OCRA GI Curriculum & Training
SELECTED CASE STUDY WORKSHEET

	PROJECT NAME	PROJECT LOCATION	PROBLEM ADDRESSED			PROJECT TYPE			PROJECT LOCATION				TYPES OF BMPS							CATEGORY - GI used to address…
			street flooding	localized flooding	CSO	new	retrofit	ADA assessibility	street	parking lot	park/recreation	public space	permeable pavement	bioretention/ bioswales	infiltration trenches	rainwater harvesting	hybrid ditch	wetlands	underground storage	
1	Rieth Village	Albion				x						x	x	x	x	x		x		*sustainable site design*
2	CSO 33	Indianapolis			x		x		x					x						*CSO*
3	CSO Wetland	Washington			x	x						x						x		*CSO*
4	Civic Center	Evansville			x		x			x				x					x	*CSO*
5	Cleo Rogers Library	Columbus		x			x	x				x		x	x					*localized flooding*
6	Athletic Facility	Purdue		x			x			x	x			x	x				x	*localized flooding*
7	Court House	Delaware County		x	x			x						x	x					*localized flooding*
8	West Elementary	Mt Vernon		x			x				x			x						*localized flooding*
9	Pendleton Pike	Indianapolis	x	x			x		x								x			*street flooding*
10	Market Street	Jeffersonville	x				x		x					x						*street flooding*
11	North Street	Lafayette	x		x		x		x				x	x						*street flooding*
12	Jefferson Street	Goshen	x				x		x				x							*street flooding*

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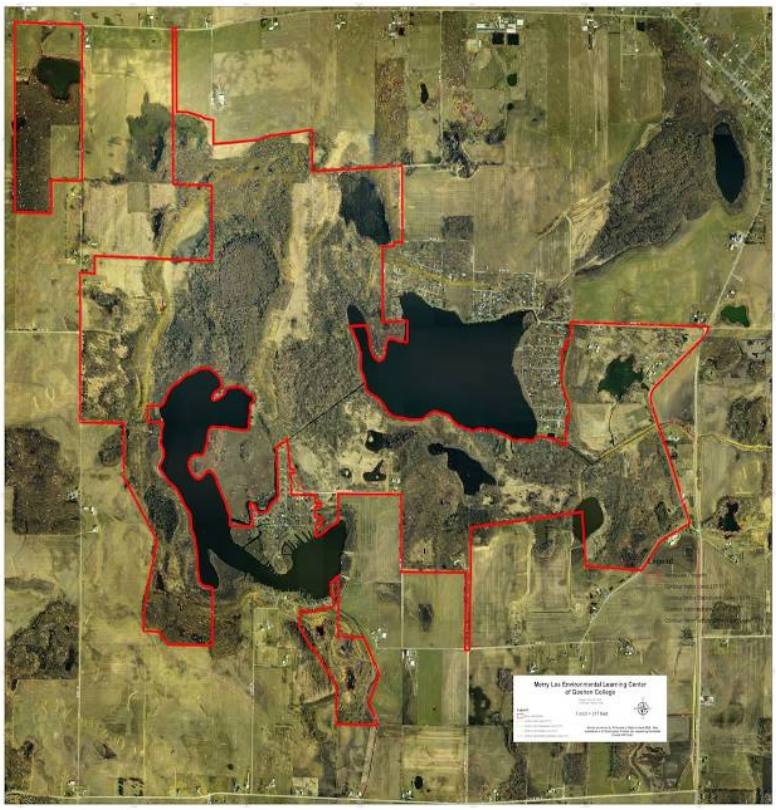
OCRA Green Infrastructure Curriculum & Training

SELECTED CASE STUDY

NAME	Rieth Village
LOCATION	Albion, IN
OWNER	Goshen College
DATE COMPLETED	April 2006
COST	$2.2 million
SCALE/SIZE	5 acres
FUNDING SOURCE	Private donations — individuals and foundations
PROBLEM	Goshen College needed to construct an undergraduate facility and field station. The College desired a sustainable development with zero stormwater discharge after construction.
SOLUTION	Infiltration and rainwater harvesting green infrastructure practices are used throughout the site to capture, treat, and reuse stormwater runoff. The landscape is designed so that irrigation is not needed, with the exception of the on-site greenhouse and vegetable garden. Water that is used for irrigation comes from the 15,000 gallon underground rainwater harvesting cistern. This water is also recycled and used in the washing machines and toilets as well as in the gardens. Potable water comes from a well which is used only in sinks and showers.
BMP(S)	Gravel parking lot and service roads Grass “parking fingers” instead of parking spaces Pervious concrete sidewalks Rain gardens Rainwater collection and reuse system Constructed wetland for effluent treatment
TYPE OF PROJECT	New construction
WHY GI USED?	Pilot campus project to create a functionally sustainable site
BENEFITS	Social Benefit: • Facility is open to the public and designed to be an educational resource Environmental Benefit: • 100% sustainable site • Zero stormwater runoff • Native plants provide habitat for wildlife Economic Benefit: • Reduced irrigation through use of native plants and water needs for plumbing by capturing and reusing stormwater runoff
PERMITS NEEDED	Indiana State Building Permit Indiana State Department of Health permit for onsite wastewater treatment system Noble County Building Department Permits Noble County Surveyor’s Office approval of the storm water management plan

LOCATION MAP	

PROJECT BOUNDARY	
Installation of wetland plants	

Constructed wetland for effluent treatment	
Construction of underground cistern to store rainwater	

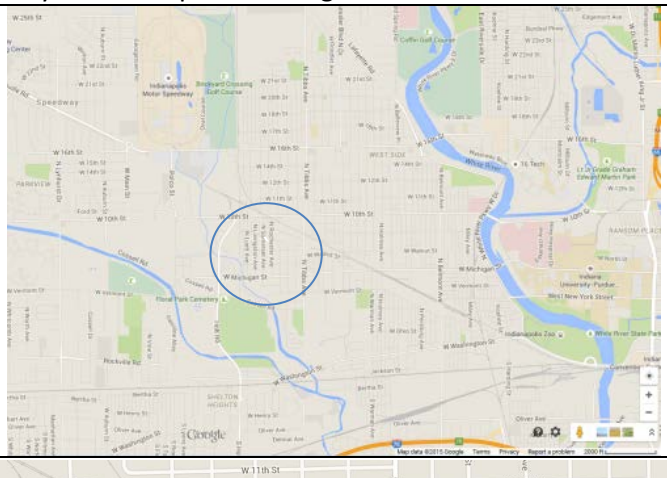
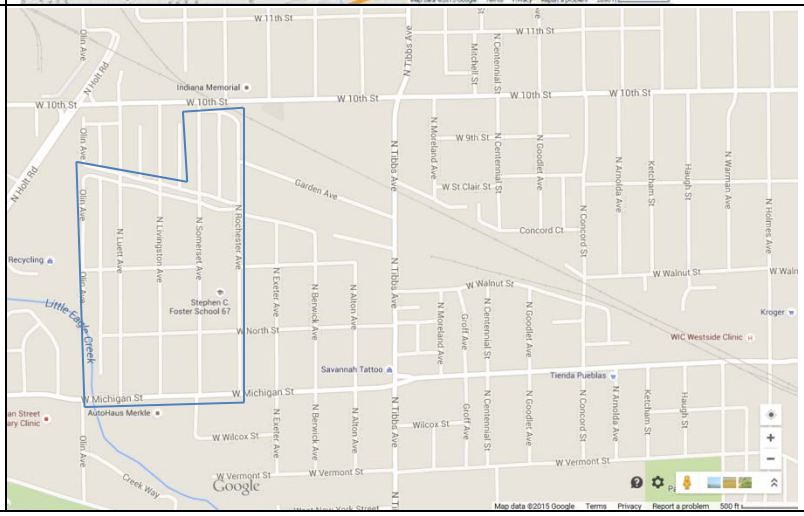
Vegetable garden irrigated from harvested rainwater	
Rain garden to capture and treat runoff	

Completed site development	
Gravel parking area, permeable concrete sidewalk, and native grasses	
NOTEWORTHY	County officials had to be educated on the project from the very beginning to head off potential permitting problems. LEED Platinum Certified
DESIGNER	MKM architecture + design for living.

OCRA Green Infrastructure Curriculum & Training

SELECTED CASE STUDY

NAME	CSO 033 Sewer Separation Improvements
LOCATION	Indianapolis, Indiana
OWNER	Citizens Energy Group
DATE COMPLETED	October 2014
COST	$950,000 (construction cost)
SCALE/SIZE	2,350 linear feet of stormwater planters
FUNDING SOURCE	Citizens Energy Group
PROBLEM	As the owner of the sanitary sewer system in Indianapolis, Citizens Energy Group (Citizens) is required by a consent decree with the EPA to mitigate combined sewers overflows (CSOs). CSO 033 is one of the many CSOs in the city that discharges raw sewage into local water bodies during even small rain events.
SOLUTION	Citizens sought to compare conventional and green alternatives for the sewer separation by analyzing various green infrastructure solutions, modeling to confirm compliance with the consent decree, developing a maintenance plan, and calculating 20-year life cycle costs. Three alternatives were proposed in the study for CSO 033: grey, hybrid grey/green, and all green. The grey alternative was an entirely new separated storm network up to 15 feet deep throughout the neighborhood with an outlet directly into Little Eagle Creek. The hybrid alternative installed a separated storm trunk line in the street with the most inlets and supplemented with green infrastructure to meet the consent decree requirements. The green alternative required 2,350 linear feet of stormwater planters throughout the neighborhood in the 5 to 7 foot wide grass area between the curb and sidewalk. The green alternative also included 200 trees throughout the neighborhood as tree infrastructure because of their ability to intercept rainfall before it reaches the ground and runs off. Stormwater planters are linear bioretention cells surrounded by curbs. After draining from the street or sidewalk, runoff is filtered through a layer of engineered soil planted with native plants. Clean runoff that has been filtered by the engineered soil and plantings can infiltrate into the ground, eventually recharging the groundwater. During rain events, runoff collects inside the stormwater planter until it reaches the height of an overflow structure, typically set 6 to 9 inches above the engineered soil layer. The overflow structure and optional perforated underdrain connect the stormwater planter to the larger pipe network, carrying excess runoff downstream.
BMP(S)	Stormwater planters (Bioretention) Tree planting
TYPE OF PROJECT	Street retrofit
WHY CHOOSE GI?	It was found that the green infrastructure solution, which integrated stormwater planters into the existing neighborhood streetscape, would not only achieve the separation goals, but would also be less inexpensive over the lifetime of the system and the added green space would improve quality of life for neighborhood residents.

BENEFITS	Social Benefit: • Improved neighborhood aesthetics Environmental Benefit: • Reduction in CSO events • Improved water quality in Little Eagle Creek Economic Benefit: • Approximately 25% cost savings from conventional solution for a 20-year life cycle • Complied with consent decree requirements and avoided associated fines • Cost saving through public private partnership with Keep Indianapolis Beautiful (KIB) for long-term maintenance of stormwater planters
PERMITS NEEDED	IDEM Rule 5 Permit City of Indianapolis Drainage Permit
LOCATION MAP	
PROJECT BOUNDARY	

PROJECT PHOTOS *Before photo of CSO 033 neighborhood*	
After photo shows the integration of stormwater planters into existing neighborhood	

Stormwater Planter under construction	
Overflow structure with domed grate	

Spring maintenance is performed by the Keep Indianapolis Beautiful Urban Naturalist Team	
NOTEWORTHY	The project utilizes a unique private public partnership with Keep Indianapolis Beautiful to maintain the stormwater planters.
DESIGNER	GUIDON DESIGN shrewsberry

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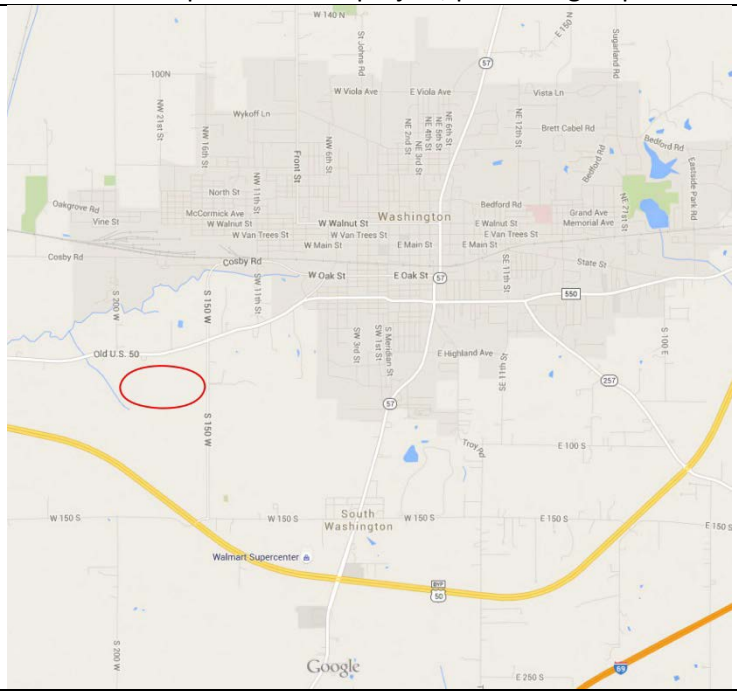
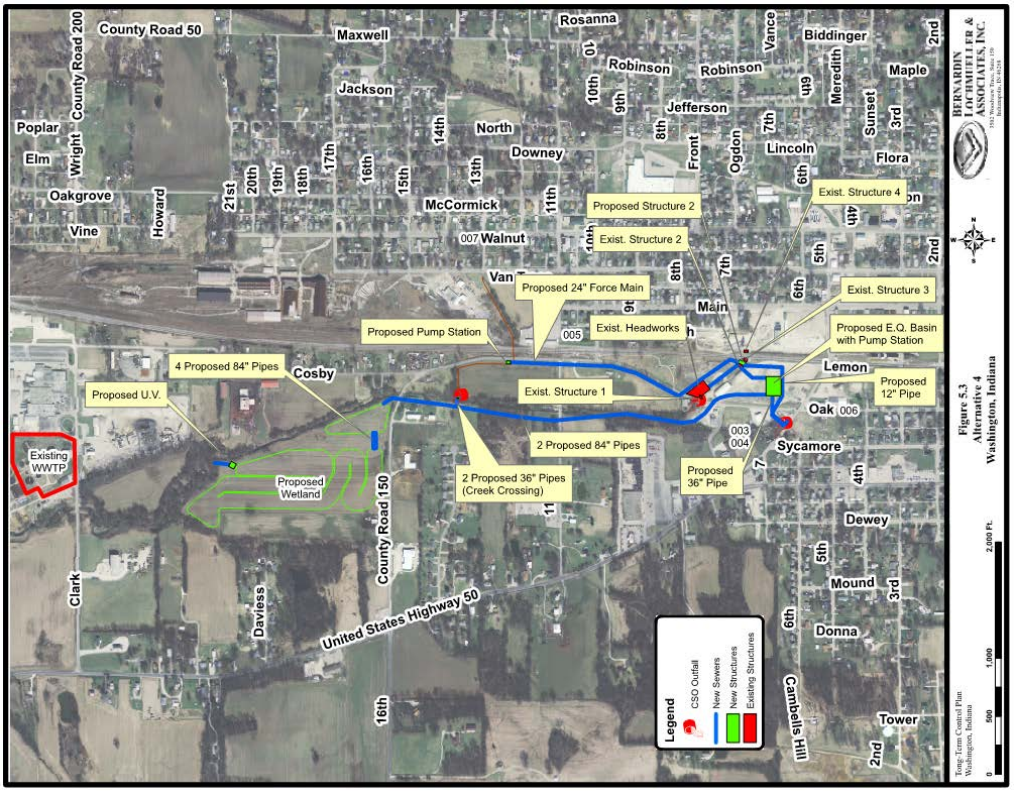
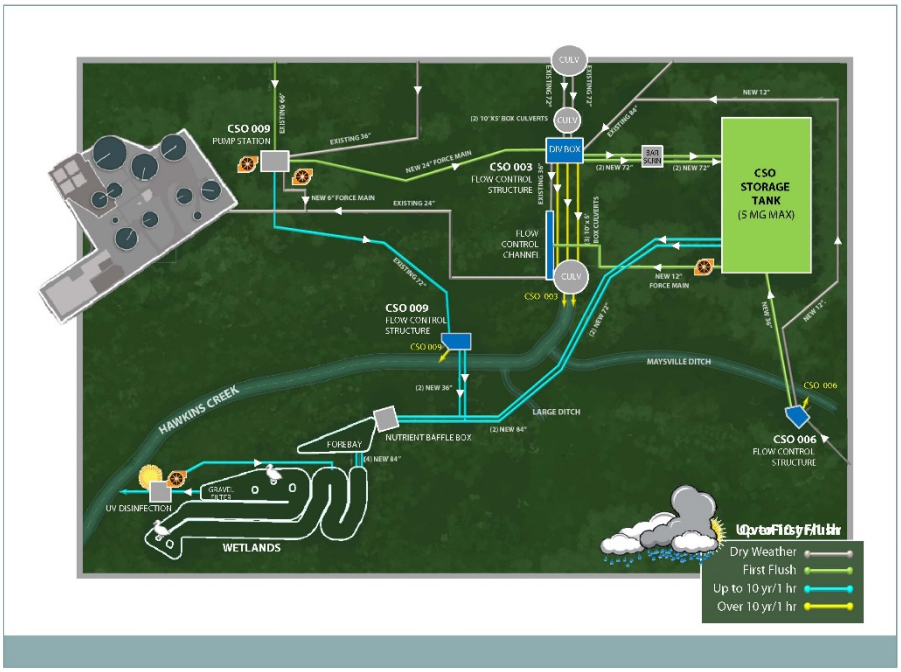
OCRA Green Infrastructure Curriculum & Training
SELECTED CASE STUDY

NAME	CSO Wetland System
LOCATION	Washington, Indiana
OWNER	City of Washington
DATE COMPLETED	July 2012
COST	**Description** — **Capital Cost** Construction Cost — $23.3 M Non-construction Costs — $2.6 M Total Cost — $25.9 M *Wetland Construction Only* — *$3.9 M*
SCALE/SIZE	27-acre Constructed Wetland
FUNDING SOURCE	OCRA grant and SRF loan
PROBLEM	The City of Washington operates a combined sanitary sewer and stormwater system and as little as one-tenth of an inch of rain will produce a combined sewer overflow (CSO). Estimates to separate the sewers were over $60 million, well beyond the capacity of the citizens to afford. The City's main waterway, Hawkins Creek that received the City's CSOs, supported no aquatic life. The creek ran dry most of the time apart from when the untreated CSO was discharged. In between rains, the water pooled and then dried up, concentrating pollutants. The only clean water being discharged into the creek came from the City's wastewater treatment plant. A 2001 study of water quality found that the water in Hawkins Creek exceeded safe levels of Biochemical Oxygen Demand, Total Suspended Solids, and ammonia.
SOLUTION	The City decided the best approach was to store the CSO effluent in a constructed wetland to allow for more time to treat the effluent, while at the same time undertaking improvements to actually separate the two systems. The City made improvements throughout the service area to maximize flow to the wastewater treatment plant and alleviate combined sewer overflows, including a 27-acre constructed wetland with ultra-violent disinfection.
BMP(S)	Constructed Wetland
TYPE OF PROJECT	New construction
WHY GI USED?	The City compared a grey only alternative to a combination grey and green alternative, and chose the combined alternative because it was the most cost-effective solution.

Description	**Capital Cost**	**Annual O&M**	**Total Present Worth Value**
Grey Only Alternative	$52.8	$1.6	$80.0
Grey and Green Alternative (includes constructed wetland)	$25.9	$0.03	$26.2

The grey and green alternative saved money both in upfront capital and ongoing

	operation and maintenance. It also requires less energy and chemicals to operate compared to traditional wastewater treatment.
BENEFITS	Social Benefit: • Constructed wetland itself is visually pleasing Environmental Benefit: • Water quality has improved in Hawkins Creek and aquatic life has been restored • Constructed wetland provides habitat for wildlife • Reduced flooding Economic Benefit: • Saved the community money, both in construction and maintenance • Requires less energy and chemicals vs. traditional treatment
PERMITS NEEDED	The permitting requirements for this project included: 1. IDEM Construction Permit 2. IDEM 'Rule 5" Erosion Control Permit 3. IDEM NPDES Permit Revision 4. US Army Corps of Engineeirs Nationwide Permit No. 12 – dredging associated with utility lines crossing the waters of the U.S. 5. IDNR – determination of the peak flow rates in Hawkins Creek 6. IDNR – determination of the floodway & floodplain for Hawkins Creek 7. IDNR Construction in a Floodway Permit 8. US Fish & WildLife mitigation for tree removal along a waterway Due to the uniquiness of this project, permitting requirements were a challenge.
LOCATION MAP	

PROJECT BOUNDARY	
SCHEMATIC OF SYSTEM	

PROJECT PHOTOS *Hawkins Creek before*	
84-inch *Conveyance pipes to the constructed wetland*	

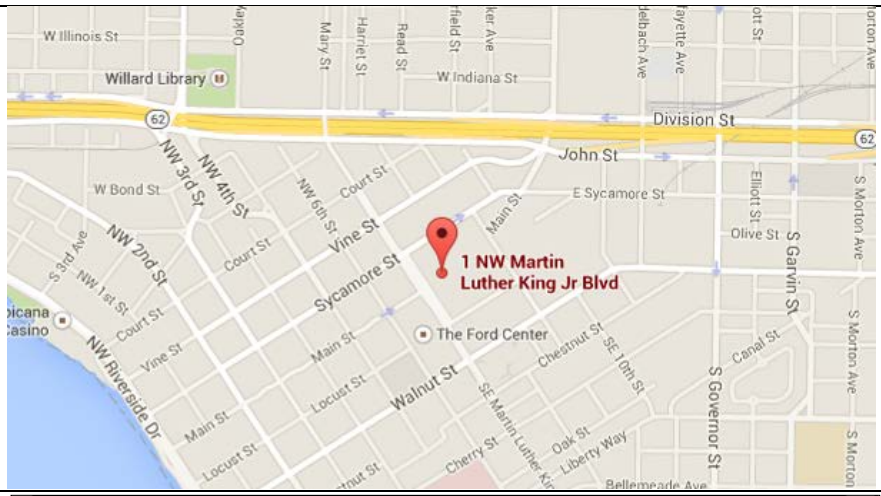
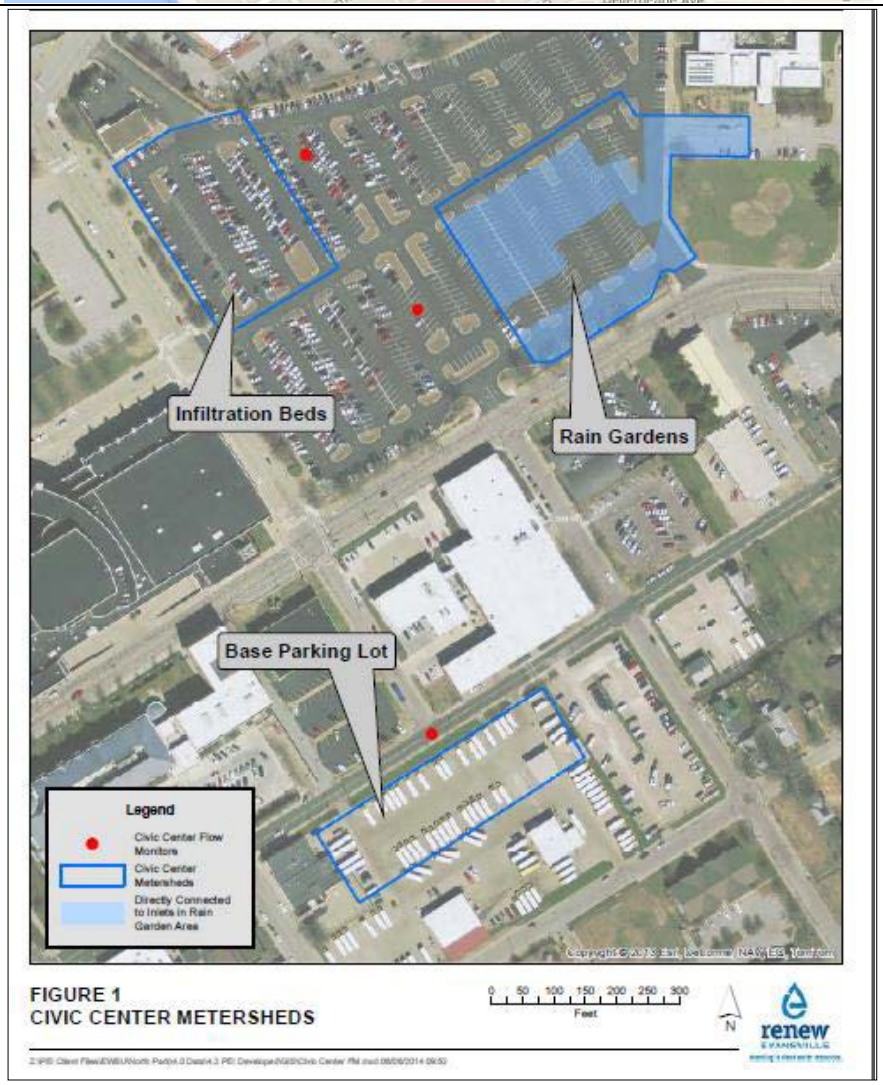
5-MG Storage Tank Under Construction	
Constructed wetland under construction	

Constructed wetland – 2nd operational season in July 2013	
NOTEWORTHY	The system was recognized with the following: 2011 *Water & Wastes Digest* Top 10 Project 2012 *ENR Midwest* Top Infrastructure Project 2013 ACEC Indiana Engineering Excellence Honor Award 2013 ACEC National Engineering Excellence Honor Award
DESIGNER	LOCHMUELLER GROUP

OCRA Green Infrastructure Curriculum & Training Program

SELECTED CASE STUDY

NAME	Civic Center Back 40 Infiltration Basin Project
LOCATION	Evansville, Indiana
OWNER	Evansville Vanderburgh Building Authority
DATE COMPLETED	January 2013
COST	$1.1M construction cost
SCALE/SIZE	190,000 square feet parking area
FUNDING SOURCE	Sewer Utility Revenue Bond
PROBLEM	Evansville's sewer system has a history of maintenance and system capacity problems that result in it being overwhelmed by rainfall, causing it to discharge untreated sewage into the Ohio River. The City of Evansville and Evansville Water and Sewer Utility entered into a consent decree, a binding legal agreement, with the EPA, Department of Justice and State of Indiana in November 2010. That agreement was approved by a federal court in June 2011. The consent decree outlines Evansville's plan to significantly reduce its combined sewer overflows. That action plan is *Renew Evansville.* This project is listed in the City's action plan to reduce stormwater runoff and combined sewer overflow (CSO) events.
SOLUTION	Retrofit an existing parking lot with areas to store and infiltration stormwater runoff and prevent it from entering the combined system and CSO event.
BMP(S)	Bioretention islands (landscaped and rock-filled) Underground infiltration system
TYPE OF PROJECT	Parking lot retrofit
WHY GI USED?	To reduce CSO events and to test pilot infiltration practices on a large scale for possible use elsewhere in the urban core.
BENEFITS	Social Benefit: • Additional landscaped area adjacent to government buildings • Additional parking for downtown businesses and amenities Environmental Benefit: • Redirects approximately 6 million annual gallons from the combination sewer system reducing CSO events Economic Benefit: • Infiltration reduces the grey infrastructure costs of handling CSO discharge
PERMITS NEEDED	IDEM Rule 5

LOCATION MAP	
PROJECT BOUNDARY	

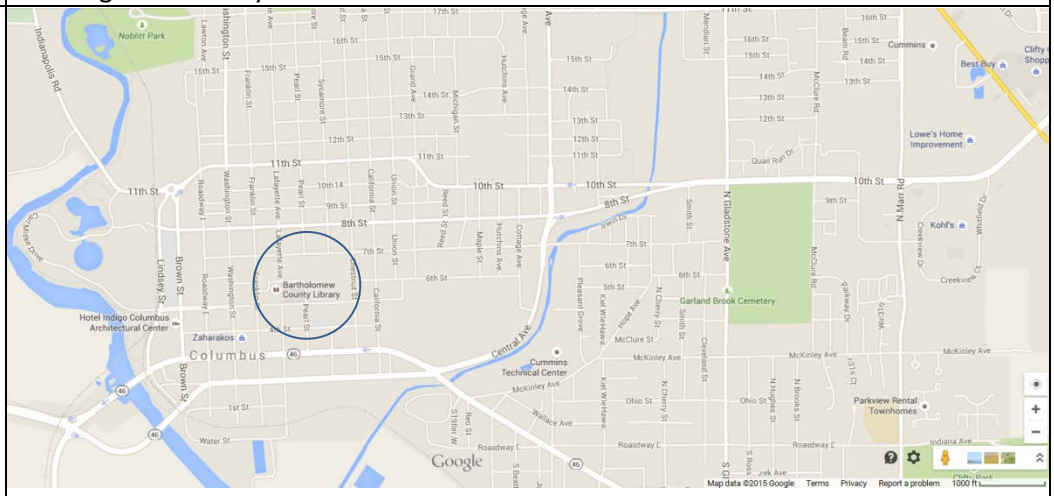
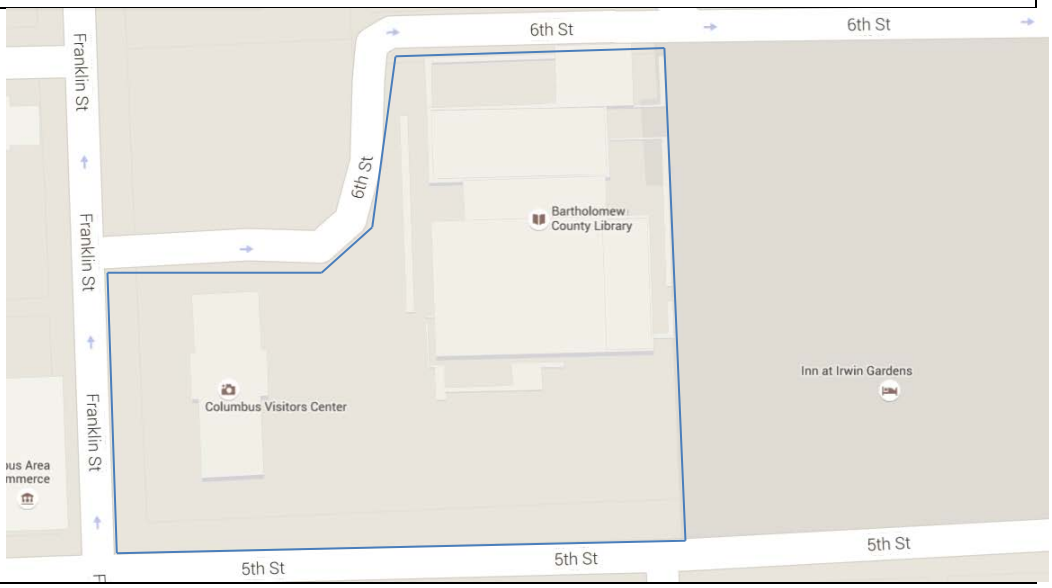
PROJECT PHOTOS *Construction of bioretention islands*	
Completed bioretention islands (landscaped near building and rock-filled in parking area)	

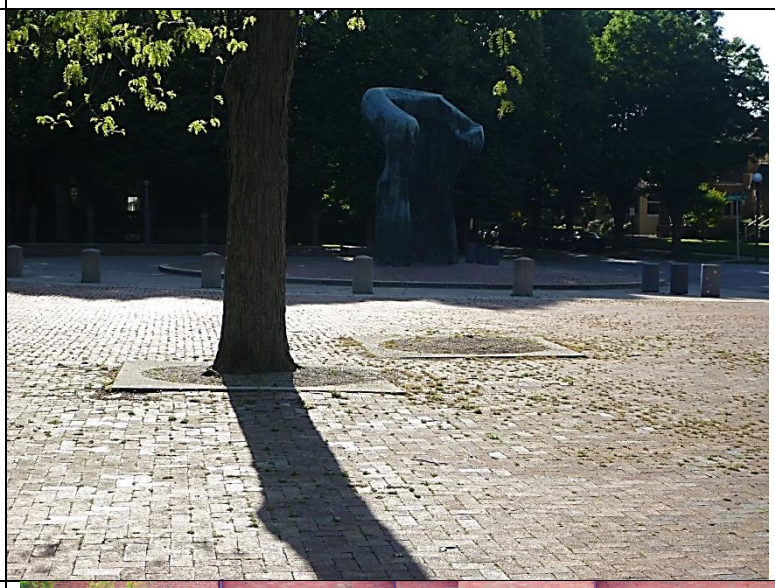
Construction of underground infiltration bed in parking lot	
NOTEWORTHY	Highly visible pilot project using green infrastructure to capture and redirect approximately 6 million gallons of stormwater runoff from the combined sewer system to reduce CSO events.
DESIGNER	AMERICAN STRUCTUREPOINT INC.

OCRA Green Infrastructure Curriculum & Training

SELECTED CASE STUDY

NAME	Cleo Rogers Memorial Library Plaza Renovation
LOCATION	Columbus, Indiana
OWNER	Bartholomew County Public Library
DATE COMPLETED	July 2014
COST	$75,000 construction cost
SCALE/SIZE	Approximately 15,000 square feet of impervious surface area routed to infiltration beds
FUNDING SOURCE	The Bartholomew County Public Library
PROBLEM	The plaza, completed in 1969, was constructed of brick pavers on a sand setting bed. The wide front steps to the main entrance were also brick. Over time, a significant portion of the bricks had settled, while others had deteriorated due to years' worth of repeated freeze-thaw cycles. The result was a plaza and main entry-way that featured significant trip hazards and ADA-compatibility concerns. Additionally, the majority of the plaza drained to a single combined sewer drain located along Fifth Street, causing it to experience significant ponding during heavy rains.
SOLUTION	The redesign of the plaza incorporated the use of a series of green infrastructure techniques including a rain garden feature, infiltration trenches, tree planters and an overflow infiltration bed. The native soil has infiltration rates which allowed for green infrastructure practices that completely eliminate the site's connection to the combined sewer. The drainage on site is connected via trench drains which have a perforated underdrain which outlets to an underground storage bed. There is an adjacent tree pit with amended soil that allows for infiltration to move from the tree pit to the storage bed.
BMP(S)	Rain garden Infiltration trench and infiltration bed Tree planters
TYPE OF PROJECT	Plaza reconstruction
WHY CHOOSE GI?	Green infrastructure was selected as an alternative to connecting the property's drainage to the existing separated storm network on the north side of the property. That would have required more demolition and disturbance of land than the proposed extents of construction for the renovation of the plaza. By using green infrastructure the design eliminated the connection to the combined sewer and the need to run a connection to the existing separated storm network.
BENEFITS	Social Benefit: • Redesigned plaza engages library patrons with its elegant and functional design • Creates an outdoor gathering place for library and other public functions • Restores ADA accessibility to the library Environmental Benefit: • 15,000 square feet of impervious surface area runoff is diverted from entering the combined sewer • 100% of stormwater runoff infiltrates into the ground on site Economic Benefit: • Cost savings by avoiding connection to the existing storm network

PERMITS	IDEM Rule 5 Permit Drainage Permit City of Columbus
LOCATION MAP	
PROJECT BOUNDARY	

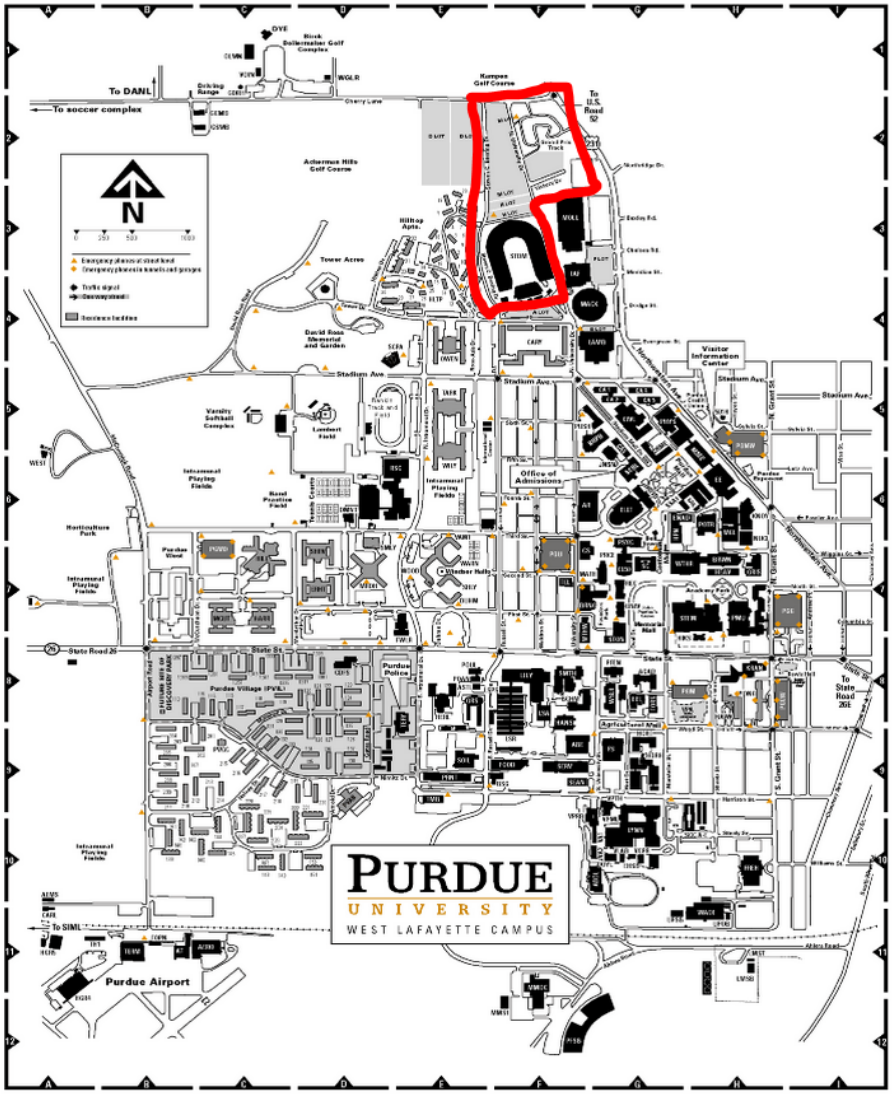
PROJECT PHOTOS	
Before photo of main plaza showing uneven settling and deterioration of brick pavers	
Main plaza after construction with rain gardens	

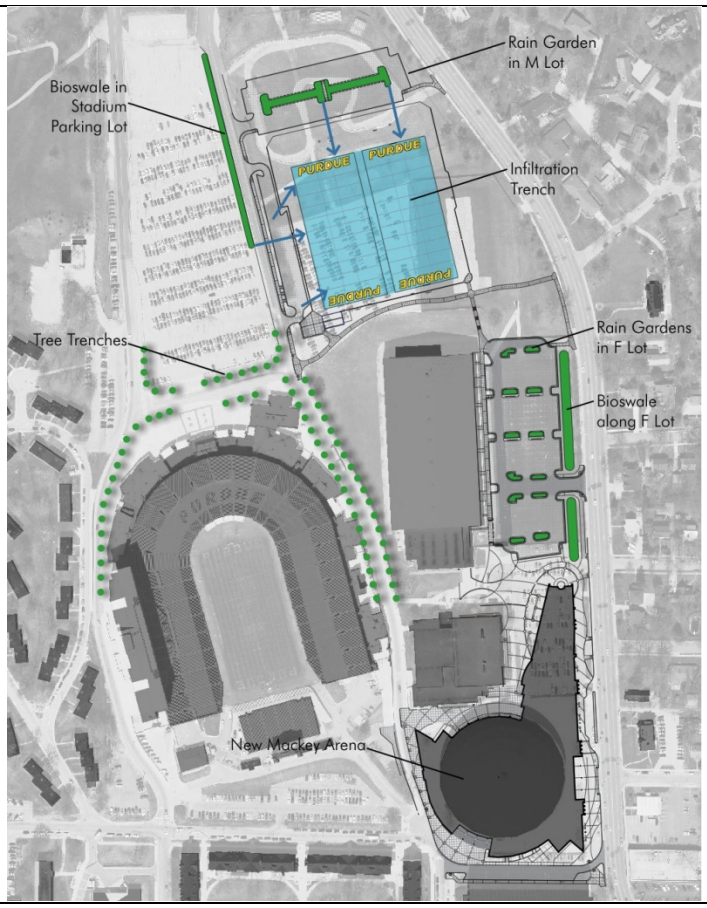
After photo of plaza being used as an event space	
Close up photo of the rain garden and new pavers	
Noteworthy	The infiltration characteristics of the native soils in Columbus allowed for zero stormwater discharge from the site. Thus eliminating the cost to connect to and contribution to existing combined sewer system.
Designer	STRAND ASSOCIATES® bluemarble design

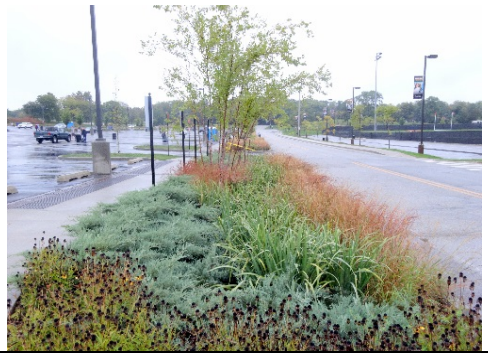
OCRA Green Infrastructure Curriculum & Training

SELECTED CASE STUDY

NAME	Purdue University, Mackey Athletic Facility
LOCATION	West Lafayette, IN
OWNER	Purdue University
DATE COMPLETED	March 2009
COST	Design: $295,000 Construction: $1,487,000 Total Cost: $1,782,000
SCALES/SIZE	Approximately 20 acres
FUNDING SOURCE	Purdue University
PROBLEM	The large existing parking lot for the Purdue Mackey Athletic Complex had no existing green space and generated a large volume of stormwater runoff. This runoff was managed with standard stormwater infrastructure with minimal volume or pollutant reduction. The area was subject to frequent localized flooding.
SOLUTION	Green infrastructure is used to capture and filter stormwater runoff. Runoff is pretreated in the bioswales and bioretention islands through the soils and vegetation before overflowing to large clean-washed stone infiltration beds below the practice football fields. During very high flow events, the infiltration beds discharge back into the stormwater system.
BMP(S)	Bioswale Bioretention Islands Subsurface Infiltration Beds
TYPE OF PROJECT	Parking lot retrofit Practice football field retrofit
WHY GI USED?	The University recognized that the parking lot coupled with the renovation of the adjacent practice football fields provided an opportunity to store and filter water close to where it was generated.
BENEFITS	Social Benefit: • Promotes campus greening • Meets the parking needs for athletic facility Environmental Benefit • Reduces campus flooding • Improves water quality • Reduces the urban heat island effect • Creates natural habitat Economic Benefit: • Used locally-sourced, sustainable materials.
PERMITS NEEDED	Purdue University Stormwater Permit

LOCATION MAP	

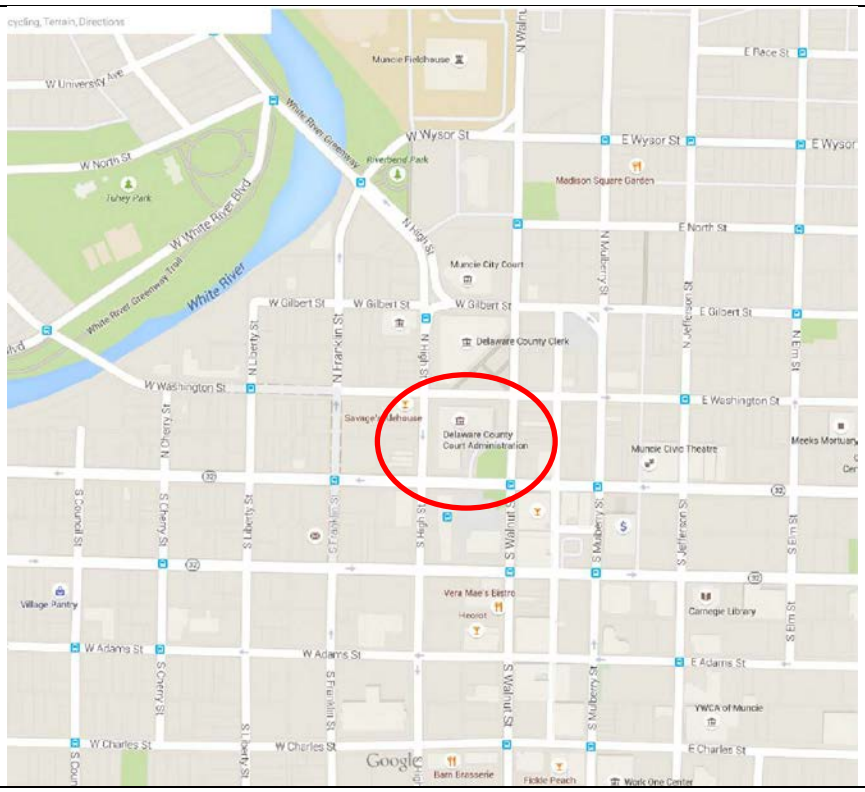
PROJECT BOUNDARY	
PROJECT PHOTOS *Parking lot before addition of green infrastructure*	
During construction	

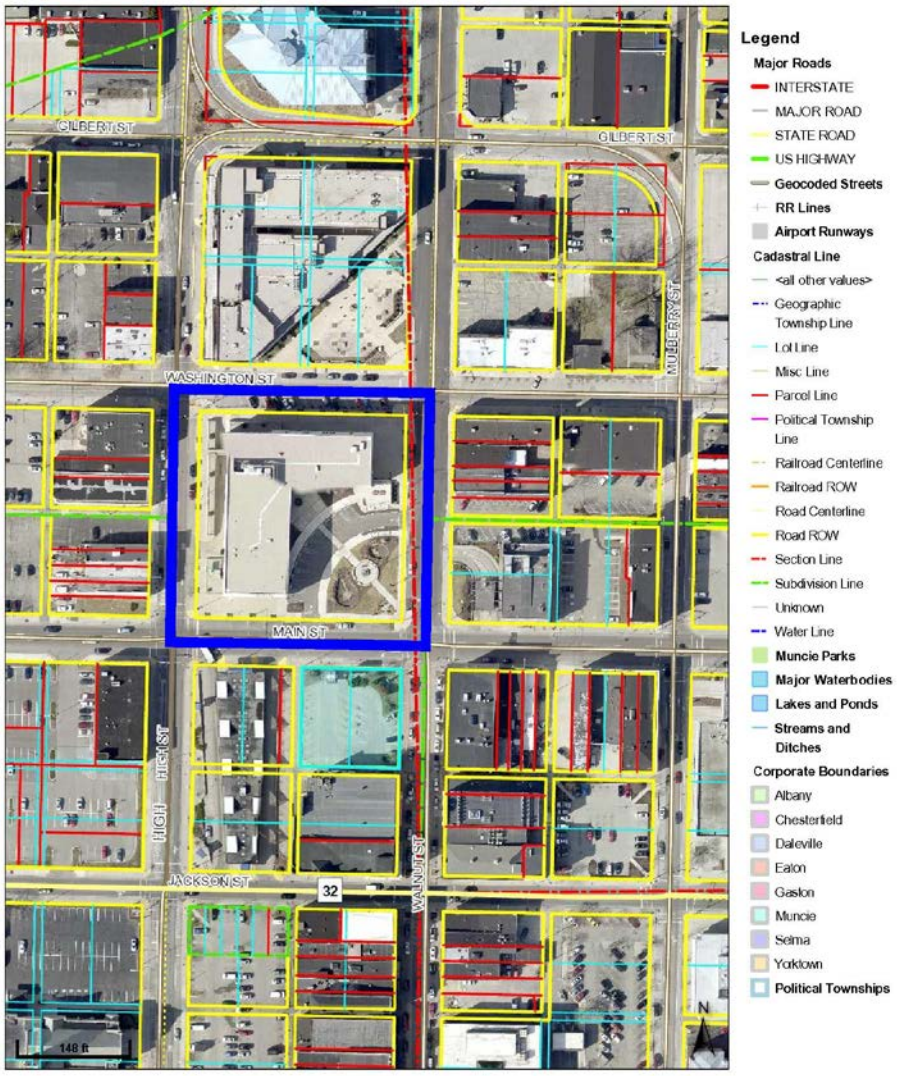
After construction	
After construction	
NOTEWORTHY	A highly visible example and effective use of green infrastructure in a parking area and under practice football fields.
DESIGNER	Meliora Design

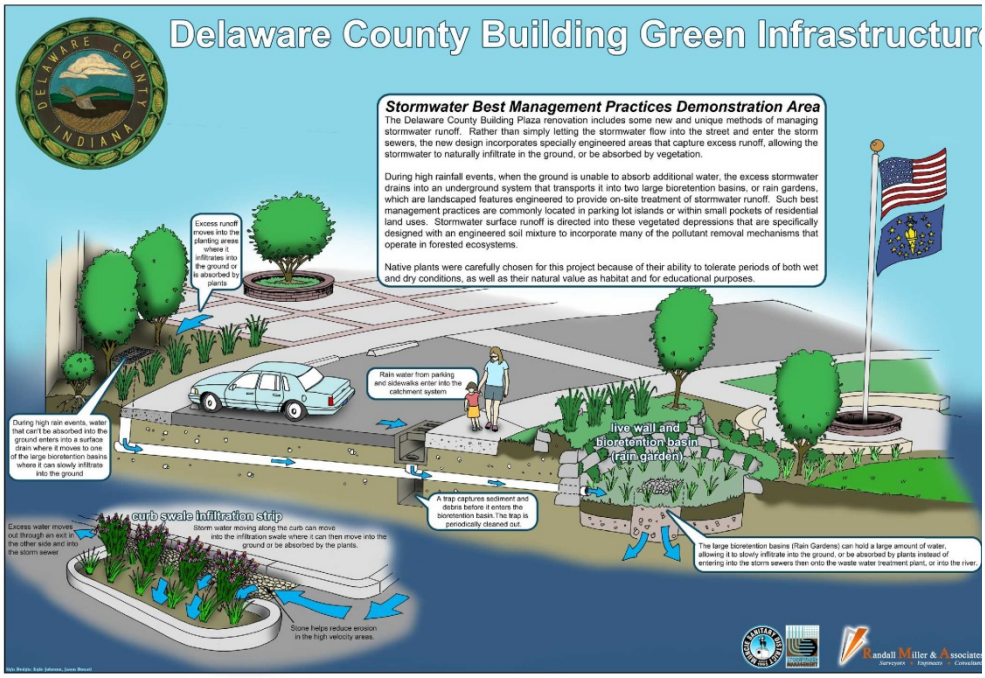
OCRA Green Infrastructure Curriculum & Training

SELECTED CASE STUDY

NAME	Delaware County Courthouse Plaza
LOCATION	Muncie, IN
OWNER	Delaware County Commissioners
DATE COMPLETED	October 2011
COST	Engineering = $47,500 Construction = $624,487 (No comparison to grey, project was designed and intended to replace grey)
SCALE/SIZE	9,500 square feet, 1 city block
FUNDING SOURCE	EDIT and local Stormwater Utility Fees
PROBLEM	The Delaware County Commissioners were faced with the problem of renovating the Courthouse Plaza. It was entirely concrete and stormwater runoff contributed to combined sewer overflow (CSO) events in the City of Muncie. In addition, the Plaza lacked ADA accessible parking.
SOLUTION	The County Commissioners desired a renovation project that included green infrastructure and to illustrate how it can reduce nuisance flooding, improve water quality, recharge the groundwater, and add green space to an otherwise impervious plaza. The project also added 10 much needed ADA parking spaces.
BMP(S)	Bioretention Infiltration trenches
TYPE OF PROJECT	Plaza retrofit
WHY GI USED?	The native soils have a high infiltration rates and stormwater could be used to recharge the groundwater and not contribute to CSO events.
BENEFITS	Social Benefit: • The landscaped courtyard is more aesthetically pleasing and has become a prominent education tool of the benefits of green infrastructure. • Provided ADA accessibility and parking Environmental Benefit: • Improved water quality, groundwater recharge, and reduced nuisance flooding. Economic Benefit: • 9,500 square feet of impervious surface was eliminated in addition to the stormwater it contributed to the combined sewer system.
PERMITS NEEDED	City of Muncie Stormwater Permit

LOCATION MAP	

PROJECT BOUNDARY	Delaware County Plaza Reconstruction 

PROJECT SCHEMATIC	
PROJECT PHOTOS *Before*	

After plaza reconstruction	
View of bioretention area	

View of bioretention area	
View of new ADA parking and bioretention area	
NOTEWORTHY	1. Recipient of the "2012 Outstanding Stormwater Project" Award by the Indiana Association for Floodplain and Stormwater Management, Inc. 2. The "live wall" on the banks of the bioretention basin is noteworthy because the application is atypical.

DESIGNER	 Randall Miller & Associates Inc. Surveyors • Engineers • Consultants	

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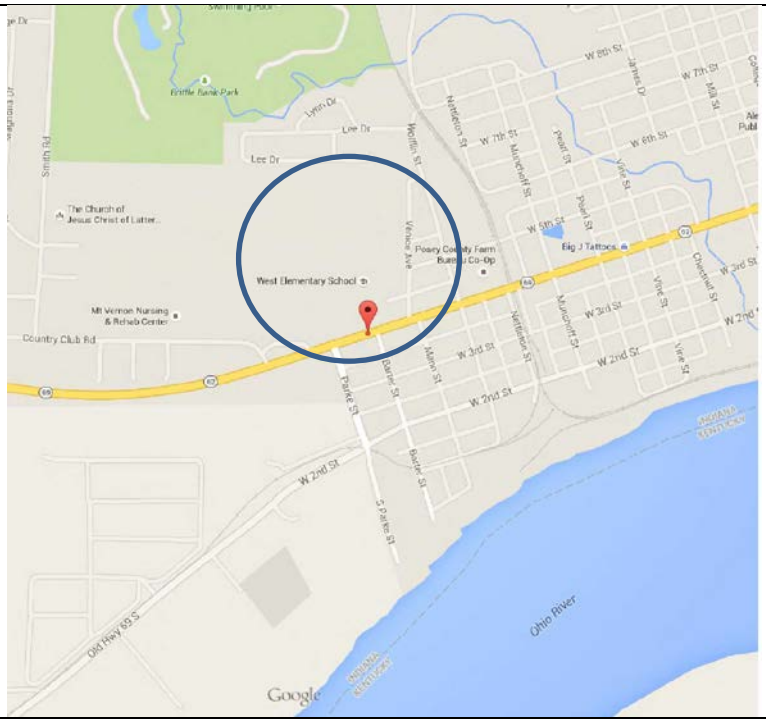
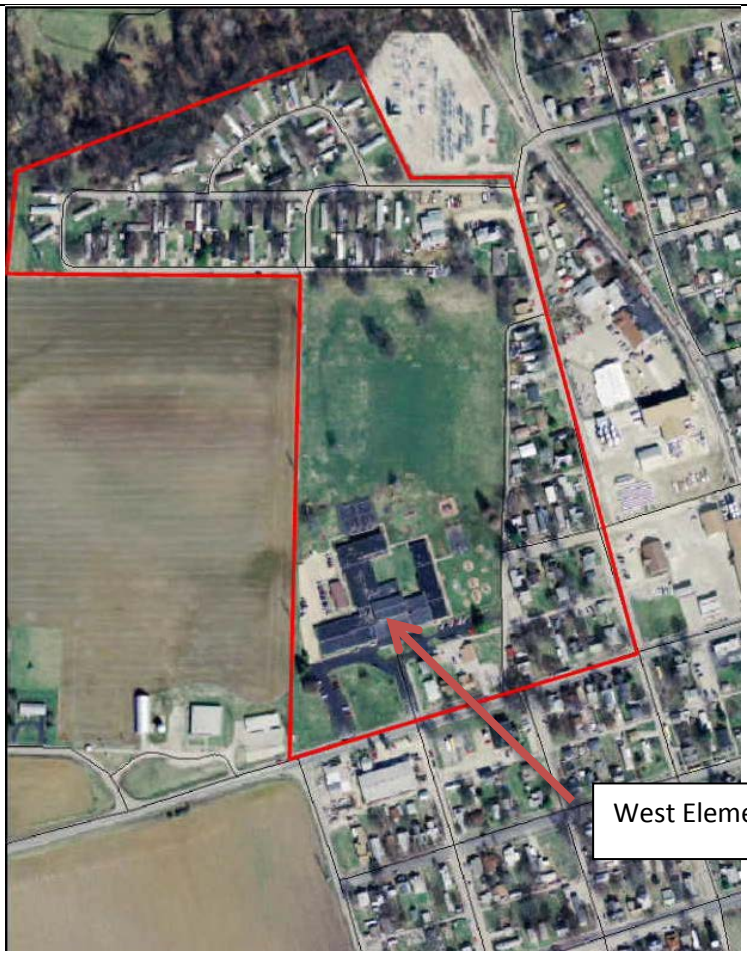
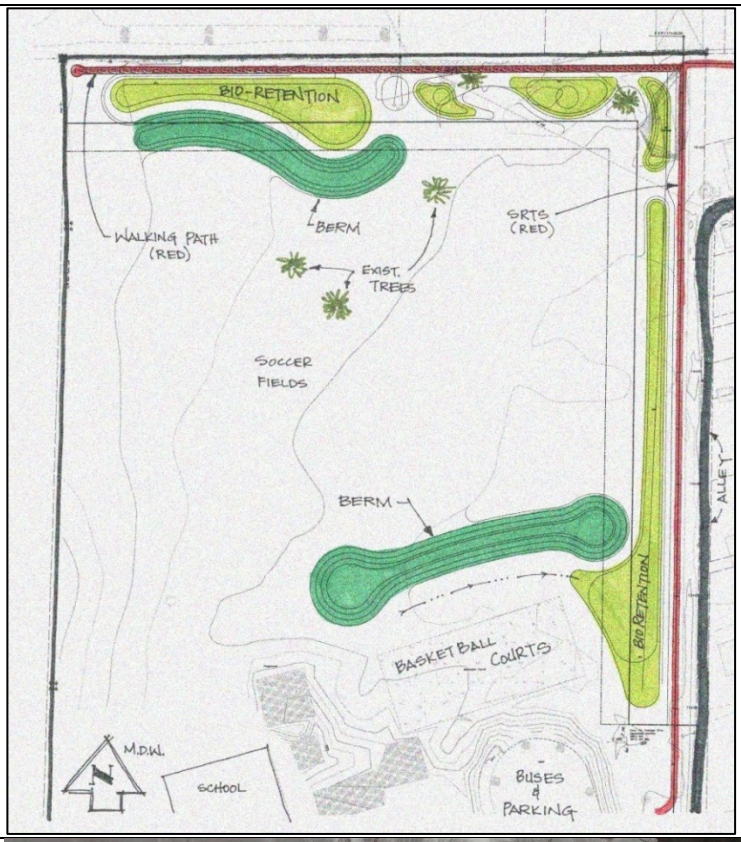
OCRA Green Infrastructure Curriculum & Training

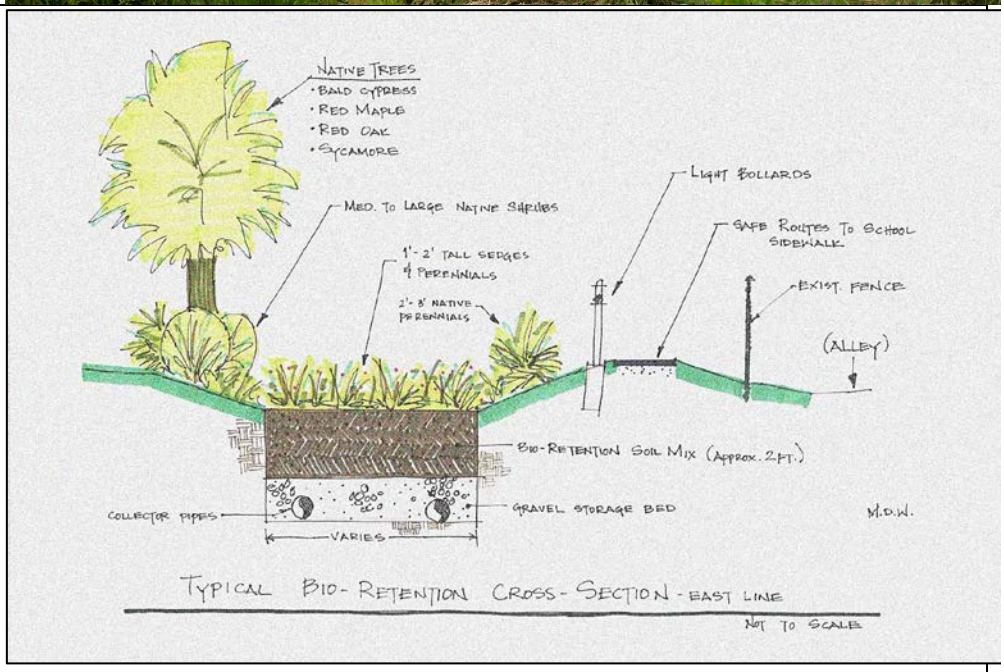
SELECTED CASE STUDY

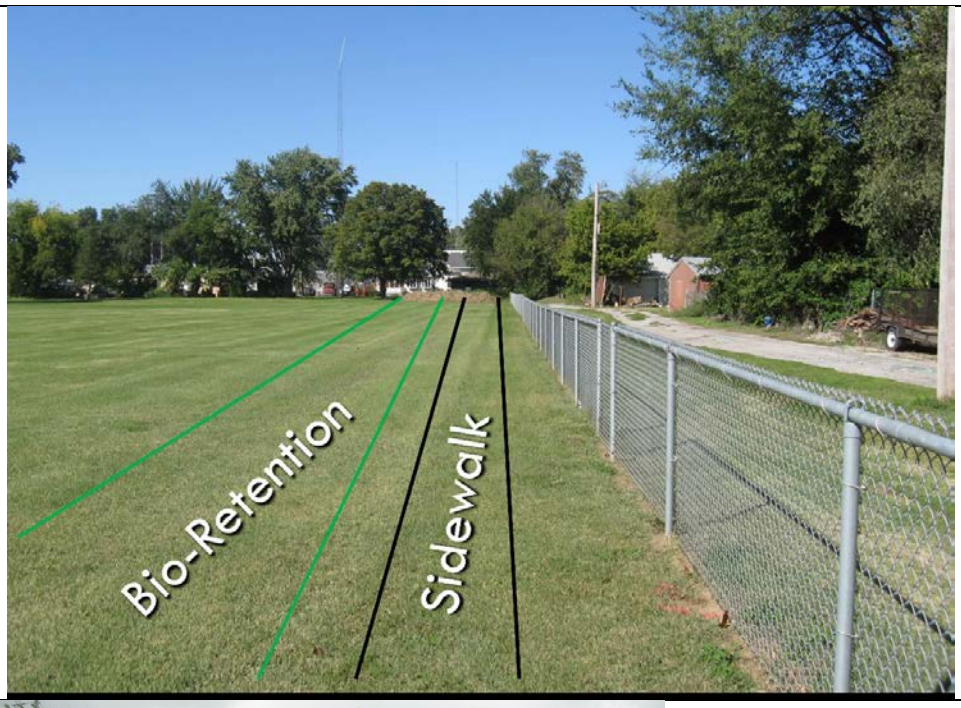
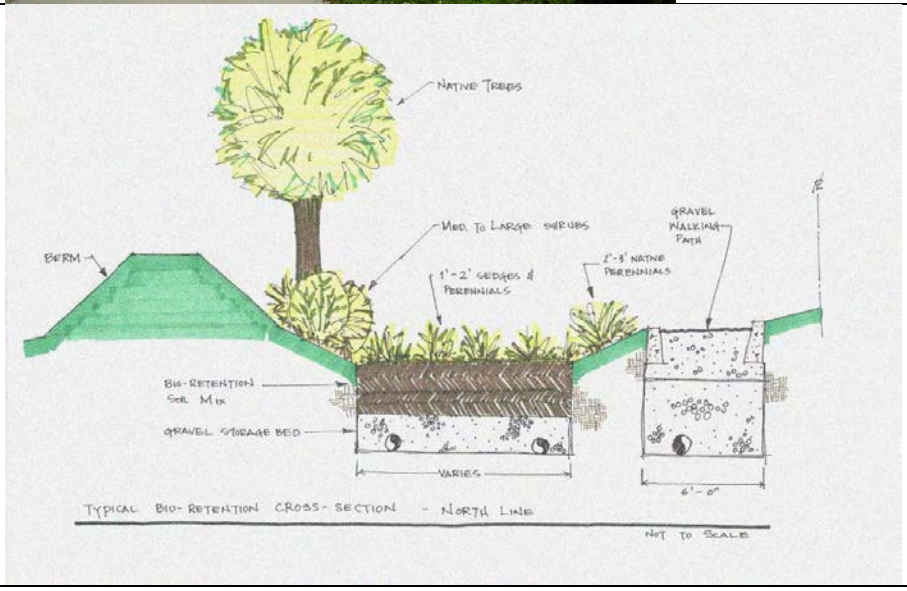
NAME	West Elementary School Drainage Improvements
LOCATION	Mount Vernon, IN
OWNER	City of Mount Vernon
DATE COMPLETED	December 2012
COST	Construction: $400,000 Non-construction: $185,287 Total: $585,287
SCALE/SIZE	22,500 square feet bioretention
FUNDING SOURCE	$524,287 OCRA grant from the Stormwater Improvements Program ("SIP") with Local Match dollars from the City Sewer Fund and the Mount Vernon School Corporation. The city paid for a portion of the design engineering and the School Corporation paid for the Preliminary Engineering Report.
PROBLEM	The City of Mount Vernon suffered from localized flooding at the West Elementary School and the surrounding neighborhoods to the north and east. Despite improvements to address the issue, the city's stormwater system was not large enough to alleviate the flooding, which would occur with as little as 2 inches of rain. The school and neighborhoods total about 34 acres. Specifically, the neighborhoods contain approximately 62 residences. The flooding forced neighborhood children to walk to school in city streets instead of sidewalks, prevented to use of the school's playground, and negatively impacted homeowners' yards, residences, and personal property. Through the use of an income survey of the neighborhoods that surrounded the school, the city discovered it would be eligible for an OCRA Community Development Block Grant (CDBG). The project meets the CDBG National Objective by serving low- and moderate-income persons. Without CDBG grant assistance for the storm water improvements, the combined monthly water and sewer bill for these 62 households would total $126.58.
SOLUTION	The city installed 22,500 square feet of bioretention areas that capture stormwater and slowly release it to the existing storm sewer system. After the stormwater project was completed the city utilized the Indiana Department of Transportation's Safe Routes to School program to construct new sidewalks. The School Corporation granted perpetual easements to the city where the bioretention areas were installed and the city is responsible for maintaining the areas.
BMP(S)	Bioretention
TYPE OF PROJECT	Site retrofit
WHY GI USED?	The city chose the green alternative because the conventional, grey alternatives were not feasible. First, a conventional detention basin was rejected because, such a waterbody, in the vicinity of a school, is considered an "attractive nuisance", thus making it an undesirable liability. Second, a connection to the storm sewer was not feasible due to the required length of pipe and relative flatness of the terrain, which would have resulted in the pipe not having enough soil cover to meet the manufacturer's installation requirements.

BENEFITS	Social Benefit: • Neighborhood children were provided a safe route to school • Improved aesthetics at the school Environmental: • Reduced flooding and improved water quality Economic: • The bioretention areas were the most cost-effective
PERMITS NEEDED	IDEM Rule 5
LOCATION MAP	

PROJECT BOUNDARY	

PROJECT SCHEMATIC	
PROJECT PHOTOS *Flooding at the school playground - before*	

School playground after a rainy weekend today	
Schematic East Line	

Before – East Line	
After – East Line showing bioretention area and new sidewalk	
Schematic – North Line	

Before – North Line	
After – North Line showing new berms and bioretention areas	
NOTEWORTHY	Recognized in 2011 by the Midwest Council of State Community Development Agencies as a Best Practice
DESIGNER	LOCHMUELLER GROUP

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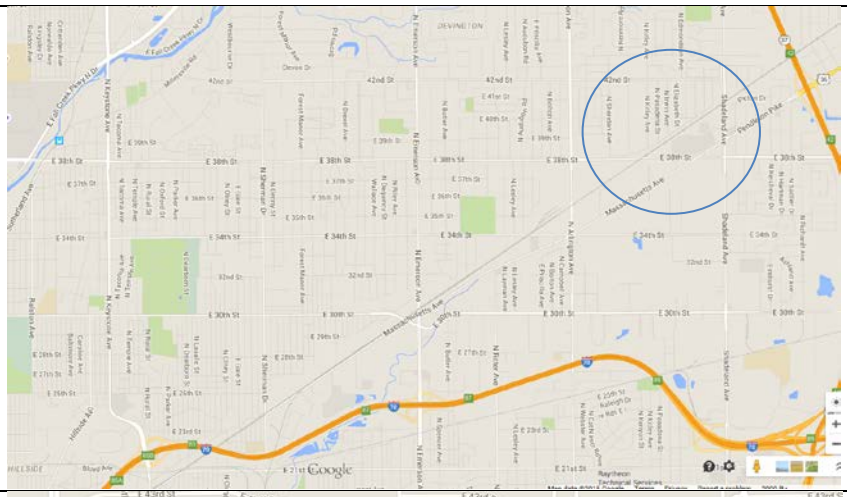
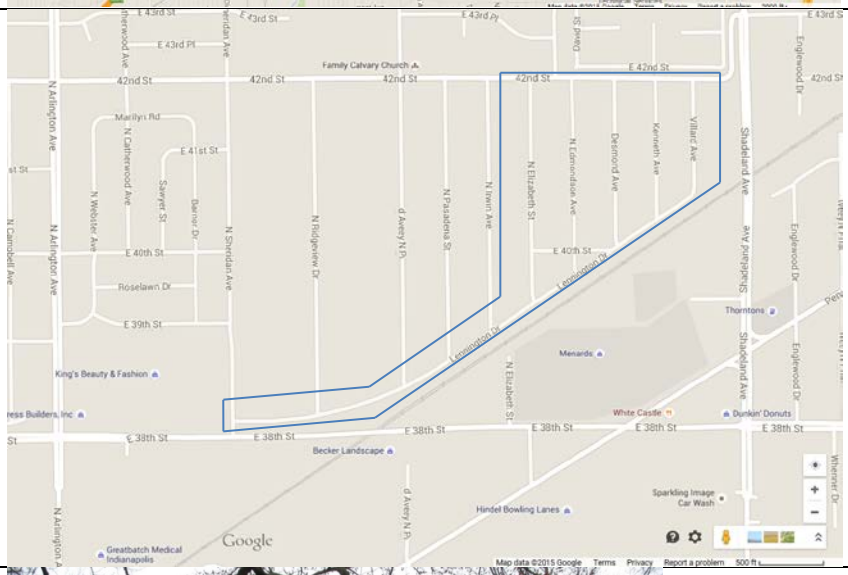
SELECTED CASE STUDY

NAME	Pendleton Pike & Shadeland Avenue Area Stormwater Improvement
LOCATION	Indianapolis, IN
OWNER	City of Indianapolis
DATE COMPLETED	April 2011
COST	$2,000,000 (construction cost)
FUNDING SOURCE	City of Indianapolis
SCALE/SIZE	4.5 miles of hybrid ditches
PROBLEM	The Pendleton Pike and Shadeland Avenue neighborhood had experienced flooding problems ranging from extensive ponding after each rain event to major flooding during more extreme events. The neighborhood was built in the 1930's with no storm sewer system. Small storm drains were added over the years as residents tried to drain local areas. However, the storm drains were ineffective because there was no appropriate outlet.
SOLUTION	As part of the Pendleton Pike and Shadeland Avenue Stormwater Improvement Project, new storm sewers in each street were installed with properly designed outlets into Pogues Run. The project also included hybrid ditches throughout the neighborhood. These are shallow swales designed to promote infiltration of stormwater, to provide water quality treatment, and to effectively reduce total runoff through volumetric storage. This system of natural swales with HDPE pipe and catch basins allowed the use of smaller storm drain pipes than would be required with a traditional storm drainage system. To ensure durability, reinforced concrete pipe was used for outlets into Pogues Run. The project included 300 new storm drain inlets, nearly 4.5 miles of hybrid ditch, and resurfacing of 3 miles of neighborhood streets.
BMP(S)	Hybrid Ditch
TYPE OF PROJECT	Street reconstruction
WHY CHOOSE GI?	Per the City ordinance, the original design was a traditional storm sewer system to accommodate a 10-year design storm. However, the required pipe sizes would have resulted in costs that were too large for the city budget. A hybrid ditch approach was developed that combined surface swales, oversized pipes for storage, and some infiltration. This is an example where green infrastructure was not the initial goal, but rather proved to be a solution that not only met the project objectives, but also resulted in realizing additional water quality and aesthetic benefits.
BENEFITS	Social Benefit: • Improved public safety and public health • Enhanced quality of life for residents in area Environmental Benefit: • Improved water quality • Eliminated street flooding Economic Benefit: • Avoided costs associated with oversized gray infrastructure to drain the project area
PERMITS NEEDED	IDEM Rule 5 Permit City of Indianapolis Drainage Permit

LOCATION MAP	
PROJECT BOUNDARY	
PROJECT PHOTOS *Before photo of the extent of street flooding*	

Before photo of typical street flooding	
After photo of the hybrid ditch showing the swale and dome grate overflow inlet	

After photo of the hybrid ditch	
NOTEWORTHY	Minimal sloping in the neighborhood presented a design contraint that challanged the project team to develop a unique drainage solution that incorporated green infrastructure into the final design.
DESIGNER	Christopher B. Burke Engineering, LLC

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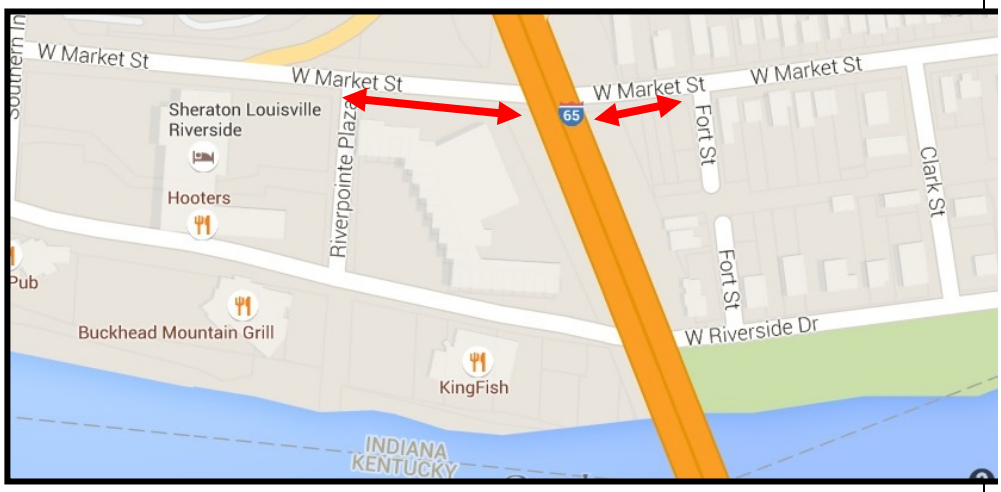
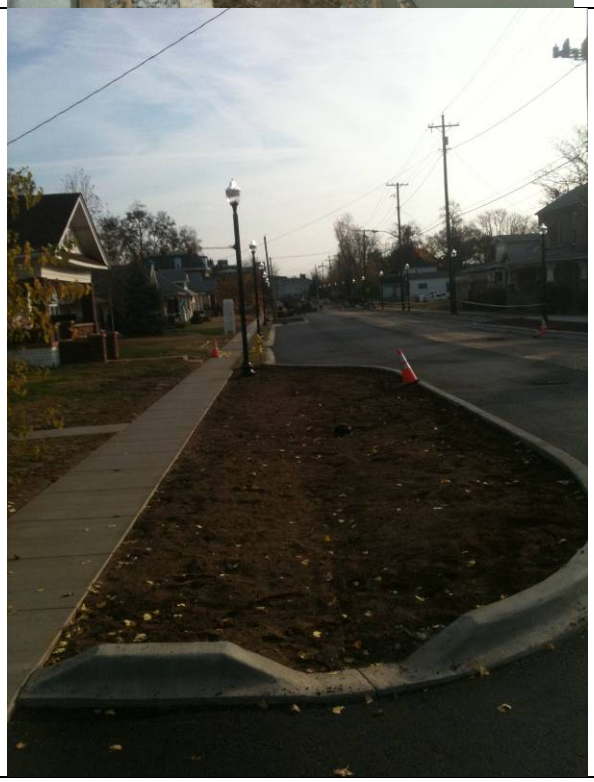
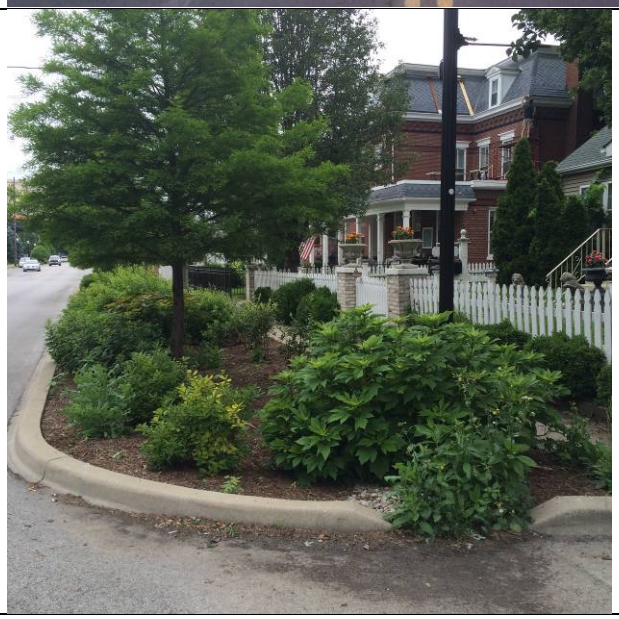
SELECTED CASE STUDY

NAME	Market Street Pilot Project
LOCATION	Market Street
OWNER	City of Jeffersonville
DATE COMPLETED	November 2010
COST	$175,000 for the street/curb/bioswale work, and an additional $40,000 for the lighting. Labor for construction and design was done in house.
SCALE/SIZE	1 city block
FUNDING SOURCE	City Wastewater, Drainage, and Redevelopment TIF
PROBLEM	The City of Jeffersonville is a combined sewer community and as such has a consent decree with the EPA to reduce combined sewer overflows (CSOs). The sewers in this stretch of Market Street needed to be separated and at the same time the city was in discussions about how the function and look of this corridor could be improved.
SOLUTION	The City Administration, Sewer Board, Drainage Board, and the neighborhood residents came together to discuss possibilities and installing a series of bioretention bump-outs were agreed upon. To accommodate these bump-outs in the street, some parking was eliminated but the City got input from the residents about which ones preferred to have parking, and which preferred to have a landscaped bump out. Both the residents and city staff are happy with the results. It served as an example and pilot project for a few other areas in the downtown area. Stormwater from the street and sidewalk enters the bioretention bump outs and is filtered by the engineered soil and native plants. During heavier rain events, the bioretention area is designed to temporarily store stormwater and discharge it into an overflow pipe to prevent the street from flooding. All of the overflow pipes are tied to a separated stormwater pipe that empties into the Ohio River. If the water level never reaches the overflow pipes, the rain water is captured and absorbed into the ground.
BMP(S)	Bioretention
TYPE OF PROJECT	Street retrofit
WHY GI USED?	GI was used for Environmental, aesthetics, and regulatory reasons.
BENEFITS	Social Benefit: • Creates a neighborhood identity • Improves the aesthetics • Provides a traffic calming effect • Included installation of new sidewalks and street lighting Environmental Benefit: • Reduces street flooding • Improves water quality • Creates green space for urban wildlife Economic Benefit: • Improves local real estate values on the street and in the adjacent

	downtown business district
PERMITS NEEDED	No permits needed
LOCATION MAP	
PROJECT BOUNDARY	From Fort Street to Mulberry Street
PROJECT PHOTOS *During construction*	

Installation of new sidewalks		
Construction of bioretention bump outs		

Street view after construction	
Four years after installation	
NOTEWORTHY	Highly visible project designed and implemented by city staff. Project success attributed to public engagement and good communication with residents.
DESIGNER	

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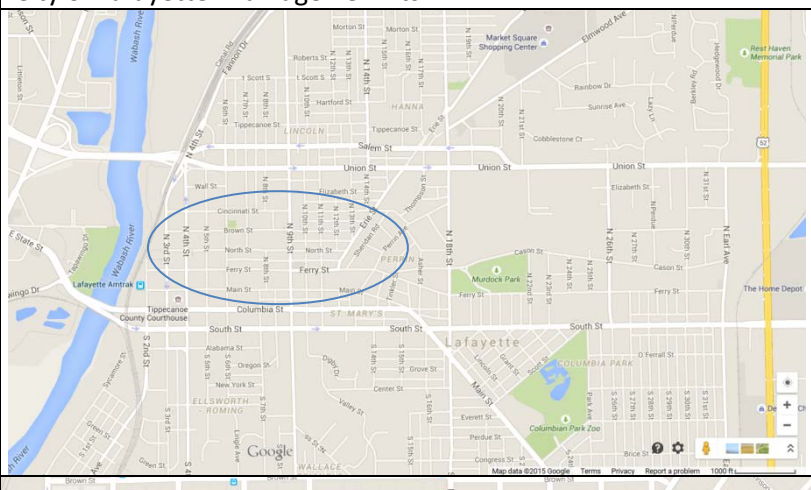
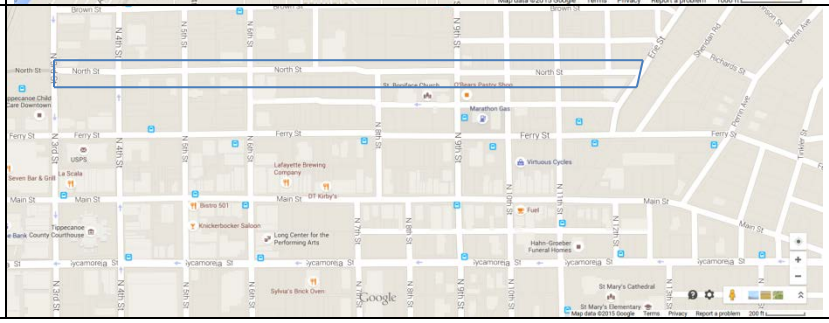
SELECTED CASE STUDY

NAME	North Street Reconstruction and Integrated Stormwater Management
LOCATION	Lafayette, Indiana
OWNER	City of Lafayette
DATE COMPLETED	October 2013
COST	$1.68 million
SIZE/SCALE	Approximately 6 city blocks
FUNDING SOURCE	Public Works Department- including transportation and stormwater funding
PROBLEM	The City of Lafayette experienced deterioration of transportation infrastructure over several decades along with combined sewer problems in their historic downtown area. North Street was identified in a Green Infrastructure Feasibility and Prioritization Study in 2010 as the best opportunity among 12 historic brick streets to utilize green infrastructure as a combined sewer overflow (CSO) abatement tool. The recommendation was based on the existing roadway condition, planned capital improvements, neighborhood revitalization efforts, and ability to eliminate volume from the combined sewer system.
SOLUTION	Based on the planning effort, the City of Lafayette moved forward with a consolidated green infrastructure solution, which incorporates green infrastructure within already planned capital improvement projects. The fully designed reconstruction effort extends approximately half a mile along North Street from 3rd Street to Erie Street. The design includes replacing the existing impervious surfaces with a new complete street concept with new drive lanes, pedestrian walkways and landscape elements. The design detains, treats, and infiltrates stormwater within the entire street section, which consists of porous pavers connected to urban rain gardens utilizing a substantial stone base throughout for underground storage and storm attenuation. The deconstructed and salvaged historic brick was reused for architectural elements throughout the project. The North Street Reconstruction project replaced the originally planned storm sewer redirection and underground storage tank project approved as part of the City's original consent decree and has helped create a catalyst for neighborhood revitalization by improving pedestrian connectivity, ADA 2012 compliance, parking and vehicular traffic controls, intersection improvements, and streetscape conditions.
BMP(S)	Permeable pavers Stormwater planters
TYPE OF PROJECT	Street reconstruction
WHY CHOOSE GI?	Green infrastructure was an effective way to address combined sewer overflows and the deterioration of the existing historic brick pavers. Green infrastructure was integrated into the existing conditions of the roadway, which contributed to neighborhood revitalization efforts, and was a cost effective solution that utilized planned capital improvements within the area.

BENEFITS	Social Benefit: • Significantly contributes to neighborhood revitalization and beautification efforts • Meets ADA accessibility needs Environmental Benefit: • Removal of approximately 6.6 million gallons annually from the combined sewer system • Reduces street flooding and improves water quality Economic Benefit: • Combined street reconstruction with stormwater management • Eliminates $44,000 annually in wastewater treatment costs
PERMITS NEEDED	IDEM Rule 5 Permit City of Lafayette Drainage Permits
LOCATION MAP	
PROJECT BOUNDARY	

PROJECT PHOTOS *Before photo of 9th and North Street*	
Post construction, a fire truck dumps water on permeable pavers to demonstrate their function.	
Stormwater planters are integrated into the existing streetscape and utilized deconstructed brick materials.	

After photo of 9th and North Street	
NOTEWORTHY	The North Street Reconstruction effort demonstrates the potential for municipalities to address two problems during one design and construction effort. The city benefited from increased transportation infrastructure and elimination of combined sewer overflows. The public was actively engaged throughout the planning and design effort to explain how tax dollars were being spent on the project.
DESIGNER	WILLIAMS CREEK CONSULTING

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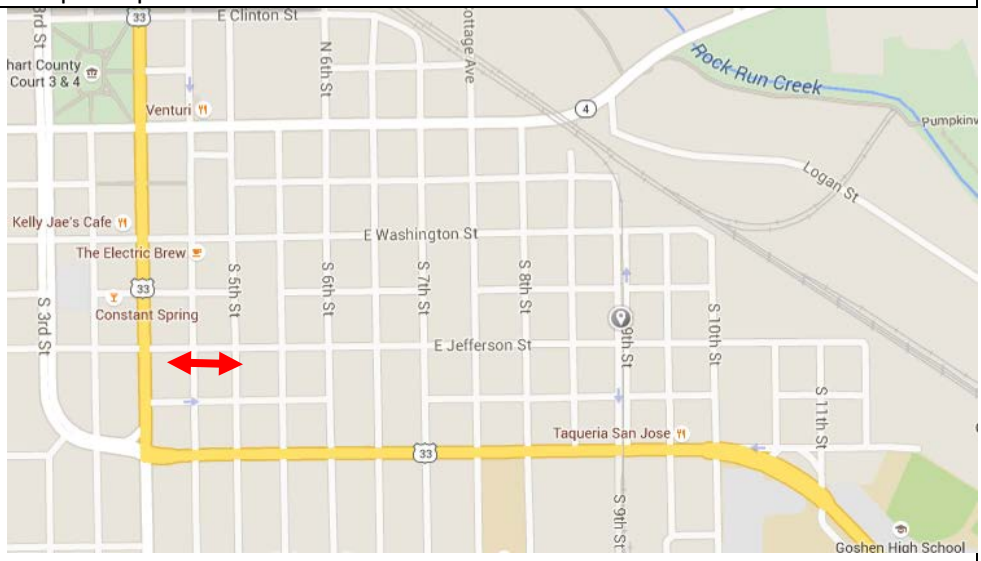
SELECTED CASE STUDY

NAME	Jefferson Street Reconstruction
LOCATION	Goshen, Indiana
OWNER	City of Goshen, IN
DATE COMPLETED	November 2013
COST	$275,000 Installation cost
SCALE/SIZE	17,000 square feet or 2 city blocks
FUNDING SOURCE	City funds
PROBLEM	Jefferson Street was plagued by an undersized sewer in the area that caused the sewer to back up into nearby building basements.
SOLUTION	The city determined that a permeable paver surface would be a cost effective solution in lieu of larger piping. Concerns about snow plowing and maintenance were at the top of the list of City officials.
BMP(S)	Permeable pavers
TYPE OF PROJECT	Street retrofit
WHY GI USED?	To reduce stormwater from entering the sewer system without having to tear up streets and install larger sewers.
BENEFITS	Social Benefit: • The selected permeable pavers look similar to cobblestone which emote a sense of unique community identity Environmental Benefit: • Less inflow of stormwater to the City's sewer system reduces the amount of water to be handled by the sewerage system. Economic Benefit: • Pavers save the City money by eliminating the need to install larger storm water pipes and as a result, having to reinstall nearby streets and sidewalks.
PERMITS NEEDED	No special permits needed
LOCATION MAP	

PROJECT BOUNDARY	
PROJECT PHOTOS *Jefferson Street before reconstruction*	
Installation of liner	

Installation of gravel base	
Installation of permeable paver system	
Close-up of permeable paver system	

After installation (8 months)	
NOTEWORTHY	The winter of 2014 (after installation) was the worst winter the City of Goshen had experienced in over 100 years with a frost depth of up to five feet and record snowfall followed by heavy spring rains. Neither extreme weather events affected the performance of the permeable paver system. In the spring of 2014, a sanctioned bicycle road race was held and no ill effects from the riders were felt while riding along the corridor.
DESIGNER	