Williamsport, Pennsylvania: Implementing a Natural Stormwater Management System to Alleviate Combined Sewer Overflow Issues

An Honors Thesis (LA 404)

by

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WILLIAMSPORT, PENNSYLVANIA: IMPLEMENTING A NATURAL STORMWATER MANAGEMENT SYSTEM TO ALLEVIATE COMBINED SEWER OVERFLOW ISSUES

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COMBINED SEWER OVERFLOW POLLUTION

40 MILLION PEOPLE

32 STATES

772 COMMUNITIES

850 BILLION GALLONS
ABSTRACT

One of the most serious injuries humans have inflicted on nature is the pollution of the earth's freshwater supply. In the United States, consistently insufficient management of stormwater runoff has led to serious combined sewer overflow issues that have worn much of the country's sewer infrastructure to the brink of collapse. Around the country, designers who attempt to address the issue by implementing new, more sustainable stormwater management practices are met with resistance by local committees and permit review boards that do not understand the need for change. The presentation of conclusive research is needed in order for decision makers at local, regional, state, and national levels to adopt sustainable stormwater management systems. This project includes comprehensive research and the development of a design in Williamsport, Pennsylvania, a city under legal obligation to improve its combined sewer overflow issues, in order to show both the environmental and economic benefits of implementing sustainable stormwater management practices in urban areas. The project will develop a natural system to improve water quality at multiple scales, including Williamsport, the Susquehanna River, and the Chesapeake Bay.
ACKNOWLEDGEMENTS

At its best, landscape architecture is a collaborative process. In the same regard, it takes a bit of a village to raise a designer. During my undergraduate studies at Ball State, my village has certainly enhanced my abilities. I am indebted to the landscape architecture faculty for their time, dedication, and persistent encouragement as I developed my skill sets. As for this project, it began with a simple idea; improve water quality through considerate, nature-embracing designs. I thank Burcu Yigit-Turan for patiently listening to my often incoherent ideas and guiding me in a more comprehensive direction during the research portion of the project. To Carla Corbin and John Motloch, thank you for your availability and feedback throughout the semester as well as your guidance regarding scheduling and time management. And Simon Bussiere, thank you for nurturing this project with your energy and ideas. As always, your enthusiasm and awareness simply make the designers around you better. I also thank all the professors and guest jurors who attended progress presentations throughout the semester. Your advice helped drive the progress of the project when it was most needed. Finally, to my classmates, your talents and products have always inspired and motivated me to improve my own. I am able to walk away from this project with the most rewarding realization; I learned a lot.
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PROJECT BACKGROUND: PROCESS OF DEVELOPING A THESIS

Across the United States, 772 communities in 32 states with a total population of 40 million people, operate on combined sewer systems (EPA Combined Sewer Overflow Demographics, 2008). Combined sewer systems are part of the country's early infrastructure, as such, most of them correlate to the places that were settled early in the United State's history, primarily the Northeast and Great Lakes region, but they have also become prominent in the Pacific Northwest. The problem arises when the combined sewer system extends its capacity and overflows. It is sized to handle septic waste demands, but as a result of large storms, the stormwater pushes it past a manageable level and by design, the system allows the combined sewer overflows (CSOs) to discharge directly into streams, rivers, lakes and any other surface waters. The EPA estimates that each year in the United States, CSOs result in the release of approximately 850 billion gallons of untreated wastewater and stormwater (EPA Report to Congress, 2004: 1). The EPA's studies have acknowledged that CSOs can 'have impacts on human health and the environment and the local watershed level.' (EPA Report to Congress, 2004: 2). Congress has approved the Clean Water Act and the CSO Control Policy, which is beginning to have a positive effect on water quality policies in the United States.

Combined sewer overflows can result in sewage being released into streets.

Runoff pollution can create hypoxic zones in bodies of water thousands of miles from the source of the pollution and result in extensive wildlife damage.

Flooding is a common result of poor stormwater management.

Figure 2

Figure 3

Figure 4
Williamsport, Pennsylvania is an example of a city that is currently being pressed by the EPA to meet the requirements laid out in the Clean Water Act regarding CSO discharges. In June of 2010, an agreement was reached between the EPA and the Williamsport Sanitary Authority, WSA, as a part of a multi-state Chesapeake Bay watershed compliance initiative (Environmental News Service). The agreement is an attempt to improve water quality in the Chesapeake Bay. The Chesapeake Bay has suffered severe pollution issues as a result of runoff from the Chesapeake Bay watershed, which includes the states of New York, Pennsylvania, Maryland, Delaware, West Virginia and Virginia. Williamsport's contribution to the water quality issues comes as a direct result of CSO discharges into the West Branch of the Susquehanna River from the Williamsport Municipal Water Authority Water Filtration Plant, which flows to the Chesapeake Bay. The city has attributed its CSO issues to the old sewer system's inability to handle the capacity of stormwater runoff during large storm events.

As a result of not complying with the Clean Water Act's standards pertaining to CSO discharges, Williamsport has been fined a $320,000 civil penalty and must make improvements that are estimated to cost approximately $10 million (Environmental News Service). The settlement requires the WSA to modify its Central Wastewater Treatment Plant in order to expand its treatment capacity and reduce overflows due to high stormwater runoff, and will reduce the amount of untreated CSO into the Susquehanna River by at least 52 million gallons per year (Environmental News Service).

This comprehensive project works to develop a natural stormwater system for Williamsport that will allow it to meet EPA regulations with a more sustainable approach to stormwater management. The hypothesis for the project is that developing sustainable water resource systems in areas affected by combined sewer overflow is the most efficient, economical, and ecologically effective approach to rectifying the pollution issues associated with stormwater runoff. The research for the project works to support this type of design through precedent studies, best management practices, and existing sustainability technique studies.
IN THE UNITED STATES, COMBINED SEWER OVERFLOW AFFECTS:
- 32 states
- 772 communities
- 40 million people

WHAT IS THE EXTENT OF CSOs IN THE UNITED STATES?
Across the United States, 772 communities in 32 states with a total population of 40 million people, operate on combined sewer systems (EPA Combined Sewer Overflow Demographics, 2008). Combined sewer systems are part of the country’s early infrastructure, and mostly correlate to the places that were settled early in the United States’ history, primarily the Northeast and Great Lakes region, but have also become prominent in the Pacific Northwest.

The United States Environmental Protection Agency (EPA) explains that, “A combined sewer system is a wastewater collection system, owned by a state or municipality, that is specifically designed to collect and convey sanitary wastewater (domestic sewage from homes as well as industrial and commercial wastewater) and stormwater through a single pipe. During precipitation events (e.g., rainfall or snowmelt), the systems are designed to overflow when collection system capacity is exceeded, resulting in a combined sewer overflow (CSO) that discharges directly to surface waters,” (EPA Report to Congress, 2004: 1).

The problem arises when the combined sewer system extends its capacity and overflows. It can handle the septic waste, but as a result of large storms, the stormwater pushes it past a manageable level and by design, the system allows the CSOs to discharge directly into streams, rivers, lakes and any other surface waters. If the stormwater was separated from the sewer system, it would be less of a problem, but in the existing scenario, raw sewage, including human waste and chemicals flushed down toilets and sinks is poured, untreated into freshwater. What is most alarming is that this is not a rare occurrence. The EPA estimates that each year in the United States CSOs result in the release of approximately 850 billion gallons of untreated wastewater and stormwater (EPA Report to Congress, 2004: 1). EPA studies have acknowledged that CSOs...
can "have impacts on human health and the environment and the local watershed level," (EPA Report to Congress, 2004: 2). Congress has approved the Clean Water Act and the CSO Control Policy, which is beginning to have a positive effect on water quality policies in the United States.

CSOs not only increase the risk of diseases such as ecoli entering the water supply, they can also be incredibly damaging to the natural ecology of the affected water body and surrounding area. "Reduced animal populations or local extinction may occur from flooding deaths, loss of eggs or larvae, reduced fertility, shortened reproductive seasons, shorter life spans, or slowed growth. Flooding can also reduce suitable habitat for nesting, rearing and cover; eliminate sources of available food; increases the risk to predators; and increases disease and parasites," (Strecker, et.al., 1992: 34-35).

Two main reasons pollution is so dangerous to the environment are because it causes decreased dissolved oxygen levels and increased nutrient levels. Decreased dissolved oxygen (DO) levels in water can kill intolerant organisms when it reaches the point where their biological oxygen demand (BOD) is no longer met (Cech, 2005: 117). Increased nutrients, such as nitrogen, which untreated stormwater runoff may pick up and deposit in water if it is not filtered, causes the excessive growth of algae, which can block sunlight in the water and choke out most of the other living organisms in a body of water, and then when the algae dies, it requires a large amount of the dissolved oxygen for decomposition.
HYPOXIC WATER

Water classified as hypoxic has lost its ability to support life due to reduced oxygen levels caused by pollution. Large areas of the eastern coast of the United States suffer from hypoxic conditions.

HYPOXIC WATER

continuing to harm other organisms in the process known as eutrophication (Cech, 2005: 131). In areas like parts of the coast of the Gulf of Mexico, the excessive runoff of nutrients is so severe that the eutrophication is classified as hypoxia, a dead zone where no life is able to survive. Clearly, from both a human health and ecological standpoint it is essential that CSO pollution is reduced.

Even though the risks are known, the astronomical cost of replacing combined sewer systems and the difficulty of accessing the systems keeps little from being done to rectify the drainage problems. Typically, actions are only taken when damage is incurred and citizens complain. Lack of maintenance and neglect of the sewer systems leads to pipes filling with sediment and debris which can cause blockage and erosion issues. Typically, the only places work is performed is within the street right-of-way and “50 to 80% of the drainage system closest to private houses and other structures is rarely or never inspected or maintained.” (Debo & Reese, 1995: 11-12). So even storms that are less intense than what the system is supposed to be capable of carrying can cause the system to fail because it is not kept at an ideal maintenance level.

Besides maintenance, the design itself becomes another major reason CSOs occur. Poor research and data leads to improper use of the calculation methodology which results in inaccurately sized sewer systems. Most municipalities size systems based on the Rational Method, but the mathematical equation involved doesn’t consider unique site conditions or natural systems, such as “actual rainfall values, inlet capacities, tidal influences,
or actual expected future maintenance-related conditions of structures," (Debo & Reese, 1995: 12). This is an area where landscape architects have opportunities to lend expertise in design. By understanding the natural systems at work, outlining spatial relationships, integrating techniques, and carefully deciding on infrastructure, material and layout, landscape architects can positively influence the direction of stormwater management techniques.

**RESEARCH QUESTIONS**

- How can stormwater management techniques best be incorporated into the existing urban fabric?
- What are the conditions of the watersheds in the project, and what is the history of water pollution there?
- Which mathematical principles support the proposed project’s design?
- How can the results of the Rational Method be more accurately applied to the design since current applications of the formula often underestimate the capacity of the system that is required?
- When accessing health and environmental cases associated with CSO instances, how can it be included in the economic projection of the project?
- What are the best plants and materials for runoff management?
- On a national level, how does the runoff from one community affect water sources around the country?
- How does stormwater management directly and indirectly benefit local economies?
- How practical is the implication of stormwater management techniques along already constructed roads and sidewalks?
To help minimize pollution, homeowners can work to keep oil, pesticides, fertilizers, and other chemicals out of storm drains. Also, by avoiding excess irrigation, runoff can be minimized.

Alternative management of stormwater can help reduce the possibility of CSOs and limit the stress on the existing sewer infrastructure. Some major factors of runoff include climate, terrain, precipitation intensity, ground conditions, and vegetation. "According to the National Water Quality Inventory: 2000 Report to Congress, as reported by the U.S. Environmental Protection Agency, only 61 percent of the streams, lakes, and estuaries that were assessed (18 percent of all rivers and streams, 43 percent of all lakes, ponds, and reservoirs in the United States) met the water quality standards evaluated. Leading pollutants in these impaired waters included sediments, bacteria, nutrients, and metals (primarily mercury). Runoff from urban areas and agricultural lands were the primary sources of these pollutants," (Cech, 2005: 112). This means that the need for stormwater management is essential for water quality and ecological health of the environment.

"The basic underlying purpose of stormwater management is to keep people from the water, to keep the water from people, and to protect or enhance the environment while doing so," (Debo & Reese, 1995: 17). The American Society of Civil Engineers (ASCE) Task Committee on Sustainability Criteria (1998) of the Water Resources Planning and Management Division proposed the following definition: "Sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity." The ASCE Task Committee highlights the need for demand management to meet this goal. Demand management is an often overlooked alternative in addressing stormwater problems. Applied to stormwater management, managing demand means limiting the demand for services or decreasing the amount of runoff from urban lands over the long term that requires disposal," (Mays, 2001: 11.3). "Butler and Parkinson (1997) identify four objectives to improve the sustainability of modern urban drainage systems: (1) maintain public health and protection from flooding, (2) avoid polluting local as well as distant environs, (3) minimize resource uses, and (4) be operable and adaptable in the long term," (Mays, 2001: 11.3).

As communities investigate their options, many are realizing that green infrastructure systems are economically better solutions than attempting to rebuild underground pipes. Green
infrastructure “is used to describe how networks of natural ecosystems also function as crucial community infrastructure, providing ecosystem services and improving environmental sustainability,” (ASLA, 2011). In Philadelphia, officials are considering a $1.6 billion design that would use natural systems to relieve most of the major problems associated with stormwater (Source: The Vancouver Sun, Grey to Green: Jumpstarting Private Investment in Green Stormwater Infrastructure) (ASLA, 2011). With interest in natural, sustainable solutions, progress can be made in the design options and effectiveness. The Stormwater Collection Systems Design Handbook by Larry W. Mays promotes a traditional piping system that would drain to a manageable detention basin. This is a possible element, but in order to filter runoff, it would be more effective to implement strategies that reflect a more natural process. Create an Oasis with Greywater by Art Ludwig suggests the development of a system on a residential property that utilizes greywater from the structures for irrigating gardens. This alternative reduces the amount of stormwater as well as the amount of sewage being placed in the combined sewer system. By reducing both inputs, the stress on the piping system is reduced and the landscape is also irrigated and assists in filtering the water through plant roots. This is another possible element to consider, but many homeowners may not agree with the implementation on their properties, so it may not be effective enough to reduce the total water runoff substantially. Also, many areas in the United States still will not approve of greywater systems due to a lack of understanding of the research and benefits. The American Society of Landscape Architects (ASLA) promotes the use of vegetations, permeable pavers, porous asphalt, porous concrete, green roofs, bioswales, and rain garden as effective techniques in stormwater management. These are all effective techniques, but in this project, a larger system will also be necessary to accommodate for flood conditions and unusually intense storms. The Use Of Wetlands for Controlling Stormwater Pollution by Strecker, Kersnar, Driscoll, and Horner calls for the use of wetlands alone or in conjunction with detention basins in order to filter and manage stormwater runoff. This seems to be the strongest research-supported argument and could work to alleviate the stress stormwater places on combined sewer systems around the United States. Not only are wetlands an effective assistant to traditional techniques such as wastewater treatment plants, they can also be better for the environment. In a natural water system, water is purified by distillation, where water is evaporated, and thus leaves polluted particles behind, and biological land treatment occurs, where “microorganisms in topsoil degrade biological contaminants into nutrients, which are removed by plant roots before groundwater recharge,” (Strecker et.al., 1992: 39.) “Both natural distillation and biological land treatment compare favorably in effectiveness with artificial options such as activated sludge treatment. Conventional water use and treatment, by ignoring the structure and logic of the natural water cycle, encourages excess, depletes and contaminates aquifers, contaminates aquatic ecosystems, and bleeds the land of nutrients,” (Ludwig, 2007: 136). This means that constructed wetlands are more effective because they are more able to mimic natural processes.
Also, when wastewater treatments plants discharge water, the water is not pure. In actuality, it has met basic requirements but still contains chemicals that can have a negative effect on the waterway. "Most wastewater treatment plants release treated effluent that contains nitrogen in the form of nitrate, a nutrient. If adequate water supplies are available, either in the treated wastewater or in the receiving water body, dilution can prevent the accumulation of nitrates, and the conversion to excessive concentrations of nitrile and ammonia, in waterways. However, if nitrate-laden wastewater is loaded into a river, lake, or estuary, BOD can cause the waterway to become anaerobic," (Cech, 2005: 131).

**The Use Of Wetlands for Controlling Stormwater Pollution** recommends combining the use of a detention basin with a constructed wetland. Detention basin/constructed wetland treatment systems have been recommended for stormwater treatment. ... Typically in these systems, stormwater runoff discharges to the detention basin which then releases the water to the wetland for additional treatment. The detention basin can provide pre-treatment for the wetland, reducing the sediment and pollutant loads to the wetland," (Strecker et al., 1992: 39.) By creating a detention basin upstream to filter the larger particles and then allowing the natural systems in a wetland to further filter stormwater runoff, most of the pollutants can be neutralized. If a detention basin is effective, it can nearly eliminate the need to maintain the downstream wetland, thus reducing the disturbances to the ecosystem, and "typically, detention basins can remove up to 90 percent of the suspended material under more favorable conditions," (Strecker et al., 1992: 41).

Using an existing healthy wetland is not recommended because the additional runoff could potentially harm the existing ecosystem. However, a constructed wetland is a better option since the plants and animals initially selected can be pollution tolerant and therefore help in the filtering process. For example, The Canning Study in 1995 found that some of "the most effective plant species found for stormwater treatment were bulrush (Scirpus lacustris), common reed (Phragmites communis), and the common cattail (Typha latifolia)." (Strecker et al., 1992: 47).

The Use Of Wetlands for Controlling Stormwater Pollution contains multiple studies of detention basin and constructed wetland systems where they each perform equally well overall based on pollution reduction. For example at the Des Plaines River Wetlands Demonstration Project north of Chicago, a detention basin wasn’t even used, only wetlands were tested. The Des Plaines River was flowed through a constructed wetland and studies showed that after the water emerged in the river on the other side of the wetlands, 80 percent of the sediment and nutrients had been cleansed from the water and as a result native plant communities began to replace invasive weeds and shore bird populations increased, (Strecker et al., 1992: 53).

Implementing constructed wetlands and detention basins should see positive results, but the project will also utilize best management practices to reduce the amount of runoff entering the combined sewer system. Porous pavements will be used to reduce the channeling effect on streets since impervious pavement is very disruptive to the natural hydrologic process. The initial cost is more expensive, but
studies have shown a lower long-term cost. "Considering pavement costs alone, some porous pavements have installation and maintenance costs approximately 10 percent greater than those of other types of pavements. However porous paving can be 12 to 38 percent less expensive when a site development is considered as a whole, because storm drainage systems can be significantly shorter and smaller where runoff is not generated," (Ferguson, 1994: 41).

Diverting water away from drain inlets and towards bioswales and rain gardens where they can infiltrate the soil will also be essential to the project. Curb cuts along streets into rain gardens will help filter water, reduce pollution, and beautify the streetscape through use of vegetation.

Vegetation is one of the most effective ways to combat stormwater runoff in cites. A green roof can retain between 40 and 60 percent of the stormwater it receives, (ASLA, 2011), while gardens can help avoid flooding in unwanted areas. According to the EPA, evergreen trees and conifers are able to reduce the amount of runoff to reach the ground by 35% (ASLA 2011). Also, "mixtures of wildflowers were successful in 10 stormwater basins in New Jersey where ponding time was usually less than 24 hours (Oertel, 1993). ... Establishments costs were higher for wildflowers than for turf but maintenance costs were lower," (Ferguson, 1994: 58). Using case studies such as the award-winning High Point in Seattle, WA will help drive the design and serve as an effective example of how these installations can greatly improve an area esthetically, environmentally, and economically.

By implementing sustainable best management practices in urban and residential areas in combination with detention basins and constructed wetlands, the stress on combined sewer systems will be substantially reduced. By nearly eliminating the risk of combined sewer overflows by reducing the infiltration into the system during storm events, the water quality will be of a higher quality and the cost of maintenance to the sewer systems will be much less of a burden to local municipalities.
STRATEGIZING RESEARCH METHODS

- DANGER OF FLOODING
- DETERIORATING SEWER SYSTEMS
- ESTABLISHED SUSTAINABILITY GOALS FOR STORMWATER MANAGEMENT
- GREYWATER POTENTIAL
- AESTHETICS OF DESIGN
- UNIQUE PRECEDENT STUDIES
- SOCIAL PERCEPTIONS
- ECONOMIC CONSIDERATIONS

- UNIQUE CONDITIONS ON SITE
- TOPOGRAPHY ON SITE
- COMMUNITY PERCEPTION OF SITE
- CLIMATE ON SITE

- CSO ISSUE IN UNITED STATES
- RUNOFF CALCULATIONS, SOIL INFILTRATION, DISSOLVED OXYGEN
- FLAW IN RATIONAL METHOD
- BEFORE AND AFTER CALCULATIONS
- NATIONAL WATER POLLUTION
- WETLAND FILTERING SYSTEM
- PERMEABLE SURFACE FOR INFILTRATION
WILLIAMSPORT, PA:
MEETING THE
CLEAN WATER ACT'S
CSO REGULATIONS

As a result of not complying with the Clean Water Act's standards pertaining to CSO discharges, Williamsport been fined a $320,000 civil penalty and must make improvements that are estimated to cost approximately $10 million (Environmental News Service). The settlement requires the WSA will have to modify its Central Wastewater Treatment Plant to expand its treatment capacity and reduce overflows due to high stormwater runoff, and will reduce the amount of untreated CSO into the Susquehanna River by at least 52 million gallons per year (Environmental News Service).

The EPA records that WSA is responsible for the service of approximately 56,500 citizens and maintains two wastewater treatment plants and 123 miles of sewers with four sewer overflow points (Williamsport Clean Water Act Settlement Information Sheet). The following is a portion of the terms as outlined in the settlement information sheet:

Injunctive Relief
WSA has agreed to improve its Central and West wastewater treatment plants and sewage collection system to address discharges into the Susquehanna River that contain:
- Raw sewage
- Industrial waste
- Nutrients
- Stormwater

It will also make substantial improvements to WSA's operations and maintenance of its two treatment plants and sewer system. The total cost for injunctive relief is estimated to be $9.4 million dollars.

Under the settlement, WSA is required to:
- Complete Central plant modifications by November 28, 2013, to increase peak flow capacity to 21 million gallons per day, including construction of a new headworks to accommodate incoming wet weather flows of 21 million gallons per day. This represents an increase from the current wet weather capacity of 14 million gallons per day.
- Complete the Chestnut Street collection system expansion (12-inch pipe replaced with 18 inch pipe) by June 30, 2013.
- Complete construction of an overflow wet well and pumping system by June 30, 2013.
- Complete construction of a 2 million gallon CSS storage tank to accept peak wet weather flow from the overflow wet well and pumping system by June 30, 2013.
- Implement, on an ongoing basis, a unified post-construction monitoring plan to evaluate the efficacy of the controls in both Long Term Control Plans, and whether the remaining CSO discharges cause or contribute to excursions from, or impairment of, uses under Pennsylvania's water quality standards.

Pollutant Reductions
- Total Suspended Solids reduction: 17,000 pounds/year
- Biological Oxygen Demand reduction: 7000 pounds/year
- Total Nitrogen reduction: 5000 pounds/year
- Total Phosphorus reduction: 3000 pounds/year

(Williamsport Clean Water Act Settlement Information Sheet)

As the report states, by November 28, 2013, Williamsport must modify its stormwater system to be able to accommodate an additional seven million gallons of water per day, from fourteen million to twenty one million. Unfortunately, this means that the existing infrastructure must be enlarged as a remedy, but the project can still be used as an opportunity to use several types of green infrastructure stormwater management practices as design solutions.

Williamsport, Pennsylvania is a small city, only about ten square miles, but it is an incredibly historic location. In 2009, its population was 29,304 people with a density of 3,456 people per square mile and the U.S. Bureau of Economic Analysis ranked Williamsport the seventh fastest growing area in the country in 2011, as it has become the largest city in Lycoming County and North Central Pennsylvania (Williamsport: A Proud Past, A Promising Future). It is home to Lycoming College, a symphony orchestra and civic ballet, and at one time in its history it had more millionaires per-capita than any other place in the world. But what makes Williamsport internationally known is that each August it hosts the Little League World Series. In fact, in 1939, Carl Stotz
The Chesapeake Bay Watershed is 64,000 square miles, including 150 major United States' rivers and streams. Over seventeen million people reside within the watershed, which includes parts of New York, Pennsylvania, Maryland, Virginia, West Virginia, and Delaware.

The entire watershed drains to the Chesapeake Bay, which in turn flows into the Atlantic Ocean. Its "land-to-water ratio (14:1) is the largest of any coastal water body in the world," (chesapeakebay.net). The five major rivers in the system are the Susquehanna, Potomac, Rappahannock, York, and James.

Severe runoff pollution in the watershed has led to the destruction of much of the Chesapeake Bay’s once vibrant ecosystem.

founded the league, allowing Williamsport to boast the title of the birthplace of Little League Baseball (Williamsport: A Proud Past, A Promising Future).

As an internationally known location, Williamsport has a platform that can allow the design of a new stormwater management system to be impressively displayed. The population is one of the fastest growing in the United States and as the demand for built area increases, a strong stormwater management system will be necessary in order to meet EPA regulation standards.

Williamsport has two operating wastewater treatment plants, the Central Wastewater Treatment Plant (Central WWTP) and the West Wastewater Treatment Plant (West WWTP). According to the EPA’s settlement information sheet, there are four sewer outflow points that lead directly to the Susquehanna River and allow raw sewage to enter the river during CSO discharges.

- Huge tourism industry offer exposure of design
- Little League World Series annually brings thousands from around the world to Williamsport, creating an incredible platform
- Rich history
- Ranked the 7th fastest growing area in the U.S. in 2011, despite recession

- EPA regulations that must be met as part of the Clean Water
- Evidence of greater connections within watersheds
- Improvement of water quality in multiple states
PORTLAND, OR

For years Portland, Oregon, has been recognized as a leader in green stormwater management. The city has won awards for projects of multiple scales and offers an incredible kit of parts as a precedent study. From a government standpoint, one percent of all construction budgets for projects in public right-of-way must be paid to the city and is put in its Green fund. Part of this money goes towards stormwater management techniques, such as the city's emphasis on green streets that include rain gardens, permeable edges, and curb cuts that keep runoff from overflowing the sewer systems. The design guides Portland offers online include detail construction drawings and can be used to help understand the various ways green streets can be retrofitted in the Williamsport design.

Portland's various green solutions such as rain gardens, ecoroofs, and grey to green water incentives are examples of how the city has consciously added green infrastructure to its stormwater management plan. Portland actively offers its citizens incentives to participate in programs, providing free rain barrels and paying residents $5 per square foot of ecoroof they include on their own properties. By involving the entire community, Portland shows increases public interest, and thereby increases support in the programs. Using these techniques in Williamsport can help expedite the process in order for the city to meet its EPA deadlines.

The image below is one of several plans for green streets to be added to Portland as a part of the Gateway Green Streets Master Plan that was developed in 2008 to manage stormwater runoff and provide urban renewal.

Green Streets: The rendering is an example of sustainable stormwater management street design in Portland. (www.walkermacy.com)
CONSTRUCTED WETLANDS

The book "The Use of Wetlands for Controlling Stormwater Pollution" prepared by Stricker, Kersnar, and Driscoll studies retention basins and constructed wetlands' effectiveness in cleaning stormwater runoff as well as combined sewer overflows. Their studies include several tested locations and provide exact data on the reduction of pollution, even specifying between chemicals. Each site study includes information on the exact size and depth of the systems in place, the percentage of pollution reduction overtime and a summary of why or why not the system was successful. Several examples compare the effectiveness of detention basins versus wetlands in a series of categories.

These site studies have been used to determine the capacity and effectiveness of the systems proposed in Williamsport as part of a green infrastructure design. Since the EPA has given strict guidelines on the amount of pollutants that must be produced, pollutants mentioned have been compared to pollutants in the study examples to determine the most effective system. The sites can be referenced based on their location in the United States, their effectiveness, and the pollutants they reduced. Some of the sites with applicable results include the Orange County Treatment Facility, The Pittsfield Arbor and Swift Run Systems, and the McCarrons Treatment Facility System. The data, which has already been gathered as the result of testing, supports the Williamsport design by offering scientific, research-based evidence.

This diagram illustrates how wetlands work as natural filtering systems for water flows.
In 1999, the Office of Watersheds (OCC) was formed as a part of the Philadelphia Water Department (PWD) to explore ways to solve combined sewer overflow issues associated with stormwater runoff. In 2009, they unveiled the Green Cities, Clean Water plan which will reduce up to 90% of the pollutants associated with stormwater runoff from entering the local watersheds. The project will be implemented in phases over the course of twenty years and will cost $1.6 billion dollars. The PWD has suggested that for every $1 invested, there will be $2 in benefits. The city estimates that this plan will be as effective as replacing the collapsing underground sewer system but will save the city billions of dollars and add an aesthetic value.

The project is praised as an innovative, long-term sustainable solution and is highly supported by the EPA.

This precedent is used to determine the feasibility, cost analysis, economic, social and health benefits, and other statistical information that is applicable to the Williamsport project. Also, observing the techniques used to retrofit the system into the city and also the elements within the plan such as constructed wetlands, creek restoration, and green infrastructure helped generate the design of the Williamsport plan and provided support to the project. The above rendering is a design that has been generated and is included within Philadelphia's Green Cities, Clean Water plan. It begins to emphasize how plants and topography will play a role in the stormwater management process.
The Cedar Creek Watershed Education Center located in Seattle, WA, serves as a regional facility for the education of citizens regarding stormwater management. By engaging visitors through interactive designs, the center has been able to bring attention to the delicate water quality issues in the area. By emphasizing the natural systems’ roles in stormwater management, the center is able to effectively teach citizens about the complex issue in an approachable, exciting way.

The Thornton Creek water quality channel project in Seattle, Washington, turned a 2.7 acre abandoned parking lot into an urban channel that treats stormwater runoff from 680 acres. The addition of the channel has reduced impervious surfaces by 78%, added approximately 50% more open space to the neighborhood, and successfully filters 90% of the total suspended solids that flow through it. The SvR design has also led to the development of nearly $200 million in private residential and commercial development adjacent to the channel.

A parking lot reclaimed for stormwater management resulted in a $200 million stimulation of adjacent construction while greatly improving local water quality.

Environmental, Social, and Economic Benefits:
- Stormwater management projects improve water quality
- A water quality project can greatly enhance the perception of place and reactivate a site
- Sites can serve as educational facilities to engage citizens
- Cities can actually profit from sustainable water management techniques
- A design that adds green space can stimulate huge residential and commercial growth
INVENTORY AND ANALYSIS:
UNDERSTANDING THE CONDITIONS THAT MAKE A PLACE

VICINITY MAP

This map indicates Williamsport and the Susquehanna River's position within the Pennsylvania water system. The Susquehanna River in Williamsport eventually empties into the Chesapeake Bay Watershed.

WILLIAMSPORT, PA VICINITY MAP

WILLIAMSPORT’S PRECIPITATION

Williamsport receives an average annual precipitation of 40.1 to 50 inches. In order to properly calculate stormwater system potentials, it is essential to use this data.

Williamsport
Average Annual Precipitation (inches)
40.1 - 50
This GIS generated map shows the main rivers and road concentrations in Lycoming County. It also highlights Williamsport’s position within the county. It is important to note that many of the flowing water bodies converge in Williamsport where they join the West Branch of the Susquehanna River.

Williamsport is one of the lower points in Lycoming County, and as such, it has a unique opportunity to greatly affect the quality of water leaving the county. A proper stormwater management system in Williamsport could filter much of the county’s water.
Williamsport has five small watersheds within its municipality borders.

Several creeks flow through the urban area of Williamsport, making it essential to properly protect them from stormwater runoff pollution.

**Legend**

- Small Watersheds in Williamsport
- Williamsport

**WATERSHEDS IN WILLIAMSPORT**

**FLOWING SURFACE WATER IN WILLIAMSPORT**

**Legend**

- Streams in Williamsport
- Williamsport
- Rivers & Lakes

**STREAMS, RIVERS, AND LAKES IN WILLIAMSPORT**
Due to its low topography, lying in a valley between mountain ranges, Williamsport has a great challenge in managing its water systems. Improving water quality while protecting residents from flooding is the challenge Williamsport must address. A careful study of how water is allowed to interact with the land is essential for understanding the measures that should be taken.

Layout of Williamsport, Pennsylvania: This map highlights the relationship between the flowing surface water in Williamsport and its urban development.

Above, is an early rendering of land use in the Susquehanna Valley near Williamsport, Pennsylvania.
This aerial view shows how Williamsport development has always had a strong correlation to the Susquehanna River.

To the south of the Susquehanna River, much of South Williamsport's land use is dominated by agriculture and recreational activities.

As the host city of the annual Little League World Series, South Williamsport has many baseball fields. The Little League World Series property is outlined on the map.
THE L.L.W.S. SITE

South Williamsport, Pennsylvania

The Little League World Series site is very much the heart of activity in the city, and as such, offers interesting opportunities to explore educational stormwater installations.
The main stadium areas are some of the most active areas on site and as such, have strong opportunities for interactive design areas.
THE L.L.W.S. ANALYSIS

South Williamsport, Pennsylvania

SCALE: NTS

- Existing Stream
- Echo Flooring parking lot
- Plaza area opportunity
- Can filter water back into stream
- Use excess water to irrigate fields
- Volunteer Stadium
- Lamade Stadium
- Little League Museum
- Severe Slope: Opportunity to gather water

Road
Paved Area
Little League Site Boundary, (approx 25 acres)
Roof

2,034'
1,096'
PROGRAM FOR WILLIAMSPORT

In the United States, Americans step over storm drains on roads daily, but often give little thought to their implications. It is easy to simplify the system; it rains, the water drains to the roads, flows down the roads, and then eventually drops out of sight and out of mind into the storm drains. At first glance, it is an incredibly effective system. It limits the amount of surface water, keeps roads from flooding, and allows traffic, and subsequently people, to continue as usual. It is only upon closer inspection that the flaws of the system are understood.

Across the United States, 772 communities in 32 states with a total population of 40 million people, operate on combined sewer systems. This project proposes to complete comprehensive research and develop a design in Williamsport, Pennsylvania, a city under legal obligation to improve its combined sewer overflow issues, in order to show both the environmental and economic benefits of implementing sustainable stormwater management practices in urban areas. The project will develop a natural system to improve water quality at multiple scales, including Williamsport, the Susquehanna River, and the Chesapeake Bay.

At a master plan level, the design incorporates sustainable stormwater management techniques such as constructed wetlands and retention ponds in order to filter and improve the quality of stormwater runoff before it reaches the Susquehanna River. Careful consideration has been given to the topography and existing water paths in the area in order to minimally disrupt the natural processes that currently exist. The design will filter runoff through the site and ultimately deposit it in constructed wetlands at the northeast corner of the site, before it returns to the existing stream, and eventually, the Susquehanna River.

The specific site design focuses on the Little League World Series area in South Williamsport. Implementing an urban stormwater management system to collect runoff from parking lots reduces flooding on the fields and creates an irrigation opportunity. Various stormwater techniques including rain gardens and street swales have been designed to improve the functionality and aesthetics of the area. Focusing on the Little League World Series property, including the fields, parking lots, and museum, allows a state of the art stormwater management system to become a prominent part of the community and visible to the thousands of people who visit Williamsport each year.
GOALS & OBJECTIVES

Goal: Improve the water quality of the Susquehanna River, and subsequently the Chesapeake Bay.

Objective: Filter water leaving the wastewater treatment plant through a series of wetlands and detention ponds.

Objective: Implement natural stormwater management practices within the urban context to minimize the amount of runoff reaching the Susquehanna River.

Objective: Create an educational opportunity to show communities how sustainable actions can have positive effects on entire watersheds.

Objective: Highlight the economic benefits of the system at various scales of design.

Goal: Meet the EPA's requirements for water quality improvement in Williamsport.

Objective: Offer Williamsport an alternative to simply expanding their wastewater treatment plant in order to meet regulations.

Objective: Target the four CSO deposit locations along the river to filter pollution.

Objective: Create a series of testing points along the Susquehanna River to highlight how the water is improved as it travels through the sustainable treatment system.

Goal: Create a model for natural stormwater management systems on the site level scale in the Little League World Series area.

Objective: Use Williamsport's growth and notoriety as a way to gain recognition for a more sustainable system.

Objective: Design a system to manage runoff near the Little League World Series fields, museum, and parking lots.

Objective: Create a successful system that will assist in popularizing natural stormwater management systems.

Scope of Comprehensive Design

- Address stormwater management at multiple scales within Williamsport.
- Create innovative solutions for runoff management.
- Implement natural stormwater management practices within the urban context.
- Highlight economic benefits of the system at various scales.
- Meet EPA requirements for water quality improvement in Williamsport.
- Offer an alternative to expanding the wastewater treatment plant.
- Target four CSO deposit locations along the river to filter pollution.
- Create series of testing points along the Susquehanna River to highlight water improvement.
- Create a model for natural stormwater management systems on the site level scale in the Little League World Series area.
- Use Williamsport's growth and notoriety to gain recognition for a more sustainable system.
- Design a system to manage runoff near Little League World Series fields, museum, and parking lots.
- Create a successful system to popularize natural stormwater management.
CONCEPT FOR MASTER PLAN
MASTER PLAN

THE FEATURES

RETENTION PONDS

The ponds will store water on site for irrigation reuse. They will also tie into the overall system during overflow times, eventually moving towards the creek below the site.

GRAVEL AREAS

These areas are designed to bring a natural feel back to the site that fits in more appropriately with the surroundings. The areas are planted with trees, creating a microclimate and increasing permeability and infiltration of water.

STAIR INSTALLATIONS

Interactive waterfall installations filter water from the street above, reducing the pollution accumulated from street runoff.

RAIN GARDENS

These gardens add aesthetic value and filtering opportunities to the site.

CONSTRUCTED WETLANDS

All water on site flows towards the northern stream. A constructed wetland filters all the water before it reaches the stream, which feeds into the Susquehanna River.

RAIN SWALE

The rain swale captures most of the water on the eastern side of the main site slope and filters it before it reaches the gravel infiltration area.

PARKING TRELLIS

The parking trellis will serve to absorb rainwater before it reaches the pavement, using vegetation to decrease the amount of runoff while creating a stunning overhead view.
This system pulls runoff off the road before it reaches the storm drain, allowing for an area of filtration. The rain garden limits the stress on the storm drain, only overflowing back into the combined sewer system in large storm events, thereby reducing flooding risks while creating a beautified streetscape.
RAIN GARDEN

This garden filters the water flowing off the road, rather than sending it straight into the storm drain. When the rain garden reaches capacity, the excess water can flow over the wall, and into the storm drain.

This is a very active area, so seating will allow visitors to enjoy the space.
RETENTION POND

The retention pond will be used for irrigation purposes and absorbs water that currently floods the lower ball fields. Excess water will be piped northeast, towards the constructed wetlands.
WATERFALL STAIRS INSTALLATION

The waterfall stairs pull water from the street and filter them through a series of rain gardens that fall with the steps. An interactive waterfall fountain flows in the center, creating interest in dry weather as well.
Waterfall Stairs Installation
Creating a zigzag flow of water through swales lengthens the distance the water travels down the slope, which increases absorption opportunities.
Dining Plaza Swale
Street swales absorb runoff and reduce flooding risks while creating a beautified streetscape.
By filtering Lycoming Creek as it flows towards the West Branch of the Susquehanna River, water quality can be greatly improved.

The Dominguez Gap wetlands serve as the precedent study for Lycoming Creek and are constructed wetlands in Los Angeles, CA, where Compton Creek meets the Los Angeles River south of Del Amo Boulevard. These constructed wetlands connect to the DeForest Park and are managed by the Los Angeles County Department of Public Works.

They offer an essential stormwater treatment before the flow is released into the Pacific Ocean. Additionally, they help recharge groundwater in the area and have substantially increased the number of species in the eco-system.

This type of system could greatly improve the water quality in Williamsport and add a strong aesthetic value along the existing bikeway.
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