No Longer Stagnant

Ohio Wesleyan University
Delaware, Ohio

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ABSTRACT

When Ohio Wesleyan University was founded in 1842, little infrastructure development surrounded the campus. As times changed, the university found itself enveloped on all sides by downtown Delaware. Since the school is on high ground, all its rainwater runoff floods downtown collecting into deep pools in the city's streets and contaminates a local channelized stream, the Delaware Run. This affects the university and Delaware. When it rains the water levels go up drastically, which causes flooding and contaminated runoff to be carried from the Delaware Run to the nearby Olentangy River. This harms both land and aquatic wildlife, as they rely on the clean water of the stream to survive.

Due to OWU sitting at the top of a hill, it has a major effect on the flooding and water contamination the surrounding area experiences. By implementing green infrastructure and better ways to stop runoff, the university can lower the amount of flooding in the surrounding areas and contamination in the water supply. This can be done by using a variety of methods. We believe the best method would be to stop the water from draining into downtown Delaware. This can be done by increasing the amount of water Ohio Wesleyan University land is able to absorb by creating green roofs, adding more rain gardens to campus, and replacing parking lots and walkways with pervious surfaces, thus creating more water-efficient campus for future students and improving the health of the communities and ecosystems surrounding the Delaware Run.

Introduction

Ohio Wesleyan is a coeducational liberal-arts university, who's campus is situated near the mouth of the Delaware Run, a tributary to the Olentangy River that flows through Columbus, Ohio. Because of this, the water quality of the Delaware Run affects hundreds of people locally, and potentially 800,00+ people regionally. Currently, the Delaware Run shows high levels of harmful bacteria such as *E. Coli* and dangerous pollutants caused by farm runoff. The impurities and pollution within this stream could be highly detrimental to both the health of the surrounding natural ecosystems and surrounding communities.

Because of Ohio Wesleyan's campus's location at the mouth of the Delaware Run, the university has the potential to change Delaware Run for the better by mitigating flooding from campus and adding clean water rather than pollutants to an already saturated environment. This could be done by adding green roofs to campus buildings to filter the water that would normally become runoff. In addition to this, porous surfaces could be added to the campus to allow water to soak into the ground, letting it be filtered naturally, instead of carrying pollutants from gasoline or pedestrian trash into the Delaware Run.

Solution

There are many possible solutions to this issue. Since OWU is a smaller university (only 200 acres!), many buildings, walkways, and parking lots end up using a lot of space. Not only do these take up space, but they're also all impervious- meaning water cannot get through. This works well to keep water off, but it allows for pooling, flooding, and possible pollution of downstream areas. In the past, this rainwater was redirected to rivers and streams through a complex system of pipes and storm drains. However, this system has similar downsides- it creates flooding, road damage, and erosion. As the water goes through the pipes and drains, it collects bacteria and pollutants from car grease, oil, copper form breaks, and other pollutants. This goes into the water supply and is unsafe for the surrounding ecosystems and communities. The flooding can also cause water to get trapped creating large puddles that make travel-- whether it is walking or driving-- not only hard but often dangerous.

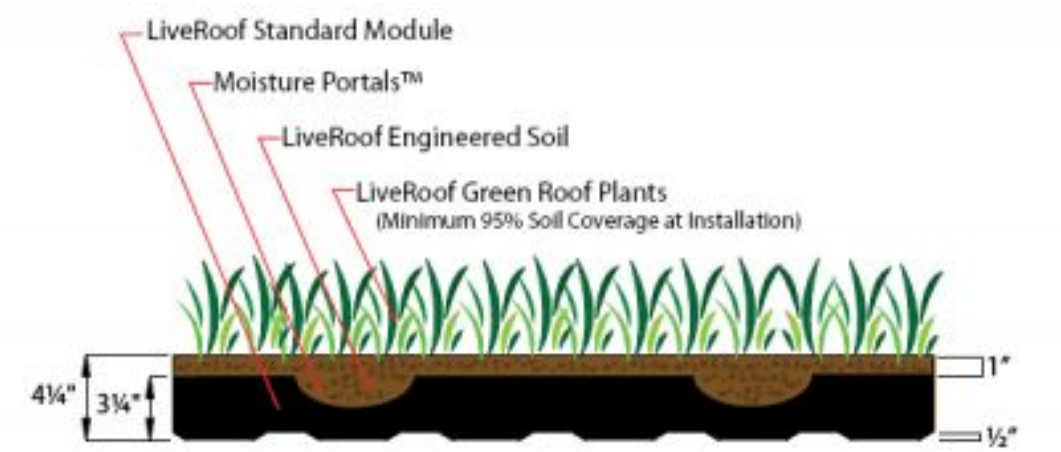
We plan to help change this issue by installing infrastructure that encourages more water to seep into the ground, preventing it from traveling into nearby other areas or bodies of water. This will be implemented in three steps; the addition of green roofs and walls, installation of more bioretention cells on campus, and replacing all parking lots and walkways with pervious surfaces. This infrastructure would help the sustainability of the campus, and prevent further damage to local ecosystems and the surrounding communities.

Step 1

Step one of our three-step plan is to install six green roofs around campus. Each roof has an approximate area of 5,500 square feet. Once all the roofs are done 600,000 gallons of rainwater will be treated annually. Sedums, a hearty perennial plant, will be used on all of the roofs and walls because of their ability to withstand Ohio's extreme and variable weather conditions. The green roofs provided by LiveRoof are not only

aesthetically pleasing but also expand green space where students can congregate. This will cause more rainwater to be absorbed and prevents runoff. Eliminating non-point source pollution. Filtering and slowing down stormwater runoff and surges to protect groundwater, lakes, and streams.

These green infrastructure would also spark conversation by giving students a chance to engage and interact with a real-world example of storm-water management, climate control, and air quality improvement and monitoring. These conversations would help students come up with new and innovative ideas in the future. Possibly even making our master plan even better. Student exposure to nature has also been correlated with higher academic performance in the humanities and natural sciences and has been shown to ease symptoms of ADHD.



Pictured above: LiveRoof rendering of green roof components from https://liveroof.com/products/modules/

Planned locations of green roofs:
-The science center - The entrepreneurial center -Phillips Hall
-The senior apartments -Smith Hall -Welch Hall

These locations were selected with great care. Not only do buildings need to be strong enough to sustain a green roof, but they also need to be flat. Each of the buildings fit these criteria. The Delaware Entrepreneurial Center (DEC) is a newly redone building on campus. The proposal to install a roof on this building has already been written. The proposal outlines how the project, initially proposed by the City of Delaware to manage storm-water, would benefit the student population, the university administration, the Delaware community, and the campus as a whole in multiple ways. We have investigated the feasibility of this project, researched its benefits, discerned key stakeholders and supporters, addressed safety and accessibility concerns, created a budget and implementation timeline, identified sources of funding, and considered maintenance planning. With the building in easy view and access to the community, it

can be enjoyed by the city and campus alike. These roofs would also include pervious pavers to allow for students to walk around the roof and still let water through.

Green roofs reduce energy (HVAC) costs significantly; on average green roofs save ~$10,000/year on heating and cooling costs. We plan to put a green roof on the science center because we plan for them to be used for student and faculty research projects. On top of that, it will give students a place to relax after a long and stressful lab. It also acts as a catalyst in pursuing the National Science Foundation research funding. For conservation, plants and soil help recreate habitats for pollinators such as bees, butterflies, insects, and songbirds. Green roofs also extend the roof's lifetime by 200-300%. This will cut down on repair costs and save materials.

Pictured above and left: These mark-ups provided by Jonathan Stechschulte show what a green roof at OWU could potentially look like

Issues and Pricing

We had to consider many different issues when it came to finding locations that were viable. The first condition was the issue of weight. The roof must be able to accommodate at least 250,000 lbs additional dead load as LiveRoof units add 30 lb dead load per sq ft, permeable pavers add 50 lb per sq ft, people will add a

considerable amount of weight, and equipment such as tables and chairs will also add weight. There was also a large safety issue. The guardrails, Sedum plants, and warning signs will serve as safety measures. The plants will put a considerable amount of distance between the paved surfaces and the edges of the roof, preventing students from being able to get close to the edges.

LiveRoof will provide a regular maintenance newsletter with tips and reminders for fertilization. The plants will need to be fertilized 20 times/year by either Building & Grounds (or students). Invasive species will require removal. Maintenance is only a major concern for the first year after installation. There will also be an educational component to the roofs. Botany professors have expressed their interest in and support for this project. They have offered to incorporate the green roof into their curriculum in some shape or form and to write letters of support.

This is the budget for the green roof that will be installed on the DEC:

Item	Company	Cost per item	Amount	Total	Note
Structural Engineer	TBD	$ 3,500.00	1	$ 3,500.00	
Green Roof (5500 sqft)	LiveRoof	$ 80,774.47	1	$ 80,774.47	
Project Specific Plant Mix	LiveRoof	$ 3,740.00	1	$ 3,740.00	
Nursery Installer	Meyers Landscaping/TBD	$ 5.50	5500	$ 30,250.00	The national average for an extensive green roof installation per sq ft
Shade	We Do Playgrounds	$ 2,000.00	1	$ 2,000.00	
Safety Railing	Wanner Metal Worx	$ 10,000.00	1	$ 10,000.00	
Stairs	Wanner Metal Worx	$ 10,000.00	1	$ 10,000.00	
Elevator	Precision Lift Industries	$ 16,000.00	1	$ 16,000.00	
Contingency Fund				$ 24,000.00	(15% of the original total of 160,864.47)
Total				**$ 180,264.47**	
Pending EPA grant				$ (30,000.00)	January deadline
Adjusted Total				**$ 150,264.47**	

With this budget in mind, we total estimate a total cost for all six green roofs to be $1,081,587. Funding is already being collected and as the school year continues funding will continue to grow. Funding will be provided by the WCSA Campus Experience Initiative Funding; grants: EPA Educational Grant, OWU Theory-to-Practice Grant (partial matching funds), and the National Science Foundation; alumni donors and community partners; and by departmental funds.

While roofs do not take long to install, they can be installed in one day. The funding will take a while. Each roof will be installed as the money is collected. We hope to install one roof per year, but to be safe we estimate 10 years to complete step one with steps two and three being funded and step two completed in tangent.

Step 2

Bioretention cells, commonly known as rain gardens, are designed and developed to improve water quality in nearby bodies of water to ensure rainwater becomes available for plants as groundwater rather than being sent through storm-water drains out to local tributaries. Rain gardens have the ability to reduce the amount of pollution reaching nearby streams and rivers by 30%. Plants used in the bioretention cells are native to the central Ohio region, including different species of grasses, sedges, milkweeds, and flowers. The plants were chosen because of their ability to store large amounts of water, blooming period, beauty, and hardiness. These plants in the bioretention cells, or rain gardens, will also have staggered growth periods throughout the regular growing season (spring to fall). This will enable the rain gardens to remain functioning for a longer period of time than if plants planted in it were in season at the same time. At OWU we already have three rain gardens in place with the framework for many others laid out for the future. Having gardens already in place shows Ohio Wesleyan's dedication to being more environmentally sustainable.

Bioretention cell size is dependent on several factors including contributing drainage area, the imperviousness of that drainage area, land use, soil type, and more. The greater the drainage area and the amount of impervious cover within that drainage area, the larger rain garden size needed. With this project there will be three sizes of rain gardens implemented across campus; small, medium, and large.

Measurements for the bioretention cells (rain gardens)

	Option One: Small	Option Two Medium	Option Three: Large
Width measurement	7 ft	14 ft	28 ft
Length measurement	14.3 ft	28.6 ft	60 ft
Area	100 ft^2	400 ft^2	1,700 ft^2
Water treatment	13,500 gallons	27,000 gallons	54,000 gallons
Holding capacity	500 gallons	1,000 gallons	2,000 gallons

The bioretention cell project started in 2017 by OWU student Janelle Valdinger, with its first two gardens located in front of Branch Rickey arena, thanks to the help of OWU Buildings and Grounds and the City of Delaware. We have identified fifty-eight locations on campus that can support and maintain rain gardens. They will come in a range of three sizes; small, medium, and large. To expand further upon the idea of rain gardens our plan is to include cisterns underneath the rain gardens so that during storms the water that would normally flow across campus, town, and into the Delaware run flows into storage tanks that can then be converted into drinking water for OWU's campus. Three of the large bioretention cells will hold these cisterns. The criteria decided upon with choosing which rain gardens will hold the cisterns were size, proximity to major OWU buildings, and rainwater collection ability. The three chosen were all close to buildings students use often, on slopes that will allow for plenty of water runoff for collection, and are large enough to adequately fit the cisterns. One will be located behind Merrick hall right below its curved roof and located on a hill. The second will be between Corns and Beeghly Library near each of their roofs, and also located on a slope that sees plenty of water runoff. The third cistern will be located in the middle of the Fraternity circle due to there being a large number of impervious surfaces located around the area and seven houses that have sloped roofs pointing towards the rain garden that will be located there.

This will be done with the contractor Rain Brothers which is located in Columbus Ohio. They have a complete 1725-Gallon complete underground rainwater harvesting system package that converts rainwater directly to drinking water that can be implemented on our campus to reduce our water usage and also increase the amount of rainwater that is collected across campus. The cisterns created and installed by Rain Brothers LLC are Ohio regulated by that they follow Ohio code 3701-28-12 Construction and surface design of cisterns, hauled water storage tanks, and roof washers.

Bioretention Water Quality Volume- Option One

Project Summary					
Project Name:	EPA Rain Works Challenge: Ohio Wesleyan University				
Subwatershed ID/Label:	Upper Olentangy Watershed				
Submitted by:	Makaila Weir				
Date:	12/1/19				
Subwatershed Drainage Area, Atotal =	0.25	acres	=	10,890	ft2
Subwatershed Impervious Area, Aimp =	0.09	acres	=	3,920	ft2
Imperviousness fraction, i =	0.39			39	%
Water Quality Volume, WQv =	344	ft3			
Filter Bed Area/Dimensions					
Minimum Filter Bed Area =	196	ft2			
Filter Bed Area, Afilter =	200	ft2			
Afilter/WQv =	0.58				
Afilter/Aimp (x 100) =	5.10	%		>5%	OKAY
Representative Filter Bed Width, Wfilter	7.0	ft			
Representative Filter Bed Length, Lfilter	14.3	ft			
Approximate Length to Width Ratio (L:W)	2.0	ft/ft			
Layer Depths					
Depth of Aggregate Drainage Layer, ddrainage =	1.00	ft			
Depth of Pea Gravel Choker Course, dpea gravel =	0.25	ft			
Depth of Sand Filter Layer, dsand =	0.25	ft			
Depth of Planting Soil Layer, dsoil =	3.00	ft			OKAY
Total Profile Depth =	4.50	ft			

Pictured Left: Option one for the bioretention cells which is the small cell option of 7.0 ft in width by 14.3 ft in length. Equating to a total of 100 ft^2.

Bioretention Water Quality Volume- Option Two

Project Summary					
Project Name:	EPA Rain Works Challenge: Ohio Wesleyan University				
Subwatershed ID/Label:	Upper Olentangy Watershed				
Submitted by:	Makaila Weir				
Date:	12/1/19				
Subwatershed Drainage Area, Atotal =	0.46	acres	=	20,038	ft2
Subwatershed Impervious Area, Aimp =	0.18	acres	=	7,841	ft2
Imperviousness fraction, i =	0.39			39	%
Water Quality Volume, WQv =	344	ft3			
Filter Bed Area/Dimensions					
Minimum Filter Bed Area =	392	ft2			
Filter Bed Area, Afilter =	400	ft2			
Afilter/WQv =	1.16				
Afilter/Aimp (x 100) =	5.10	%		>5%	OKAY
Representative Filter Bed Width, Wfilter	14.0	ft			
Representative Filter Bed Length, Lfilter	28.6	ft			
Approximate Length to Width Ratio (L:W)	2.0	ft/ft			
Layer Depths					
Depth of Aggregate Drainage Layer, ddrainage =	1.00	ft			
Depth of Pea Gravel Choker Course, dpea gravel =	0.25	ft			
Depth of Sand Filter Layer, dsand =	0.25	ft			
Depth of Planting Soil Layer, dsoil =	3.00	ft			OKAY
Total Profile Depth =	4.50	ft			

Pictured Right: Option two for the bioretention cells which is the medium cell option of 14.0 ft width by 28.6 ft in length. Equating to a total of 400 ft^2.

Bioretention Water Quality Volume- Option Three					
Project Summary					
Project Name:	EPA Rain Works Challenge: Ohio Wesleyan University				
Subwatershed ID/Label:	Upper Olentangy Watershed				
Submitted by:	Makaila Weir				
Date:	12/1/19				
Subwatershed Drainage Area, Atotal =	1.00	acres	=	43,560	ft2
Subwatershed Impervious Area, Aimp =	0.36	acres	=	15,682	ft2
Imperviousness fraction, i =	0.39			39	%
Water Quality Volume, WQv =	344	ft3			
Filter Bed Area/Dimensions					
Minimum Filter Bed Area =	784	ft2			
Filter Bed Area, Afilter =	800	ft2			
Afilter/WQv =	2.32				
Afilter/Aimp (x 100) =	5.10	%		>5%	OKAY
Representative Filter Bed Width, Wfilter	28.0	ft			
Representative Filter Bed Length, Lfilter	60.0	ft			
Approximate Length to Width Ratio (L:W)	2.1	ft/ft			
Layer Depths					
Depth of Aggregate Drainage Layer, ddrainage =	1.00	ft			
Depth of Pea Gravel Choker Course, dpea gravel =	0.25	ft			
Depth of Sand Filter Layer, dsand =	0.25	ft			
Depth of Planting Soil Layer, dsoil =	3.00	ft			OKAY
Total Profile Depth =	4.50	ft			

Pictured left: Option three for the bioretention cells which is the large cell option of 28.0 ft in width by 60.0 ft in length. Equating to a total of 1,700 ft^2.

Pictured right: Bioretention cell on Ohio Wesleyan University's campus.

Issues and Pricing

Ohio Wesleyan University has already accepted funding for three rain gardens on campus with the help of The City of Delaware they were able to install them on campus and they have been properly maintained through Ohio Wesleyan University's Building and Grounds team. Upkeep of the rain gardens will be added into the annual expense of Ohio Wesleyan's Building and Grounds cost and will not be of worry due to it being a system they already have in place. The installation of all fifty-eight will take nearly ten years and through this building and grounds will have time to gradually adjust to the increase in time dedicated to the care of the rain gardens. The rain gardens will only need to be cleaned out every couple of months and this does not cost anything nor

does it take long. The Rain Brothers will install three of their 1725-gallon complete underground rainwater harvesting system package inside three bioretention cells. The installation of these will have to be done simultaneously with the installation of the three large bioretention cells. The cisterns will be hooked up to the already existing water fountain systems located in the buildings that the cisterns are outside of. The cisterns will have to be checked by buildings and grounds monthly also, but this will be added to their list of things to do regularly.

Keeping in mind this budget, we total estimate a total cost for all rain gardens to be $169,750.00, and complete installation and cost of the cisterns to be $30,879.00. Funding for the rain gardens has already been collected and implemented through the three rain gardens located on campus and will be continued to be collected for the following fifty-eight. Funding will be provided by the WCSA Campus Experience Initiative Funding; grants: EPA Educational Grant, OWU Theory-to-Practice Grant (partial matching funds), and the National Science Foundation; alumni donors and community partners; and by departmental funds. We are also submitting a proposal to The PepsiCo Recycling Zero Impact Fund Contest. If we win this contest we will have $10,000 to install several bioretention cells around campus.

The installation of the cisterns can be done in one day, but the gardens can take multiple days to install. The funding will take a while. Each garden will be installed as the money is collected. Our hope to install six of the rain gardens per year, but to be safe we estimate 10 years to complete step two with steps one and three being funded and step one completed in tangent.

The estimated cost of bioretention cells and cisterns.

Item	Company	Cost per item	Amount	Total	Note
Large rain garden (sqft)	The City of Delaware	$7,000.00	6	$ 42,000.00	
Medium rain garden (sqft)	The City of Delaware	$ 3,500.00	21	$ 73,500.00	
Small rain garden (sqft)	The City of Delaware	$ 1,750.00	31	$ 54,250.00	
Total Rain Garden Cost				**$169,750.00**	
Cistern (1,725 gallon-potable)	Rain Brothers LLC	$ 5,293.00	3	$ 15,879.00	
Cistern Installation	Rain Brothers LLC	$ 5,0000	3	$ 15,000.00	
Total Cistern Cost				**$ 30,879.00**	
Combined Total				**$ 200,629.00**	

Step 3

OWU has many iconic landmarks, but one of the hallmarks of the campus is the JAYwalk. The JAYwalk (James A. Young Memorial Walkway) is a long brick walkway, used by students to go back and forth between the academic and residential sides of campus. To prevent pooling on the JAYwalk, we will be installing permeable pavers on the JAYwalk. Pervious surfaces allow for water to travel through without causing issues for pedestrians or vehicles, and are ADA compliant. They require fewer repairs in the long run and are extremely durable. To do this, we will remove the bricks and create a storage reservoir, a layer of crushed rocks, and a filter cloth beneath the surface. From there we will put the bricks back with spacing between them and fill the gaps with small rocks. The bricks will not allow water through but the crushed rocks will. This will cause the water to sink into the ground rather than drain into downtown and the Delaware Run.

After the pavers are in place, every parking lot on campus will be replaced with permeable asphalt. This asphalt allows for water to flow through it without causing issues for the cars, and it is installed just like normal asphalt. The only upkeep it requires routine checking to ensure the pores are not clogged. The only place we would not be able to install it is at the top of the parking lot outside of the main campus building; this area is a loading dock and has many heavy trucks that turn around here, which would be too much weight and damage the asphalt. However, since it is at the top of a hill, and the rest of the parking lot will be permeable, the water that runs off of it will be able to sink into the ground once it reaches the permeable asphalt. To continue the theme of sustainability, the previous asphalt will be recycled and reused in this process, thus saving on cost and material.

By strategically placing pervious surfaces on walkways, parking lots, and low traffic roads, we can decrease the amount of water that flows into streams, rivers, and other waterways making guiding it to sink directly into the ground. As a bonus, this would also decrease flooding and other issues. Pervious surfaces such as pervious pavers are easy to repair and replace, benefit tree and root systems, decrease flooding, recharge groundwater, look aesthetically pleasing, and much more. By replacing the walkways and driveways on campus with pervious surfaces we can not only make OWU look more pleasing to look at, but also help the environment and increase learning among students about environmental solutions. It will also bring more students to OWU for the forward-thinking attitude the university holds.

Left: A demonstration of permeable asphalt in contact with water

Pictured Right: Side by Side Comparison of preamble versus nonpermeable asphalt
Image Credits: https://pros.techo-bloc.com/porous-Asphalt-vs-segmental-permeable-pavement

Issues and Pricing

The estimated price for pavers and asphalt is around $12 per square feet. Totaling around $3,240,000 for the 270,000 square feet of pavement on campus. To help offset this price we will recycle as much material as possible. This includes reusing the bricks on the Jaywalk and recycling any asphalt we can. The rest of the money will be raised by the university through alumni donations. This funding will be collected as one and two are being funded and completed. This will help us go into step three seamlessly as the first two steps are completed.

In order to repave everything, the current pavement needs to be brought up ($6 per square foot). Adding another $1,620,000 to our total making it $4,860,000. By reusing asphalt and the bricks on the JAYwalk the price will be brought down. Pavers can be made to still be ADA approved and allow easy movement of wheelchairs. This lets the campus and its beautiful green roofs, and rain gardens are easily available to students, staff, and community alike.

The pavers and asphalt will take time to complete. Students also need areas to walk, and all members of the campus need to be able to park their cars. The process will have to be done in small steps as to not cause a major inconvenience. For that reason, we plan to do each parking lot one at a time during the school year and doing more during the summer when there isn't as strong of a need for parking. The walkways will be done in steps, with the JAYwalk being done in the summer. The JAYwalk is the longest walkway and goes through the middle of campus. For that reason, the JAYwalk should be done when the least amount of students are on campus. We estimate 4 years to complete this step. With at least one parking lot being completed a semester, weather permitting two, and the rest of the parking lots being done over the summers. The walkways will be done at the same time in small sections with the JAYwalk being completed over the summer.

Summary & Conclusion

Through the implementation of green infrastructure and better ways to reduce runoff, we will lower the amount of flooding in the areas surrounding Delaware, which in turn decreases contamination in the water supply. We believe the best method by which to accomplish this would be to stop the water from draining through downtown

Delaware. This will be done by increasing the amount of water Ohio Wesleyan University's land is able to absorb. We will create and install six green roofs, add fifty-eight rain gardens around campus, and replace every parking lot and walkway with pervious surfaces creating more land that can absorb water. This would help treat over 4 million gallons of rainwater annually. With a total cost of $6,142,216. Ohio Wesleyan has shown a commitment to decreasing flooding by taking on accomplishing steps one and two already. The green roofs are underway with the installation for the future in the works, and there are already three rain gardens existing on campus. With our plan, Ohio Wesleyan University can take even larger steps in helping the Delaware area and everywhere downstream by increasing the water it absorbs through these three in-depth steps. We owe it to the Delaware community to lead by example in decreasing flood water as we are a University that prides itself on innovation and the betterment of the community.

Strategies	Planning Outcome			Approximated Cost	Funding Plan	Timeline
	Estimated Flooding Prevented	Direct Outcome	Social Value	Exact price predicted	TPG Grants Pepsi Contest Community University Recycled Material Other	Number of years estimated for project to be complete
Step 1 Green Roofs	600,000 gallons of water treated annually	Decrease flooding Conservation Energy reduction	Educational Aesthetic Increases Health Helps birds and bees	$1,081,587	TPG Grants Community University Other	10 years in tangent with step two
Step 2 Rain Gardens Cistern	1 million gallons of water treated annually	Increase water filtration Decrease runoff	Aesthetic Increase habitat for natural wildlife	$200,629.00	TPG Grants Community University Pepsi Contest	10 years in tangent with step one
Step 3 Pervious Pavers Permeable Asphalt	3 million gallons of water treated annually	Decrease flooding Decrease runoff Recharges groundwater	Aesthetic Fewer pools of water Prevent overflow	$4,860,000	Community University Recycled Material Other	5 years
Total	**Over 4 million gallons of water treated annually**			**$6,142,216**		**15 years**

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