Environmental Benefits of Clean Water State Revolving Fund Green Infrastructure Projects

INTRODUCTION

Across the United States there is increasing awareness of the need to address pollution generated by stormwater runoff. As stormwater moves through the landscape it captures and carries trash, bacteria, heavy metals, and other pollutants from the urban environment. These pollutants degrade the quality of receiving waters and threaten public health. Stormwater can also cause erosion and flooding, damaging wildlife habitat, property, and infrastructure.

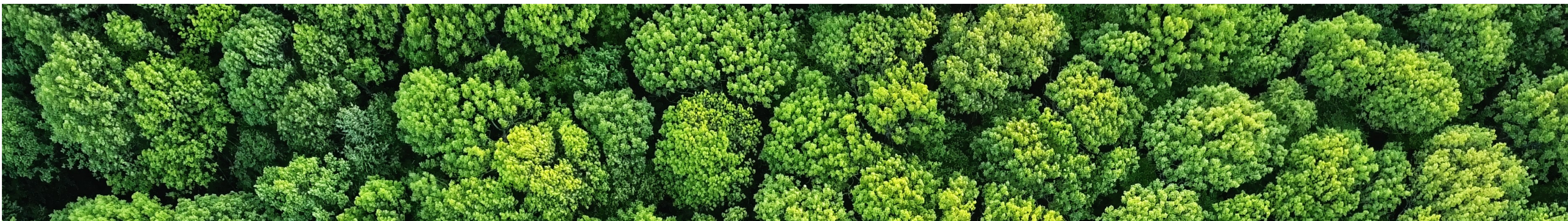
Green infrastructure practices offer flexible solutions for managing stormwater runoff and protecting public health and water quality. Green infrastructure works by incorporating both the natural environment and engineered systems to protect, restore, or mimic the natural water cycle. A variety of green infrastructure practices can be used to capture, treat, infiltrate, and evapotranspire stormwater runoff. At the local level, green infrastructure practices include land conservation, rain gardens, permeable pavements, green roofs, infiltration planters, trees, rainwater harvesting systems, and more. Applied at scale, green infrastructure preserves and restores natural landscapes and allows for better management of stormwater runoff in the urban environment. At any scale, green infrastructure practices can provide a wide array environmental benefits.

Since 1988, EPA's Clean Water State Revolving Fund (CWSRF) has grown to become one of the largest sources of public financing for water infrastructure projects in the country. Each of the 51 programs operating independently across the 50 States and Puerto Rico demonstrate the power of federal and state partnerships to protect the nation's water resources. States have significant flexibility within the CWSRF to set competitive interest rates, establish their own funding priorities, assist communities of all sizes, and leverage financial resources to address a wide range of water quality concerns. The flexibility, affordability, and eligibilities inherent to the CWSRF make it an ideal vehicle for funding green infrastructure projects.

EPA developed its Green Infrastructure Policy for the CWSRF to capitalize on this compatibility. Released in December of 2015, the policy promotes CWSRF investment in green infrastructure projects and broadly encourages investment in sustainable infrastructure. Amongst the variety of sustainable projects that CWSRF programs finance, green infrastructure offers flexible, innovative solutions for stormwater management.

The CWSRF's Green Project Reserve (GPR) also encourages investment in green infrastructure. Established under the American Recovery and Reinvestment Act (ARRA) and carried forward with subsequent appropriations, the GPR directs state programs to provide a variable percentage of their capitalization grants to a range of sustainable water infrastructure projects, including green infrastructure. CWSRF programs have been very successful at implementing the GPR, providing an impressive $5.5 billion in assistance to GPR projects since EPA began tracking loan level data in 2010. As part of the GPR, CWSRFs have provided $1.2 billion to over 900 green infrastructure projects.

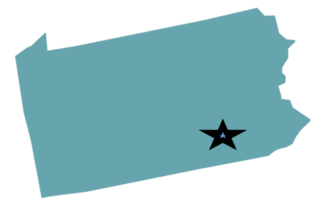
Eligible CWSRF recipients can choose from a wide array of green infrastructure projects that are eligible for funding through the CWSRF. The Water Resources Reform and Development Act (WRRDA) of 2014 specifically amended the CWSRF program eligibilities with respect to stormwater, authorizing each CWSRF program to provide financial assistance "for measures to manage, reduce, treat, or recapture stormwater or subsurface drainage water." This language encompasses virtually any green infrastructure project that mitigates stormwater runoff and opens a wide range of green infrastructure projects to CWSRF eligibility for both public and private borrowers.



Post-construction monitoring is not a requirement of CWSRF assistance. Nonetheless, recipients with adequate technical, financial, and managerial capacity recognize that there is value in documenting and sharing environmental outcomes: demonstrated success offers a path for other stakeholders to follow. As the largest public source of water quality financing in the United States, the CWSRF program has the national reach and resources to help expand the adoption of green infrastructure across the wastewater sector.

This collection of case studies explores the efforts of five CWSRF assistance recipients to monitor or model the environmental benefits of green infrastructure practices. Their results are quantifiable, and not only highlight the environmental benefits of green infrastructure, but tell an important story: across a wide variety of projects and multiple geographic areas, CWSRF programs are making a substantial difference in the national effort to prevent stormwater pollution.

Lancaster, PA



CWSRF Funding Integrates Green Infrastructure and Public Works Projects

BACKGROUND

Lancaster City is the county seat of Lancaster County in central Pennsylvania. Like many urban communities with deep historical roots, a complex system of infrastructure evolved to handle wastewater and stormwater runoff from areas of dense urban development. Approximately half of Lancaster City is served by a combined sewer system (CSS) while the other half is served by a municipal separate storm sewer system (MS4). Both systems discharge to the Conestoga River, a tributary of the Susquehanna River that ultimately discharges to the Chesapeake Bay. During wet weather events, partially treated or untreated sewage can exceed the local treatment capacity, resulting in the discharge of combined sewage directly to the Conestoga River. Each year, hundreds of millions of gallons of combined sewage impact contact recreation during and after wet-weather events. Combined sewage overflows are only part of the runoff-driven pollution sources to the Conestoga River, with large expanses of upstream agriculture and MS4 systems also creating impacts to recreation and aquatic life. Many of the runoff management techniques the City is using are applicable to these sources as well.

Lancaster City's Department of Public Works is embracing the potential of green infrastructure to address stormwater runoff at the source before it can enter the CSS, improving water quality from the Conestoga to the bay, while also creating urban green spaces that strengthen neighborhood communities and look inviting to new businesses. In 2011, an ambitious Green Infrastructure Plan laid out a long-term path to integrate green infrastructure as part of the City's normal public works projects in parks, streets, alleys, and as part of private redevelopment projects. Making this vision a reality requires a clear and transparent business case demonstrating the value of the green infrastructure project relative to the public funds invested and funding sources that are cost-effective, flexible, and have the capacity to finance dozens of projects over a multi-year time horizon: qualities embodied by the CWSRF program. In 2014, the City embarked on a landmark partnership with funding from Pennvest to pilot green infrastructure across the City with a public-private partnership which has played a critical role in the transformation of Lancaster City's stormwater infrastructure.

PROJECT ELEMENTS - REBUILDING LANCASTER TO MANAGE RUNOFF LOCALLY

When Lancaster City issued its Green Infrastructure Plan in 2011, opportunities to increase green infrastructure implementation were plentiful: impervious surfaces, mainly comprised of roadways, parking lots, and buildings covered 48 percent of the city's 7.3 square miles. Located across a mosaic of public and private properties, these impervious areas were not contiguous. Each prospective site presented unique stormwater management challenges but also promised a variety of environmental, economic, and social benefits to residents. Municipal officials recognized that achieving these benefits would require flexible implementation of green infrastructure practices in numerous locations. Lancaster City's Green Infrastructure Plan laid out a path to accomplish exactly that through the city-wide implementation of green infrastructure across several priority areas.

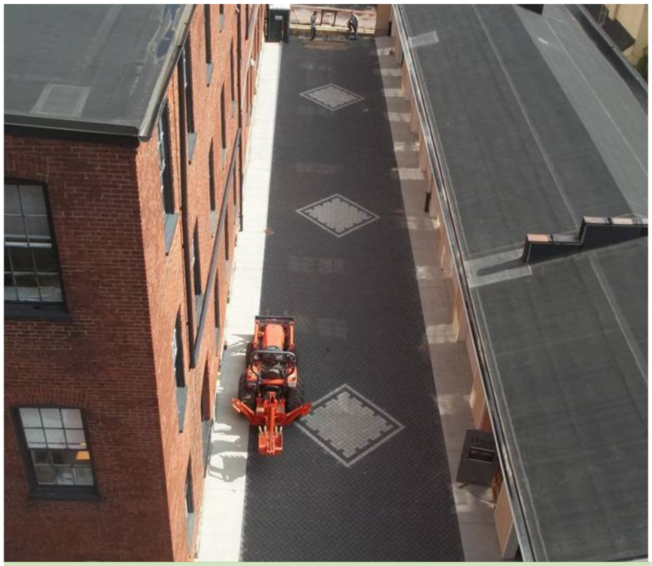
Parks

Tree plantings, bioretention, and other green infrastructure practices located in parks and other public spaces present opportunities to manage the stormwater runoff from relatively large land areas. Depending on the type and scale of the selected green infrastructure practices, green parks can also help manage stormwater runoff from adjacent impervious surfaces such as streets, parking lots, and residential roofs. In addition to preventing stormwater pollution, vegetated green infrastructure practices, particularly those that incorporate native plantings, have the potential to create and/or restore urban wildlife habitat, provide environmental education and recreational opportunities, and help create a more aesthetically pleasing urban environment.

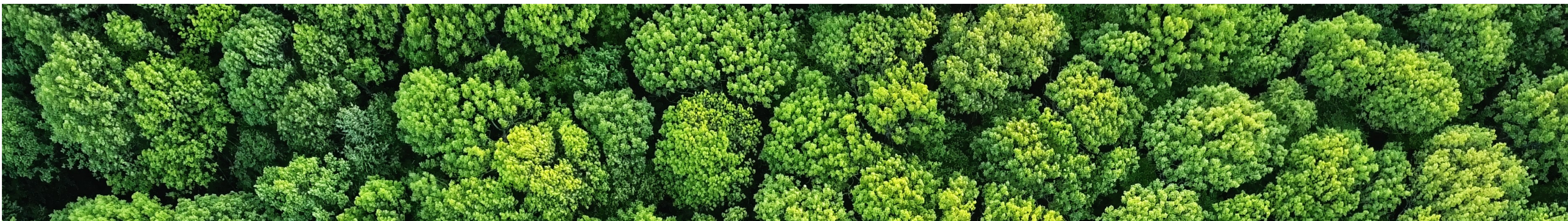
Lancaster City's Brandon Park is home to a basketball court constructed over permeable macadam, allowing stormwater to infiltrate into the soil underneath the playing surface. (Photo courtesy of the Lancaster City Department of Public Works)

Green Streets, Alleys, and Sidewalks

City streets and the alleys, sidewalks, and other pedestrian rights-of-way that accompany them can be a major source of stormwater runoff. Incorporating tree trenches, bioretention, permeable pavers, and other green infrastructure practices into these locations converts them into assets that manage stormwater runoff. When designed and sited carefully, these assets can even be capable of capturing runoff from adjacent properties. Because these green infrastructure practices are cheaper to implement when they are incorporated during repaving, reconstruction, and other routine maintenance activities, Lancaster City's Green Infrastructure Plan identified 468 blocks of green streets that will be implemented as streets are reconstructed over the long term. The plan also identified existing tree canopy in the City and set the long-term goal of increasing coverage from 28 to 40 percent. Realizing this goal will increase stormwater infiltration capacity along the City's streets, create urban wildlife habitat, and lower summer temperatures.



Permeable pavement lines an alley in downtown Lancaster City. (Photo courtesy of the Lancaster City Department of Public Works)



A 750-gallon cistern and bioretention basin outside of the Lancaster Brewing Company. (Photo courtesy of the Lancaster City Department of Public Works)

Private Property

Municipal officials recognized that to achieve optimum green infrastructure implementation, public property wouldn't be sufficient: Lancaster City needed to engage citizens, local business owners, and other private stakeholders. Local ordinances require property owners who are adding new impervious surface areas to manage the first inch of rainfall on their property and not allow it to discharge to the City's CSS. Green infrastructure practices offer an effective means of doing so, and property owners in Lancaster City are taking advantage. One such property is the Lancaster Brewing Company, which allowed the City to install a 750-gallon cistern to store runoff from the brewery roof. Other green infrastructure practices on-site include permeable pavers and bioretention basins. Collectively, these green infrastructure practices not only help manage stormwater runoff, but serve as public art that engages with and educates brewery patrons and passing pedestrians.

CWSRF ASSISTANCE

Thanks to $7 million in CWSRF funding from Pennvest, Lancaster City has successfully implemented 59 green infrastructure projects that address their Green Infrastructure Plan's key priorities. 20 of these projects were financed entirely through the CWSRF with the remainder paid for through a combination of CWSRF dollars and funding from other sources. With more projects in the funding pipeline, Lancaster City is taking significant steps to protect public health and water quality and bring the vision outlined in its Green Infrastructure Plan to life.

ENVIRONMENTAL BENEFITS

Building 59 projects over 7 years is a significant step toward realizing Lancaster City's vision for institutionalizing green infrastructure, but city officials realized up front that transforming a system of infrastructure is a complex, long-term process that requires commitment and planning.

The City's current suite of completed green infrastructure projects demonstrate the scalability of these technologies. When applied to wider area over a long-term time horizon, the potential environmental benefits are substantial. Before moving forward with the City's Green Infrastructure Plan, city officials conducted a thorough analysis of the predicted environmental benefits using a green infrastructure benefits calculator developed by the engineering firm CH2M HILL, now Jacobs Engineering Group. Based on the characteristics of various green infrastructure practices, the calculator yielded potential benefits of implementing selected green infrastructure practices over 5 and 25-year periods. Major inputs to the calculator included:

- Lancaster City's impervious surface area;
- Capture volume of green infrastructure practices;
- The amount of impervious area captured by green infrastructure practices;
- An average annual runoff coefficient of 85 percent based on other comparable cities;
- An average annual rainfall of 42.04 inches;
- The relationship between stormwater reduction and CSO reduction within the CSS;
- Implementation periods of 5 and 25 years; and
- Typical pollutant concentrations for urban stormwater runoff and CSO discharges

The calculator's analysis yielded the following results:

Parameter	5-Year Implementation	25-Year Implementation
Impervious Area Managed by Green Infrastructure (ac)	221	1,265
Average Annual Runoff Reduction (MG/yr)	182	1,053
Average Annual Total Suspended Solids (TSS) Reduction (lb/yr)	252,000	1,457,000
Average Annual Total Phosphorous (TP) Reduction (lb/yr)	4,800	27,800
Average Annual Total Nitrogen (TN) Reduction (lb/yr)	10,700	61,600

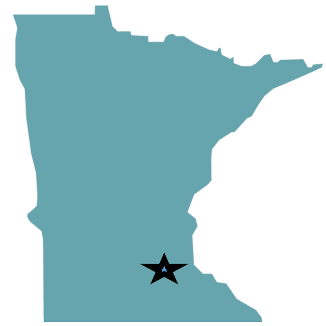
Long-term implementation of green infrastructure practices in accordance with Lancaster City's Green Infrastructure Plan will manage nearly 2 square miles of impervious surface, resulting in the capture of over 1 billion gallons of stormwater per year: enough runoff to fill over 1,500 Olympic size swimming pools. Capturing this runoff will prevent significant amounts of sediment and nutrient pollution from impacting local water bodies and polluting the Chesapeake Bay watershed.

Lancaster City's Green Infrastructure Plan lays out an ambitious new vision for how the City can manage stormwater runoff and protect public health and water quality, but like all infrastructure projects, prospective benefits are accompanied by logistical and financial challenges. Full implementation of the plan will require 25 years and an estimated $77 million. Affordable funding from the CWSRF program helped the City's Department of Public Works take crucial first steps toward implementation. With 59 projects on-the-ground and more in the funding pipeline, Lancaster City is proving it has both the commitment and the capacity to make its vision for green infrastructure a reality.

Maplewood Mall, MN

CWSRF GPR Funds Green Infrastructure Project in Maplewood, Minnesota

BACKGROUND



The Maplewood Mall is situated within the Ramsey-Washington Metro Watershed District (District). The District is a 65-square mile urban and suburban watershed on the east side of the Twin Cities Metropolitan area in Minnesota, 40 percent of which is comprised of impervious streets, highways, parking lots, and driveways. Within the District, the Kohlman Lake Total Maximum Daily Load (TMDL) requires the reduction of phosphorus in addition to the already defined District-wide goal of stormwater volume reduction. In 2008, the District identified Maplewood Mall and the associated parking lot as a major contributor of phosphorus loadings into Kohlman Lake which sits just one mile west. Maplewood Mall is a 70-acre site, approximately half of which is covered by a parking lot and is 97 percent impervious.

PROJECT ELEMENTS AND CWSRF ASSISTANCE

A bioretention installation helps manage stormwater runoff from adjacent streets and sidewalks. (Photo courtesy of the Ramsey-Washington Metro Watershed District)

In collaboration with Simon Property Group and the City of Maplewood, the District broke ground on the four-phase, multi-year project in 2009. The project involved the installation of 55 rain gardens, one mile of tree trenches, 375 trees, 6,733 square feet of permeable pavers to intercept runoff from parking lot areas, and a 375-gallon cistern to catch runoff from the mall roof. The project design specified enhancements for certain green infrastructure features, including iron aggregate material in rain gardens to capture dissolved phosphorus present in stormwater and hydraulically-linked tree trenches that provide treatment in series. Construction was completed and all project elements were in service by May 2013. The project was the recipient of approximately $1,570,000 in SRF GPR funds, including approximately $392,000 in principal forgiveness, in July 2012. The total project cost was $6.4 million dollars which, in addition to SRF funds, also included local funds, Minnesota Pollution Control Authority (MPCA) Clean Water Fund Grants, a MPCA TMDL Implementation Grant, and a MPCA 319 Grant.

DATA COLLECTION AND METHODS

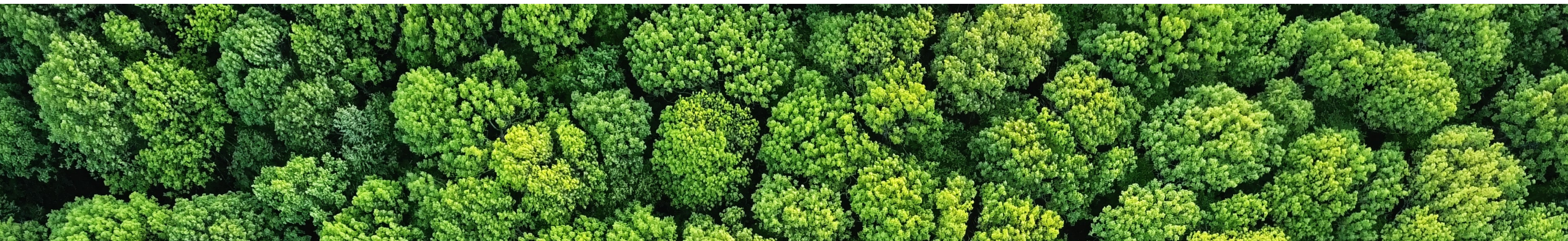
In 2013 monitoring data was collected from the Woodlyn rain garden, located at one of the entrances to the mall. Rain gardens installed during later construction phases were modeled after the Woodlyn installation and are likely to yield similar environmental benefits data. Water quality sample data was paired with rainfall and flow monitoring data to calculate flow-weighted concentrations of total phosphorus, ortho phosphorus, and total suspended solids entering and leaving the rain garden. The total volume entering and leaving the rain garden was also measured. Inflow and outflow concentrations (and volumes) were compared to determine the reduction in concentration and the pounds of removal for each constituent. Fourteen samples representative of five distinct rainfall events were collected between May 17, 2013 and July 22, 2013.

RESULTS AND BENEFITS

Data collected showed a 61 percent reduction of total phosphorous, a 51 percent reduction of ortho phosphorous, and a 94 percent reduction of total suspended solids. These reductions are consistent with the rain garden's removal rate design. The data also showed a 20 percent average reduction in stormwater volume at the rain garden outflow point for the entire monitoring period. During a 0.64-inch storm event on June 10, 2012, the rain garden reduced both peak discharge and outflow volume by 95 percent and 49 percent, respectively.

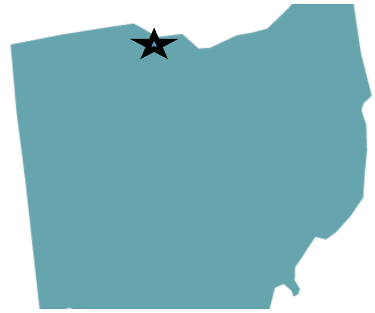
The District is planning to collect and monitor more data from the tree trenches. Water levels in the tree trenches will be monitored during a series of storm events via installed water level loggers. In addition, tree trenches will undergo a synthetic storm analysis in which a controlled volume of water is applied to each tree trench and the drawdown time is observed.

GI TYPE	DATA COLLECTED	UNITS	RESULTS
RAIN GARDEN	Stormwater Volume	(cubic feet, ft^3)	Reduced stormwater volume by an average of 20%
	Peak Flow	(cubic feet per second, cfs)	Reduced peak flow by 85% during June 10, 2012 event
	Total Phosphorus Load	(mg/L)	Reduced total phosphorus concentration by 61%
	Total Ortho Phosphorous	(mg/L)	Reduced total ortho phosphorous concentration by 51%
	Total Suspended Solids Load	(mg/L)	Reduced total suspended solids concentration by 94%
TREE TRENCH	Drawdown Time		To Be Determined



Maywood Ave, OH

CWSRF GPR Funds Green Street Project in Toledo, OH



BACKGROUND

Maywood Ave is a residential street in Toledo, OH, composed mainly of single-family homes prone to basement flooding. The street was selected by the City for a pilot project to determine the effectiveness of installing green infrastructure to reduce combined sewer overflows.

PROJECT ELEMENTS AND CWSRF ASSISTANCE

The pilot project involved the installation of approximately 1,300 linear feet of bioswales along both sides of the street in the right-of-way and pervious concrete in driveway aprons and sidewalk areas. The street surfaces were restructured to drain toward the green infrastructure features and curb cuts were engineered to allow access to the bioswales in the right-of-way. Construction was completed on the project in 2010. Though the project was intended to be a demonstration project for green infrastructure and a way to educate and foster participation in the community, it had additional benefits including neighborhood beautification and reducing neighborhood flooding. The project was the recipient of approximately $864,000 in ARRA SRF GPR funds in February 2010, all of which was principal forgiveness. The project also received approximately $278,000 from Lucas County funds and U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) to support additional green infrastructure.

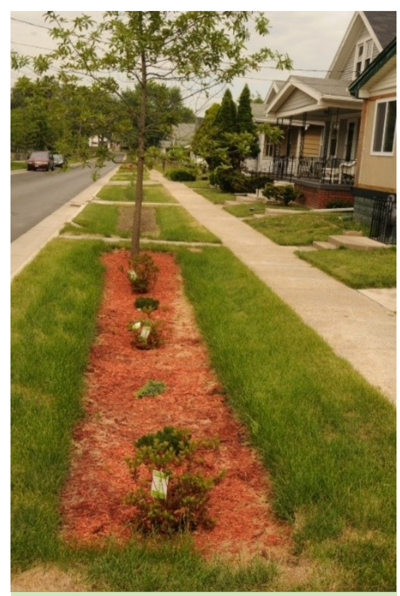
DATA COLLECTION AND METHODS

To determine if bioswales and pervious concrete were effective in achieving the project's goals, a data collection and monitoring effort was initiated. Two flow meters were installed in storm drains; one downstream at the east end of Maywood Avenue and a surrogate monitor on the adjacent Russell Street for comparison purposes. Pre-construction meter readings were recorded between the months of March and June 2010 at both locations to provide baseline flow readings.

RESULTS AND BENEFITS

Following construction completion, flow meter readings over a six-month period showed decreased peak flows in gallons per minute (gpm) and increased stormwater storage and infiltration compared to pre-construction monitoring results. In addition to the stormwater reductions achieved, zero instances of basement flooding were reported through August 18, 2011. The flow monitoring period was extended through fall and winter months in 2011 to evaluate year-round effectiveness of the green infrastructure projects.

In addition to flow meter monitoring, a Stormwater Management Model (SWMM) was prepared to simulate the long-term impact of installed green infrastructure. The model was calibrated using the pre- and post-construction data collected by the two flow meters and rainfall data collected by tipping bucket rain gauges. Simulation results showed an annual reduction of 10,560 gallons of runoff volume, approximately a 64 percent reduction, equal to about three combined sewer exceedances per year. The model also showed a 60-70 percent reduction in peak flows at equivalent rainfall intensities.



A bioretention installation manages stormwater runoff from adjacent impervious surfaces. (Photo courtesy of the City of Toledo)

GI Type	Data Collected	Units	Results
Bioswales	Peak Flow	gpm	Decreased peak flow compared to pre-construction results (see graph 1)
	Storage/Infiltration	mg	Increased storage/ infiltration compared to pre-construction results (see graph 2)
	Modelled Annual Run-off Volume	gallons	Reduced annual runoff volume by 10,560 gallons (64%)
	Modelled Peak Flow	gpm	Reduced peak flow by 60-70%

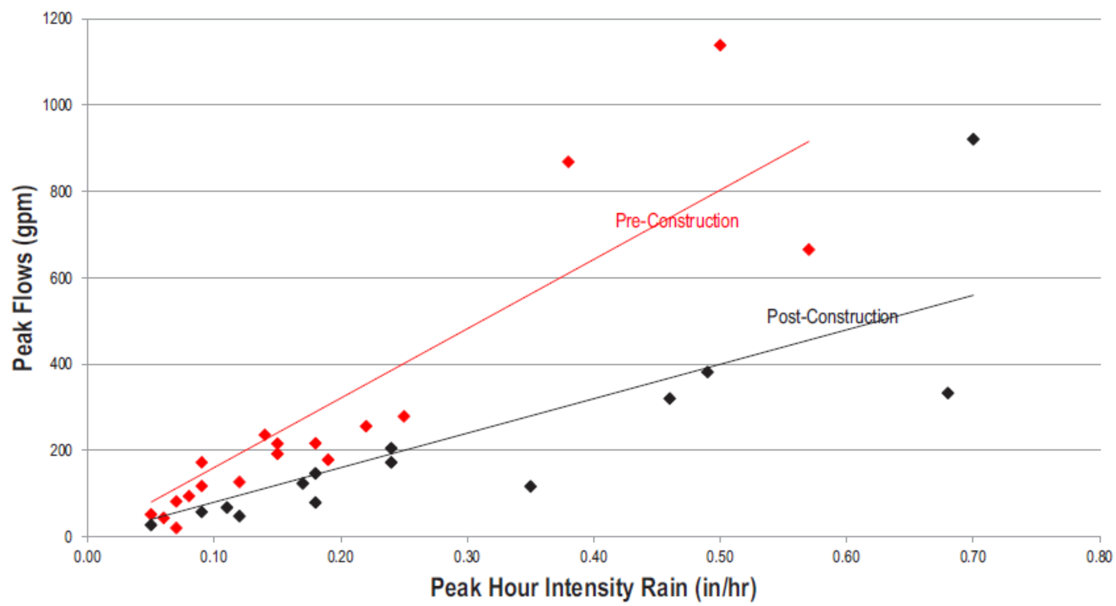


Figure 1: Graph of pre- and post- construction peak flows.

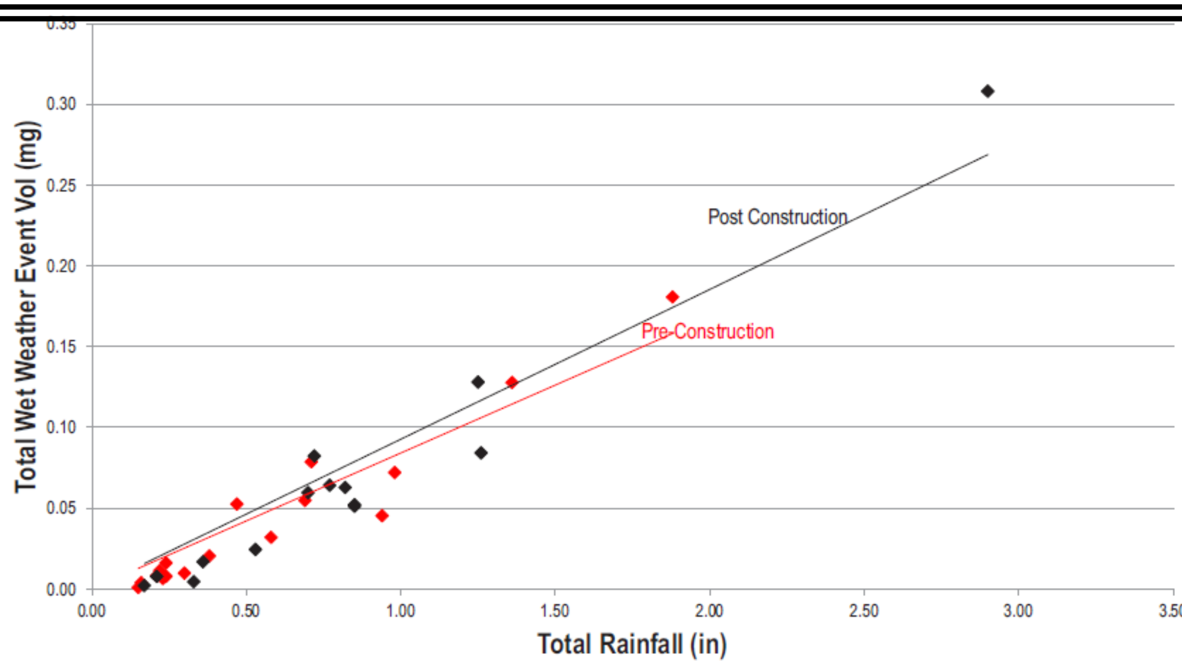


Figure 2: Graph of pre- and post- construction storage/infiltration.

Williamsville, NY

CWSRF GPR Funds Green Infrastructure Project in Williamsville, New York

BACKGROUND

The Village of Williamsville is located in Erie County in western New York. The nationally historic Williamsville Water Mill is located on Spring Street in the central business district for the Village. The mill sits atop a bedrock ledge that was being adversely impacted by stormwater runoff from Spring Street, Rock Street, and adjacent parking areas. This runoff was significantly eroding the bedrock ledge and affecting the stability of the mill's foundation. Additionally, the existing drainage system of drop inlets and collection lines on Spring Street was clogged with sediment and not functioning properly. This resulted in uncontrolled runoff over the 30-40 foot ledge, eroding the ledge and carrying silt and sediment into the system of swales, streams, and ponds in Glen Park, which is located below Spring Street. This stream system discharges directly to Ellicott Creek, which is listed by the New York State Department of Environmental Conservation (NYSDEC) as a Priority Waterbody that is impaired due to silt and sedimentation. The known source of contamination to the creek is urban stormwater runoff.

PROJECT ELEMENTS AND CWSRF ASSISTANCE

To reduce erosion and improve water quality in Ellicott Creek, the Village of Williamsville, in collaboration with the Buffalo Niagara Riverkeeper (BNRK), developed plans to reconstruct Spring Street to install green infrastructure. The project includes the installation of bioretention planters, rain gardens, and porous pavers. These features are designed to capture, filter, and slowly release runoff that is currently conveyed directly over the bedrock ledge into the system of swales and ponds in Glen Park. A green wall system was installed to reinforce a portion of the bedrock ledge and reduce erosion while also treating stormwater runoff. The green infrastructure work was part of a larger downtown revitalization project, which includes the redevelopment of the Spring Street area as a village green focal point in the downtown area.

The project was funded through a $799,160 grant from the New York CWSRF's Green Innovation Grant Program administered by the New York State Environmental Facilities Corporation. Additional funding was provided by a $1,902,180 Water Quality Improvement Project program grant administered by the New York State Department of Environmental Conservation, $722,856 in matching funds from the Village, and $250,000 from Senator Michael Ranzanhofer (administered through the Dormitory Authority of the State of New York).

Signage describing green infrastructure installed as part of project. (Photo courtesy of the NY State Environmental Facilities Corp.)

A rain garden installed as part of Williamsville green infrastructure improvements. (Photo courtesy of the NY State Environmental Facilities Corp.)

DATA COLLECTION AND METHODS

The BNRK conducted post-construction monitoring of stormwater quality and quantity from April through May 2017. Riverkeeper staff collected samples from the stormwater outfall pipe during four post-construction rain events. The samples were analyzed for Total Kjeldahl Nitrogen (TKN), Nitrate-Nitrite, Total Phosphates, Turbidity, and Total Suspended Solids (TSS). Total Nitrogen was calculated from TKN and Nitrate-Nitrite (N-N). In addition, precipitation was measured using a standard plastic four-inch rain gauge and flow volume was monitored during the four rain events. The post-construction monitoring data was compared to pre-construction monitoring results in which similar precipitation levels fell to determine any reduction in flow volume and pollutants as a result of the project.

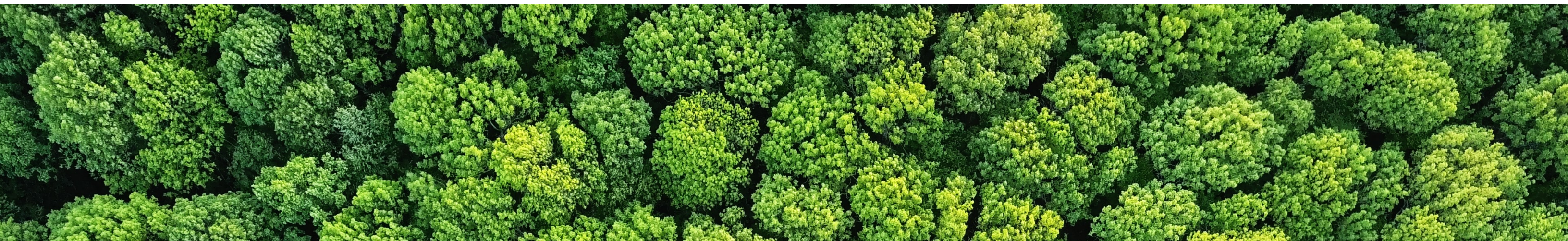
RESULTS AND BENEFITS

Monitoring results showed a substantial decrease in volumetric flow rate, turbidity, and TSS. Average volumetric flow rate decreased by nearly 90 percent after the project was completed. Additionally, during post-construction sampling there were 11 occasions where the flow of water from the outfall pipe was too low to measure. The average turbidity decreased by almost 70 percent post-construction. This reduction in turbidity indicates a reduction of suspended particles flowing off East Spring Street and into Glen Park and ultimately, Ellicott Creek. The results of the TSS measurement reinforce this finding, with average TSS decreasing by approximately 64 percent from pre-construction measurements.

Nutrient measurements were taken as an amount per volume of water. It is important to note that with the 90 percent reduction in volumetric flow rate resulting from the project, there is also a corresponding reduction in overall nutrients from the outfall. Therefore, the nutrient reduction provided by the project is actually far greater than indicated by the measurements in the table, below. On average, post-construction samples showed lower nutrient levels than those collected pre-construction. Average TKN was reduced by approximately 16 percent. Average phosphorus decreased by about 44 percent. Samples collected and analyzed for Nitrate-Nitrite, which are naturally occurring, inorganic ions present in the environment remained fairly consistent, with a slight increase of nearly nine percent.

	Pre-construction	Post-construction
Average volumetric flow rate	10,199.25 cm3 /sec	1,082.06 cm3 /sec
Average turbidity	112.11 NTU	34.7 NTU
Average TSS	57.39 mg/L	20.44 mg/L
Average TKN	0.8688 mg/L	0.7315 mg/L
Average phosphorus	0.182 mg/L	0.102 mg/L
Average N-N	0.30464 mg/L	0.33135 mg/L

The information collected during post-construction monitoring is important, as the Village hopes that this project can serve as a model for other communities in the region and across the state, particularly for areas with steep slopes. The Village is also looking to effectively use the project technology for other streetscaping improvements in the area, and for the development of new standards for streetscaping design.



Illinois River and Euchaw/Spavinaw Watersheds, OK

CWSRF GPR Funds Streambank Stabilization in the Illinois River and Euchaw/Spavinaw Watersheds, Oklahoma

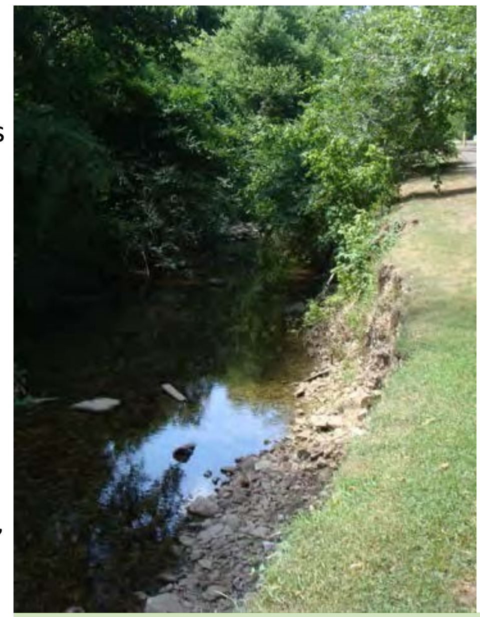
BACKGROUND

The Illinois River begins in the Ozark Mountains in the northwest corner of Arkansas and flows west into Oklahoma, where the Oklahoma Conservation Commission sees it as one of the highest priority watersheds. Once entering Oklahoma, it then flows southwest and south through the mountains of eastern Oklahoma into Tenkiller Ferry Lake, a popular recreational destination for Oklahomans that supports a sizable tourism industry. The Illinois River and most of its major tributaries are classified as state scenic rivers. However, the River, Lake Tenkiller, and some of the principal tributaries in the watershed are not meeting water quality standards for nutrients, bacteria, and other issues, creating a threat to not just the environment but public health and the economy. One significant contributor to nutrient loads and sediment is unstable and degrading streambanks.

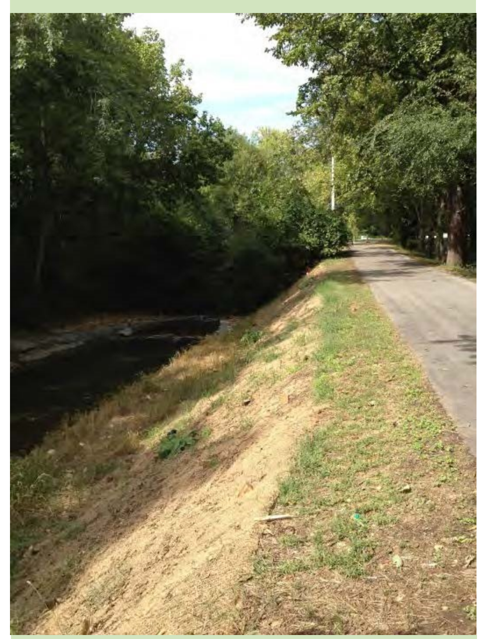
PROJECT ELEMENTS AND CWSRF ASSISTANCE

In 2009, the Oklahoma Conservation Commission (OCC) identified 35 sites in the Illinois River Watershed with significant bank erosion where landowners and land managers were requesting assistance to address sustained streambank erosion. Of these sites, 12 were selected for streambank stabilization projects to reduce erosion of sediments and nutrients.

These 12 streambank stabilization projects restored almost 7,000 linear feet of stream. They were very successful, weathering many significant flood events. Approximately three years after project completion, the watershed experienced its largest flood event ever recorded. Fortunately, none of the projects lost further ground beyond the originally protected banks; however most experienced some damage, and a few required repairs to prevent damage to the originally protected bank. In 2016, repair work was completed on four of the sites. In addition, one new site was repaired, in partnership with the Oklahoma Department of Transportation (ODOT), which restored an additional 2,830 feet. This site was restored because ODOT had seen the original 12 restorations and was anxious to implement similar methods near a threatened highway in the watershed.



Streambank before project. (Photo courtesy of the Oklahoma Conservation Commission)



Streambank after project. (Photo courtesy of the Oklahoma Conservation Commission)

The project was funded with a $2,000,000 loan from the Oklahoma CWSRF program, administered by the Oklahoma Water Resources Board, for the restoration of 11 sites. The U.S. Fish and Wildlife Service provided an additional $100,000 to address one site.

DATA COLLECTION AND METHODS

To estimate reductions in nutrients and sediment loading as a result of the streambank stabilization projects, the OCC collected measurements of the length of eroding bank at the 12 restoration sites using site and land bed surveys. This data was analyzed using GIS to determine streambank migration rates over time and provide an estimate of the volume of sediment lost. The OCC also collected bank sediment analysis data for other OCC projects in the basin to provide an estimate of nutrient concentrations in streambank soils in the basin, based on generalized stream order. Load reduction results for the 12 streambank stabilization projects were then modeled, based on relative stream order and length of bank stabilized.

RESULTS AND BENEFITS

Using the model, it is possible to estimate load reductions, per year, that have resulted from the 12 streambank stabilization projects (and subsequent project efforts).

Project	Linear Feet Restored	Tons Sediment Reduced/ year	Pounds Phosphorus Reduced per year	Pounds nitrogen reduced per year
12 streambank stabilization sites	6,657	3,954	1,669	3,535
Repairs + ODOT	3,146	3,030	1,256	2,546
Total	9,803	6,984	2,925	6,081

Since construction, accounting for the sediment (and related nutrient loss) that occurred during the two major storm events, load reductions from the 12 streambank stabilization projects and additional linear repair and ODOT site work are estimated to be:

Project	Tons Sediment Reduced	Pounds Phosphorus Reduced	Pounds Nitrogen Reduced
12 streambank stabilization sites	20,760	8,760	18,560
Repairs + ODOT	6,460	2,690	5,500
Total	27,220	11,440	24,060

This load reduction is critical since modeling suggests that 80–90 percent load reductions will be required to meet water quality standards in the watershed. Significant reductions in NPS loading will be required, which may be impossible without streambank stabilization and protection.

The measured impacts in the watershed are significant, but more importantly, the projects served as the impetus for new partners to do additional streambank work in the watershed, resulting in more stabilization and greater load reduction impacts. The projects also resulted in additional interest in the methods across the state. ODOT is using these methods in other watersheds throughout Oklahoma, and the workshops associated with the project introduced many people to the concept of natural channel restoration resulting in many additional projects.

For more information about the CWSRF please contact us at:

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