reducing public expenditures on stormwater infrastructure, and enhancing aesthetics and property values (Asleson, 2009). The reduction of public expenditures on stormwater infrastructure has been reported by various sources that the use of permeable surfaces, rain gardens, and bioswales can greatly reduce the demand for conventional stormwater controls. Some additional benefits of bioretention include lower lifetime costs, multifunctionality, reduced infrastructure cost, lower maintenance, chemical pollution

reduction, protection from flooding, increased wildlife habitat, and overall cost-effective stormwater management (Coffman et. al., 1999). It is important to look at initial costs as well as additional costs over a structures lifetime including maintenance and operation. Bioretention structures, like rain gardens and bioswales, can be left as natural areas at the end of their functional lifetime whereas high costs may be required to take conventional gray infrastructure out of commission. During the lifetime of bioretention areas, the maintenance costs are minimal and just require ensuring that drainage areas are kept clear (Coffman et. al., 1999). Utilizing ecosystem services gained from natural landscaping will also reduce infrastructure cost in the city of Oshkosh. Bioretention practices can be incorporated in a wide variety of places, like along streets, which will take less time and require less labor than traditional drainage piping systems. Additionally, bioretention improves water quality by allowing filtration of pollutants from water when it seeps through the soil and root system of the plants. To maximize the infiltration of water, it is recommended to use plants with long root systems native to the area. Chemicals are filtered in the roots and soil in bioretention areas. The soil in rain gardens interact with pollution using two main processes: absorption and volatilization. Volatilization occurs when the pollutants evaporate and adsorption occurs when the pollutants stick to soil particles (Dietz & Clausen, 2006). Maximizing infiltration will lead to less flooding in parking lots, roads, and residential areas which put less strain on sump pumps in residents homes and underground pipe systems. In some cases, green infrastructure may have a higher initial cost but the costs over these structures lifetimes will be minimal. Taking that into consideration along with the ecosystem services gained, it is clear that the benefits of green infrastructure outweigh the costs of standard gray infrastructure. Since costs are so variable, we recommend

that Oshkosh look into the costs of implementing these landscaping techniques while keeping in mind that these are investments that pay themselves off over time.

Barriers:

When attempting to implement these green infrastructure techniques, various barriers present themselves. Some of the main barriers include lack of legislative mandates, lack of funding, lack of effective market incentives, and the overall resistance to change. Some proposed solutions include using grassroots efforts to garner support for ordinances and regulations, addressing hurdles in market approaches to provide funding mechanisms, and to educate and engage the community through demonstrations and events (Roy et. al., 2008). The use of grassroots efforts to support for ordinances and regulations will help new legal mandates for stormwater runoff gain popularity. The city of Oshkosh would need widespread public support to be successful. For example, to gain this support, watershed groups and other stakeholders can encourage local government agencies to communicate and adopt uniform watershed regulations and engage the rest of the city to do so as well.

Since stormwater runoff isn't just an issue that the city has to deal with, finding ways to motivate the public to implement native plants and bioretention within their own property is another barrier. An incentive approach may be successful but the rebate amount must be high enough to encourage green infrastructure practices (Roy et. al., 2008). Following up with one of Margy's concerns, that incentive program/ tax credit must be enforceable and less complicated to avoid issues like the credit for rain barrels in Oshkosh. To avoid some of this confusion, the

credit should be connected explicitly with runoff volume from a property to maximize effect. To relate this to our recommendation, the point system in the city of Oshkosh's landscaping ordinance can be utilized to increase market incentives to build rain gardens within their property.

Lastly, to the city of Oshkosh needs to educate the community. To reduce skepticism of these new best management practices, demonstrations, events, and talks should be conducted on a regular bases to help the public understand the benefits of bioretention practices and native plantings as well as give them the knowledge on how to implement them themselves on their own property. The tools to educate people is already available and on the city of Oshkosh's stormwater utility section. Already created is a how-to manual for homeowners to install and maintain rain gardens - it just needs to be utilized to engage citizens. This guide is a great tool to use to educate residents and should be handed out to homeowners like in our first case study, Prairie Crossing, Illinois.

There will always be barriers when moving away from the status quo but working to overcome these barriers is essential to see real change within the quantity and quality of stormwater runoff. Educating the citizens of Oshkosh is necessary to create public support and awareness of runoff issues so solutions will be implemented. If all these barriers are properly addressed, the use of bioretention and native landscaping throughout Oshkosh will greatly mitigate the stormwater runoff issues we are currently facing.

Significance of Sustainability:

Sustainability can be defined as meeting the needs of the present without hindering future generations ability to meet their needs. Sustainability is made up of three different pillars: the environmental pillar, the economic pillar, and the social pillar. All of these are important to consider when proposing actions and they are all things that Oshkosh needs to analyze before implementing any of the landscaping techniques that we are proposing.

Being environmentally sustainable means conserving the natural environment and the resources it supplies, while also reducing the negative impacts on ecosystems. When a city is concerned with being environmentally sustainable, it is conscience of ensuring clean water and air, reducing pollutants, protecting natural habitats, and using and developing eco-friendly products for its residents and and society at large. Native plants are an important aspect within the landscaping features that we recommend the city of Oshkosh implement. The use of native plants within these features will improve the environmental sustainability in Oshkosh by increasing the level of biodiversity in the city. Biodiversity is crucial for environmental sustainability because it creates an ecosystem that is resilient to disease, invasive species, and other factors that may bring harm to the ecosystem. In addition to the use of native plants, plants that have deep root systems will also ensure environmental sustainability. Plants with a deep root system that extends further into the soil than the traditionally used turf grass, provide more support for the soil. This additional support provided by deep root systems, holds the soil in place and reduces the amount of erosion that occurs during rain events and from wind and stormwater runoff. Finally, by implementing these landscaping features throughout the city, Oshkosh will be increasing the volume of vegetation within the city. This goes a long way in

ensuring environmental sustainability because this vegetation will naturally clean the natural and urban environment of Oshkosh by filtering pollutants out of the air, soil, and water.

In order to be truly sustainable, a city must ensure the health and well-being of its residents while also ensuring the health of the natural environment . The measures that Oshkosh would take to improve the health of the natural environment would also go a long way in improving the human well-being as well. Aside from the potential for pollen allergies amongst some residents of the city, the implementation of landscaping features will clean the urban environment and therefore make it healthier for its human inhabitants by reducing the risk of exposure to contaminants in the air, water, and soil (Hasse et al. 2017). It is also generally accepted that landscaping features and green infrastructure improve the appearance of cities. The improvement of human health and the appearance of the city creates an environment that enables and encourages citizens to be active within their community.

Perhaps the most difficult pillar of sustainability to satisfy is that of the economy. The economic pillar focuses on the likelihood that practices that are environmentally and socially sustainable are also going to be financially feasible now and in the future. This is especially important when dealing with a limited budget whose allocation is often heavily contested by competing interests. Although it is presumed that many green infrastructure and landscape features may be too expensive to implement, it has been shown that the installation of such features does, in fact, save and make money for those that decide to adopt the practices. An examination of the gray infrastructure in New York City revealed that the city was likely to save approximately \$1.5 billion from converting cost-ineffective gray infrastructure to green infrastructure. Complementing cost-effective gray infrastructure (the paved over and cement

stormwater management features) with green infrastructure features reduces maintenance costs and the costs associated with filtering and treating stormwater runoff. Green infrastructure and landscaping features also encourage new residents to move into an area. Relating to the social sustainability aspect of improving the appearance of a city, green infrastructure makes a city more aesthetically pleasing and will draw in more people and therefore more money for the city (Berkooz 2011). Implementing these ideas will address all three pillars of sustainability by benefiting the environment, the people, and the economy.

Conclusion:

In conclusion, our recommendation to the City of Oshkosh is to require public and commercial land to implement green infrastructure and encourage private landowners and existing structures to do so as well. We want to require all new construction (especially in parking lots and on main streets) to use rain gardens and bioswales with native plants. Within Article IX, Section 30-253, item (2) paved areas, we recommend altering the current plan of requiring 40% shrubbery to specifically requiring 40% native shrubs only. The current plan in Article IX, Section 30-255, item (3) street frontages, states that the minimum of 50% of all points are devoted to decorative and medium trees and we recommend changing that to requiring 30% be native trees and a minimum of 30% must be deep rooted native grasses. Native grasses will filter out pollutants and slow down soil erosion more than trees will. Within Article IX, Section 30-255, item (2) requirements part (A), our recommendation is to change the current plan where bioswales and rain gardens get 20 points per 20 square foot area and cannot exceed

100 points to assigning bioswales and rain gardens 30 points each without a point limit. We believe that by not having a point limit and increasing the points bioretention receives, it will help motivate people to implement rain gardens and bioswales in their own yards as well as in parking lots and on main streets. We also recommend changes to Section 30-251: Applicability (B), which would reduce the percentage of expansion of existing buildings that must follow landscaping requirements. Finally, our recommended changes to Section 30-251: Applicability (E)-Exemptions, include no longer exempting single family and two family dwellings from landscaping requirements upon construction of the units.

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