Monroe County, Indiana

Long Range Stormwater Improvement Plan

February 11, 2016

MONROE COUNTY GOVERNMENT

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Monroe County Board of Commissioners

Monroe County Council

Monroe County Stormwater Management Board
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Monroe County Drainage Board

Monroe County Soil and Water Conservation District

Monroe County Parks and Recreation Department

Indiana Department of Natural Resources (IDNR)

Executive Summary

Monroe County, the gateway to Southern Indiana, is a vibrant region with a unique blend of urban, agricultural, forested, campus, and residential land uses and abundant natural beauty.

Through its history, the County has experienced stormwater issues related to the natural features of the region, as well as those due to increasing development and ever expanding maintenance requirements.

Monroe County Government recognized the need to develop a county-wide comprehensive stormwater improvement plan to provide an accounting of known stormwater drainage issues, along with a plan for identifying, prioritizing and implementing sustainable solutions and providing a guideline for future improvements. The Stormwater Management Board has expressed the desire for a County wide strategy that allows for budgeting and implementation of prioritized projects over a 20 year period with flexibility to adjust solutions based on continual, ongoing and iterative feedback and input from residents.

The Long Range Stormwater Improvement Plan:

- Identifies and analyzes the existing drainage deficiencies throughout the County
- Provides a range of drainage concepts for the repair, retrofit, and enhancement of existing facilities and construction of future facilities
- Establishes criteria for selecting and prioritizing drainage projects
- Combines the demands of flood risk reduction with ecosystem enhancements and considers development and rural land uses in providing an effective plan
- Included active participation and involvement of a diverse set of key stakeholders; including the public, County staff, community organizations, and County Commissioners
- Outlines potential funding sources for stormwater projects

This Long Range Stormwater Improvement Plan is integral to:

- The improvement of the quality of life of Monroe County residents
- The protection of unique natural resources
- The Health and Safety of residents and visitors
- The support of recreation and tourism
- Responsible fiscal planning for County stormwater improvement and maintenance activities as part of overall capital improvements
- Meeting Federal USEPA regulations to improve the quality of stormwater runoff reaching our lakes and streams

The process for development of the Long Range Stormwater Improvement Plan included:

- Data collection
- Field Reconnaissance
- Analysis and categorization of all watersheds within the County
- Identification of typical stormwater conditions, problems, and reoccurring issues
- Completion of an Existing Conditions Report outlining the data compilation, inventory, and field reconnaissance process followed in support of the overall Plan
- Preparation of standardized maintenance and retrofit solution concepts
- Evaluation and prioritization of identified stormwater management solutions
- Public input and outreach including informational meetings and questionnaires
- Staff/Board of Commissioners/surveyor interviews
- Development of Conclusions, Recommendations, and Next Steps for Stormwater Management in Monroe County.

This plan can be used as a strategic document for the application and implementation of projects for the purpose of reducing flooding, maintaining existing natural and man-made stormwater conveyances, and improving stormwater runoff conditions while improving water quality and meeting Clean Water Act regulatory requirements.

Results Show:

Implementation of the projects outlined in this plan will contribute to management of over 260,000 acres across 23 watersheds and will have a significant positive impact on flooding, public safety, ongoing maintenance and water quality.

The estimated total of all currently identified projects is approximately **$12 Million** including design services, land acquisition, and permitting. A 20% contingency has been applied due to the preliminary nature of the information used for the pricing analysis.

Sixteen (16) projects totaling just over $3.0 Million are identified for completion by 2021 (Year 5 of the document). All of these projects are primarily related to the alleviation of roadway flooding, creating a significant improvement to public health and safety for the citizens of Monroe County.

The Long Range Stormwater Improvement Plan Recommends the following initial action items:

- Refine proposed stormwater project costs and ranking to determine final number of projects for construction for years 1 through 5 based on available staff and budget resources.
- Develop a database entry form and accompanying Standard Operating Procedure (SOP) to populate future projects within the project ranking system and track project completion, implementation, and ongoing maintenance.
- Implement project SW 48a – Phase 1 of the Remote Monitoring Program for Roadway Flooding.
- Complete topographic survey and preliminary design documents and make recommendation for the implementation of the SW 01 N. Mt. Tabor Road drainage project.
- Develop a Commercial and Industrial Park stormwater basin retrofit program.
- Develop Guidelines of future Commercial and Industrial Development.
- Perform an Ordinance / Policy / Incentive review relevant to Stormwater Management with recommendations and guidance for future development standards for stormwater management.
- Develop and issue a Request for Qualifications for annual on-call contracting services for storm infrastructure general contractor and stream stabilization specialty contractor for maintenance & improvement projects $50,000 or less.
- Develop and implement an internal project tracking and review process to ensure compliance with MS4 regulatory requirements and stormwater management on County Capital Improvement Projects.
- Establish a budget line item for maintenance of stormwater infrastructure specific to multi-use trails.
- Establish a budget line item for ongoing maintenance and funding of improvements outlined in this plan.
- Engage consultant to capitalize on the multiple grants identified in this report and assist with strategic grant writing, administration and targeting opportune public, private, and nonprofit partnerships.
- Develop a public outreach strategy to promote and consistently brand the Long Range Stormwater Improvement Plan and the implemented projects.

Recommended 5 year, 10 year and 20 year goals are outlined in detail in the results portion of this document.

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1.0 Introduction and Background

Lake Monroe is a valuable asset to Monroe County

We all live in a watershed and have a role to play in the health of our local waterways. In Monroe County, water from rainfall and snow melt flows into surrounding creeks (including Clear Creek, Jacks Defeat Creek, and Bean Blossom Creek), eventually going to the White River and making its way all the way South to the Gulf of Mexico. One way to contribute to a healthy watershed is for individuals, businesses, and public agencies to understand stormwater drainage issues and to take positive steps toward improving the water flowing over their property. As Monroe County residents it is up to us to make sure we live in a healthy environment with clean water. Everyone from individual homeowners to the County Highway Department can have an impact.

Monroe County government, through its Stormwater Management Board and infrastructure departments, can contribute to protecting and improving the waterways and the natural resources of Monroe County utilizing Planning and education, followed by strategic, thoughtful action.

1.1 Purpose and Need

Cherry Lane surface drainage

The purpose of the Long Range Stormwater Improvement Plan is to provide a comprehensive stormwater management strategy addressing storm drainage and flood control in a sustainable manner that protects the safety of the public and enhances the quality of County's waterways and natural resources.

The Stormwater Management Board has expressed the desire for a County Wide strategy that allows for budgeting and implementation of prioritized projects over a 20 year period with flexibility to adjust solutions based on continual, ongoing and iterative feedback and input from residents.

1.1.1 Problem Definition

Stonechase subdivision detention pond

Like many communities, Monroe County experiences flash flooding and, in the vicinity of Monroe Reservoir, extended duration flooding. Much of the flooding occurs within County controlled Right of Way (ROW) and can be attributed to low lying roadways adjacent to creeks and streams. These roadways are impacted by flash flooding that results from significant topography and geologic karst features in the region.

Uncontrolled stormwater can threaten public health and aquatic life, negatively affect recreational activities, reduce the service life of existing roadway infrastructure, increase water treatment demands, contribute to flooding events, and cause erosion of valuable land. This costs the County money in the form of property damage, increased road and bridge maintenance demands, lost crops, erosion, and water quality treatment expenses.

1.1.2 Goals and Objectives

- Develop master plan vision opportunities on a large regional scale as well as public/private partnership and individual property projects.
- Combine the need for flood risk reduction with ecosystem enhancements while supporting urban development and rural residential land uses to provide an effective plan that meet both the County's and the community's vision.
- Identify opportunities to reduce the impact of storm runoff on localized flooding using targeted system improvements to control runoff issues in prioritized watersheds.
- Provide a framework for assessing and implementing projects within the County.

1.2 Study Area Limits

Monroe County is located in south central Indiana and has a land mass of 394 square miles. The county contains thirty watersheds and an estimated 1,243 miles of streams and rivers. The three main water bodies within the county encompassing 21 square miles of area; Monroe Reservoir, Griffy Lake, and Lake Lemon. Approximately half of the Monroe Reservoir watershed and most of the Lake Lemon watershed are located in Brown County. See Figure 1 for reference.

This report and the study excludes the three incorporated areas of Stinesville, Ellettsville and Bloomington. The study also excludes the Morgan Monroe State Forest and the Hoosier National Forest located in the north and southeast portions of the county respectively. These areas were excluded from the study as they are outside the jurisdiction of the Monroe County Government.

Monroe County is largely dominated by deciduous forest, which makes up approximately 64% of the land mass. Only approximately 8% of the unincorporated county's land is considered developed. The county is experiencing a major infrastructure project; the routing of the Interstate 69 corridor from Indianapolis, IN to Evansville, IN. The Monroe County portion of the corridor will extend just over 10 miles and impact three watersheds and approximately ten stream reaches. These watersheds are likely to experience significant impacts that will include changing the flow path, direction of flow, and quantity and quality of flow of their streams.

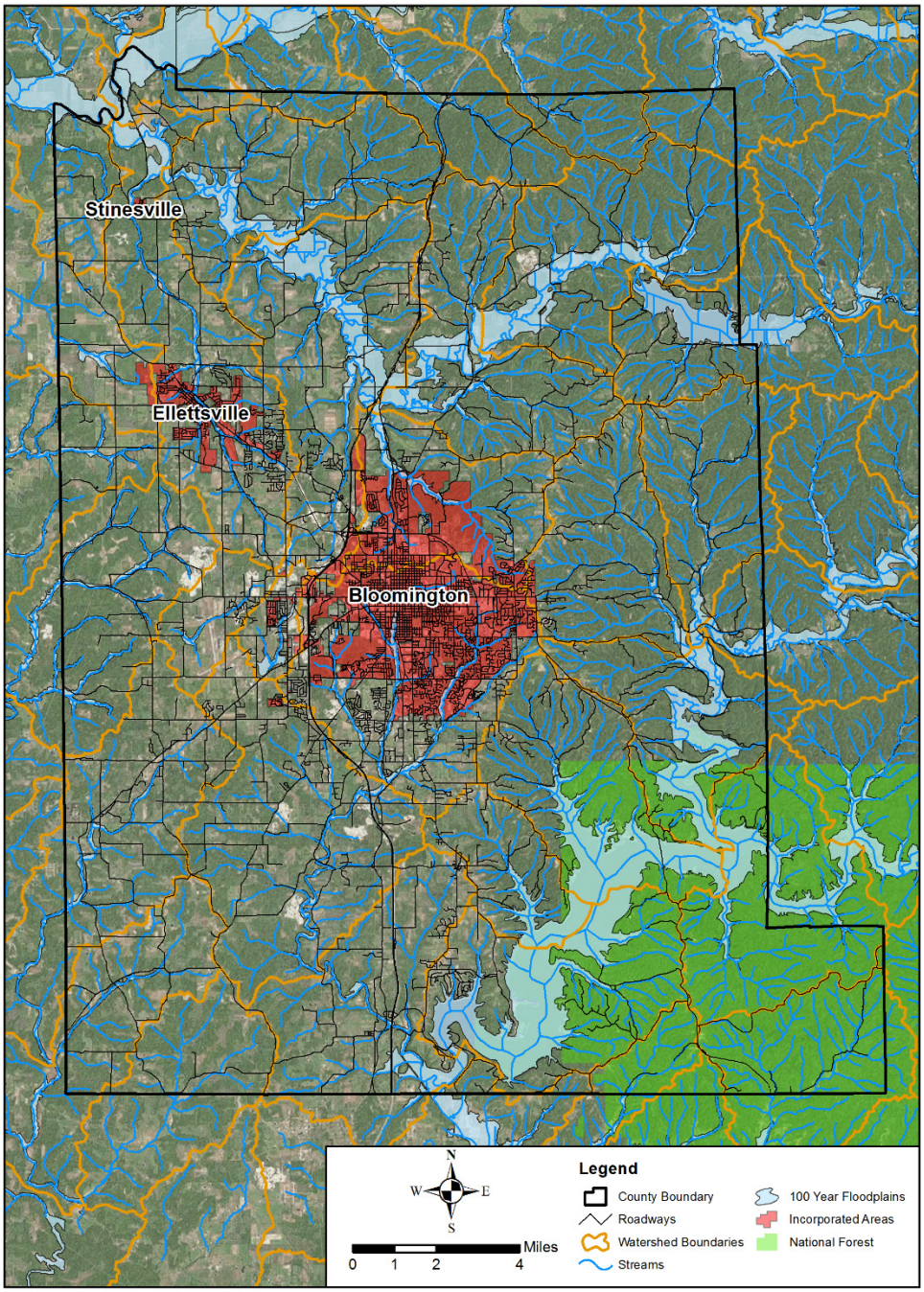

Figure 1: Monroe County

2

Data Compilation and Inventory Analysis

2.0 Data Compilation and Inventory Analysis

A comprehensive understanding of the existing conditions across the study area is integral to all aspects of developing and implementing a Long Range Stormwater Improvement Plan. This section describes the natural and built systems for each watershed and their relationship within the overall Plan.

2.1 Supporting Documents

An Existing Conditions Report was prepared to document the data compilation, inventory, and field reconnaissance process completed in support of the overall plan.

The Monroe County Comprehensive Plan adopted in February 2012 provides an in depth record of the natural systems of the region including climate, geology, watersheds, floodplains, soils, slopes, wetlands, endangered species, agriculture and forestry. This document provides a brief summary of the natural system elements, and references the Comprehensive Plan as appropriate.

Monroe County contains 36 prominent watersheds (Figure 2). Utilizing compiled GIS data, natural systems information was tabulated and evaluated on a watershed level basis.

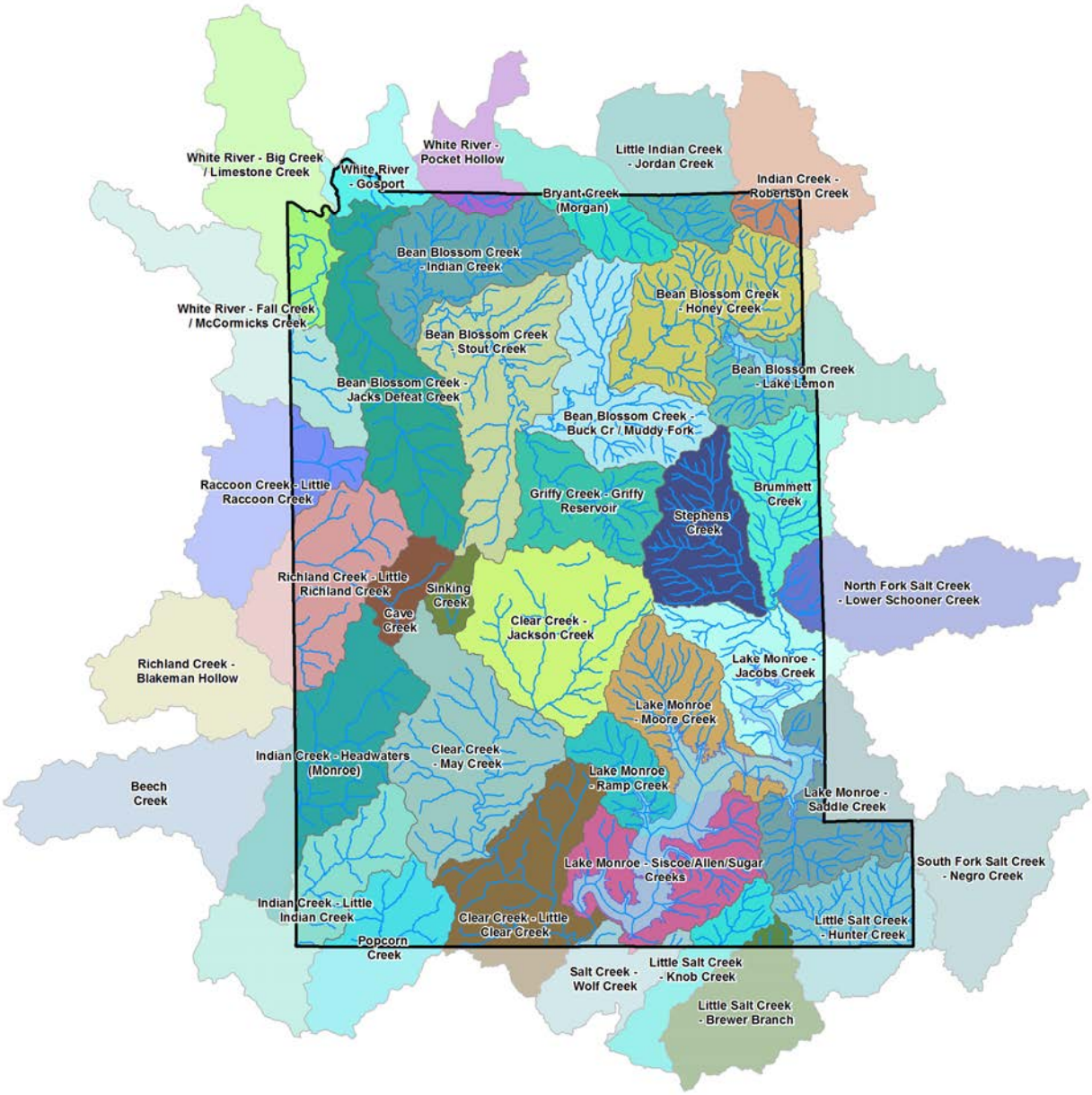

Figure 2: Monroe County Watersheds

2.2 Natural Systems

Monroe County contains natural features that are impacted by existing residential, commercial, and industrial development. The impact of existing development on the environment was recognized by County leaders and, as a result, several Zoning Ordinance chapters were created to protect these unique environmental features which contribute to the character and economy of Monroe County. Examples include protection of limestone deposits, floodplains, karst features, steep slopes, and water quality, especially in the Monroe Reservoir and Griffy Lake watersheds. Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8 show pertinent features along with brief descriptions of the following: Land Cover, Karst Features, Soils, Wetlands, Steep Slopes, and Stream Network.

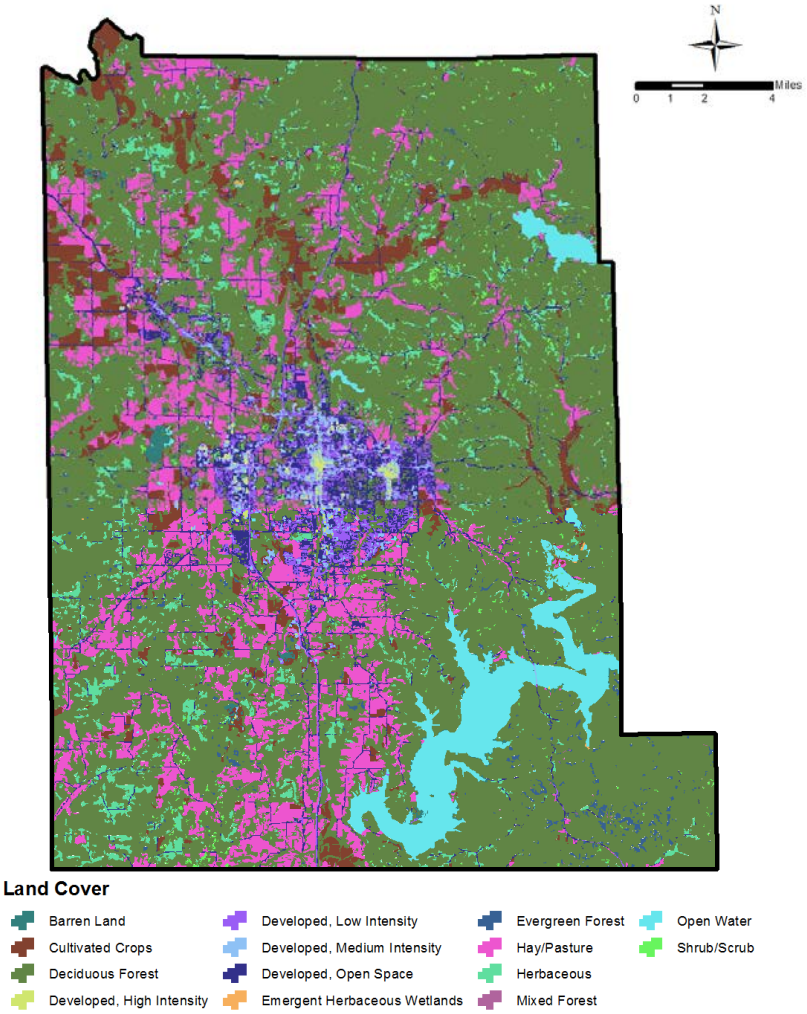

Figure 3: Monroe County Land Cover

Land Cover

Land in unincorporated Monroe County is predominately covered by Deciduous Forest and steep slopes, making up approximately 64% of the County. 13% of the County's land cover is composed of hay and pasture with only 8% of the land considered developed. The remaining land is primarily composed of cultivated crops, open water, and herbaceous land cover. (GIS data). Agricultural land is devoted to enterprises such as the production of row crops, pasture, and livestock.

Acreage devoted to farming has steadily declined over the years. Several factors account for the changing nature of the number of farms, including the number of agriculture census survey respondents, indebtedness, the impacts of fluctuating land values, state and federal agricultural policies, market supply and demand, and finally, federal subsidies.

Much of the traditional farmland has been converted to other uses, such as public and semi-public lands (Sycamore Land Trust, parks, schools and commercial). Some has been zoned as Rural Residential. While livestock may be raised on property that is zoned as Rural Residential, the property may not meet the qualifications to be classified as farmland.

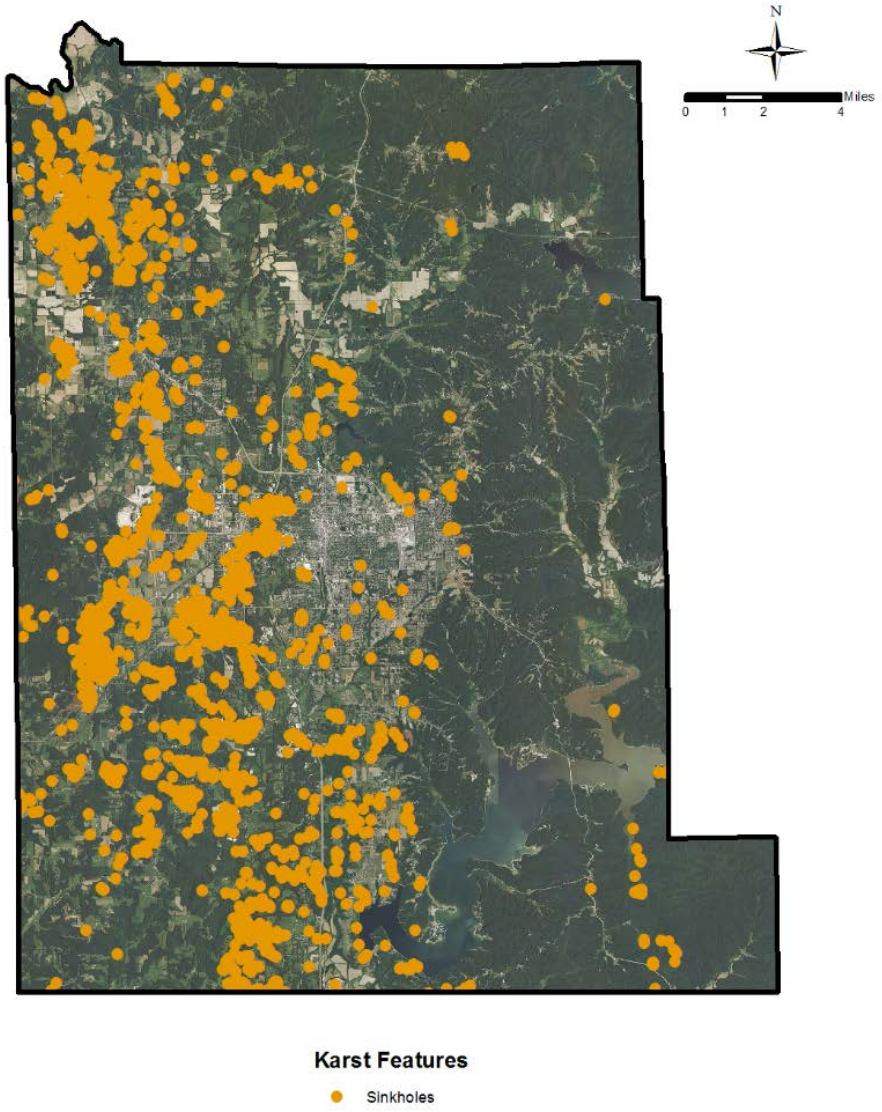

Figure 4: Monroe County Karst Features

Karst Features

Karst landscape usually occur where carbonate rocks (limestone and dolomite) underlie the surface. Limestone and dolomite in particular, are soluble in water. Freely circulating slightly acidic rainwater and the water in the soil slowly dissolve the factures in the limestone and create sinkholes, caves, underground streams, and other features that characterize karst landscapes. Sinkholes are a common karst-related feature and are defined as closed depressions in the lands surface formed by dissolution of near-surface rocks or by the collapse of the roofs of underground channels and caverns in the limestone or dolostone located below. The major karst areas in Indiana are estimated to contain 300,000 sinkholes.

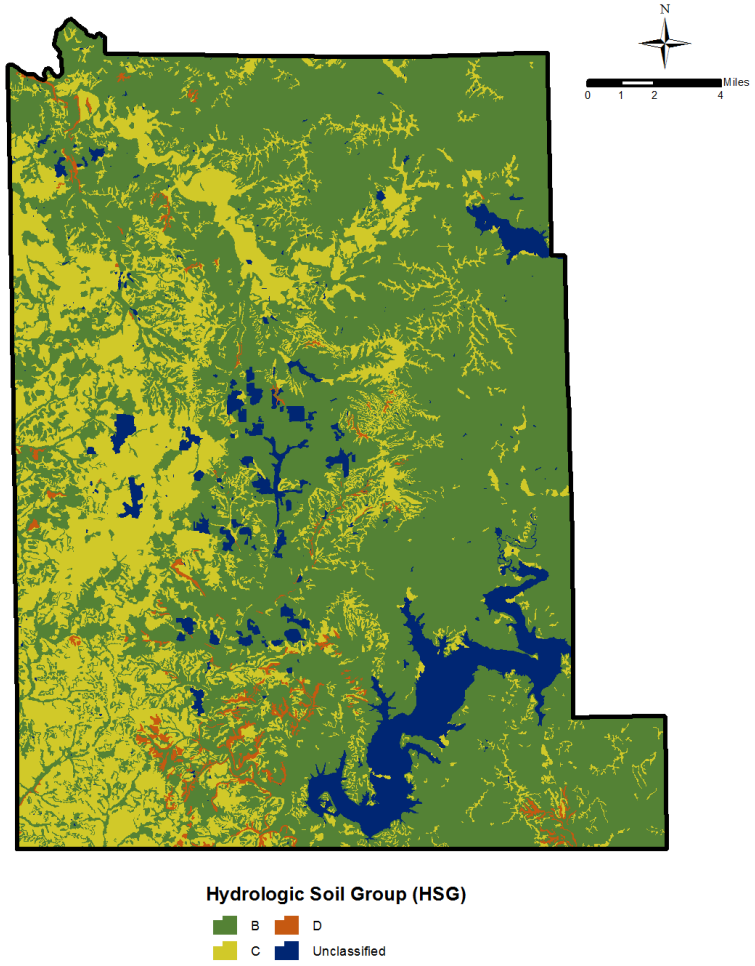

Figure 5: Monroe County Soils

Soils

The soils of Monroe County are classified by the United States Department of Agriculture and can be accessed via the Web Soil Survey. Soils range from deep and well drained soils to shallow and poorly drained soils. Approximately 80% of Monroe County soils are prone to erosion for most uses (crops, woodlands, urban areas and recreation areas) when located on slopes and in areas of minimal soil depth to bedrock. When planning for development, soil suitability and limitations play a significant role in determining the layout for streets, suitable septic and building sites, recreation areas, and stormwater management facilities. It is appropriate to leave highly erodible soils undisturbed to prevent sedimentation of degradation of water-quality. Hydric soils are also common throughout Monroe County. These soils, as defined by the Natural Resources Conservation Service (NRCS) of the US Department of Agriculture, are “soils formed under the conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

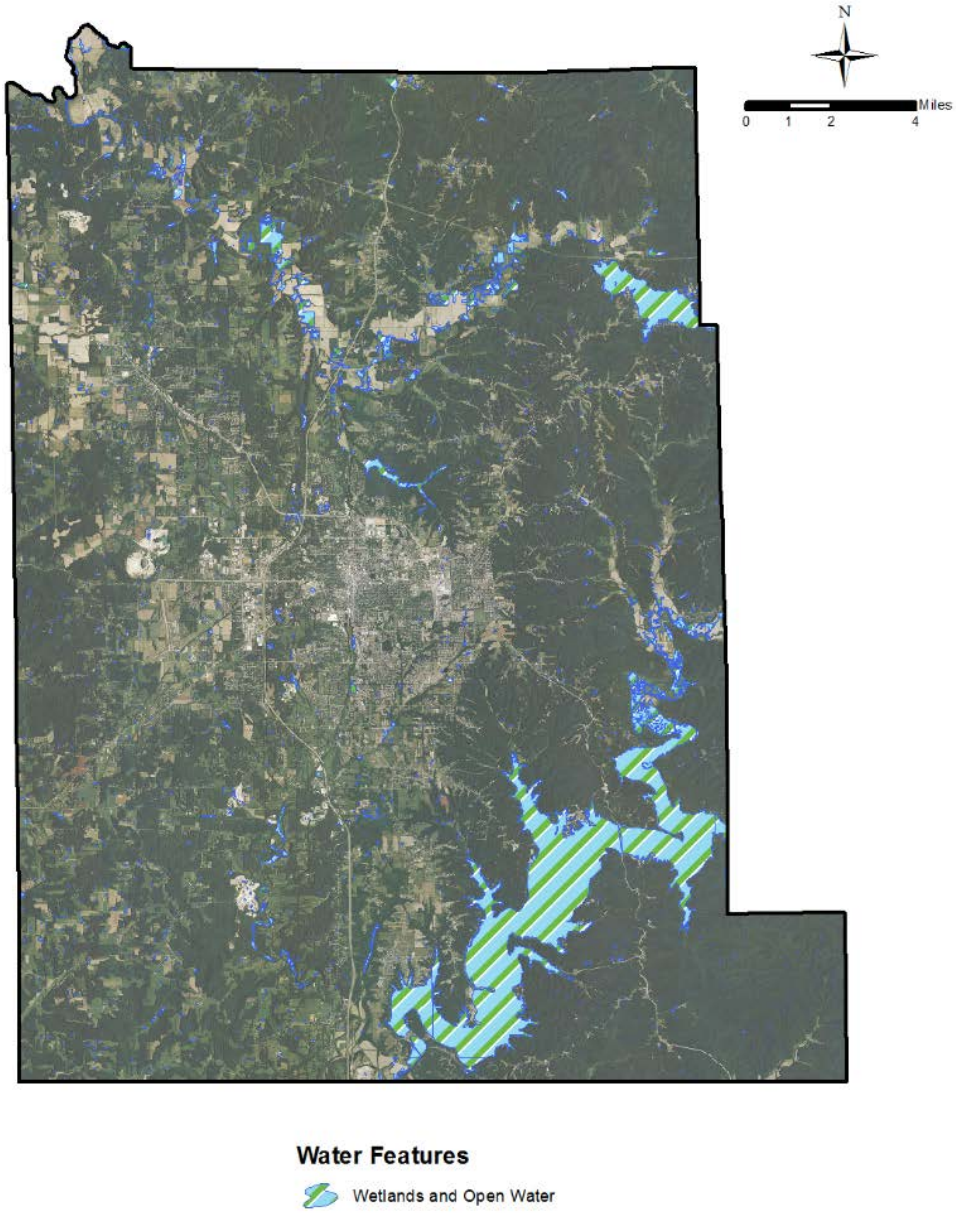

Figure 6: Monroe County Wetlands

Wetlands

According to a 2000 IDEM National Wetland Inventory, there is also an estimated span of 633 to 5,105 acres of Wetland. The Indiana Department of Natural Resources indicates that there may be upwards of 11,000-19,999 acres of wetland in Monroe County.[20] This is a sharp difference from that indicated by the 2000 IDEM study. This variance in statistical data indicates a need to accurately inventory the wetlands features found in Monroe County to ensure effective analysis and decision-making.

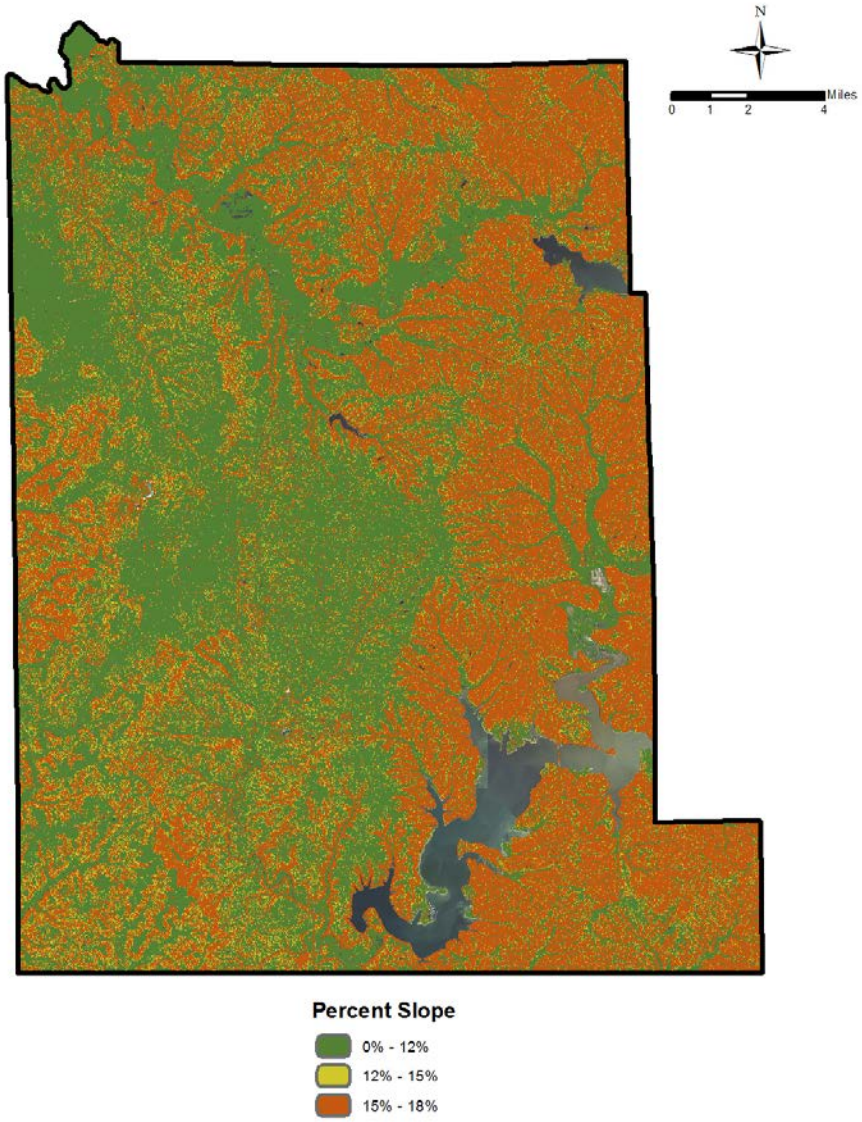

Figure 7: Monroe County Steep Slopes

Steep Slopes

An area of land designated as having a “steep slope” is one where the change in elevation over a particular distance, or slope is classified as “steep”. Since there is no universal definition of “steep”, government units may set their own values. In 2007, the Indiana Department of Natural Resources published a Storm Water Quality Manual defining steep slopes as 15% or greater. The manual recommended development of slopes with a grade of 15% or greater be avoided whenever feasible in order to minimize erosion, soil loss, degradation of surface water, and excessive stormwater runoff. An analysis of vacant lands in Monroe County revealed the majority of undeveloped land in the County Contained slopes of 15% or greater.

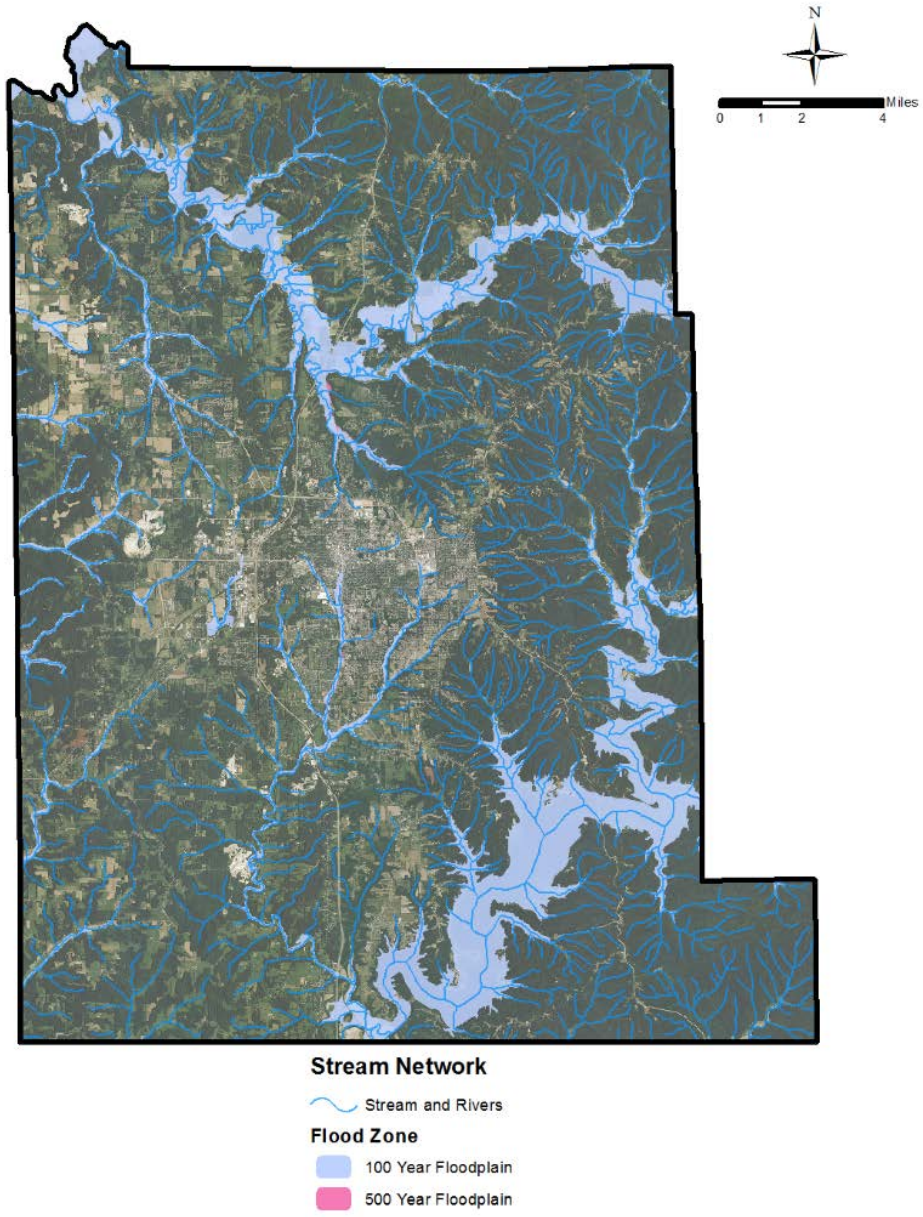

Figure 8: Monroe County Stream Network

Stream Network

Monroe County, IN covers 394 square miles in southern Indiana and is made up of 30 HUC14 watersheds the largest being the Clear Creek-May Creek Watershed which encompasses approximately 19,182 acres. There are an estimated 1,243 miles of streams in Monroe County, many of which flow into one of the three major water bodies in the County; Monroe Reservoir, Griffy Lake, and Lake Lemon. Of these, the Monroe Reservoir is the largest by far, approximately 16.58 square miles in size, and provides the majority of the drinkable/usable water for the County.

Floodplain Mapping and Community Rating System (CRS)

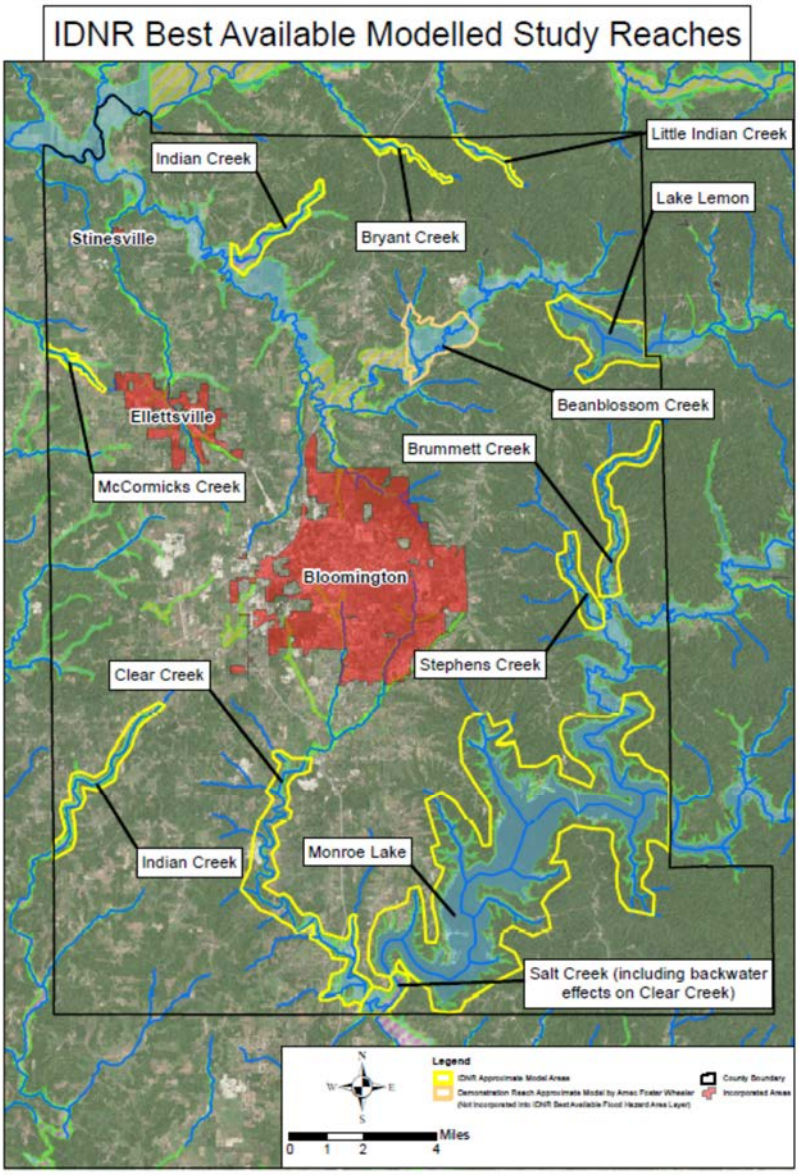

Figure 9: IDNR Best Available Flood Hazard Area

The above figure represents the IDNR's data layer "Best Available Flood Hazard Area" ("Best Available") is the Effective with additional studies that have been reviewed and approved by the Division of Water. While this data has not yet been submitted to FEMA for inclusion in the FIRMs or NFHL (DFIRMs), this data can be used for general planning, construction, and development purposes. However, Best Available cannot be used for flood insurance determinations. The majority of local jurisdictions have options for using best available data; however typically only the FEMA floodplain limits have been adopted into the local floodplain ordinance.

The floodplain data shown in the Best Available layer is generally more recent than the official FEMA NHFL data in the Effective layer. However, while the Best Available layer has been approved by the Division of Water, this data has not gone through the due process standards FEMA requires for publication in the NFHL.

Where a floodway analysis has been completed, an "Approximate Floodway" is included in the Best Available layer. These floodways are based on non-detailed floodplain modeling (i. e. no bridges), but otherwise meet the guidelines for development of floodways in Indiana. These floodways are acceptable for general use in determining jurisdiction for the Indiana Flood Control Act, but should be used with caution. These floodways do not meet the requirements for publication in the FIRMs or NFHL.

Waterways with approximate studies completed by Indiana Department of Natural Resources (IDNR) include the following:

- Beanblossom Creek
- Brummetts Creek
- Indian Creek (both the north Indian Creek and the South Indian Creek)
- Stephens Creek
- Bryant Creek
- Little Indian Creek (the north Little Indian Creek)
- Monroe Lake
- Lake Lemon

*High water information for some of these waterways is not yet present in the Indiana floodplain portal.

As part of the Long Range Stormwater Improvement Plan a demonstration reach was completed. This is a 5 mile reach that an approximate study was completed using the updated countywide digital elevation model (DEM). The Zone A reach upstream of the existing Zone AE reach ending at the Old Hwy 37 bridge crossing, and the WSEL at that crossing as the downstream boundary condition was selected for the demonstration model. A floodway based on the 0.14 ft rise criteria to demonstrate what a calculated floodway would look like on Beanblossom Creek, since the Zone AE reach downstream maps the whole floodplain as floodway. Figure 10 compares the effective Zone A delineation the demonstration model completed, with one overview map and a sample area at the FIRM scale. This model could possibly be reviewed and potentially expanded to become the IDNR best available layer it was submitted to IDNR on January 27, 2016.

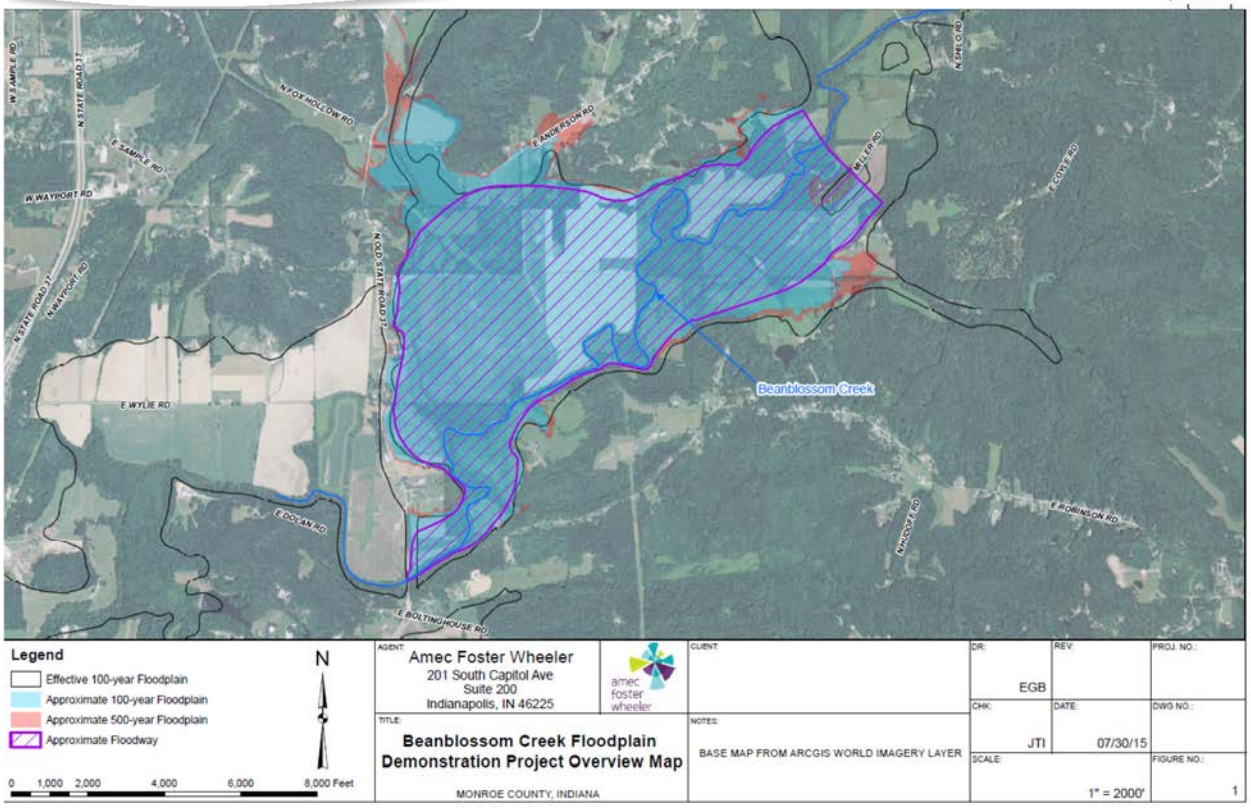

Figure 10: Bean Blossom Approximate Study

Residential Flood Loss and Community Rating System (CRS)

The Community Rating System (CRS) recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program (NFIP) standards. Depending upon the level of participation, flood insurance premium rates for policyholders can be reduced up to 45%. Besides the benefit of reduced insurance rates, CRS floodplain management activities enhance public safety, reduce damages to property and public infrastructure, avoid economic disruption and losses, reduce human suffering, and protect the environment. Technical assistance on designing and implementing some activities is available at no charge. Participating in the CRS provides an incentive to maintaining and improving a community's floodplain management program over the years. Implementing some CRS activities can help projects qualify for certain other Federal assistance programs. To be eligible for a CRS discount, Monroe County would have to complete FEMA Activity 310, Elevation Certificates and FEMA Activity 510 Floodplain Management Planning. Stinesville began participating in the NFIP following the 2008 flood.

Prior to the December 2013 flooding there was only one repetitive loss structure in unincorporated Monroe County (6677 N. Shuffle Creek Road – 3 claims, about $52,000 total). Since 1988, there has been 12 claims totaling $160,000. There are 145 flood insurance policies in the unincorporated county.

2.3 Built Systems

Monroe County is responsible for over 700 miles of roads, 137 bridges, over 2,800 pipes, and over 7,000 traffic signs and signals. The Monroe County Highway Road Maintenance Department is responsible for maintenance of all roads and drainage systems.

2.3.1 Drainage Assets/Infrastructure

Drainage assets and infrastructure include culverts, bridges, stormwater collection systems, outfall locations, and detention and retention facilities including ponds, dams, and subsurface storage chambers. The following figures compare the drainage infrastructure in each watershed, indicating the number of stream and road intersections (Figure 11), the number of bridges (Figure 12) and number of culverts (Figure 13) per 1,000 acres of watershed. This information provides an understanding of which watersheds are burdened with the most infrastructure to be maintained on a comparative basis and where drainage improvements may have the most impact. Figure 14 through Figure 25 provide the locations of culverts, bridges, outfalls and detention pond structures for each watershed.

2.3.2 Outfalls

Throughout Monroe County, a system of pipes transport water from rain events away from streets, parking lots, rooftops and parking garages and channels that water into neighborhood streams, creeks, or other water bodies. The site where the water flows from the pipe and into the water body is called the outfall. An outfall is technically defined as any point where a separate storm sewer system discharges to either Water of the United States or to another MS4. Outfalls include discharges from pipes, ditches swales, and other points of concentrated flow. Indiana Department of Environmental Management (IDEM) Rule 13 requires all Phase 2 MS4s to map all known storm water outfall systems (within 5 years of their first permit term), with pipe diameters 12 inches or greater or open ditches with 2 feet or larger bottom width. Monroe County has a total of 70 mapped outfalls in 9 of the watersheds. The number of outfalls varies from 22 in the Jack's Defeat Creek watershed to 2 in the Lake Monroe Ramp Creek watershed.

Table 1: Outfall Locations

Watershed	Number of Outfalls
Bean Blossom Creek - Jacks Defeat Creek	22
Bean Blossom Creek - Stout Creek	3
Cave Creek	1
Clear Creek - Jackson Creek	17
Clear Creek - Little Clear Creek	3
Clear Creek - May Creek	5
Griffy Creek - Griffy Reservoir	5
Lake Monroe - Ramp Creek	2
Sinking Creek	12
All Other Watersheds	0
Total Monroe County Mapped Outfalls	**70**

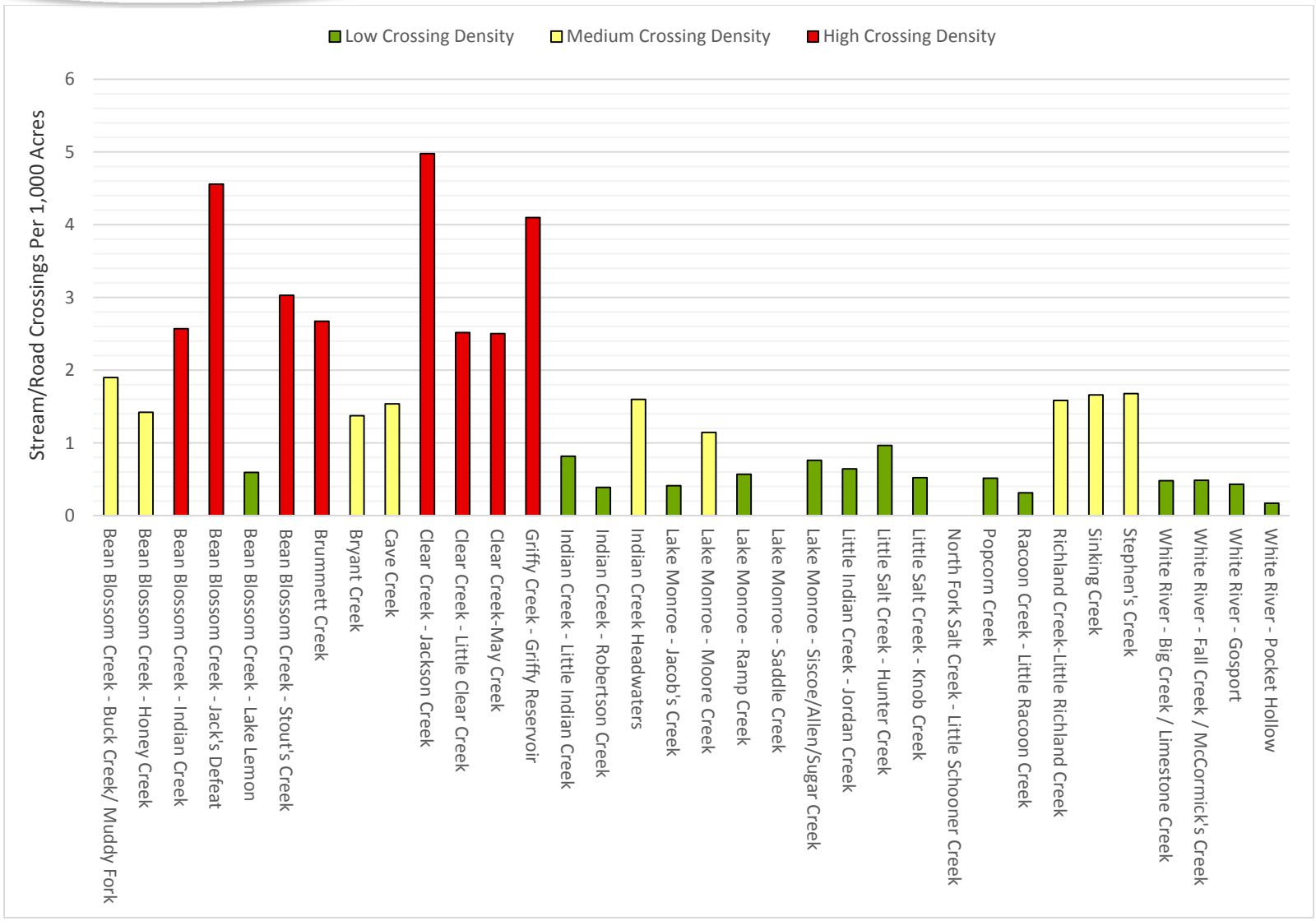

Figure 11: Stream & Roadway Intersections by Watershed

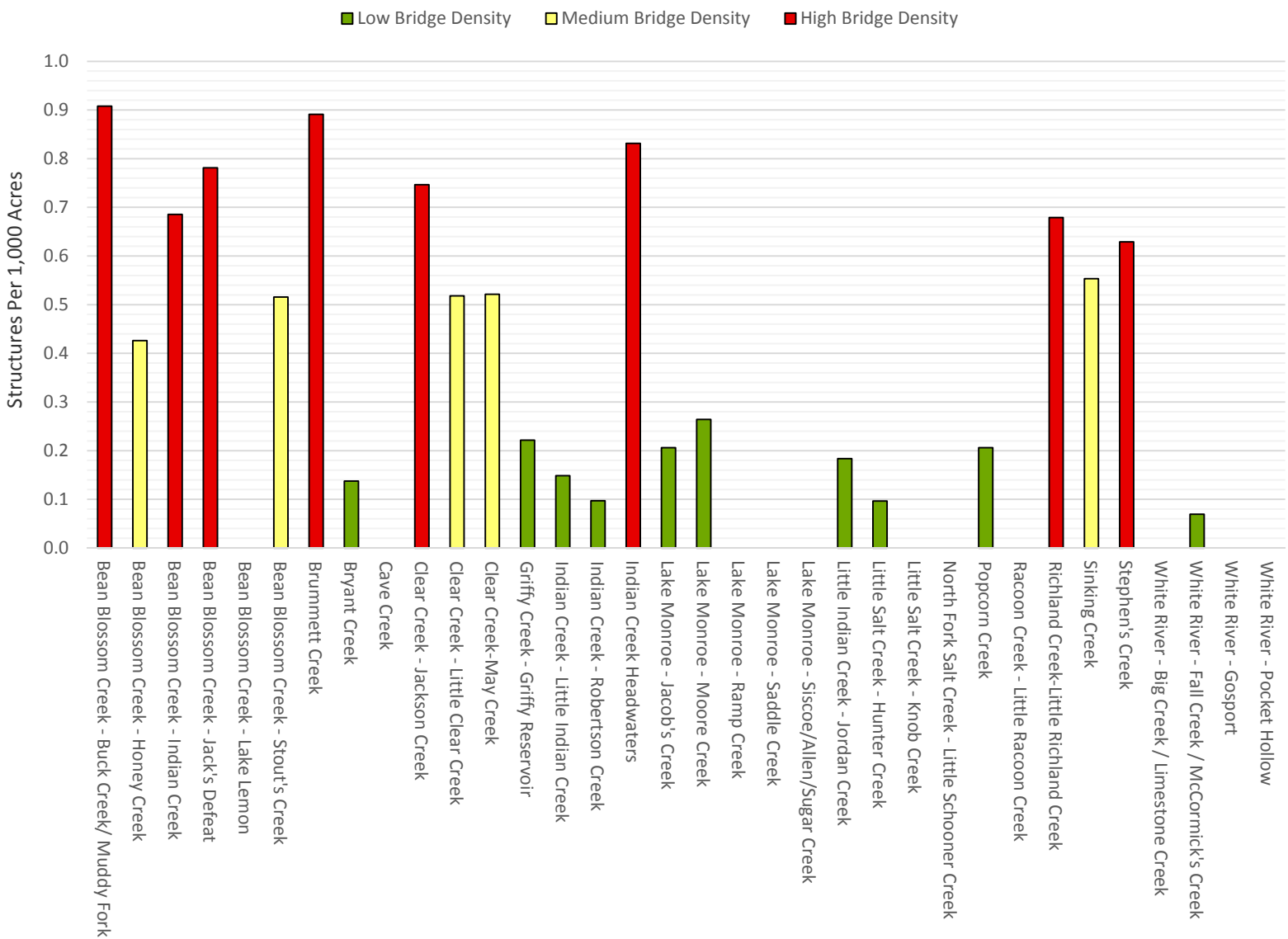

Figure 12: Bridge Structures by Watershed

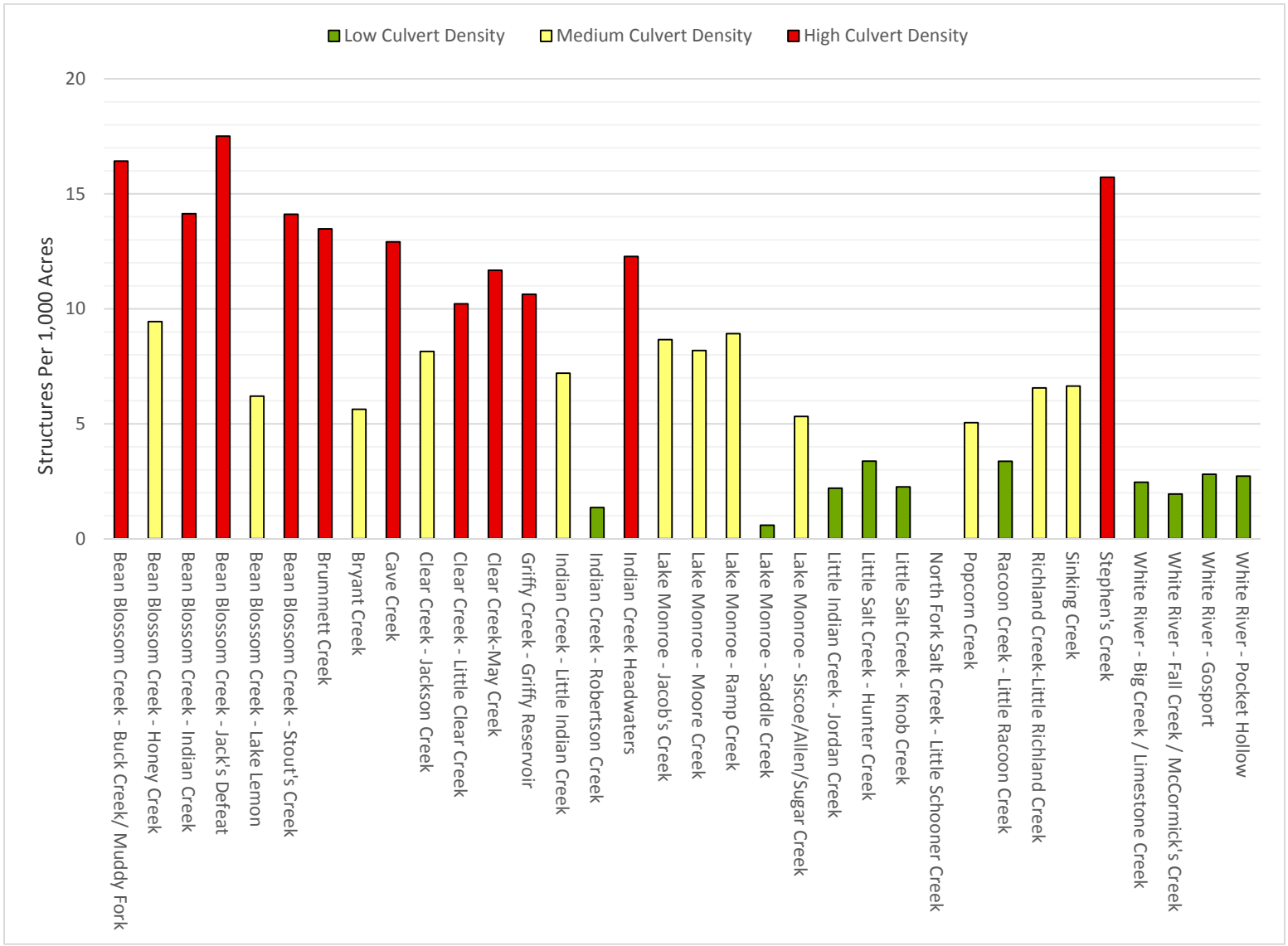

Figure 13: Culvert Structures by Watershed

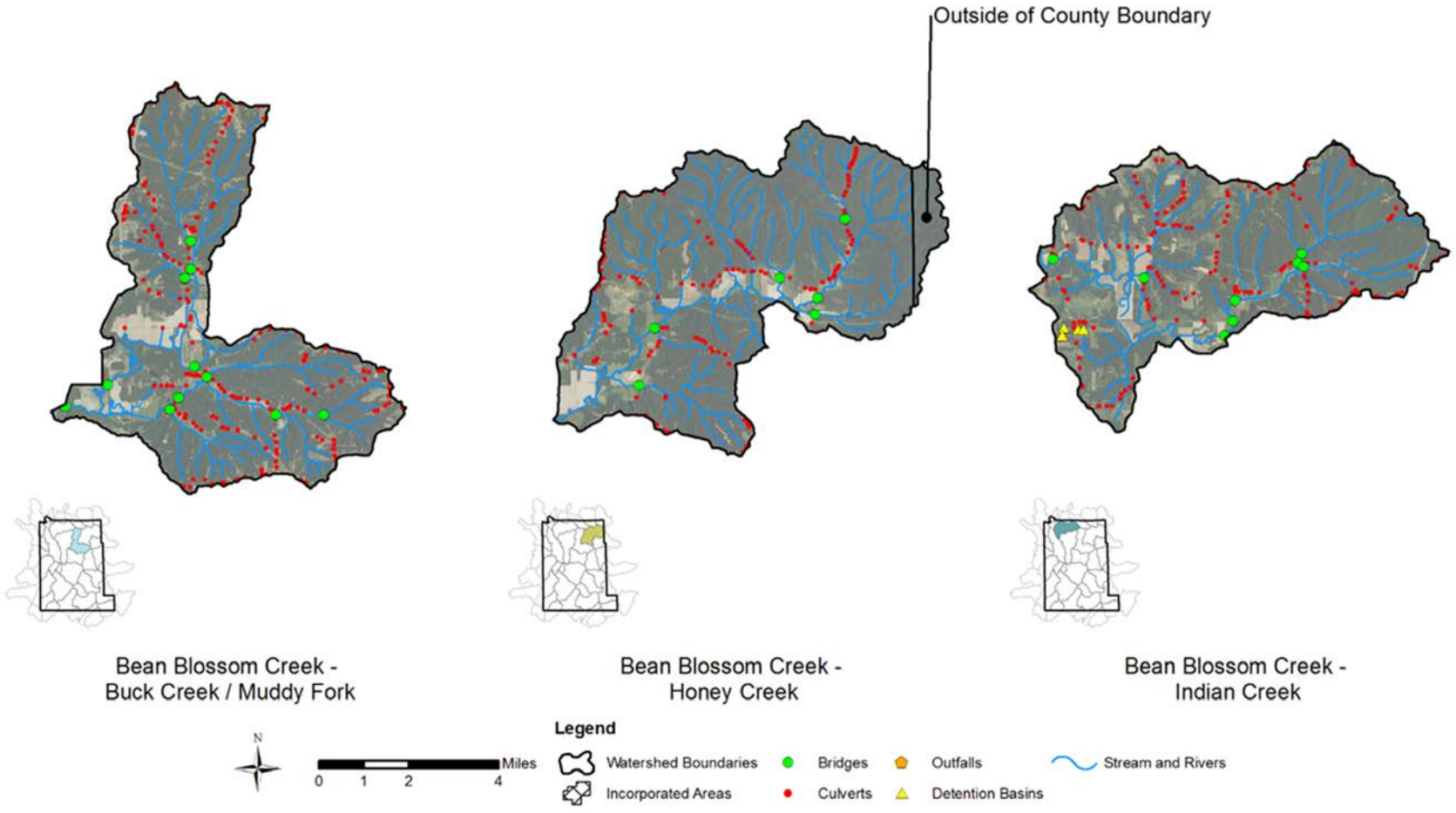

Figure 14: Stormwater Infrastructure Locations by Watershed Part A

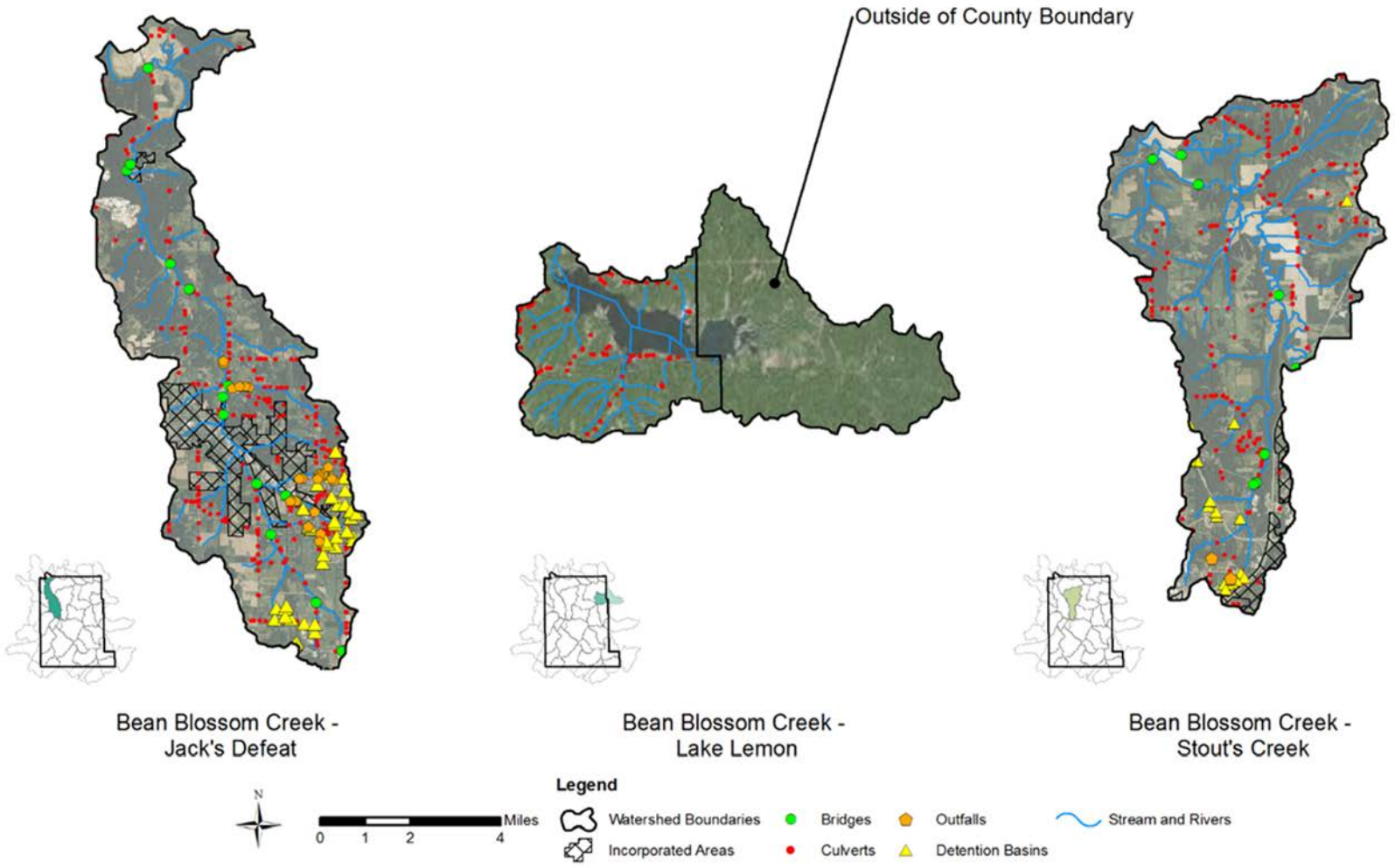

Figure 15: Stormwater Infrastructure Locations by Watershed Part B

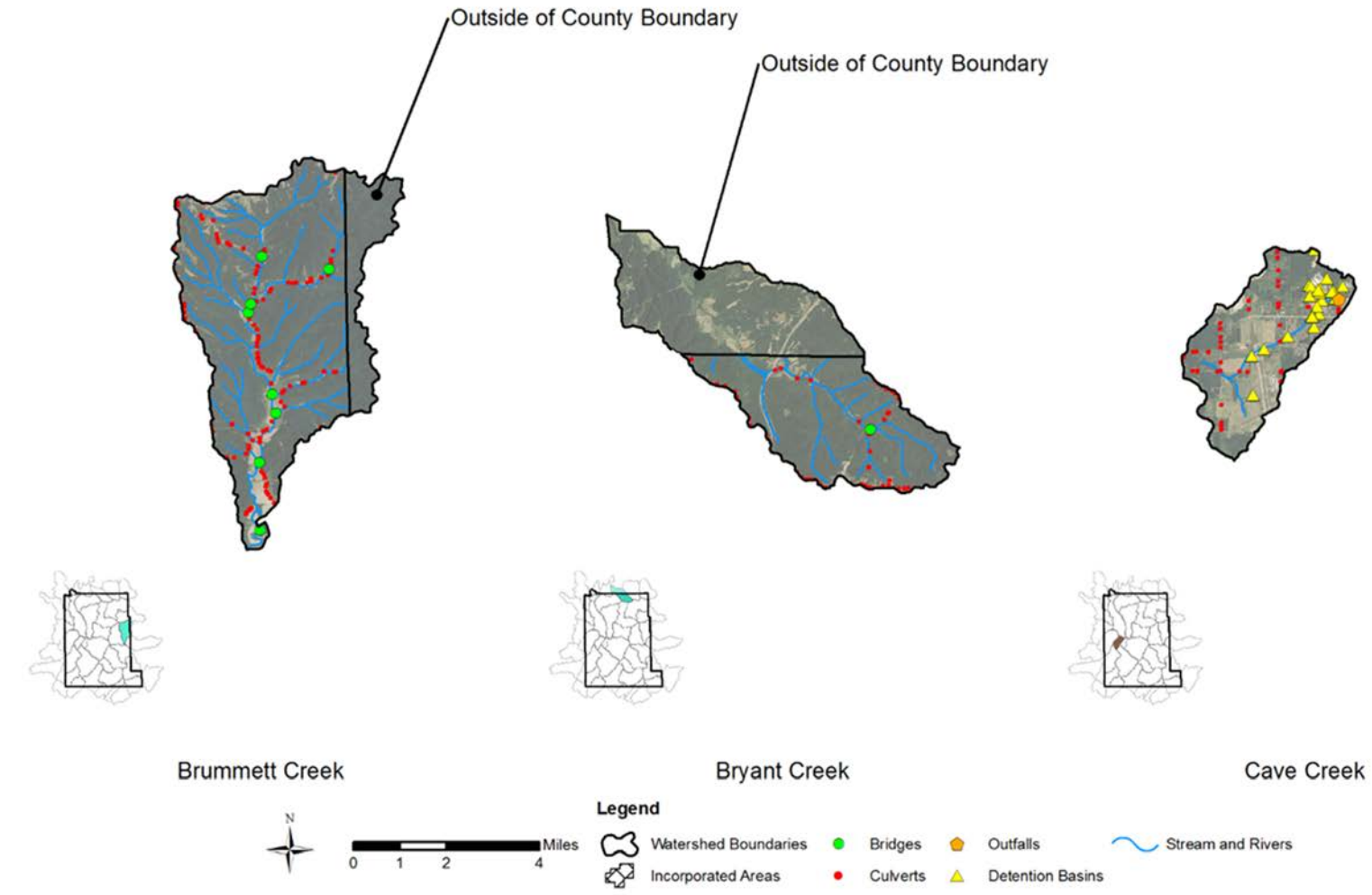

Figure 16: Stormwater Infrastructure Locations by Watershed Part C

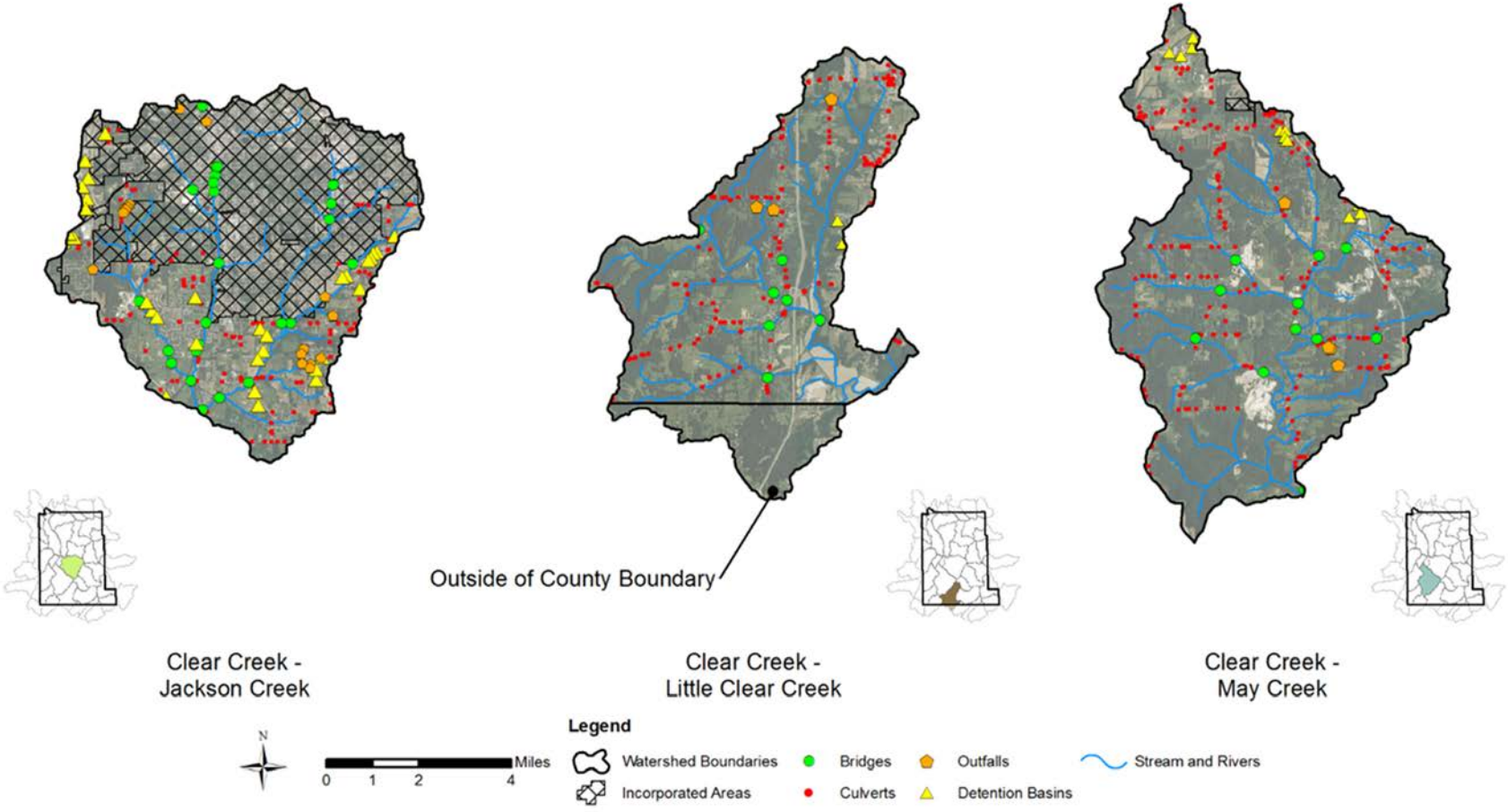

Figure 17: Stormwater Infrastructure Locations by Watershed Part D

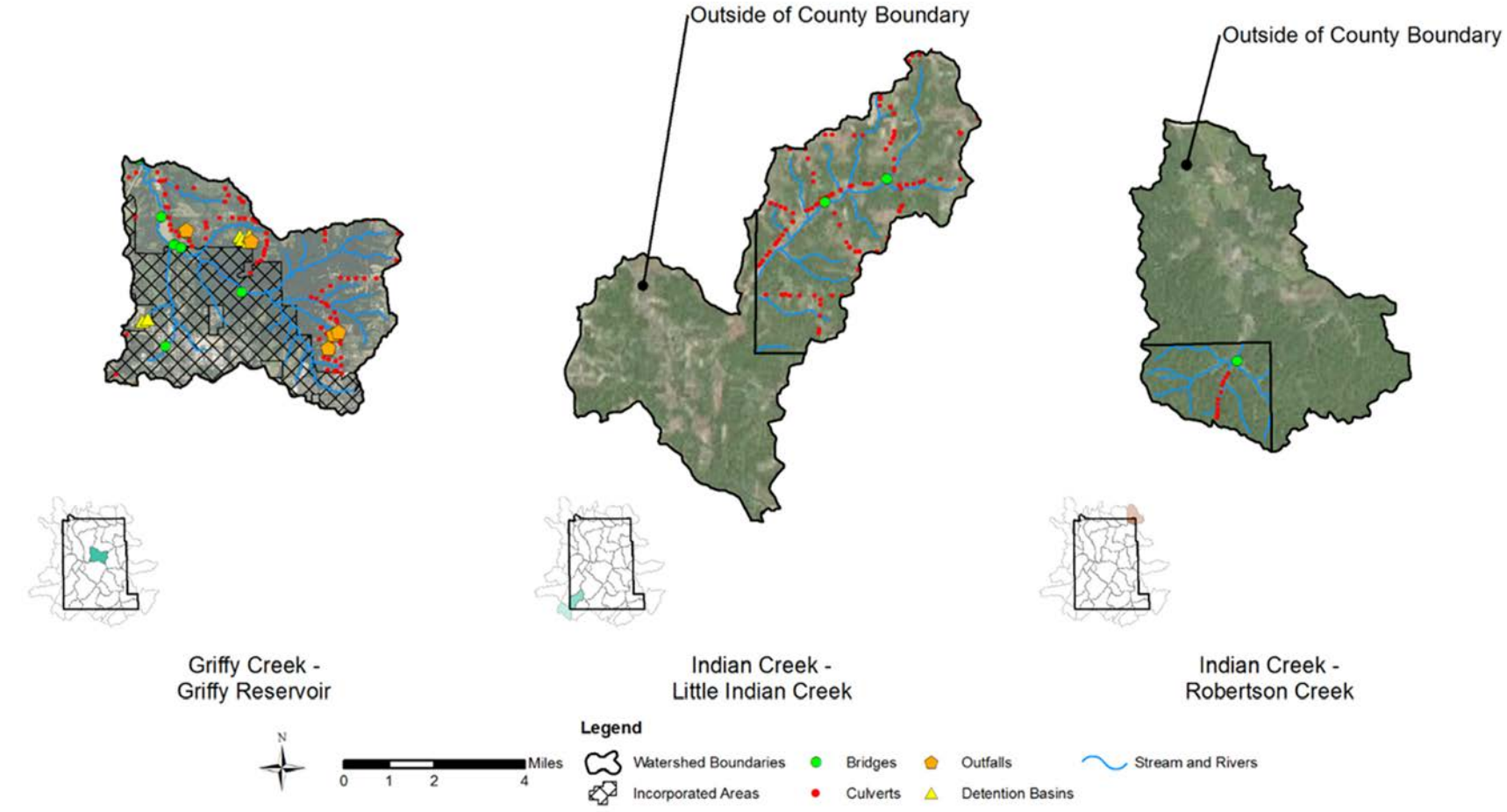

Figure 18: Stormwater Infrastructure Locations by Watershed Part E

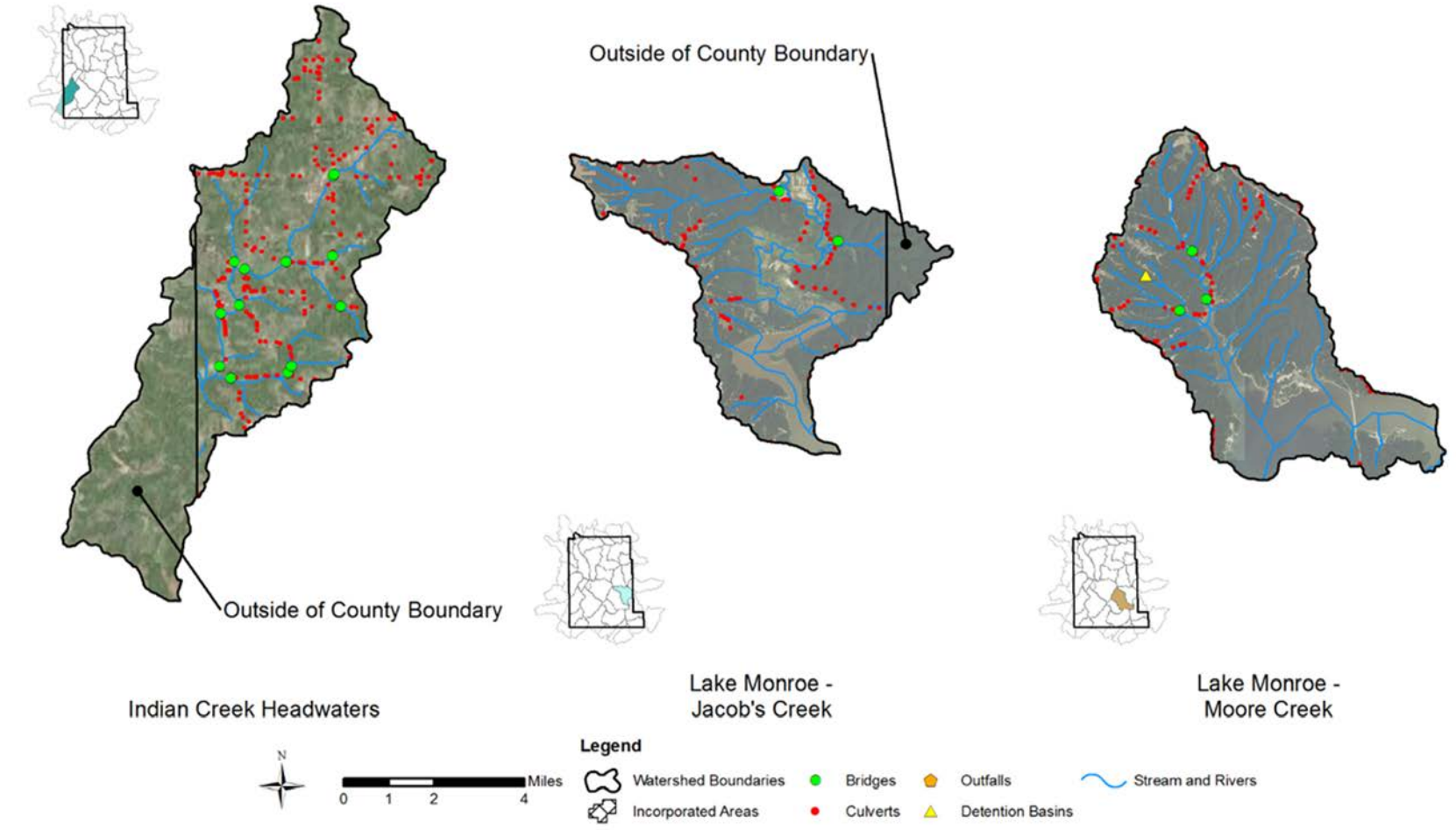

Figure 19: Stormwater Infrastructure Locations by Watershed Part F

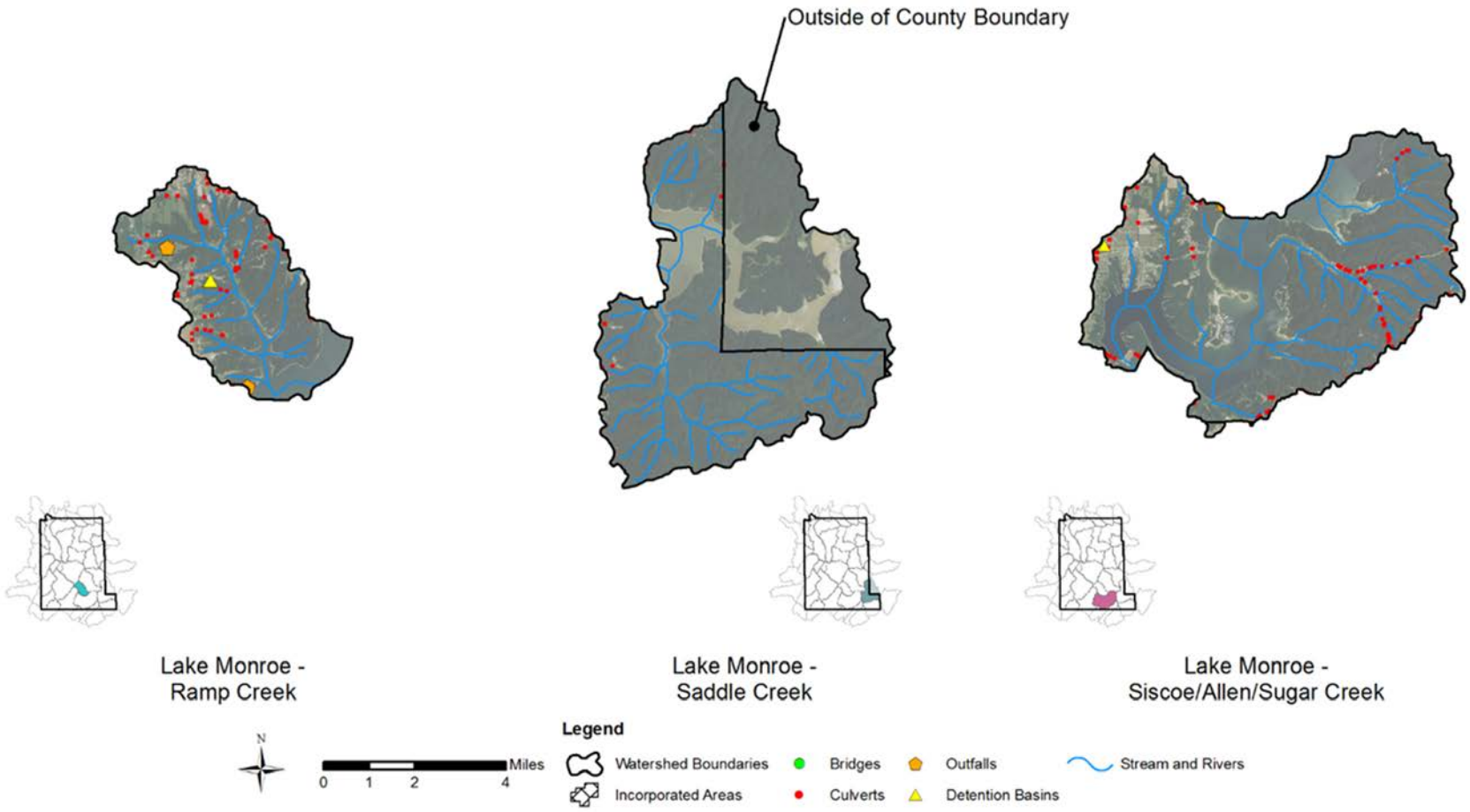

Figure 20: Stormwater Infrastructure Locations by Watershed Part G

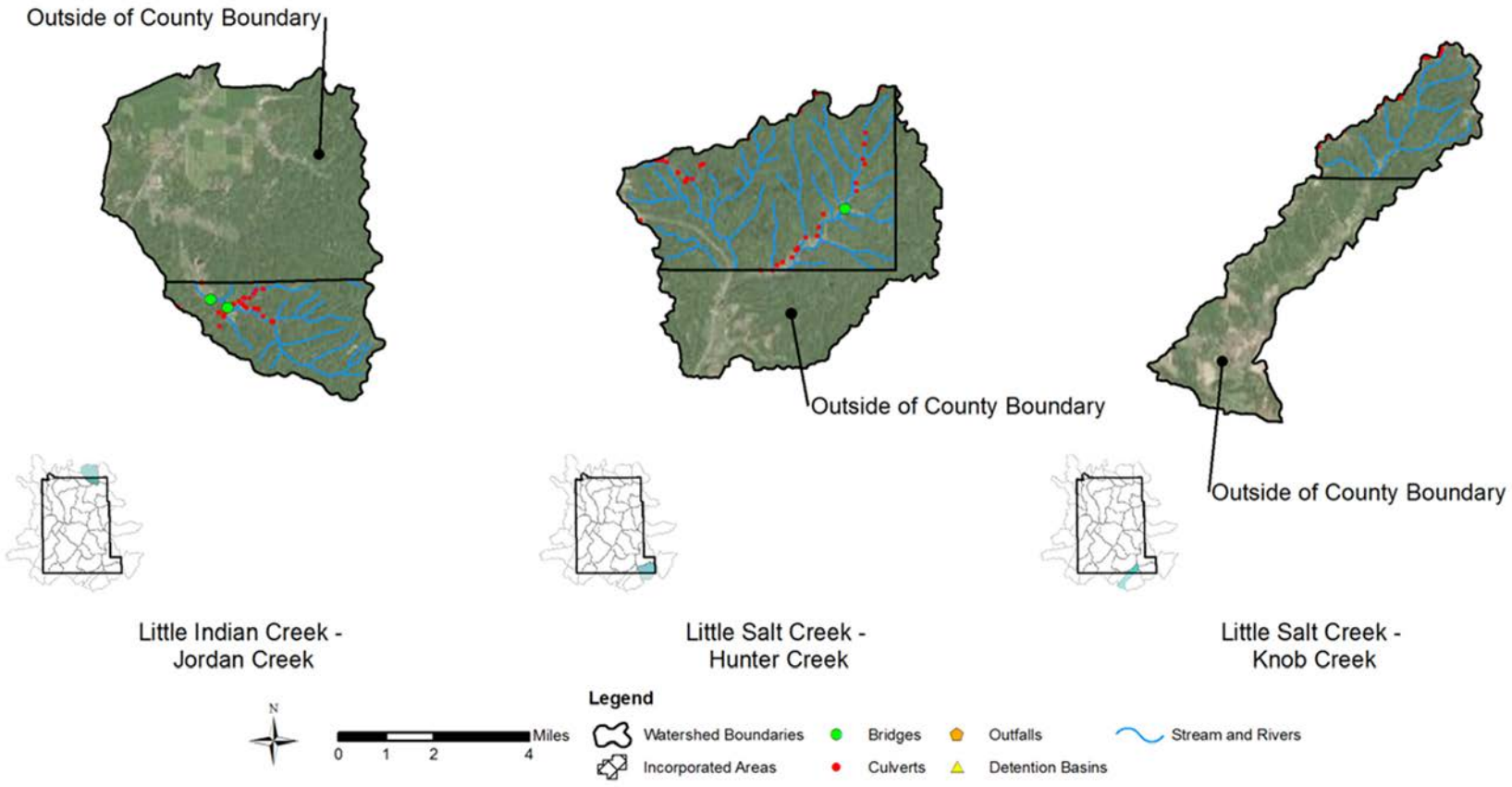

Figure 21: Stormwater Infrastructure Locations by Watershed Part H

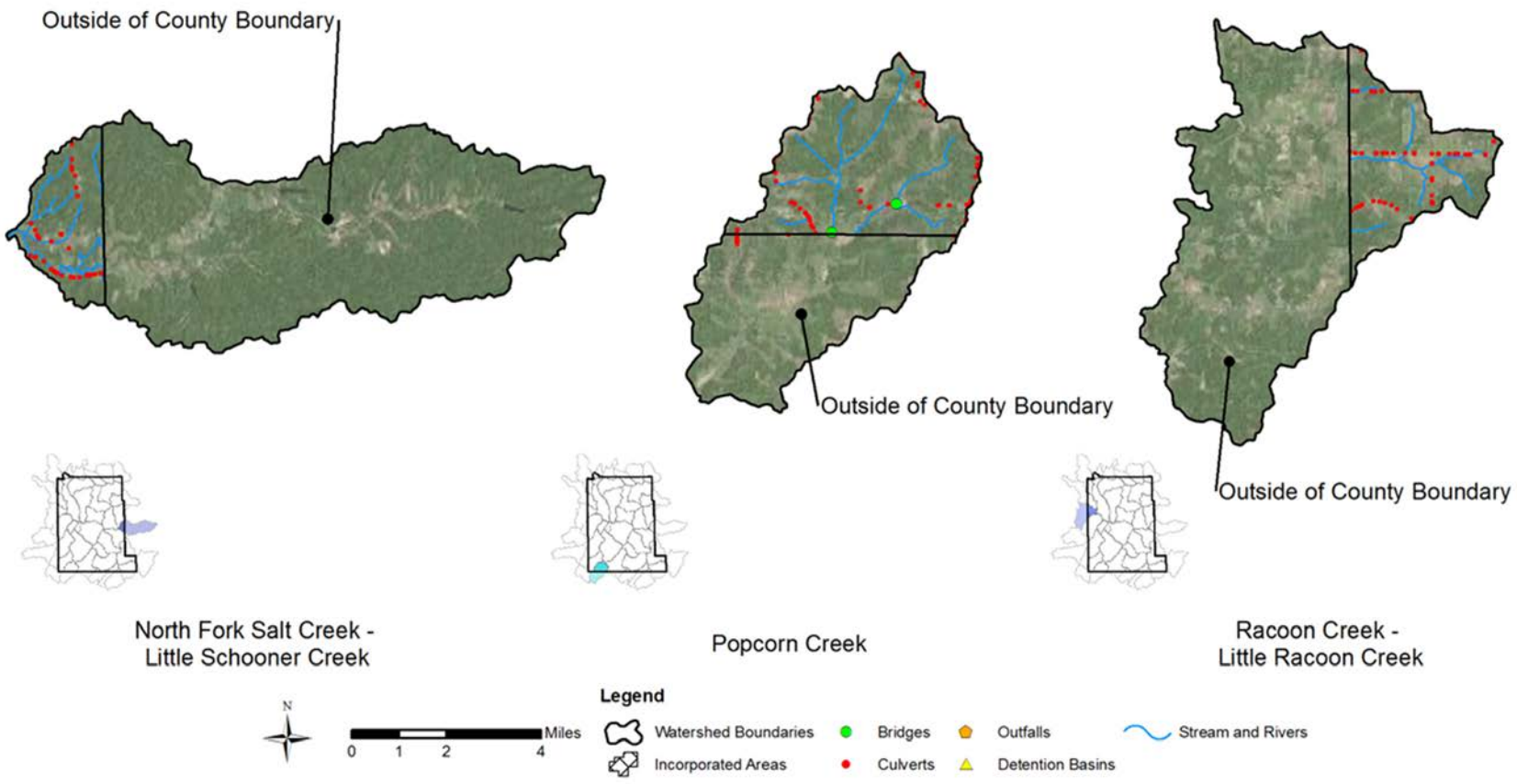

Figure 22: Stormwater Infrastructure Locations by Watershed Part I

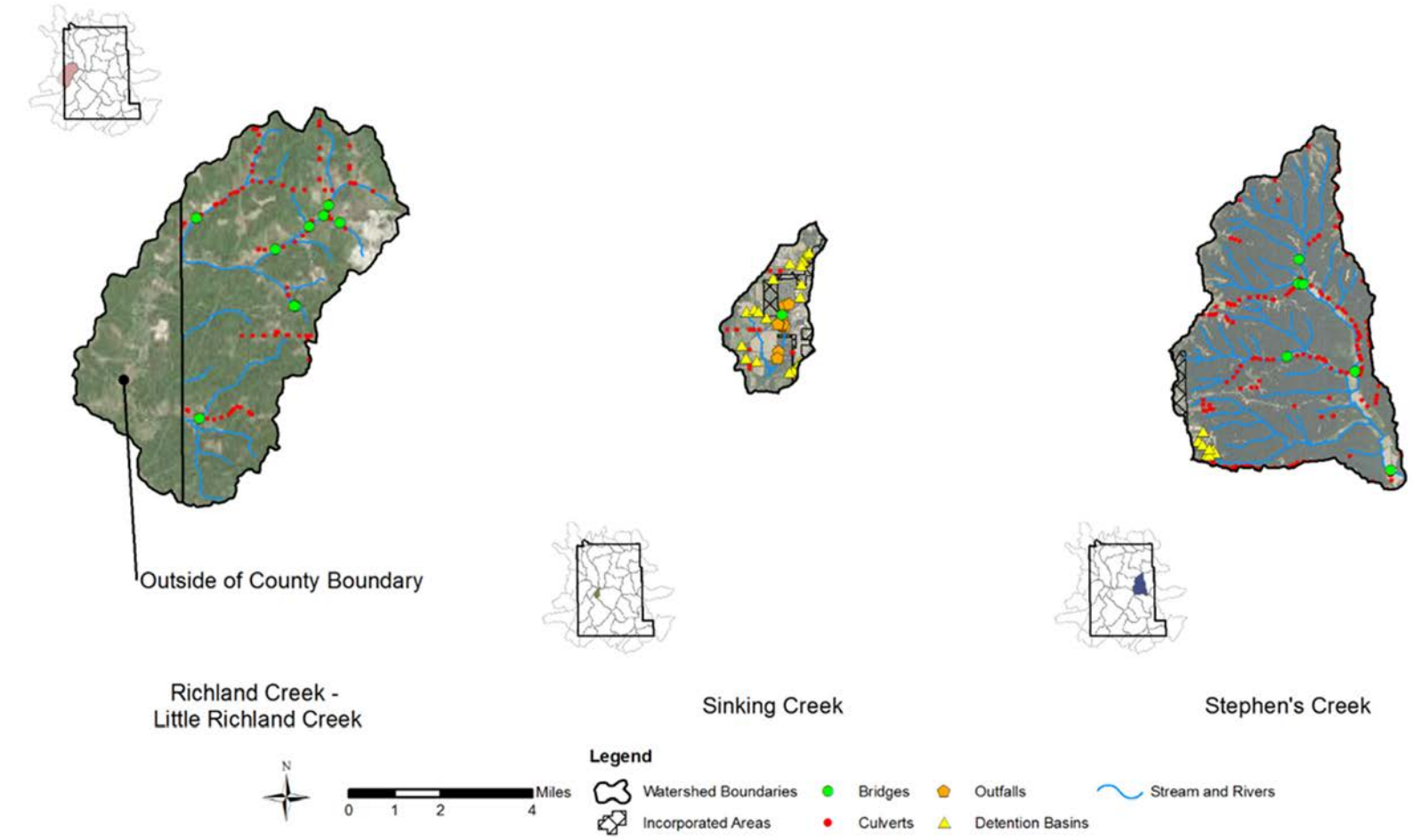

Figure 23: Stormwater Infrastructure Locations by Watershed Part J

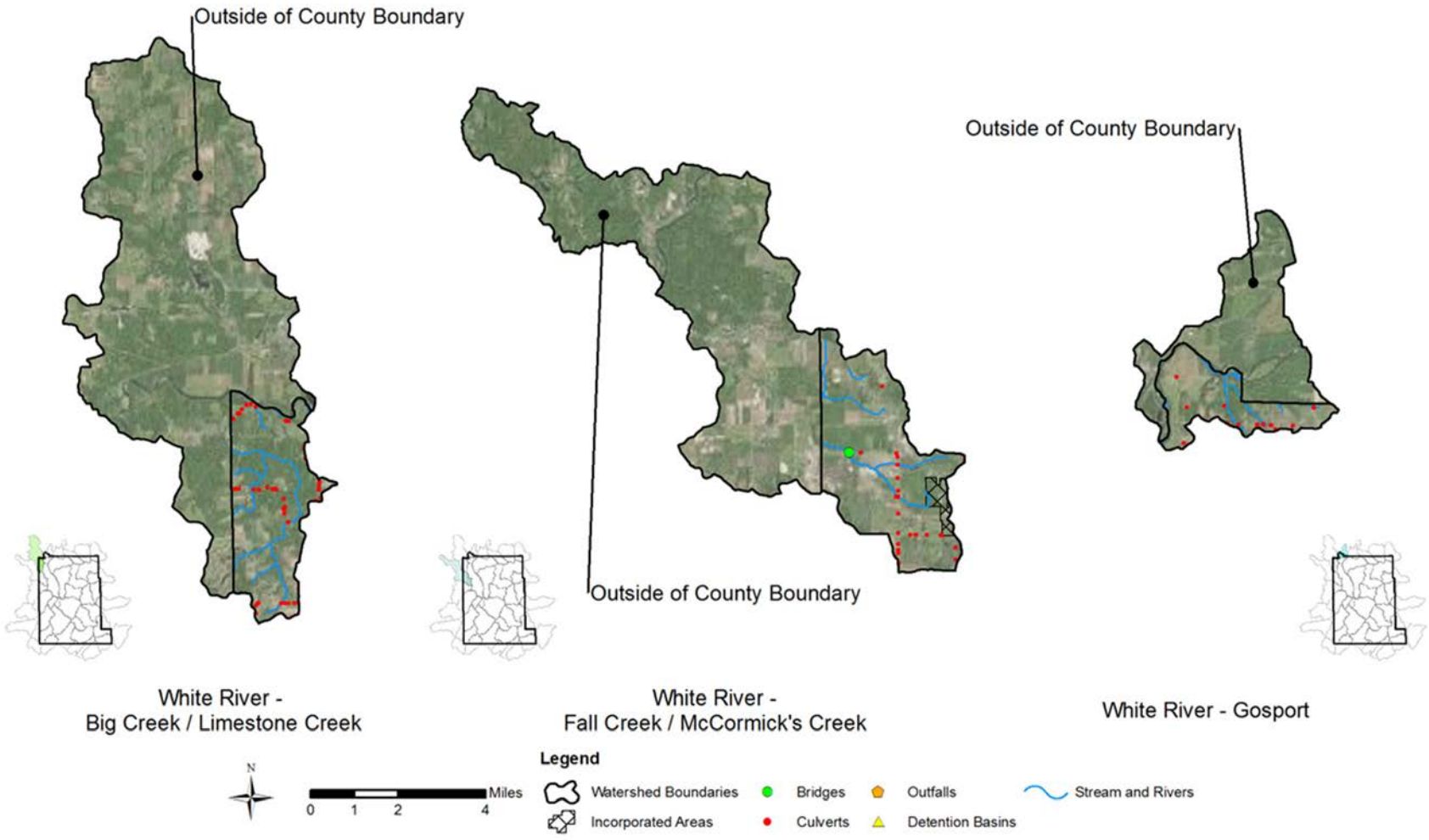

Figure 24: Stormwater Infrastructure Locations by Watershed Part K

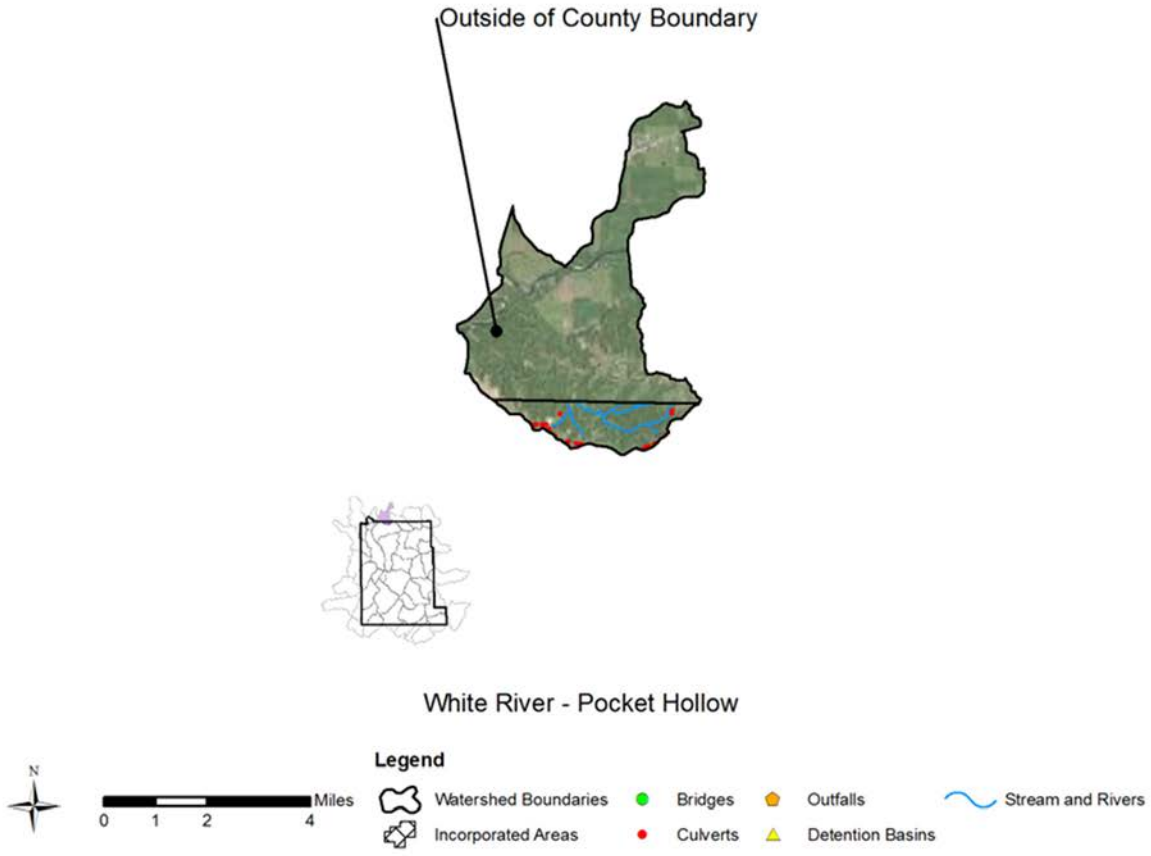

Figure 25: Stormwater Infrastructure Locations by Watershed Part L

2.3.3 Current Capital Improvement Projects

Capital Improvement Projects identified, planned for, and budgeted in Monroe County do not currently include stand-alone stormwater projects. The Bridge Replacement Program budget and schedule has been developed through 2019 and includes an overall anticipated cost of $17,114,477 with the County portion listed at $8,613,217. The Monroe County Highway Department provides quarterly status reports to INDOT for state and federally funded projects.

2.3.4 I-69 Routing

Over the past 50 years the idea of having an interstate corridor between Indianapolis and Evansville has been passed around between INDOT and other agencies throughout the state. In the early 1990s the idea of this corridor was propelled into the forefront when Congress designated it as “Corridor 18” in the Intermodal Surface Transportation Efficiency Act of 1991. Then, in the late 1990s Congress made a push to enhance the travel from the north in Canada all the way to the South in Mexico. This congressional jolt resulted in I-69 being chosen as part of the national highway project.

I-69 under construction

The purpose of the I-69 corridor from Indianapolis to Evansville, that includes a major path through Monroe County, is stated in the Tier 2 study as:

- Strengthens the transportation network in southwest Indiana
- Supports economic development in southwest Indiana
- Completes the portion on the National I-69 Project between Evansville and Indianapolis

Monroe and Green Counties are part of Section 4 of the I-69 project. This corridor stretches between US231 and ending at SR 37 and is currently under construction with a target completion by the end of 2015. Originally slated to be done earlier, the previous two wet summers of 2012 and 2013 and the harsh winter in between those years has delayed some of the construction progress. Section 4 opened on December 9th, 2015.

Just over 10 miles of the new I-69 corridor have been cut directly through Monroe County. The construction has impacted 3 watersheds and approximately 10 streams changing the path and flow of these waterways. During the construction phase, small streams and karst areas were affected by heavy sediment losses. Harp Spring in particular was contaminated.

Turbid water from Harp Spring (right) enters a local creek during Section 4 construction

Sinkhole excavated and later filled with crushed limestone

Section 4 of I-69 is a new terrain route through the Mitchell plateau in the southwest part of Monroe County. Characterized by karst topography, the Mitchell plateau developed on Mississippian limestone. A divide at Harmony Road splits the interstate between the Indian Creek and Clear Creek watersheds. Many sinkholes were altered by this project. When sinkholes were capped and filled the runoff from the corresponding sinkhole watersheds was diverted to surface streams.

Heavy sediment loss during construction contaminated sinkholes. This was especially prevalent in the Indian Creek watershed. Harp Spring would often become highly turbid about a day after significant rain events.

Although the standards for detention contained in the Monroe County Stormwater Management Ordinance were not met, some detention and some water quality practices were incorporated in this project. Long term impacts to karst systems and to surface runoff are unknown. One property owner has documented silt laden runoff from Section 4 of I-69 despite the fact that the project is complete. All vegetation may not be fully established but steep constructed side slopes in some areas are probably a contributing factor as well. Section 5 of I-69 follows the route of State Road 37 north of Victor Pike in Monroe County and is currently under construction.

The construction of Section 4 of I-69 in Monroe County serves as an example to all of the need for the best possible stormwater practices to be incorporated in public projects. Observation of area streams convinced the Monroe County MS4 Operator that effluent limitation standards will be necessary to improve water quality from earth disturbing projects.

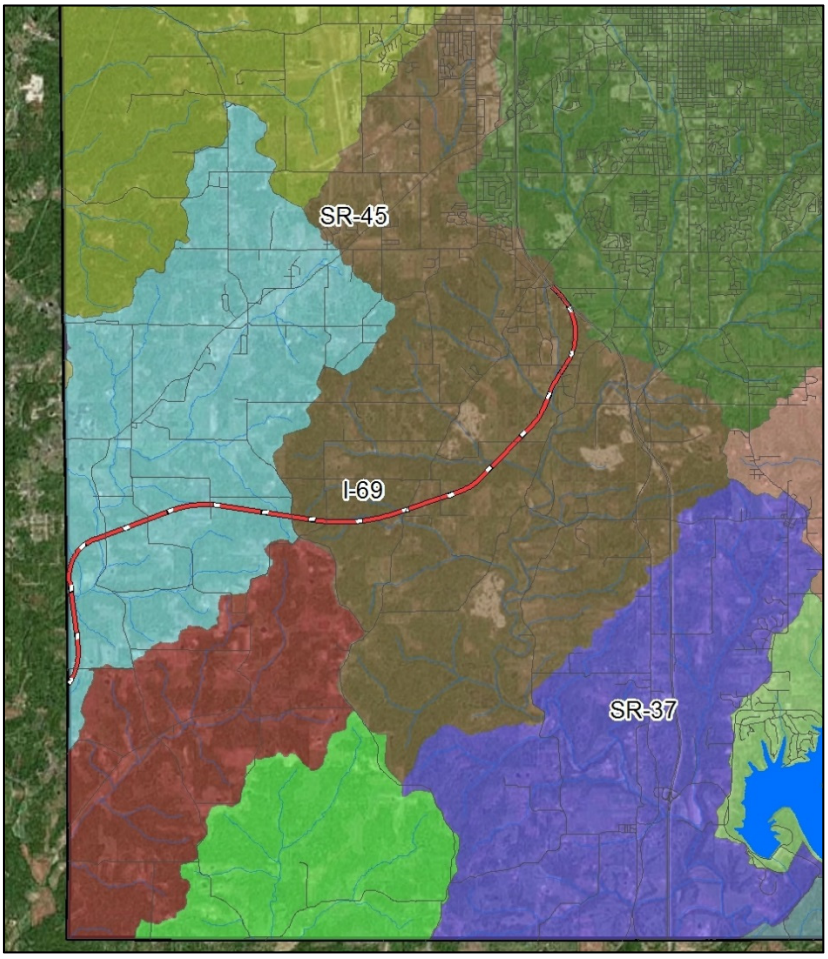

Figure 26: Interstate 69 Route

2.4 Documented Complaints and Field Reconnaissance

Calls and emails from the public regarding drainage issues come to the Highway Maintenance Facility and to the Drainage Engineer and Stormwater Inspector. These calls tend to fall into the following categories:

1. Roadside ditches, driveway pipes, culverts under county roads, inlets, and storm sewers that are clogged (often in part due to sand deposited on the roads for snow and ice removal).
2. Runoff from county roads onto private property.
3. Runoff from neighbors onto private property. Sometimes the concern has to do with the quality of the water and trash carried by the runoff.
4. Runoff from new development onto private property. Often the concern has to do with water quality.
5. Deposition of sand from roads into yards – often through storm sewers draining county roads.
6. Track out of dirt onto county roads. This is often from sites under construction.
7. Private driveways being eroded by runoff. This is often due to driveway culverts that are either damaged, clogged, or not present.
8. Sinkholes forming in yards or close to county roads.
9. Inlets, culverts under county roads, and storm sewers that are in need of repair.
10. Additional inlets needed.
11. Eroding ditches and erosion at culvert outlets.
12. Chronic backyard drainage problems.
13. Log jams.
14. Water standing on county roads. This is often due to accumulation of sand on the shoulders.
15. Ice on roads.

Many times the concerns can be dealt with by cleaning the road shoulder, the roadside ditch, or the culvert or storm sewer. Items No. 9, 10, and 15 (inlets, culverts, and storm sewers in need of repair or to be added, and ice on road) are ones for which the County needs to seek more timely solutions. The stormwater equipment operators may be able to address some or most of these issues with proper equipment. It may be best in some cases to assign work to a contractor on retainer.

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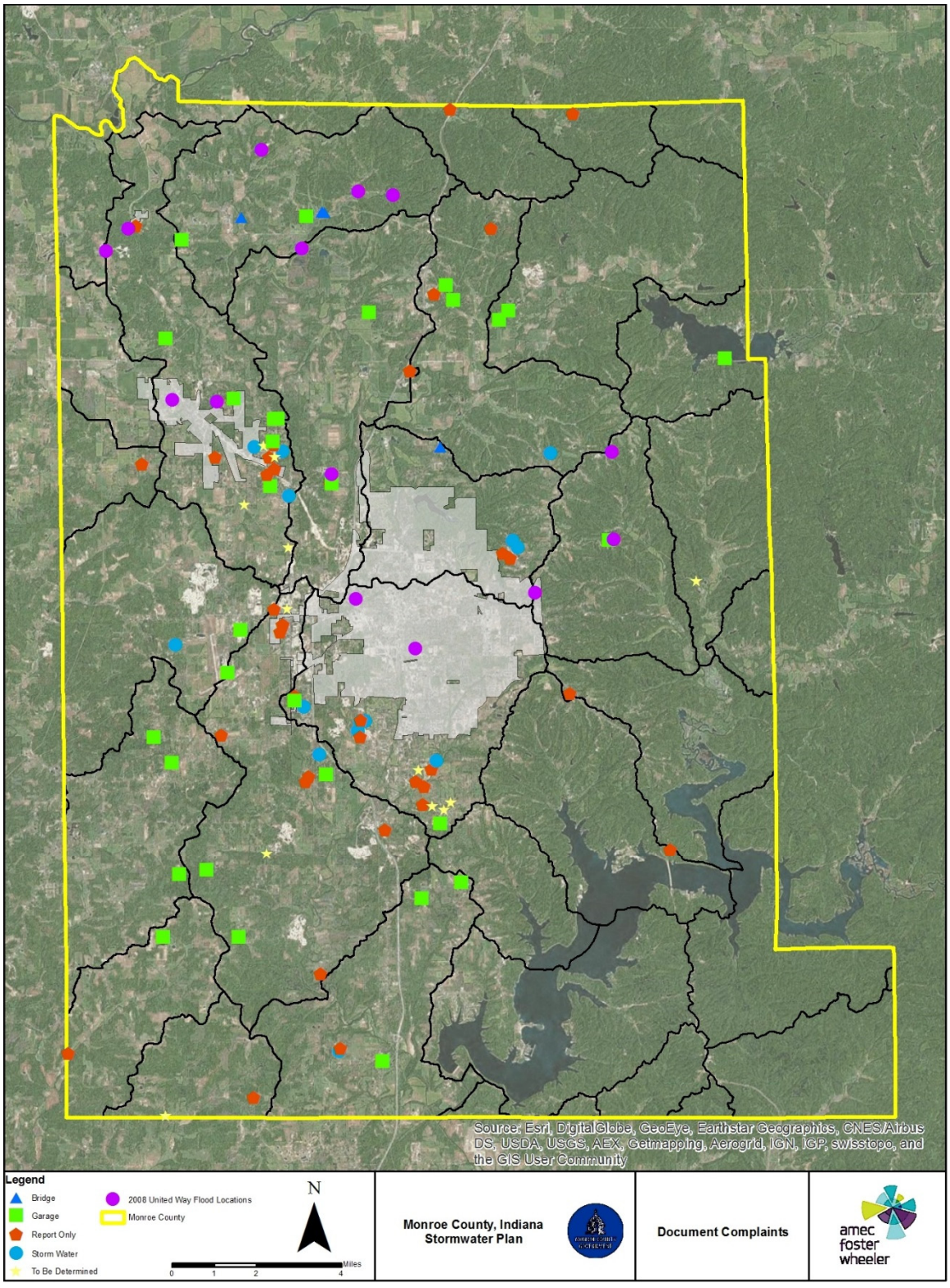


Figure 27: Documented Stormwater Complaints by Type and Location

Table 2: Monroe County Flood Prone Roads is grouped by flooding source. Three groups of flooding sources are apparent. Beanblossom Creek runs generally east to west across the northern part of the county from Lake Lemon to West Fork White River. Roads that cross this creek and that run parallel to it in the floodplain generally flood from one to two days on two or three occasions a year.

Monroe Lake is a flood control reservoir operated by the Corps of Engineers. The lake level generally varies between the normal pool elevation of 538 feet, MSL to the emergency spillway elevation of 556 feet. This is an 18 foot range. On May 4, 2011 the highest level (557.3 feet – 19.3 feet above normal pool) was recorded. Whenever the lake level exceeds 556 (which has happened three times) water runs over Valley Mission Road.

McGowen Road begins to flood when the lake is only 5 feet above normal pool level. The lowest part of Friendship Road is flooded at 7 feet above normal pool. When North Fork Salt Creek is flooding, the upper end of the lake is higher than the rest of the lake. This can cause low sections of roads in the upper lake region (Friendship, Kent, Brummet Creek, and Old State Road 46) to be under water for about a day even though the level of the main body of the lake is not abnormally high.

The third major grouping of flooding source is small streams. This type of flash flooding normally lasts only a few hours or less during and immediately following intense rain storms. Since segments of most county roads experience some effects of flash flooding, only the roads with more severe or chronic flash flooding issues are listed.

Projects have been assigned to some but not all of the listed flood prone roads. This does not preclude that possibility that projects could be undertaken within the next 20 years to reduce the risk of flooding on these roads.

Reduction of flood hazards is a primary goal for Stormwater Management. Since 2000, people drove on Monroe County Roads into floodwaters and lost their lives in three separate cases. Flood mitigation projects have been proposed for some but not all of these roads. Improving notice and warning of flooding will improve safety for those roads that will continue to experience occasional flooding.

- Moores Creek Road – October 5, 2000 (This was at a low water crossing that was subsequently replaced with a bridge)
- Friendship Road – January 28, 2007
- Moon Road – April 5, 2014 (two people)

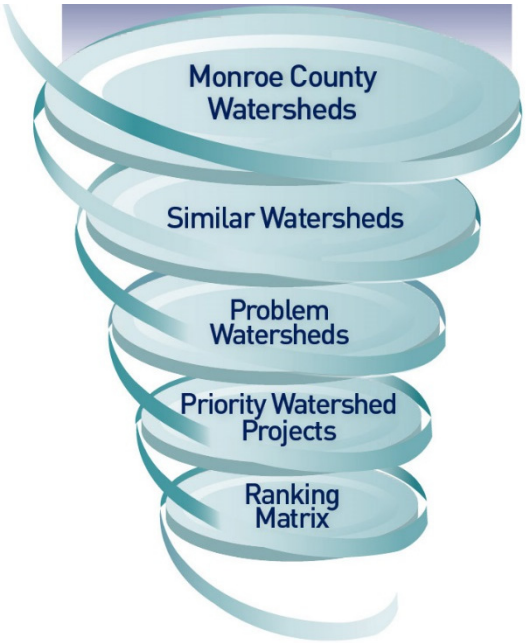
Table 2: Monroe County Flood Prone Roads

Road	Primary Flooding Source	Type of Flooding	Duration of flooding	Additional Flooding Source	Type and Duration of Additional Flooding	Comments and Proposed Stormwater Projects
Baby Creek Road	Baby Creek	flash flooding - low water crossings	hours			SW 03 and SW 04: There are 4 low water crossings.
Anderson Road	Beanblossom Creek		about a day	local crossing waterways	flash flooding - shallow water	SW 02: This is an important road. The most frequent flood problems occur near Bridge 192 & intersection with Fish Road.
Bottom Road	Beanblossom Creek		one or two days			SW 20
Mel Currie Road	Beanblossom Creek		about a day			
Miller Road	Beanblossom Creek		about a day			This is backwater from Beanblossom Creek and is therefore not flowing water
Mt. Tabor Road	Beanblossom Creek	road overflow at Bridge 13	one or two days	small creeks	hours	SW 11 and SW 25
Old Maple Grove Road	Beanblossom Creek		one or two days			
Shilo Road	Beanblossom Creek	road overflow at Bridge 59	about a day			
Showers Road	Beanblossom Creek		about a day			
Wampler Road	Beanblossom Creek		one or two days	White River	several days	
Woodall Road	Beanblossom Creek		one or two days			
Woodland Road	Beanblossom Creek		one or two days			
Wylie Road	Beanblossom Creek		about a day			
Maple Grove Road	Beanblossom Creek near Bridge 42		one or two days			
Dillman Road	Clear Creek	flash flooding - overflow at Bridge 83	usually less than one day			
Fluck Mill Road	Clear Creek	flash flooding	usually less than a day			
Gordon Pike east of S Rogers Street	Clear Creek	flash flooding - overflow at Bridge 74	hours			This may be addressed in Fullerton Pike project
Gore Road	Clear Creek	flash flooding	about a day			
S. Rogers Street near Bridge 78 and That Road	Clear Creek	flash flooding - overflow at Bridge 78	hours			
Breeden Road	Indian Creek	flash flooding				SW 32
Fry Road	Indian Creek	flash flooding				
Mt. Pleasant Road	Indian Creek					Since the inadequate crossing at Bridge 915 was replaced with larger structure in 2014 this road floods much less often
Tom Phillips Road	Indian Creek	flash flooding - overflow at Bridge 70	hours			
Matthews Dr	Jacks Defeat Creek					Bridge 33 project completed this year will reduce flooding
Shuffle Creek Road	Lake Lemon	lake flooding	about a day			SW 42
Brummett Creek Road	Monroe Lake	lake flooding	days to weeks	Brummett Creek and North Fork Salt Creek	hours	SW 05: Road used to be impassable for weeks at a time before it was raised 5 feet.
Friendship Road between Lampkins Ridge and Gross	Monroe Lake	lake flooding - starting around 545.0 ft. (7 ft above normal pool)	days to weeks	North Fork Salt Creek	hours	There is one residence at the end of Friendship Road.
Friendship Road between State Road 46 and Lampkins Ridge	Monroe Lake	lake flooding - starting around 549.5 ft. (11.5 feet above normal pool)	days to weeks	North Fork Salt Creek	about a day	
Gross Road near intersection with Friendship Road	Monroe Lake	lake flooding - starting around 550 ft. (12 feet above normal pool).	days to weeks			
McGowen Road	Monroe Lake	lake flooding - starting around 543.0 ft. (5 ft above normal pool)	days to weeks			
Moores Creek Road	Monroe Lake	lake flooding - starting around 551.5 ft (13.5 ft above normal pool)	days to weeks			SW 07: This road provides access to several houses and a campground.
Roberts Road	Monroe Lake	lake flooding - starting around 554 ft (16 ft above normal pool level)	days to weeks			
Stipp Road near 4745	Monroe Lake	lake flooding - starting around 551 (13 ft above normal pool)	days to weeks			SW 08
Stipp Road near Bridge 907	Monroe Lake	lake flooding - starting around 544.0 (6 ft above normal pool)	days to weeks			
Old State Road 46	Monroe Lake	lake flooding - starting around 555 (17 feet above normal pool)	days	North Fork Salt Creek	about a day	This road used to be impassable for weeks at a time before it was raised five feet.

Road	Primary Flooding Source	Type of Flooding	Duration of flooding	Additional Flooding Source	Type and Duration of Additional Flooding	Comments and Proposed Stormwater Projects
Stipp Road near Bridge 907	Monroe Lake	lake flooding - starting around 544.0 (6 ft above normal pool)	days to weeks			
Valley Mission Road	Monroe Lake emergency overflow	road overflow when the lake level exceeds 556 ft (18 ft above normal pool level)	hours up to a couple of days			This is emergency overflow for Monroe Lake. Water has flowed from the lake across the road several times since the dam was built in 1965 (all in the last 15 years). Nothing can or should be done to prevent this overflow. Road needs to be closed when the depth of water exceeds a few inches. This is easy to monitor.
Kent Road	North Fork Salt Creek	flash flooding - large watershed	about a day	Monroe Lake - starting around 554 (16 ft above normal pool)	lake flooding - typically several days to weeks	
Bunger Road	sinkhole - Bunger Sinkhole	Terminal sinkhole	one or two days			raise road - SW
Cave Road near W Gifford Road	sinkhole - Cave Creek	terminal sinkhole	one or two days			
Cavewood Court	sinkhole - Cave Creek	terminal sinkhole	one or two days			SW 17
W Gifford Road	sinkhole - Cave Creek	terminal sinkhole	one or two days			
Terrace Drive	sinkhole - local drainage	sinkhole flooding	hours			SW 29 A neighbor is concerned the floodwater will ruin his septic system.
Fernwood Drive	Sinking Creek	flash flooding	hours	terminal sinkhole of Sinking Creek	about a day	SW 19 (a, b, and c) This flooding from Sinking Creek affects not only the road but potentially quite a few houses.
Fleener Road	small stream - Brummett Creek	flash flooding	hours	Monroe Lake	lake flooding - typically several days	SW 05 Since a new culvert was installed on Hash Road just west of Fleener, this road does not flood as frequently as before.
Bryant Creek Road	small stream - Bryant Creek	flash flooding - low water crossing	hours			replace low water crossing - SW
Brock Road	small stream - Conrad Branch	flash flooding				SW 12
S. Rogers Street at Bridge 77	small stream - Jackson Creek	flash flooding - overflow at Bridge 77	hours			
Bennett Lane	small stream - Judah Branch	flash flooding	hours			
Kerr Creek Road	small stream - Kerr Creek	flash flooding	hours			SW 14
Vernal Pike	small stream - Unnamed tributaries to Richland Creek	flash flooding	hours			SW 28
Prather Road	small stream - Unnamed tributary to Beanblossom Creek	flash flooding	hours			The road is traversable except during and shortly after intense storms.
Hash Road	small stream - Unnamed trib to Brummetts Creek	flash flooding	hours			SW 13
Ketchum Road	small stream - Unnamed tributary to Clear Creek	flash flooding	hours			Since inadequate driveway culverts were replaced several years ago flood frequency has been greatly reduced
San Juan Drive	small stream - Unnamed tributary to Clear Creek	flash flooding	hours			SW 21 Monroe County has done a couple of drainage improvement projects along San Juan Drive. The conveyance under South Rogers Street needs to be increased to prevent potential flooding to houses along San Juan.
Whisnand Road	small stream - unnamed tributary to Griffy Creek	flash flooding	hours			The west end of Whisnand floods during intense rains in part because of inadequate culverts under Stone Mill Road and Business 37 North.
Evans Road	small stream - Unnamed tributary to Indian Creek	flash flooding	hours			SW 39
Walnut Street Pike	small stream - Unnamed tributary to Jackson Creek	flash flooding	hours			The flooding is shallow and is mainly a concern from the standpoint of potential hydroplaning and diversion of flow to the Bloomington Speeday.
Richardson Road at railroad underpass	small stream - Unnamed tributary to Lake Lemon	flash flooding	hours	Lake Lemon	about a day	culverts added in 2014 reduced flash flooding issue
Boltinghouse Road near Bridge 44	small stream - Unnamed trib to Muddy Fork Creek	flash flooding	hours			
Earl Young Road	small stream - Unnamed tributary to Muddy Fork Creek	flash flooding	hours			The road is low around 4565. A low water crossing at the base of the big hill was replaced around 2013 with a large culvert.
Cherry Lane	small stream - Unnnamed tributary to "Fall Creek" (tributary to Jackson Creek)	flash flooding	hours			SW 15 Flooding is shallow but affects not only Cherry but Fairfax Road. In addition water comes close to several homes on Cherry Lane and affects septic systems.
Strain Ridge Road	small stream - Unnnamed tributary to Little Salt Creek	flash flooding	hours			SW 45 Not only the road but the post office floods.
Victor Pike	small stream - West Fork Clear Creek	flash flooding - overflow at Bridge 80	hours			
That Road near S Rogers Street and east of Victor Pike	small stream - West Fork Clear Creek and Clear Creek	flash flooding - overflow at Bridge 79	hours			
Owen County Line Road	White River	river flooding	several days			
Moon Road	White River	river flooding	several days	Beanblossom Creek and Jacks Defeat Creek	a couple of days for Beanblossom Creek - hours for Jacks Defeat	

2.5 Watershed Data and Characterization

The 36 Watersheds were characterized based on physical characteristics including:



- Overall size (acres and acres within County)
- Percent of Watershed within County
- Representative Land Use (Urban, Agricultural, Forest)
- Percent Developed
- Length of stream (overall and within County)
- Potential for additional development
- Number of documented flooding/drainage issues
- Runoff contribution from outside County
- Protected areas (National Forest, Conservation areas, wetlands)
- Steep Slopes (over 50% of watershed has slopes 15% or greater)
- Number of water management structures (dams, reservoirs, NPDES outfalls)
- Stormwater management facilities (detention ponds, storm sewers)
- GIS Structures (bridges and culverts)
- Stream/Road crossings

Similar watersheds were grouped, and a ranking matrix was developed identifying priority watersheds based on reoccurring flooding issues, complaints, number of drainage structures per acre, and potential for additional development to occur within the watershed. Watersheds encumbered by numerous issues and with the potential for additional growth and development were identified as “high” priority. Those with little area or opportunity for development and containing mostly rural or park property were categorized as “low” priority from an active stormwater management standpoint.

A brief description of each watershed follows. Table 3 contains the detailed watershed characterization and priority ranking and Figure 28 provides a color coded geographic representation of the information.

Table 3: Monroe County Watershed Characterization Data

MONROE COUNTY WATERSHED CHARACTERIZATION																			
Watershed Name/ID	Size (Acres)	Acres Within Monroe Co.	% of WS in Monroe Co	Representative Land Use	% Developed	Length of Stream (NHD High Res)	Length of Stream Within Monroe Co (NHD High Res)	Potential for Land Use change / growth (low-high)	# of Documented Flooding /Drainage Issues	Runoff Contribution from outside County	Runoff leaves County	Protected Area - National Forest, Conservation, Wetland	Over 50% Steep Slopes (>15%)	# of Water Mgmt structures - Dams, Reservoirs, NPDES Outfalls	Stormwater Management facilities (detention ponds / storm sewers)	GIS Structures (bridges)	GIS Structures (culverts)	Stream / Road Intersections	Priority Ranking
Bean Blossom Creek - Buck Creek/ Muddy Fork	12,115	12,115	100%	Deciduous Forest	4%	53.2	53.2		5				X	Bethel Lake Dam, Griffy Reservoir, Griffy Reservoir Dam	More than 5	11	199	23	High
Bean Blossom Creek - Honey Creek	14,078	13,527	96%	Deciduous Forest	2%	68.3	66.0		2	Yes			X	Lazy Lake Dam, Bean Blossom Dam, Egenolf Lake Dam	1 to 5	6	133	20	High
Bean Blossom Creek - Indian Creek	11,672	11,669	100%	Deciduous Forest	2%	48.0	48.0		5				X	Henke Lake Dam (a.k.a. Bugher Lake Dam)	1 to 5	8	165	30	High
Bean Blossom Creek - Jack's Defeat	15,361	15,361	100%	Deciduous Forest	12%	40.5	40.4		18						More than 5	12	269	70	High
Bean Blossom Creek - Stout's Creek	15,518	15,518	100%	Deciduous Forest	9%	56.2	56.2		3						0	8	219	47	High
Cave Creek	3,252	3,252	100%	Deciduous Forest	15%	3.9	3.9		1					Fieldstone Lake Dam	More than 5	0	42	5	High
Clear Creek - Jackson Creek	16,073	16,073	100%	Urban / Suburban	55%	34.1	34.1		17	Runoff from City of Bloomington				Weimer Lake Dam	1 to 5	12	131	80	High
Clear Creek-May Creek	19,182	19,182	100%	Deciduous Forest	7%	49.6	46.9	High (I-69 expansion)	9	Runoff from City of Bloomington					1 to 5	10	224	48	High
Griffy Creek - Griffy Reservoir	9,027	9,027	100%	Deciduous Forest	24%	28.1	28.1		5	Runoff from City of Bloomington				Griffy Reservoir	More than 5	2	96	37	High
Indian Creek Headwaters	15,636	11,182	72%	Deciduous Forest	4%	36.0	25.1	High (I- 69 expansion)	2		X				1 to 5	13	192	25	High
Bean Blossom Creek - Lake Lemon	11,763	5,411	46%	Deciduous Forest	2%	56.6	23.8		0		X		X	Lake Lemon, Lake Lemon Dam	0	0	73	7	Medium
Brummett Creek	8,979	7,814	87%	Deciduous Forest	2%	44.4	38.7		1	Yes			X	Shawnee Lake Dam	0	8	121	24	Medium
Clear Creek - Little Clear Creek	13,509	11,627	86%	Deciduous Forest	5%	37.4	34.3		3	Yes					1 to 5	7	138	34	Medium
Indian Creek - Little Indian Creek	13,465	6,828	51%	Deciduous Forest	2%	38.8	17.8		1		X				0	2	97	11	Medium
Lake Monroe - Moore Creek	11,361	11,361	100%	Deciduous Forest	2%	44.4	44.4		1			X	X	Monroe Reservoir	1 to 5	3	93	13	Medium
Lake Monroe - Ramp Creek	5,269	5,269	100%	Deciduous Forest	3%	18.6	18.6		0			X	X	Monroe Reservoir	1 to 5	0	47	3	Medium
Lake Monroe - Siscoe/Allen/Sugar Creek	13,154	13,112	100%	Deciduous Forest	3%	42.2	42.2		0			X	X		0	0	70	10	Medium
Racoon Creek - Little Racoon Creek	12,765	3,053	24%	Deciduous Forest	3%	32.0	6.2		1		X				1 to 5	0	43	4	Medium
Richland Creek-Little Richland Creek	13,256	9,760	74%	Deciduous Forest	1%	34.7	23.9		0		X				1 to 5	9	87	21	Medium
Sinking Creek	1,807	1,807	100%	Cultivated Crops	29%	2.7	2.7		2						More than 5	1	12	3	Medium
Stephen's Creek	9,540	9,540	100%	Deciduous Forest	5%	44.9	44.9		1				X	Schacht Lake Dam	0	6	150	16	Medium
Bryant Creek	7,276	3,872	53%	Deciduous Forest	2%	29.5	14.6		1		X		X		0	1	41	10	Low
Indian Creek - Robertson Creek	10,297	1,872	18%	Deciduous Forest	1%	43.3	9.6		0		X		X		0	1	14	4	Low
Lake Monroe - Jacob's Creek	9,699	9,097	94%	Deciduous Forest	2%	37.3	34.4		1	Yes		X	X		0	2	84	4	Low
Lake Monroe - Saddle Creek	13,512	8,517	63%	Deciduous Forest	1%	59.1	36.4	Low (N. Forest / Reservoir)	0	Yes		X	X	Monroe Reservoir	0	0	8	0	Low
Little Indian Creek - Jordan Creek	10,896	2,776	25%	Deciduous Forest	1%	48.3	13.9		0		X		X		0	2	24	7	Low
Little Salt Creek - Hunter Creek	10,367	6,258	60%	Deciduous Forest	1%	51.3	33.2	Low (National Forest)	0	Yes	X	X	X		0	1	35	10	Low
Little Salt Creek - Knob Creek	5,756	2,120	37%	Deciduous Forest	2%	22.8	9.4	Low (National Forest)	0		X	X	X		0	0	13	3	Low
North Fork Salt Creek - Little Schooner Creek	14,876	1,872	13%	Deciduous Forest	4%	13.4	2.5		0	Yes					0	0	0	0	Low
Popcorn Creek	9,700	4,816	50%	Deciduous Forest	2%	26.6	11.5		2		X		X		0	2	49	5	Low
White River - Big Creek / Limestone Creek	16,682	3,071	18%	Deciduous Forest	3%	47.8	10.5		0		X				0	0	41	8	Low
White River - Fall Creek / McCormick's Creek	14,391	4,124	29%	Cultivated Crops	6%	31.2	7.6		0		X				0	1	28	7	Low
White River - Gosport	4,636	1,613	35%	Deciduous Forest	3%	11.3	4.8		0		X				0	0	13	2	Low
White River - Pocket Hollow	5,873	949	16%	Deciduous Forest	2%	22.6	4.3		0		X		X		0	0	16	1	Low

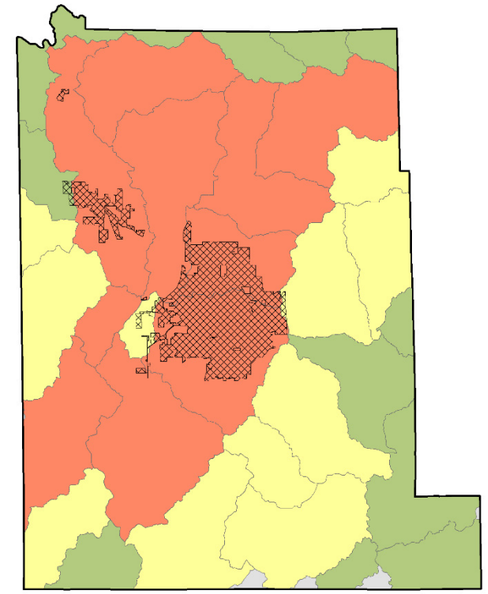
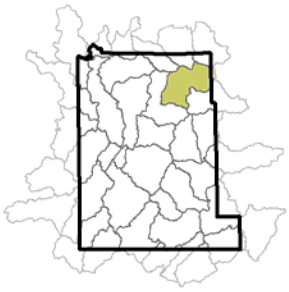


Figure 28: Priority Rating of Watersheds within Monroe County

Bean Blossom Creek - Buck Creek / Muddy Fork

The Bean Blossom Creek – Buck Creek / Muddy Fork watershed has a High Critical Rating and has 5 instances of documented flooding and other stormwater issues. The watershed is 12,115 acres and is 4% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and over 50% of the watershed has slopes steeper than 15%, which limits the potential for future development. The watershed contains 11 bridges and 199 culverts. Twenty-three of those locations are road crossings and the watershed. The watershed contains Bethal Lake Dam, Griffy Reservoir, Griffy Reservoir Dam, University Lake Dam, Linnemeier Lake Dam, and 5 or more stormwater management facilities.

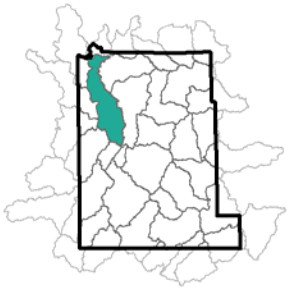


Bean Blossom Creek - Honey Creek

The Bean Blossom Creek – Honey Creek watershed has a High Critical Rating and has 2 instances of documented flooding and other stormwater issues. The watershed is 14,078 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 96% of the watershed and a portion of the runoff is generated from outside of the county. Over 50% of the watershed has slopes steeper than 15. The watershed contains 6 bridges and 133 culverts. Twenty of those locations are road crossings. The watershed contains Lazy Lake Dam, Bean Blossom Dam, Egenolf Lake Dam, and 1 to 5 stormwater management facilities.

Bean Blossom Creek - Indian Creek

The Bean Blossom Creek – Indian Creek watershed has a High Critical Rating and has 5 instances of documented flooding and other stormwater issues. The watershed is 11,672 acres and is 2% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and over 50% of the watershed has slopes steeper than 15%. The watershed contains 8 bridges and 165 culverts. Thirty of those locations are road crossings. The watershed contains Henke Lake Dam (also known as Bugher Lake Dam) and 1 to 5 stormwater management facilities.

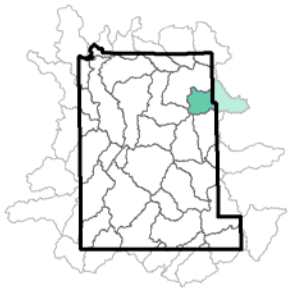


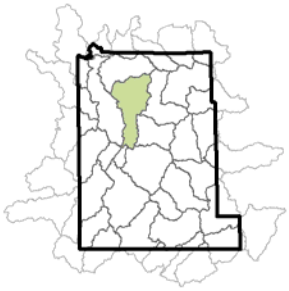
Bean Blossom Creek - Jack's Defeat

The Bean Blossom Creek – Jack's Defeat watershed has a High Critical Rating and has 18 instances of documented flooding and other stormwater issues; the highest number of issues documented in any watershed within Monroe County. The watershed is 15,361 acres and is 12% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County. The watershed contains 12 bridges and 269 culverts. Seventy of those locations are road crossings. The watershed contains more than 5 stormwater management facilities and does not contain any dams or reservoirs.

Bean Blossom Creek - Lake Lemon.

The Bean Blossom Creek – Lake Lemon watershed has an Average Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 11,763 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 46% of the watershed and runoff from the watershed leaves the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 73 culverts and 7 of those locations are road crossings. The watershed contains Lake Lemon and Lake Lemon Dam.



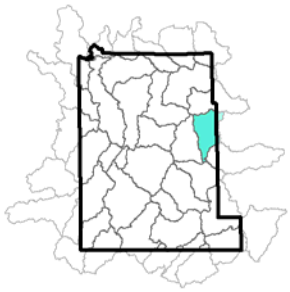


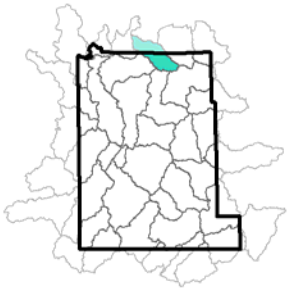
Bean Blossom Creek - Stout's Creek

The Bean Blossom Creek – Stout's Creek watershed has a High Critical Rating and has 3 instances of documented flooding and other stormwater issues. The watershed is 15,518 acres and is 9% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County. The watershed contains 8 bridges and 219 culverts. Forty-seven of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

Brummett Creek

The Brummett Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 8,979 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 87% of the watershed and a portion of the runoff comes from outside of the county boundary. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 8 bridges and 121 culverts. Twenty-four of those locations are road crossings. The watershed contains Shawnee Lake Dam.



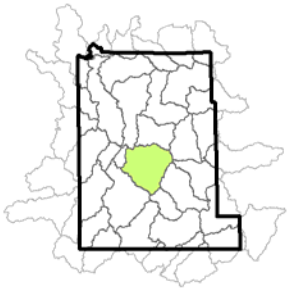


Bryant Creek

The Bryant Creek watershed has a Low Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 7,276 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 53% of the watershed and the flow from the watershed leaves the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 1 bridge and 41 culverts. Ten of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

Cave Creek

The Cave Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 3,252 acres and is 15% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County. The Cave Creek watershed drains to a terminal sinkhole location and does not connect above ground to any downstream watershed. The watershed contains 42 culverts and 5 of those locations are road crossings. The watershed contains Fieldstone Lake Dam and more than 5 stormwater management facilities.

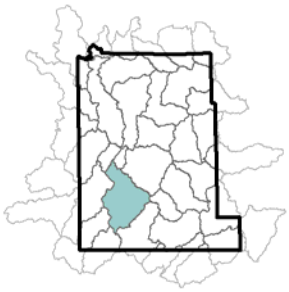


Clear Creek - Jackson Creek

Rating and has 17 instances of documented flooding and other stormwater issues; the second highest number of issues documented in any watershed within Monroe County. The watershed is 16,073 acres and is 55% developed with a representative land use of urban/suburban. This watershed is the most developed watershed within Monroe County and receives runoff from the City of Bloomington. The watershed is contained entirely within Monroe County. The watershed contains 12 bridges and 131 culverts. Eighty of those locations are road crossings. The watershed contains Weimer Lake Dam and 1 to 5 stormwater management facilities.

Clear Creek - Little Clear Creek

The Clear Creek – Little Clear Creek watershed has an Average Critical Rating and has 3 instances of documented flooding and other stormwater issues. The watershed is 13,509 acres and is 5% developed with a representative land use of deciduous forest. Monroe County contains 86% of the watershed and a portion of the runoff comes from outside of the county boundary. The watershed contains 7 bridges and 138 culverts. Thirty-four of those locations are road crossings. The watershed contains Shawnee Lake Dam and 1 to 5 stormwater management facilities.

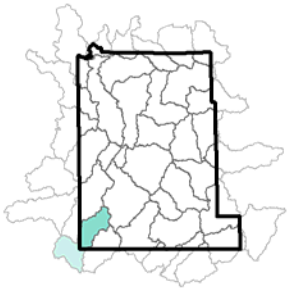


Clear Creek - May Creek

The Clear Creek – May Creek watershed has a High Critical Rating and has 9 instances of documented flooding and other stormwater issues. The watershed is 19,182 acres and is 7% developed with a representative land use of deciduous forest. The watershed is entirely contained within the county and receives runoff from the City of Bloomington. The watershed contains 10 bridges and 224 culverts. Forty-eight of those locations are road crossings. The watershed contains 1 to 5 stormwater management facilities. The Interstate 69 expansion project is proposed to cross through the Clear Creek – May Creek watershed, which could have significant impact on the volume and timing of stormwater runoff, the location of watershed boundaries, and the condition and function of natural waterways.

Griffy Creek - Griffy Reservoir

The Griffy Creek – Griffy Reservoir watershed has a High Critical Rating and has 5 instances of documented flooding and other stormwater issues. The watershed is 9,027 acres and is 24% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and receives runoff from the City of Bloomington. The watershed contains 2 bridges and 96 culverts. Thirty-seven of those locations are road crossings. The watershed contains Griffy Reservoir and more than 5 stormwater management facilities.

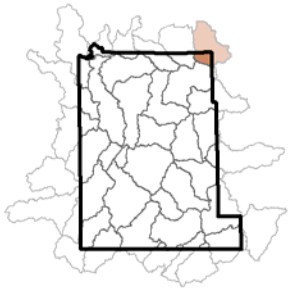


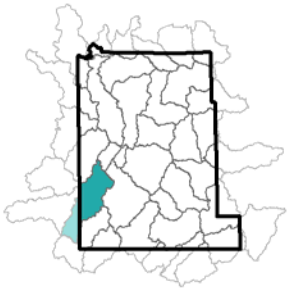
Indian Creek - Little Indian Creek

The Indian Creek – Little Indian Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 13,465 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 51% of the watershed and runoff from the watershed leaves the county. The watershed contains 2 bridges and 97 culverts. Eleven of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

Indian Creek - Robertson Creek

The Indian Creek – Robertson Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 10, 297 acres and is 1% developed with a representative land use of deciduous forest. Monroe County contains 18% of the watershed and the flow from the watershed leaves the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 1 bridge and 14 culverts. Four of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.



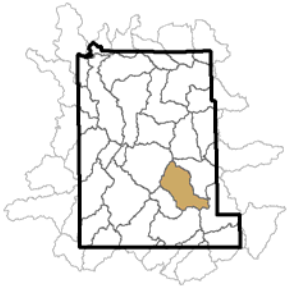


Indian Creek Headwaters

The Indian Creek Headwaters watershed has a High Critical Rating and has 2 instances of documented flooding and other stormwater issues. The watershed is 15,636 acres and is 4% developed with a representative land use of deciduous forest. Monroe County contains 72% of the watershed and flows from the watershed leave the county. The watershed contains 13 bridges and 192 culverts. Twenty-five of those locations are road crossings. The watershed contains 1 to 5 stormwater management facilities. The Interstate 69 expansion crosses through the Indian Creek Headwaters watershed, which has had significant impact on the volume and timing of stormwater runoff, the location of watershed boundaries, and the condition and function of natural waterways.

Lake Monroe - Jacob's Creek

The Lake Monroe – Jacob's Creek watershed has a Low Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 9,699 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 94% of the watershed and a portion of the runoff comes from outside of the county boundary. The watershed contains a portion of the Hoosier National Forest and over 50% of the watershed has slopes steeper than 15%, both of these factors limit the potential for future development. The watershed contains 2 bridges and 84 culverts. Four of those locations are road crossings. The watershed contains Lake Monroe.

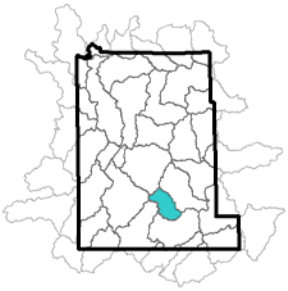


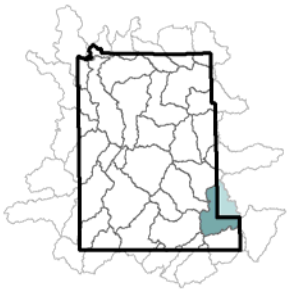
Lake Monroe - Moore Creek

The Lake Monroe – Moore Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 11,361 acres and is 2% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and contains a portion of the Hoosier National Forest. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 3 bridges and 93 culverts. Thirteen of those locations are road crossings. The watershed contains Lake Monroe and 1 to 5 stormwater management facilities.

Lake Monroe - Ramp Creek

The Lake Monroe – Ramp Creek watershed has an Average Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 5,269 acres and is 3% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and contains a portion of the Hoosier National Forest. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 47 culverts and 3 of those locations are road crossings. The watershed contains the Monroe Reservoir and 1 to 5 stormwater management facilities.



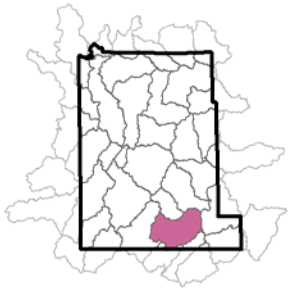


Lake Monroe - Saddle Creek

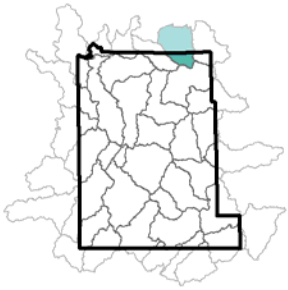
The Lake Monroe – Saddle Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 13,515 acres and is 1% developed with a representative land use of deciduous forest. Monroe County contains 63% of the watershed and a portion of the runoff received by the watershed comes from outside of the county boundary. The watershed contains a portion of the Hoosier National Forest, which limits the potential for changes in land use and urban development. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 8 culverts and the Monroe Reservoir.

Lake Monroe - Siscoe/Allen/Sugar Creek

The Lake Monroe – Siscoe/Allen/Sugar Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 13,154 acres and is 3% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and contains a portion of the Hoosier National Forest. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 70 culverts and 10 of those locations are road crossings. The watershed contains Lake Monroe.



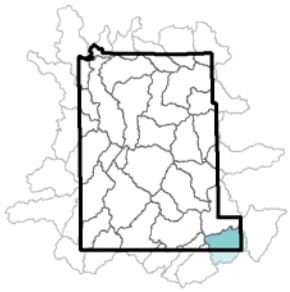
Little Indian Creek - Jordan Creek



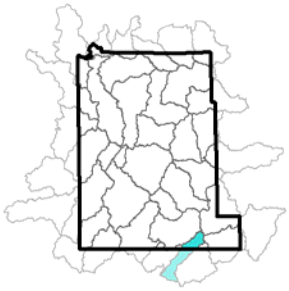
The Little Indian Creek – Jordan Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 10,896 acres and is 1% developed with a representative land use of deciduous forest. Monroe County contains 25% of the watershed and a portion of the runoff leaves the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 2 bridges and 24 culverts. Seven of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

Little Salt Creek - Hunter Creek

The Little Salt Creek – Hunter Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 10,367 acres and is 1% developed with a representative land use of deciduous forest. Monroe County contains 60% of the watershed. A portion of the runoff received by the watershed comes from outside of the county boundary and flows from the watershed leave the county. The watershed contains a portion of the Hoosier National Forest, which limits the potential for changes in land use and urban development. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 1 bridge and 35 culverts. Ten of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.



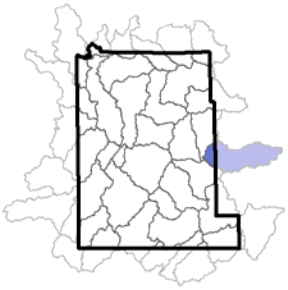
Little Salt Creek - Knob Creek

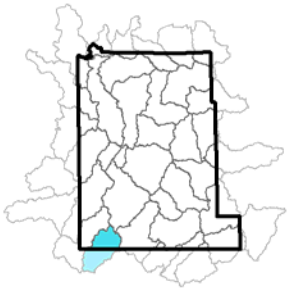


The Little Salt Creek – Knob Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 5,756 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 37% of the watershed. A portion of the runoff received by the watershed comes from outside of the county boundary and flows from the watershed leave the county. The watershed contains a portion of the Hoosier National Forest, which limits the potential for changes in land use and urban development. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 13 culverts and 3 of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

North Fork Salt Creek - Little Schooner Creek

The North Fork Salt Creek - Little Schooner Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 14,876 acres and is 4% developed with a representative land use of deciduous forest. Monroe County contains 13% of the watershed and a portion of the runoff received by the watershed comes from outside of the county boundary. The watershed does not contain any bridges, culverts, water management structures, dams, or reservoirs.



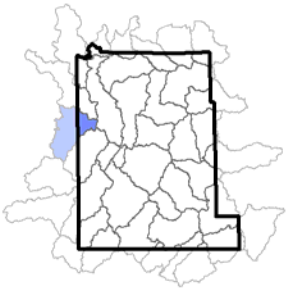


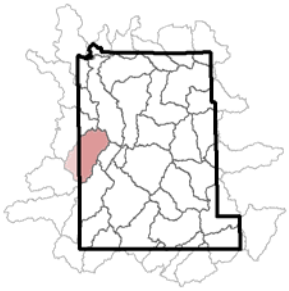
Popcorn Creek

The Popcorn Creek watershed has a Low Critical Rating and has 2 instances of documented flooding and other stormwater issues. The watershed is 9,700 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 50% of the watershed and a portion of the runoff leaves the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 2 bridges and 49 culverts. Five of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

Raccoon Creek - Little Raccoon Creek

The Raccoon Creek - Little Raccoon Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 12,765 acres and is 3% developed with a representative land use of deciduous forest. Monroe County contains 24% of the watershed and a portion of the runoff leaves the county. The watershed contains 43 culverts and 4 of those locations are road crossings. The watershed contains 1 to 5 stormwater management facilities.



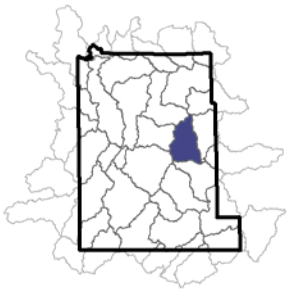


Richland Creek - Little Richland Creek

The Richland Creek - Little Richland Creek watershed has an Average Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 13,256 acres and is 1% developed with a representative land use of deciduous forest. Monroe County contains 74% of the watershed and a portion of the runoff leaves the county. The watershed contains 9 bridges and 87 culverts. Twenty-one of those locations are road crossings. The watershed contains 1 to 5 stormwater management facilities.

Sinking Creek

The Sinking Creek watershed has an Average Critical Rating and has 2 instances of documented flooding and other stormwater issues. The watershed is 1,807 acres and is 29% developed with a representative land use of cultivated crops. The watershed is contained entirely within Monroe County and drains to a terminal sink hole instead of connecting to an above ground waterway. The watershed contains 1 bridge and 12 culverts. Three of those locations are road crossings. The watershed contains more than 5 stormwater management facilities.

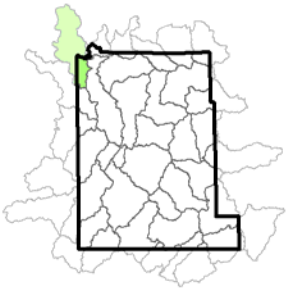


Stephen's Creek

The Stephen's Creek watershed has an Average Critical Rating and has 1 instance of documented flooding and other stormwater issues. The watershed is 9,540 acres and is 5% developed with a representative land use of deciduous forest. The watershed is contained entirely within Monroe County and over 50% of the watershed has slopes steeper than 15%. The watershed contains 6 bridges and 153 culverts. Sixteen of those locations are road crossings. The watershed contains Schacht Lake Dam.

White River - Big Creek / Limestone Creek

The White River Big Creek - Limestone Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 16,682 acres and is 3% developed with a representative land use of deciduous forest. Monroe County contains 18% of the watershed and the runoff from the watershed flows out of the county. The watershed contains 41 culverts and 8 of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs

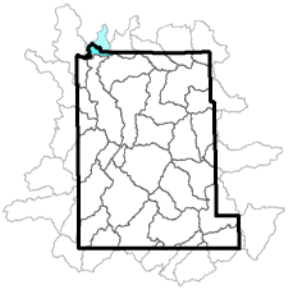


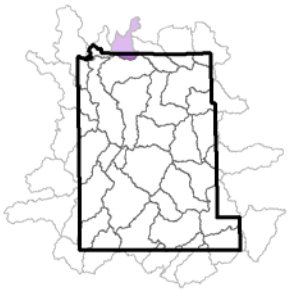
White River - Fall Creek / McCormick's Creek

The Fall Creek – McCormick's Creek watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 14,391 acres and is 6% developed with a representative land use of cultivated crops. Monroe County contains 29% of the watershed and runoff from the watershed leaves the county. The watershed contains 1 bridge and 28 culverts. Seven of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

White River – Gosport

The White River – Gosport watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 4,636 acres and is 3% developed with a representative land use of deciduous forest. Monroe County contains 35% of the watershed and a portion of the watershed flows out of the county. The watershed contains 13 culverts and 2 of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.





White River - Pocket Hollow

The White River – Pocket Hollow watershed has a Low Critical Rating and has no instances of documented flooding and other stormwater issues. The watershed is 5,873 acres and is 2% developed with a representative land use of deciduous forest. Monroe County contains 16% of the watershed and the runoff from the watershed flows out of the county. Over 50% of the watershed has slopes steeper than 15%. The watershed contains 16 culverts and only 1 of those locations are road crossings. The watershed does not contain any water management structures, dams, or reservoirs.

2.6 Local Policy, Regulations, and Ordinances

2.6.1 Monroe County Stormwater Management Governance

Monroe County was created by the State Legislature on January 14, 1818. The Monroe County Board of Commissioners have a wide range of executive and administrative authority. There are several County Departments that are directly under the authority of the Monroe County Commissioners, including the Highway Department. The Monroe County Highway Road Maintenance Department is responsible for maintenance of all county roads and drainage systems. The department's specific functions include street resurfacing, snow removal, fleet maintenance of all county owned vehicles, street sweeping, dust and vegetation control, chip and sealing, grading gravel roads, and sign maintenance.

The responsibilities of the Engineering Department include infrastructure design, traffic signals and signs, pavement markings, major capital improvements, driveway and utility permits and all drainage projects. The Engineering Department also has administration duties associated with the Monroe County Traffic Commission, Monroe County Drainage Board and provides support to various other commissions. Figure 29 provides an organizational chart of the Stormwater Governance Structure.

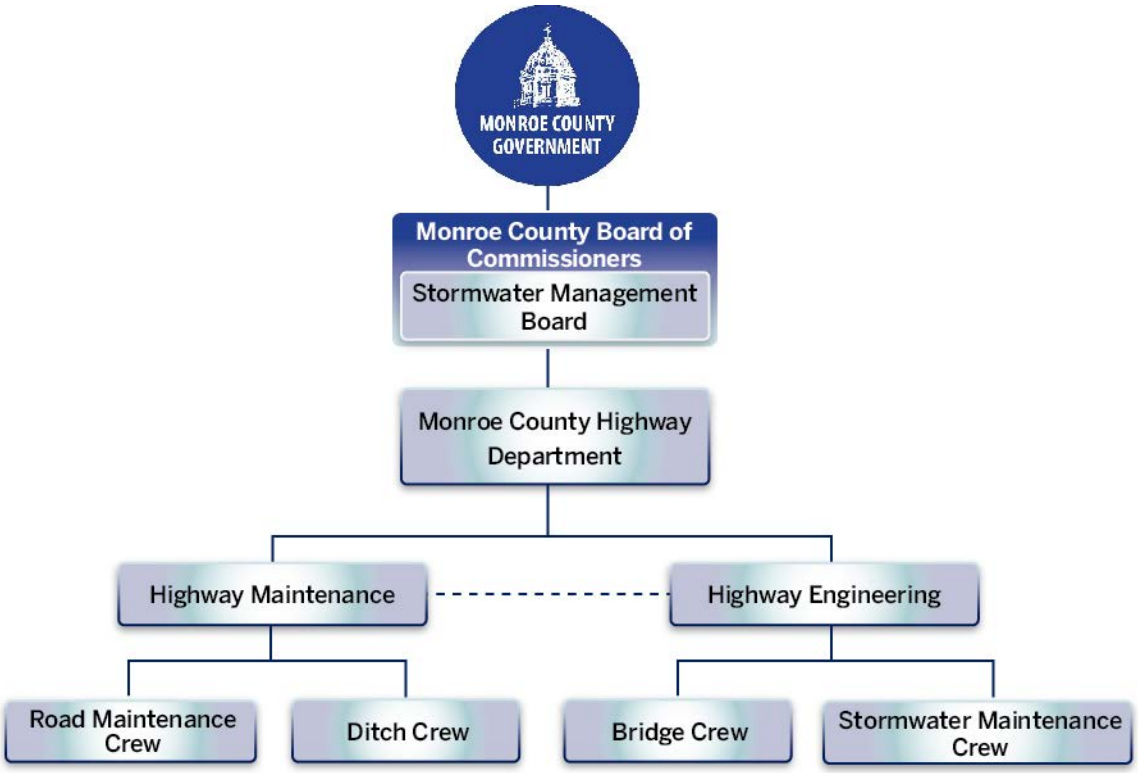


Figure 29: Stormwater Management Governance Structure

2.6.2 Local Policy, Regulations and Ordinances

To promote the public health, safety, and welfare, among other things, Monroe County has adopted local policies, regulations, and ordinances. The local policies, regulations, and ordinances that relate to Natural Systems are further identified below: These documents include:

Clean Water Act

Monroe County is one of the 22 Indiana counties that are regulated under Rule 13, Indiana's implementation of Phase II of the Clean Water Act**.** Rule 13 or 327 Indiana Administrative Code 15-13-1 outlines the clean water requirements. The rule outlines how entities are supposed to improve or maintain the quality of stormwater before it is drained into the surrounding watershed. The rule requires a permit for discharge of stormwater. There are 6 minimum control measures that the County must comply with including: public awareness, public participation, illicit discharges, sediment and erosion control practices for construction sites, long term clean water practices such as ponds and rain gardens, and setting good examples with County operations. Details related to Monroe County's obligations under Rule 13 can be found on the official Monroe County website.

Monroe County Comprehensive Land Use Plan

The Comprehensive Land Use Plan identifies Vulnerable Land and Undisturbed Land. A means of protection shall be established for each identified Vulnerable Land category. Some of these protective instruments shall be in the form of specific ordinance requirement related to a property's use: e.g. sink-hole conservancy areas, slope disturbance restrictions, and dedications for inter-connections with the transportation system. Other protective instruments may apply

more broadly to large area and encompass many pieces of property, e.g. Lakeshore building restrictions, forest canopy maintenance and protection, and drainage ways.

The plan adopts a value proposition that the special environments of karst, steep slopes, floodways, riparian areas, wetlands, and endangered species habitat shall be reserved and remain undeveloped and undisturbed, with the exception of low intensity non-invasive educational and recreational uses.

Monroe County Zoning Ordinance (Chapter 761 Storm Water Management)
The intent or objective of this Chapter is to promote the public benefits associated with well-designed and well-maintained stormwater drainage systems, to minimize the external costs and impacts that may arise from substandard storm water drainage systems and maintenance practices and to achieve and maintain compliance with federal, state, and local water quality and flood damage prevention regulations.

- Stormwater quantity and quality regulations apply for all developments with greater than 4,000 square feet of proposed hard surface.
- For the developed condition two, ten, and 100 year storms shall not exceed the natural condition two, ten and100 year peak discharges
- For proposed developments that drain to sinkholes, additional release rate and capacity criteria shall be required. For developments within Sinking and Cave Creek a minimum of three inches of runoff over the disturbed area must be released at a rate that results in a draw down time from the end of a 100 year-48 storm of no less than two days
- In critical watersheds and in other areas with downstream flooding problems, the Drainage Board may require that the allowable release rate be reduced to a rate that is safely within the capacity of the receiving downstream natural features.
- A long term storm water quality management plan shall be required. The goal of this plan shall be to apply technologies intended to mimic natural hydrologic conditions of peak runoff rates, peak runoff volumes, and storm water pollutants. The level of mitigation is based on the total % impervious of the development.
- Riparian buffer zones encompassing the 100-year floodplain shall be provided for all waterways with a drainage area greater than ten acres. The buffer zone shall be at least 20 feet in width.

o **Chapter 802 Zones and Permitted Uses**

- **Forest Reserve (FR) District.** The character of the Forest Reserve (FR) District is defined as that which is primarily intended for the preservation of forests, recreational areas, parks and greenways, limited agricultural uses and very, very low density single family residential uses. Its purposes are to permit limited single family residential development on very large lots, to discourage the development of residential subdivisions and nonresidential uses, to protect environmentally sensitive areas, such as floodplain and steep slopes and to maintain the character of the surrounding neighborhood. Development in the FR District is hindered by extreme topography, poor access and the availability of few or no public services. Therefore, the number of uses permitted in the FR District is limited. Some uses are conditionally permitted. The conditions placed on these uses are to insure their compatibility with the low-density residential and public open space uses.
- **Conservation Residential (CR) District.** The character of the Conservation Residential (CR) District is defined as that which is primarily intended to provide a residential option (planned unit or cluster development) at environmentally sound locations while protecting

the environmentally sensitive watersheds of Lake Griffey and Monroe Reservoir. Its purposes are to protect the environmentally sensitive watershed, especially the floodplain and steep slopes, to permit limited single family residential development on very large lots or in subdivisions (planned unit or cluster development) at environmentally sound locations, to discourage the development of nonresidential uses, to discourage the development of sanitary sewer systems except for existing development and to maintain the character of the surrounding neighborhood. Development in the CR District is hindered by concern over the watershed environment, and, in some cases, extreme topography, poor access and the availability of few or no public services. Therefore, the number of uses permitted in the CR District is limited. Some uses are conditionally permitted. The conditions placed on these uses are to insure their compatibility with the watershed environment and low-density residential uses. The development of new residential activities proximate to known mineral resource deposits or extraction operations may be buffered by increased setback distance.

- **Environmental Constraints Overlay (ECO) District.** The character of the Environmental Constraints Overlay (ECO) District is defined as those areas of Monroe County, Indiana, that are within both the Monroe Reservoir and Lake Griffey watershed boundaries, as located by the Environmental Systems Applications Center, Indiana University, Bloomington, and the County Jurisdictional Area. The ECO District is divided into four areas based on topography and proximity to Monroe Reservoir and Lake Griffey and to stream beds that convey water to Monroe Reservoir and Lake Griffey.

- **Chapter 829 Karst and Sinkhole Development Standards**
  - The purpose of this chapter is to establish review procedures, use limitations, design standards and performance standards applicable to site developments that encompass or affect sinkholes or other karst features.

Monroe County Subdivision Control Ordinance

- **Drainage**: The Commission shall not approve a subdivision plat which does not make adequate provision for the safe and efficient disposal of storm and/or flood water runoff. The storm water and/or flood water drainage system shall be separate and independent of any sanitary sewer system and shall be designed and completed in the manner prescribed by: Monroe County Code Chapter 761 (Storm Drainage Control); Monroe County Code Chapter 808 (Flood Damage Prevention); Indiana Department of Transportation Road Design Manual; Indiana Department of Transportation Bridge Design Manual; A Policy on Geometric Design of Highways and Streets (AASHTO); and, all relevant Indiana Code and Indiana Administrative Code Section.
- **Preservation of Natural Features and Amenities:** In the design of the subdivision, the preservation of existing features which would add value to the type of intended development or to the County as a whole, such as trees, watercourses falls, beaches, historic spots, and similar irreplaceable assets, shall be encouraged. No trees shall be removed from any proposed subdivision site nor any change of grade of the land affected until preliminary approval has been granted. All trees on the plat which are required to be retained shall be preserved, and all trees, where needed, shall be welled and protected against change of grade. The preliminary plat shall show the number and location of existing trees 11” in diameter or greater (measured 4.5 feet above finish grade) located in areas where any land disturbing activity is proposed, as required by these regulations, and shall further indicate all those marked for retention.

Table 4: Municipal Stormwater Practices Summary

Summary of Stormwater Management Practices for Municipalities within Monroe County										
Governing Agency	City of Bloomington	Ellettsville	Stinesville	Lake Lemon	Morgan Monroe State Forest	Hoosier National Forest	I-69 Corridor	Smithville	Higher Education Facilities (Ivy Tech, Indiana Unionville/New Unionville	
Governing Agency (Board, Utility etc)	City of Bloomington Planning/Utilities	Council	Monroe Co. Highway Dept	Lake Lemon Conservancy District; Monroe County Planning	DNR	USDA	INDOT; State of Indiana Finance Authority	Monroe Co.	State of Indiana	Monroe Co.
Complies with State and Federal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MS4 Community Separate from Monroe County	✓	✓							✓	
Stormwater Management Ordinance (Separate from Monroe County)	✓	✓							✓	

2.6.3 Current Reporting and Response Process

Engineering staff compiles and tabulates complaints, identifies actions needed, and assigns appropriate resources as available. The current list has approximately 90 reported issues. Details are provided in Section 2.4.

2.7 Field Reconnaissance

A site field visit occurred on April 4, 2014. Figure 30 identifies the locations of the site visits.

Part of the data collection and analysis strategy includes identifying “typical” or reoccurring conditions across the County for development of standardized design solutions. The field reconnaissance allowed us to:

- Examine the common and recurring problems throughout the county and classify them into Project Types such as roadway flooding issues, private drainage issues, or collection & conveyance problems.

- Create and compile a toolbox of Typical Solutions that can be used to solve each identified Project Type.

Detailed information regarding the site visits can be found in the Existing Conditions Report submitted to Monroe County by Amec Foster Wheeler on May 11, 2015.

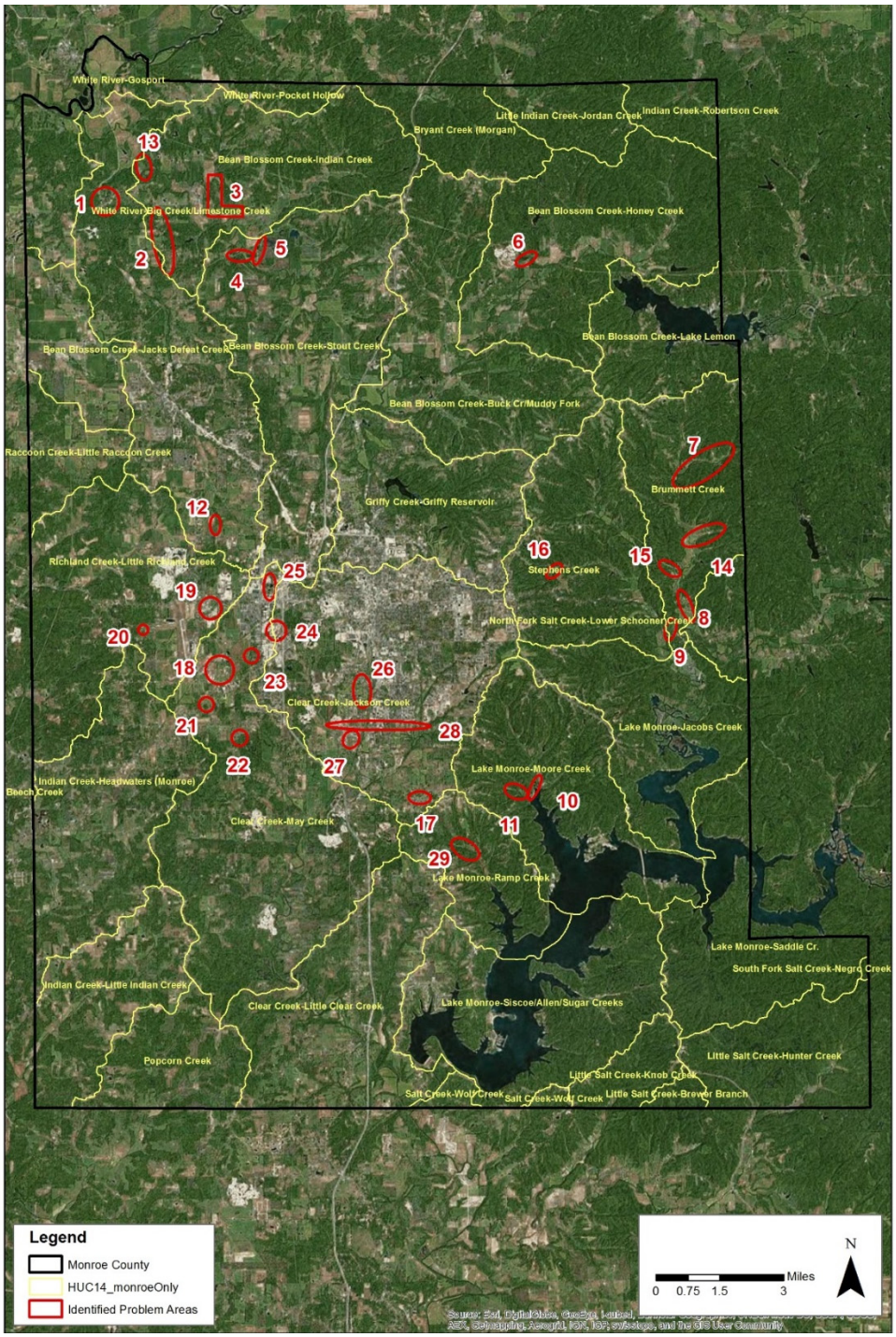


Figure 30: Existing Condition Site Visit Locations

3

Analysis and Visioning

Opportunities & Constraints
Project Types
Typical Concept Solution for Retrofit/Repair
Conceptual Project Identification
Project Screening
Ranking Criteria
Weighted Ranking Factors

3.0 Analysis and Visioning

3.1. Opportunities & Constraints

The field reconnaissance and existing conditions evaluation outlined in Section 2 and further detailed in the Existing Conditions Report provided the information to support watershed and project level analysis and visioning.

This section focuses on identifying similar drainage issues across the watersheds, grouping them logically into categories or project types that can be addressed through the application of related types of solutions, and providing concept level solutions and costs.

3.2. Project Types

- Roadway Flooding
- Collection & Conveyance
- Bridges & Culverts
- Stream Stabilization
- Regional Detention
- Stormwater Basin Retrofit
- Private Property Drainage/Flooding
- Dams Impoundments
- Stream Maintenance & Blockage Prevention – Woody Debris/Log Jams
- Ongoing Maintenance, Cleaning, Repair

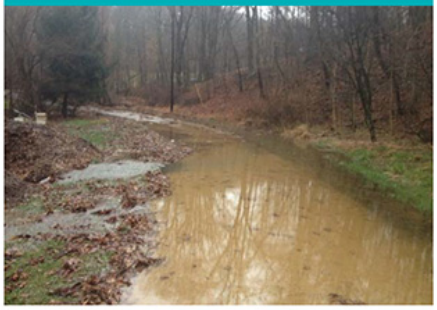
3.3. Typical Concept Solution for Retrofit / Repair

Standard conceptual design details are provided to address typical stormwater issues and conditions observed across the County. Solution concept designs are detailed enough to be constructible but general enough to be tailored as needed to site conditions. **Appendix A** contains typical details related to the concept level design solutions.

These include:

Roadway Flooding

Existing Conditions



Hash Road

Mt. Tabor Road at Bean Blossom Creek

Roadway flooding is a common and reoccurring problem throughout the County. Flooding deteriorates the road surface and supporting base over time and generates extreme public safety concerns. Roadway flooding in Monroe County is primarily due to roadways lying adjacent to creeks overflowing their banks and roads within the flood elevation of Lake Monroe. Backup flooding form terminal sinkholes also impacts several roadways.

N. Brummett's Creek Road

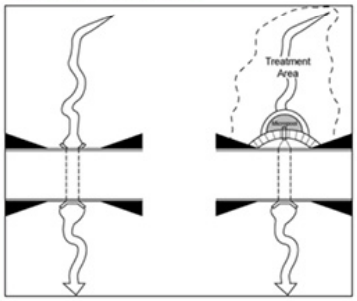


Figure 1: Strategy for getting free storage above a road crossing

Typical Solutions

- Storm sewer collection & conveyance
- Grassed swale conveyance
- Localized detention storage
- Diversion berms
- Elevate roadway
- Regional Detention (upstream storage)

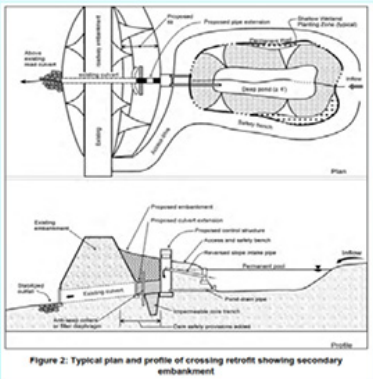
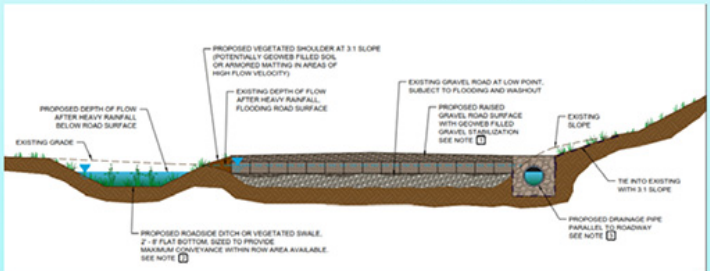


Figure 2: Typical plan and profile of crossing retrofit showing secondary embankment

Provide Upstream Staged Storage

Implementation of a solution appropriate to the specific location needs to include an evaluation of watershed impacts, specific causes of flooding, volume of stormwater, and ability to mitigate the overall problem.

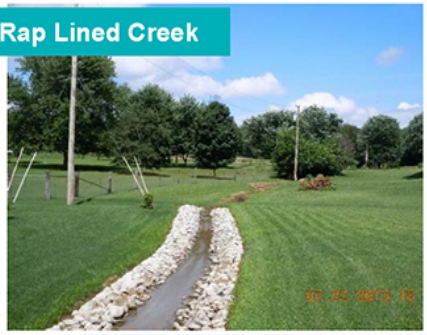


Raise & Stabilize Gravel Roads

Residential Flooding & Erosion

Existing Conditions

Stream Erosion and Rip Rap Lined Creek



Water flowing over parking lots, industrial sizes, roads, and lawns picks up heavy metals, toxins, trash, pathogens, and other pollutants that eventually end up in our creeks. This runoff is often conveyed through open channels across private property, including residential yards. Although residents have long loved neatly manicured grass, expanding your lawn to the water's edge, blocking of filling drainage channels, or clearing trees to provide a view of the water can contribute to the following problems:

- Erosion
- Flooding
- Water Quality Impairment
- Damage to Aquatic Life
- Loss of Habitat

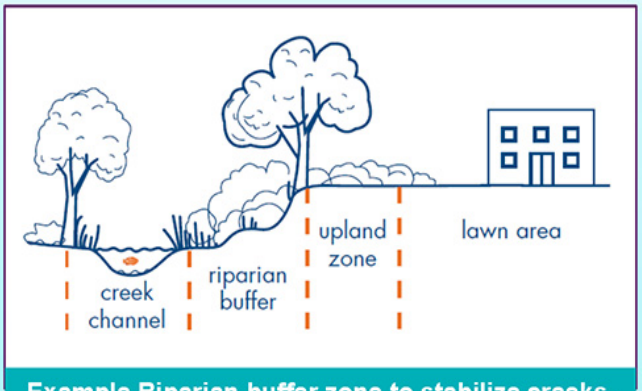
Creek Restoration

Native plantings help prevent erosion and improve water quality.

Typical Solutions

- Riparian Plantings
- Rain Barrels
- Rain Gardens
- Native Plantings
- Riparian Setback Buffers

Example Rain Barrel



Example Riparian buffer zone to stabilize creeks.

Collection and Conveyance: Built Systems

Existing Conditions

Cherry Lane Ditches

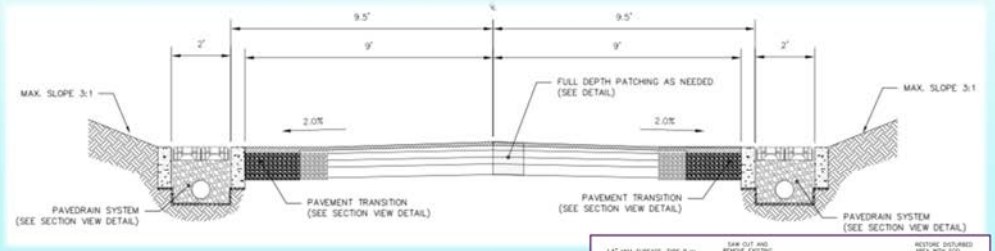
Smithville Open Channel

Roadside drainage problems and failing or undersized conveyance systems present issues including erosion, impeded property access, safety hazards related to rapidly flowing water, further degradation of downstream infrastructure and nuisance items including mosquito breeding.

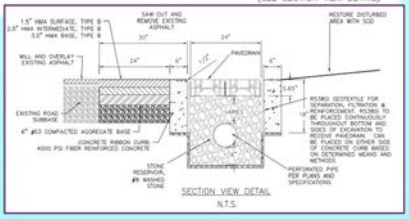
Fairfax at Cherry Lane

Typical Solutions

- Pave drain
- Storm sewer system
- Grassed swale
- Riprap channel
- Infiltration & subsurface storage

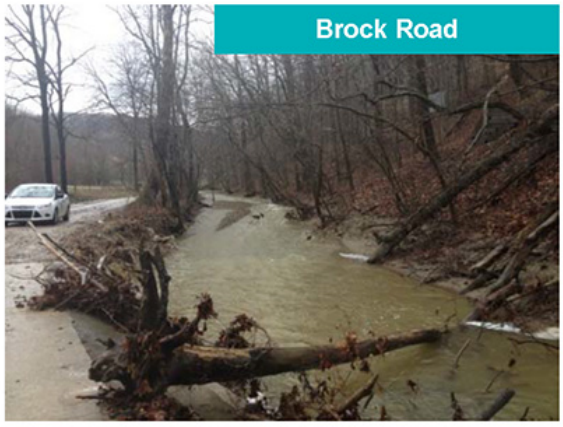


Residential drainage problems can be improved and addressed with integrated conveyance, storage, and infiltration systems, both open and enclosed. Pave drain is an application that provides storm water conveyance, storage, and infiltration on the shoulder of the road.



Collection and Conveyance: Natural Systems

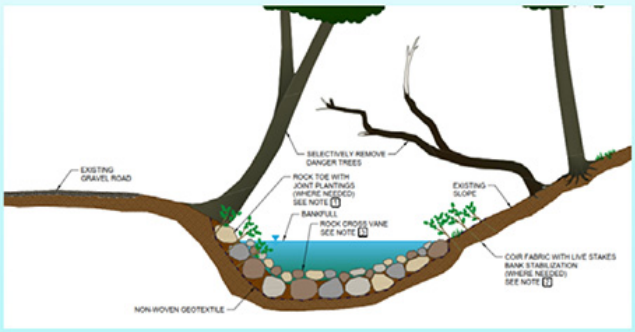
Existing Conditions



With over 1,200 miles of streams and rivers, natural systems provide the primary method of stormwater conveyance in Monroe County. Erosion, log jams, washouts, and clogging debris are typical problems encountered throughout the natural conveyance systems.

Typical Solutions

- Velocity and Volume Control
- In-stream structures (Riffles, J-Hooks, Cross Vanes, Step Pools)
- Bank Treatments (riprap with joint planting, coir fabric and live stakes, root wad)
- Excavation of floodplain bench (multi staged channels)
- Off line flood storage



The size of the upstream contributing watershed and the geometry of the waterway, including slope, cross section, depth, and steepness of banks all contribute to potential conveyance constraints. Using natural stream design solutions, these items can be optimized to improve performance.

Bridges and Culverts

Existing Conditions

E. Baby Creek Road

Sinking Creek Crossing at Curry Pike

Smithville Downstream Outlet

Monroe County is responsible for over 700 miles of roads, including 137 bridges and over 2,800 pipes. Bridges and culverts are integral to the efficient conveyance of stormatwer and are an ongoing maintenance concern. These structures may be undersized for the upstream runoff volumes or can fail in several ways including clogging and blockages that reduce capacity and ultimately cause flooding and road washouts.

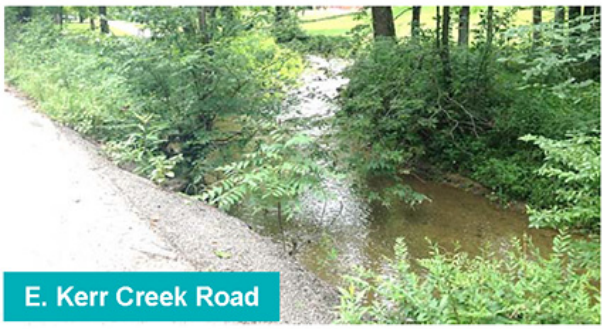
Typical Solutions

- Structure replacement/upsizing
- Slip line Culverts
- 3 Sided Culverts
- Secondary elevated floodplain culverts
- Inline upstream storage

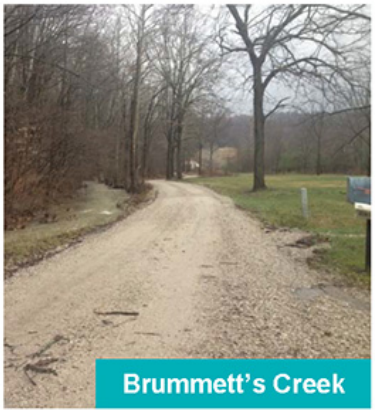
Fishpot Ck tributary, west St. Louis County, Missouri 200

Stream Stabilization

Existing Conditions



E. Kerr Creek Road

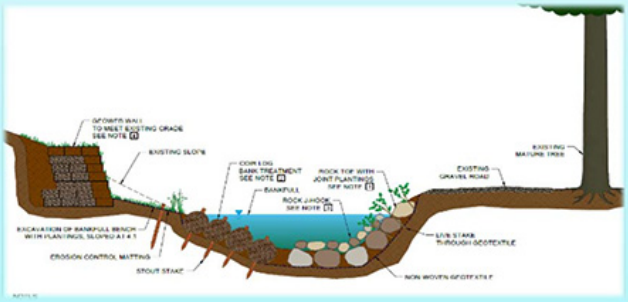


Brummett's Creek

Streams running alongside roads and constrained by steep slopes are common in Monroe County. The flowing water has nowhere to move laterally and erodes the road slope.

Typical Solutions

- Riprap with joint planting to protect road
- Coir log bank treatment to protect stream bank
- Excavation of floodplain bench to provide storage
- Geoweb wall to meet existing grade



Regional Detention

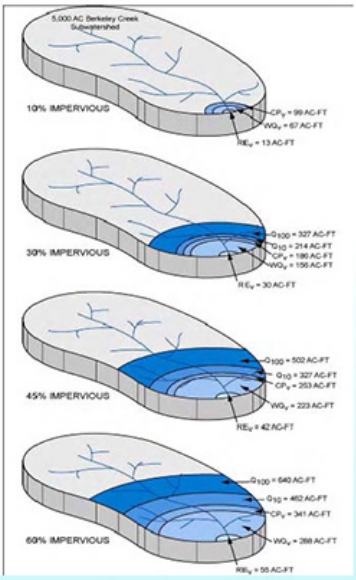
Existing Conditions

Curry Commercial Park

Potential detention pond retrofits at upper end of Sinking Creek

Fieldstone subdivision Dam Impoundment

Existing regional detention facilities can be used to help alleviate flooding and improve water quality. In addition, regional detention provides an excellent opportunity to integrate public parks, walking and biking trails, and other amenities. Grant funding is often available for projects that demonstrate multi uses.



Example: Confluence Park, Cincinnati, Ohio

Many regional stormwater management facilities can be designed as parks and serve as multifunctional facilities.

Typical Solutions

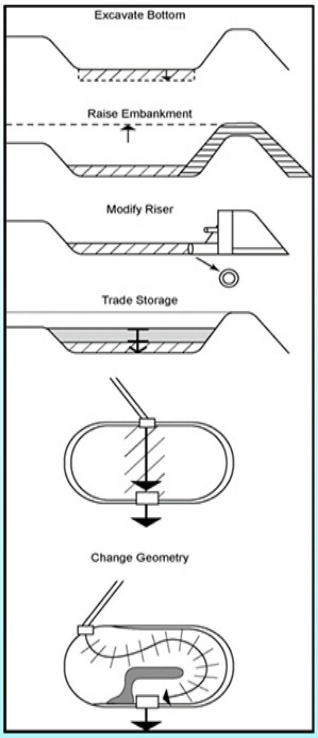
- Re-grading
- Stormwater re-routing
- Berms
- Integrated flood storage
- Additional outlet controls to maximize pond storage

Stormwater Basin Retrofits

Existing Conditions

Detention Pond – Jack's Defeat Watershed

Monroe County has several private and publically owned detention and retention basins. These basins were constructed at various times and designed to meet different regulations both from a water quality and quantity standpoint. Over time stormwater basins may lose capacity due to sediment build up on the bottom, clogged inlet and/or outlet structures, vegetation growth, and inadequate sizing for larger storm events. Retrofitting existing stormwater basins provides an excellent opportunity to help alleviate downstream flooding and improve water quality.



Example: Bioretention storage Cincinnati State University

Typical Solutions

Example Typical Solutions:

- Maintenance plan
- Site regrading
- Installation of outlet structure

3.4. Conceptual Project Identification

A total of 60 projects were identified from the following sources:

- Stormwater Engineer's list
- Stormwater Engineer correspondence
- Site visits
- Resident complaints & correspondence
- Drainage Board meetings
- Highway Dept. staff interviews


Conveyance Flooding on Cherry Lane

Identification of projects such as the S. McCormick Lane Storage & Conveyance Improvement example followed the following process:

1) Identification by various source
2) Site visit
3) Desktop review of drainage area and watershed characteristics
4) Categorization of typical problem
5) Identification of typical solutions
6) Prepare concept plan

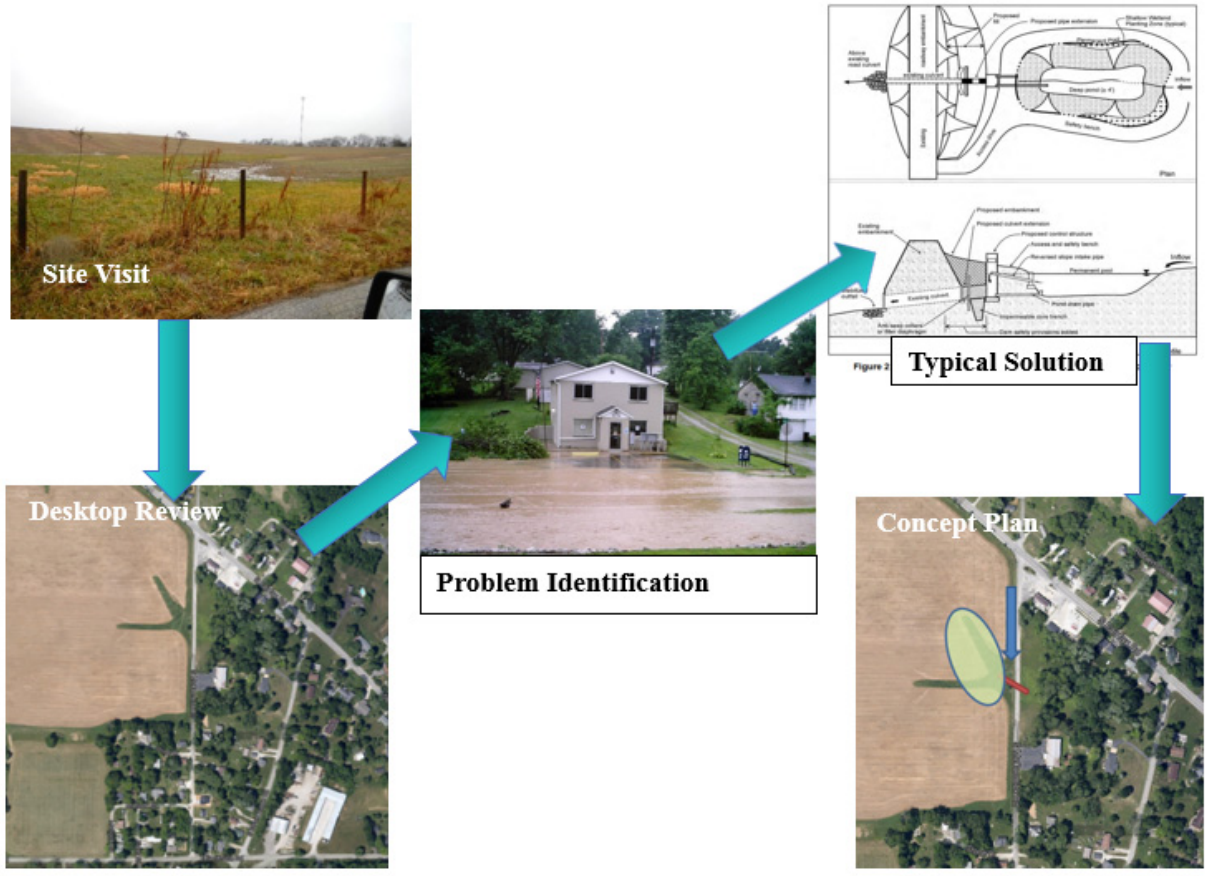


Table 5 lists the projects and includes the following data for each:

- Project Identification Number
- Site Visit ID
- Site Description
- Project Type (based on identified project type list)
- Origin of Project
- Project Notes & Details
- Proposed Solution Methods
- Special Project Needs (Land acquisition, permitting, etc.)
- Watershed Data – Primary Land Use
- Estimated Project Watershed Area
- Traffic Conditions at Project Area (Low, Moderate, High)
- Location on Critical Emergency Access Route
- Condition of Existing Roadway/Infrastructure
- Preliminary Costs
- Complexity of Project Construction (County Crew, General Contractor, Specialty Contractor)

Figure 31 shows the location of each project. Individual project concept plans for each of the 60 projects are provided in **Appendix C**.

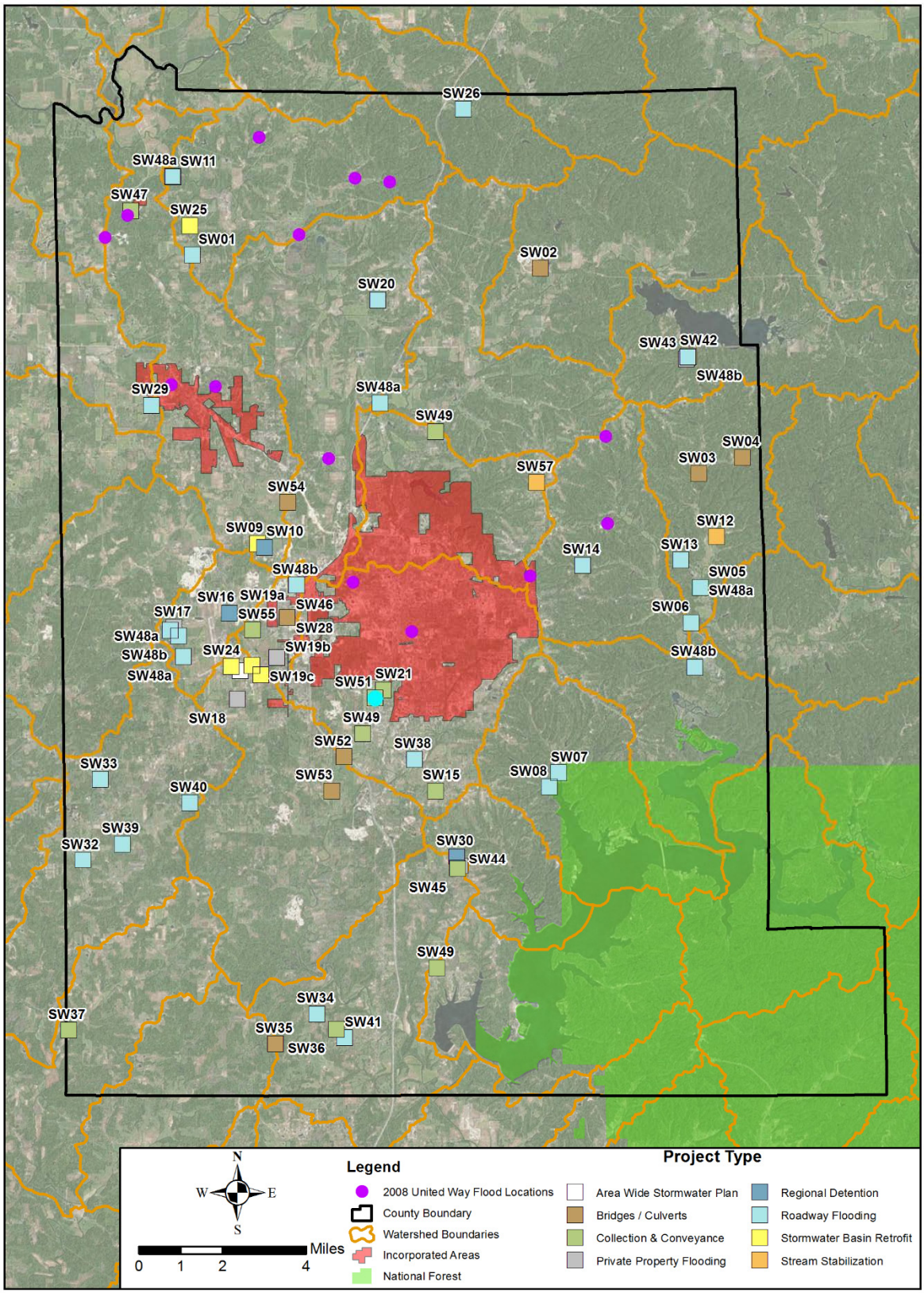
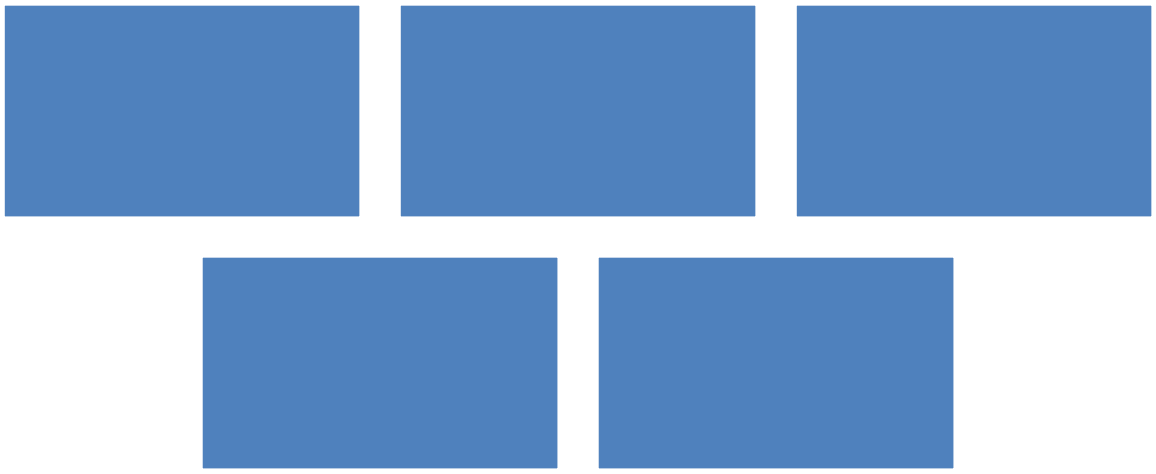


Figure 31: Identified Project Locations by Type

REPLACE WITH TABLE 5

Table 5: Project Site Data



3.5. Project Screening

In order to compare and prioritize the 50 identified projects, each project was evaluated based on site data and performance measures including watershed area and primary land use, current system conditions, impervious surface managed, construction and maintenance costs, and engineering judgment of non-monetary implications. The evaluation of the 50 locations was a screening process leading to the development of a recommended prioritization schedule for implementation. The process included consideration of the following attributes:

- Cost and Performance
- Non-Monetary Factors
- Advantages / Disadvantages

The Monroe County Long Range Stormwater Questionnaires were developed to gather input for the Monroe County Long Range Stormwater Improvement Plan and help assist in the project screening process. There were three questionnaires developed for the following groups: the Monroe County Board of Commissioners, county employees, and the general public. Each questionnaire is further described below and a detailed analysis can be found in **Appendix B.**

Board of Commissioners
The questionnaire was distributed to the Board of Commissioners during the board meeting on October 9th, 2014. The key information gathered from the questionnaire included drainage project ranking metrics that were discussed during the presentation and that were used to prioritize potential projects. These comments were integrated into the final project ranking matrix.

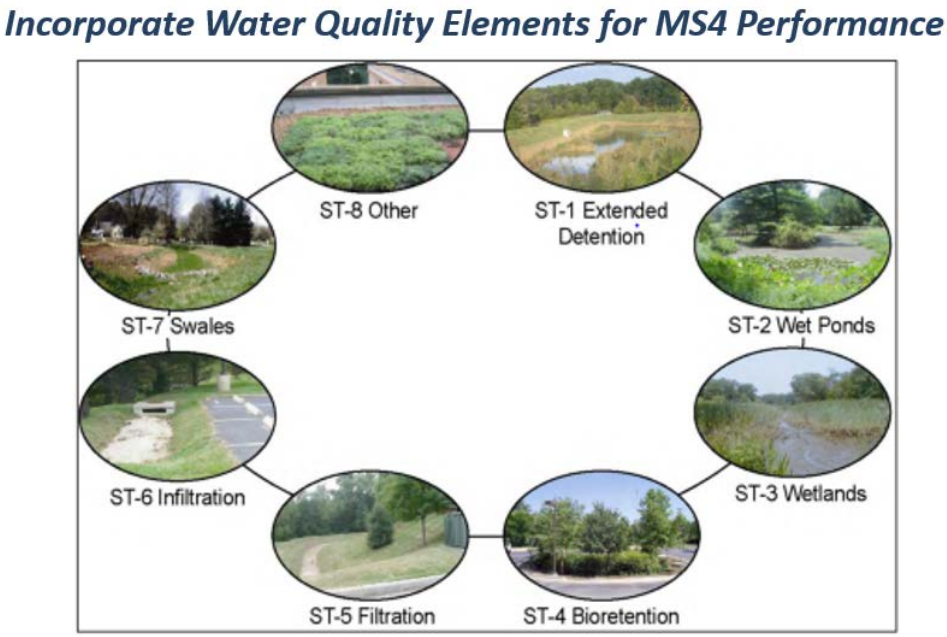
County Employees
The questionnaire was distributed to county employees at the various county garages on October 9th, 2014. The key information gathered from the questionnaire included stormwater problem collection process information, available equipment to handle stormwater complaint projects, and the importance and familiarity (providing repairs/solutions) of various stormwater projects. These comments were integrated into the final project ranking matrix.

General Public
The general public questionnaire was distributed by using a form hosted on the County website and was also made available at the Public Meeting held on January 15th, 2015. A total of 10 surveys were completed.

Selection and prioritization is not based solely on cost, therefore, non-monetary factors were considered in the prioritization. For the proposed projects, Non-Monetary Factors include:

- Watershed Characterization Ranking
- Frequency of Flooding
- Severity and Duration of Flooding
- Public Health & Safety (Emergency Access Risk)
- Location and Project Visibility (including traffic, site access, and tourism considerations)
- Water Quality & Habitat Enhancement Potential
- Number of Residents Served/ Level of Traffic

- Number of Complaints Managed
- Ease of Construction
- Floodway, Floodplain and Wetland Constraints and Permitting
- Opportunity for Coordination with other CIP Projects or Funding Sources
- Potential for Additional Development (project in desirable development area)



(Source: Urban Stormwater Retrofit Practices Version 1.0)

Figure 32: Eight Stormwater treatment options available for retrofitting

3.5.1. Ranking Criteria

The attributes above are compiled in Table 7: Project Scoring and each column containing a ranking attribute was generally ranked as described below:

Watershed Characterization Ranking

Projects in a high priority watershed receive a ranking of “3”; those in an average priority watershed receive a “2”, and projects in low priority watersheds receive a “1”. See Section 2.2 for a detailed description of watershed priority ranking factors.

Frequency of Flooding

Project areas that report flooding more than four times per year receive a ranking of “3”. Those that flood on average two to four times per year receive a “2”, and projects that flood once per year receive a “1”. Projects where flooding was not an applicable criteria scored a 0.

Severity and Duration of Flooding

Severity of flooding is based on the flooding at the project location limiting or blocking access for a given time period. A location where flooding does not limit access scores as a “0”, while a site that limits or blocks access to residences, goods, or services for more than 48 hours is considered severe = 3; Mild = 1. No flooding = 0.

Public Health & Safety (Emergency Access risk)
Projects that solved critical access or emergency response issues or that are on the EMS plan route or a major through route receive a “3” for this metric. Those that are not, receive a “0”.

Location / Project Visibility (traffic, access, and tourism considerations):
The proposed projects that are along a major roadway, part of visitor or tourist areas, support significant public use, and are highly visible to the general public are ranked highest. Remote or lightly traveled areas with minimal public impact received low scores for this parameter. 3 = yes; 0 = no.

Water Quality/Habitat Enhancement Potential:
The sites were divided into 4 sections. The sites that had the highest opportunity for Water Quality or Habitat Enhancement received a score of “3”. The next sites in the ranking received a score of “2”, the following, a “1”, and projects with no potential to improve water quality, such as studies or monitoring were given a score of “0”.

Number of Residents Served / Level of Traffic:
Projects are categorized based on the number of residents or landowners that potentially benefit from the project. The ranking breakdown is as follows:
High (more than 10 landowners) = 3
Moderate (5 to 10 landowners) = 2
Low (less than 5 landowners) = 1

Number of Complaints Managed
The projects that have the potential to mitigate the most complaints receive a score of “3”. If no complaints are managed, the project receives a “0” for this parameter.

Ease of Construction:
Projects are evaluated based on the level of complexity. Projects with complex mitigating issues or projects that require a specialty contractor, receive a score of “1”, while projects that can be addressed by a general contractor are given a “2” and those that can be constructed by County forces using standardized solutions score a “3” on this metric.

Floodway, Floodplain, Wetland, Other Permitting:
Sites not requiring any special permitting were scored a “3” and sites with significant or complex permitting requirements were given a “0”. Sites with standard permitting issues were listed with a “2”.

Opportunity for Coordination with other CIP Projects or other funding sources:
At this time, there is minimal information available regarding other projects that may be underway near the proposed projects. Projects on the Bridge CIP list were given a ranking of “2”, while projects that might be submitted for grant funding were scored as 1 and standalone projects were given a “0”. If a project is on the CIP list and has a grant opportunity, like Stinesville, it rated a “3”.

Potential for Additional Development

Additional development upstream of an identified problem area could serve to exacerbate the situation, making the improvements more critical. Project identified in areas where additional development is likely were ranked with a "3".

Project Capital Cost/Benefit:

This parameter was evaluated based on the construction cost per acre managed and ranked with the highest cost benefit (lowest construction cost per acre managed) receiving the highest score. The estimates of probable construction cost are conservative and contain a 20% contingency amount since they were developed at a conceptual level.

3.5.2. Weighted Ranking Factors

After the raw ranking numbers were applied, the project attributes were weighted based on relative importance with respect to their overall impact in relation to the project objectives. Based on input from County staff, the weighting multipliers below were applied. For the columns weighted other than 1, the multiplier was applied and the weighted total calculated.

Table 6: Weighted Attribute Multiplier

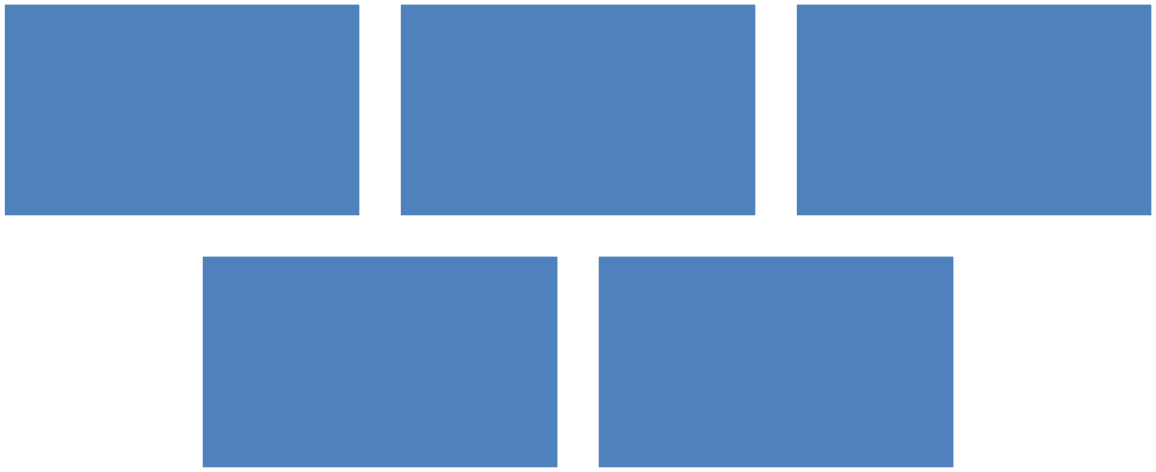
PROJECT ATTRIBUTE	WEIGHTING MULTIPLIER
Watershed Characterization Ranking	1
Frequency of Flooding	1.5
Severity and Duration of Flooding	1
Public Health & Safety (Emergency Access Risk)	3
Location and Project Visibility	1
Water Quality & Habitat Enhancement Potential	1
Number of Residents Served/ Level of Traffic	1.5
Number of Complaints Managed	2
Ease of Construction	1
Floodway, Floodplain and Wetland Constraints and Permitting	1
Opportunity for Coordination with other CIP Projects or Funding Sources	2
Potential for Additional Development	2
Capital Cost/Benefit	2

3.5.3. Prioritized Ranking

Once the weighted total was calculated, the spreadsheet was sorted by the Weighted Total column, and the results noted as the "Overall Priority Ranking" in Table 8.

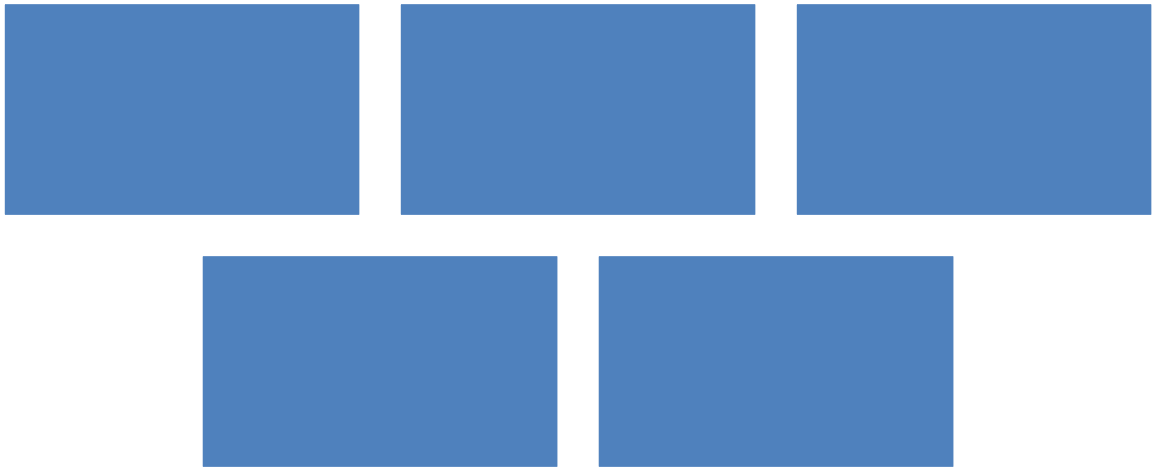
REPLACE WITH TABLE 6

Table 7: Project Scoring



REPLACE WITH TABLE 7

Table 8: Project Prioritization



4

Results

Project Characteristics

Funding

4.0 Results

All of the proposed projects show beneficial results in improving flooding and stormwater conveyance across the County.

The results of the analysis and prioritized project ranking using the specified parameters indicate that the highest priority project to benefit the overall stormwater management in Monroe County is implementation of Phase 1 of the Remote Monitoring Program for Roadway Flooding (Project SW 48a). The full prioritized project list is presented in Table 8.

4.1 Project Characteristics

Specific characteristics of note are listed below:

Most Effective Characteristics:

1. Lowest Capital Cost Per Area Managed = ***SW 05 N. Brummetts Creek Road Reflective Delineators***
2. Largest Raw Scored Impact = ***SW 01 N. Mt. Tabor Road Drainage Bar to Woodland***
3. Largest Weighted Scored Impact = ***SW 48a Remote Monitoring Program for Road Flooding***
4. Most Overall Watershed Area Managed = ***SW 11 Mt. Tabor Road at Bean Blossom Creek***

Least Effective Characteristics:

1. Highest Capital Cost Per Area Managed = ***SW09 – Post Office Pond Retrofit***
2. Smallest Raw Scored Impact = ***SW 13 Hash Road***
3. Smallest Weighted Scored Impact = ***SW 13 Hash Road***
4. Least Overall Watershed Area Managed = ***SW21 – S. Rogers Road at San Juan Drive***

The estimated total of all currently identified projects is approximately **$12 Million** including design services, land acquisition, permitting. A 20% contingency has been applied due to the preliminary nature of the information used for pricing analysis.

Sixteen (16) projects totaling just over $2.0 Million are identified for completion by 2021 (Year 5 of the document). All of these projects are primarily related to the alleviation of roadway flooding.

Implementation of the projects outlined in this plan will contribute to management of over 260,000 acres across 23 watersheds and will have a significant positive impact on flooding, public safety, ongoing maintenance and water quality.

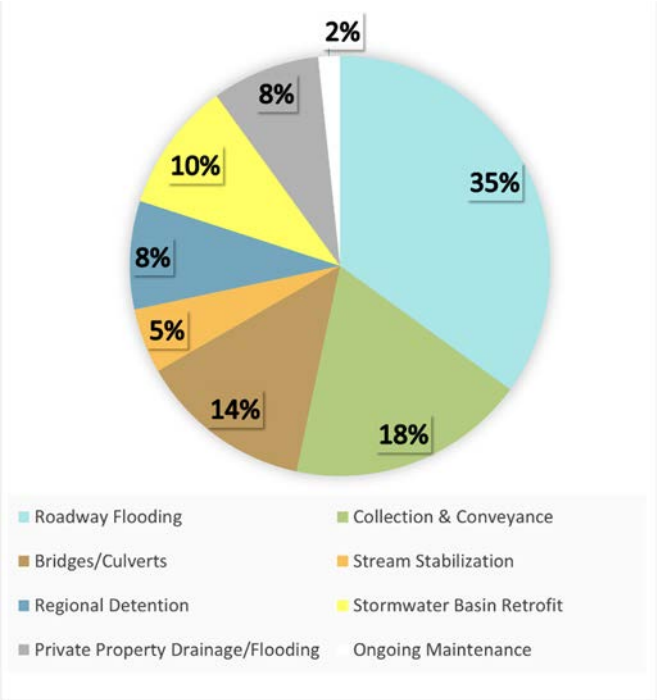


Figure 33: Number of Projects by Type

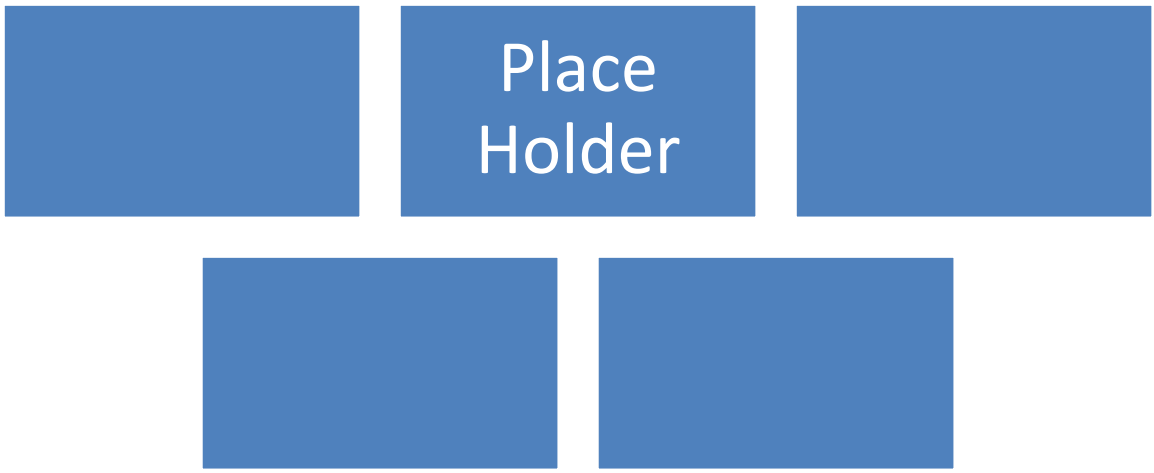


Figure 34: Cost of Projects by Type

4.2 Funding

This funding analysis is intended to present information on mechanisms that may be utilized to fund the range of stormwater problem mitigation projects that are recommended in the report. As will be seen, there are a number of federal, state, county, and private programs available to assist with the funding of stormwater projects. Each method has qualifications and limitations on how the funding may be used and for whether local matching funds (local financial participation) will be required.

Currently, Monroe County operates a $1.13 million stormwater budget generated from the County Stormwater Utility Fee. The Monroe County Stormwater Budget of $1.13 million is divided into the following categories: Personal Services ($293K), Expenses ($146K), Other Services & Charges ($513K) and Capital Outlays ($105K). The items funded under Personal Services include staff salaries, overtime, and uniforms expenses. The items funded under Expenses include: office supplies, vehicle maintenance, see/mulch/compost/plantings, pipes, backfill/pavement repairs, and signs. The items funded under Other Services and Charges include: General Engineering Studies, Equipment Repair, Equipment Rental, General Contract Services, and Misc. Drainage Improvements. The items funded under the Capital Outlays include: vac truck, street sweeper, dump truck, and computer hardware. Approximately $228,000 is allocated to misc. drainage improvements, $50,000 to seed/mulch/composting/plantings and $40,000 to pipes. It is unlikely that the stormwater projects identified in this report would be funded from the general fund.

The state, federal, and private funding sources that might be utilized to by the County to fund stormwater projects are identified in the following table. The table below identifies the funding program name, the name of the administering entity in the state of Indiana, a website for additional information, a description of the program, eligibility requirements for each identified funding program.

Applying for and receiving grants identified in the table will allow the County to perform more projects than it would by relying only on local funding. Some of the below grants would require private public partnerships or the County partnering with a local 501 C (3) non for profit.

It should be noted that government assistance programs are ever evolving, particularly in the funding levels and application requirements. Existing programs may not be suitable, or adequate, for a given project at the time of implementation. In addition, some of these programs may sunset and new programs become available in the future.

Table 9: Identified Grant Programs

Grant Name	Sponsoring Agency	Link to Further Information	Description	Eligibility Requirements or Funding Restrictions
Targeted Watersheds Grant Program	EPA: Office of Water	http://water.epa.gov/grants_fuding/twg/initiative_index.cfm	The targeted watersheds grant program through EPA encourages successfully community-based approaches to protect and restore the nation's waterways. Grant funds can be used to support activities relating to the prevention, reduction, and elimination of water pollution. Projects cannot be activities required or regulated under the Clean Water Act.	None
Environmental Justice Collaborative Grant	EPA: Office of Water	http://www3.epa.gov/environmentaljustice/grants/ej-cps-grants.html	Cooperative agreements (120K) will be awarded to local community-based organizations seeking to address environmental and/or public health concerns in their communities through collaboration with other stakeholders.	Must be a 501(c)(3) non-profit organization to qualify. Individuals and for-profit organizations are not eligible.
Highway Safety Improvement Program	Funding provided by USDOT, Federal Highway Administration; administered by InDOT	http://safety.fhwa.dot.gov/hsip/	Types of projects funded include the rehabilitation and new development of parks and recreation facilities; acquisition of land for active or passive park and conservation purposes; and planning for feasibility studies, trails studies, conservation plans, site development planning, and comprehensive recreation, greenway and open space.	Municipalities and authorized non-profit organizations.
EPA Urban Waters Small Grants	EPA's Urban Waters Program	http://www.epa.gov/urbanwaters/funding/index.html	Eligible projects are those which involve the acquisition of land, easements or rights-of-way and the construction, improvement, expansion, extension, repair or rehabilitation of either a system for the supply, treatment, storage or distribution of water not used solely for residential pourposes, or a system for the collection, treatmenet or disposal of wastewater (including industrial waste and the separation of sanitary sewers and storm sewers) not used solely for residential purposes. Grants are provided at a $5 million maximum or 75% of total eligible project costs, whichever is less. Loans are also available at a $5 million maximum per project with a 2% interest rate and repayment terms up to 20 years.	Municipalities; Industiral Development Corporations; Municipal Authorities; Investor-owned water or wastewater enterprise
TIGER Grants	United States Department of Transportation	http://www.dot.gov/tiger	Funds work designed to transform systems so that environmental problems are not created in the first place; supports efforts to reduce the damage currently being done by unsustainable practices; looks for programs and initiatives that help repair the damage caused by unsustainable practices; looks for places where capital investment are not available to correct an environmental problem.	Must be a 501(c)(3) non-profit organization to qualify. Individuals and for-profit organizations are not eligible.
Clean Water State Revolving Fund (CWSRF)	Funding provided by EPA; administered by IDEM	http://www.in.gov/idem/4103.htm#srf	The SRF Loan Programs provide low interest loans to eligible entities for the planning, design, construction, renovation, improvement or expansion of wastewater and drinking water systems. SRF Program Loans or other financial assistance is available for improvements to wastewater and drinking water plants, sewer line and water line extensions projects. Funds are also available for the costs associated with non-point source water pollution abatement projects, such as wetland restoration/protection, erosion control measures, storm water projects that improve water quality practices, and wellhead and source protection measures	Political subdivisions including incorporated cities, towns, counties, regional sewer/water districts, conservancy districts and water authorities are eligible for both DWSR and WWSRF. Private and not-for-profit facilities are eligible only for DWSRF. Private and not-for-profit facilities are eligible only for drinking water SRF loans
National Fish and Wildlife Foundation (NFWF) Funding	National Fish and Wildlife	http://www.nfwf.org/whatwedo/grants/Pages/home.aspx	NFWF provides funding on a competitive basis to projects that sustain, restore, and enhance our nation's fish, wildlife, and plants and their habitats	Municipality, county, state agency, or not-for-profit agency.
Flood Control Revolving Fund (IC 14-28-5)	Indiana Department of Natural Resources	http://www.in.gov/dnr/water/2459.htm#6	The Flood Control Revolving Fund was created by the Indiana General Assembly in the 1950's to provide a low interest loan program to help finance local flood control programs. Through I.C. 14-28-5, a loan may be made to a municipality, city, town, county, or special taxing district for the purpose of instituting, accomplishing, and administering any approved flood control program as defined in the Flood Control Revolving Fund Act. The Indiana Department of Natural Resources (DNR), Division of Water, is the agency that coordinates matters related to the Flood Control Revolving Fund. Loans to any local unit of government cannot exceed $300,000. Loans may be made for a period not to exceed ten years and bear a 3% interest rate.	The Flood Control Revolving Fund is available to a municipality, city, town, county, or special taxing district for the purpose of instituting, accomplishing, and administering an approved flood control program.
Community Focus Fund (CFF)	Indiana Office of Community and Rural Affairs	http://www.in.gov/idem/4103.htm#cff	The CFF is a grant program administered by the Indiana Office of Community and Rural Affairs (OCRA) and is funded with federal Community Development Block Grant (CDBG) dollars. These grants support a variety of projects that either benefit low-to-moderate income persons or eliminate slum/blight in communities. Eligible projects typically include infrastructure improvement (water, sewer, and storm drainage), fire protection, downtown revitalization, community centers, day care centers, senior centers, historic preservation, and infrastructure in support of housing. Up to $500,000 for individual projects. A 10% local match of total project cost is required.	Small cities which do not receive CDBG funds directly from U.S. Housing and Urban Development (HUD), incorporated towns and counties (excluding Lake and Hamilton, which are entitlement counties).

5

Conclusions and Recommendations

5.0 Conclusions and Recommendations

Summary

Immediate Short Term Actions

Based on the outcomes of this report, the County should consider how best to allocate its staff and financial assets to meet stormwater management goals and obligations. Recommended short term actions include:

- Refine proposed stormwater project costs and ranking to determine final number of projects for construction for years 1 through 5 based on available staff and budget resources.
- Develop a database entry form and accompanying Standard Operating Procedure (SOP) to populate future projects within the project ranking system and track project completion, implementation, and ongoing maintenance.
- Implement project SW 48a – Phase 1 of the Remote Monitoring Program for Roadway Flooding. **(Appendix D)**
- Complete topographic survey and preliminary design documents and make recommendation for the implementation of the SW 01 N. Mt. Tabor Road drainage project.
- Develop a Commercial and Industrial Park stormwater basin retrofit program.
- Perform an Ordinance / Policy / Incentive review relevant to Stormwater Management with recommendations and guidance for future development standards for stormwater management.
- Develop and issue a Request for Qualifications for annual on-call contracting services for storm infrastructure general contractor and stream stabilization specialty contractor for maintenance & improvement projects $50,000 or less.
- Develop and implement an internal project tracking and review process to ensure compliance with MS4 regulatory requirements and stormwater management on County Capital Improvement Projects. A draft outline of this process is included as **Appendix E**.
- Establish a budget line item for maintenance of stormwater infrastructure specific to multi-use trails, including temporary rehabilitation of bridges and replacement of culverts.
- Establish a budget line item for ongoing maintenance and funding of improvements outlined in this plan.
- Engage consultant to capitalize on the multiple grants identified in this report and assist with strategic grant writing, administration and targeting opportune public, private, and nonprofit partnerships.
- Develop a public outreach strategy to promote and consistently brand the Long Range Stormwater Improvement Plan and the implemented projects.

5 Year Goals and Actions

Complete design and implementation of top 16 ranked projects from Table 8, totaling approximately $3.0 Million

- Establish a database to track, monitor, and report efforts to improve stormwater management through implementation of projects in this plan as well as ongoing projects identified.
- Apply projects for local and national awards and recognition (e.g. Indiana Association of Floodplain and Stormwater Managers (INAFSM)
- Provide presentation of Long Term Stormwater Master Plan and completed projects at local, state, and national conferences (e.g. StormCon)
- Implement an outreach program for multiple audiences with appropriate delivery mechanisms and venues specific to each target audience to build interest in the new incentives program(s)
- Expand intern program to allow for data collection, analysis, and monitoring of expanding stormwater management infrastructure across the County.
- Re-analyze the 10, 15, and 20 year goals based on accomplishments in years 1-5 and incorporation of newly identified CIPs, stormwater projects, and funding opportunities.
- Develop Municipal Staff training workshops
- Develop Contractor training program

10 Year Goals and Actions

Complete design and implementation of projects 17-32 from Table 8, totaling approximately $3.1 Million

- Identify additional projects to be implemented in the next 5 years beyond year 20.
- Re-analyze the 15, and 20 year goals based on accomplishments in years 1-5 and incorporation of newly identified CIPs, stormwater projects, and funding opportunities
- Hire/Engage a grant coordinator to build public private partnerships, refine and update funding matrix, and administer grants

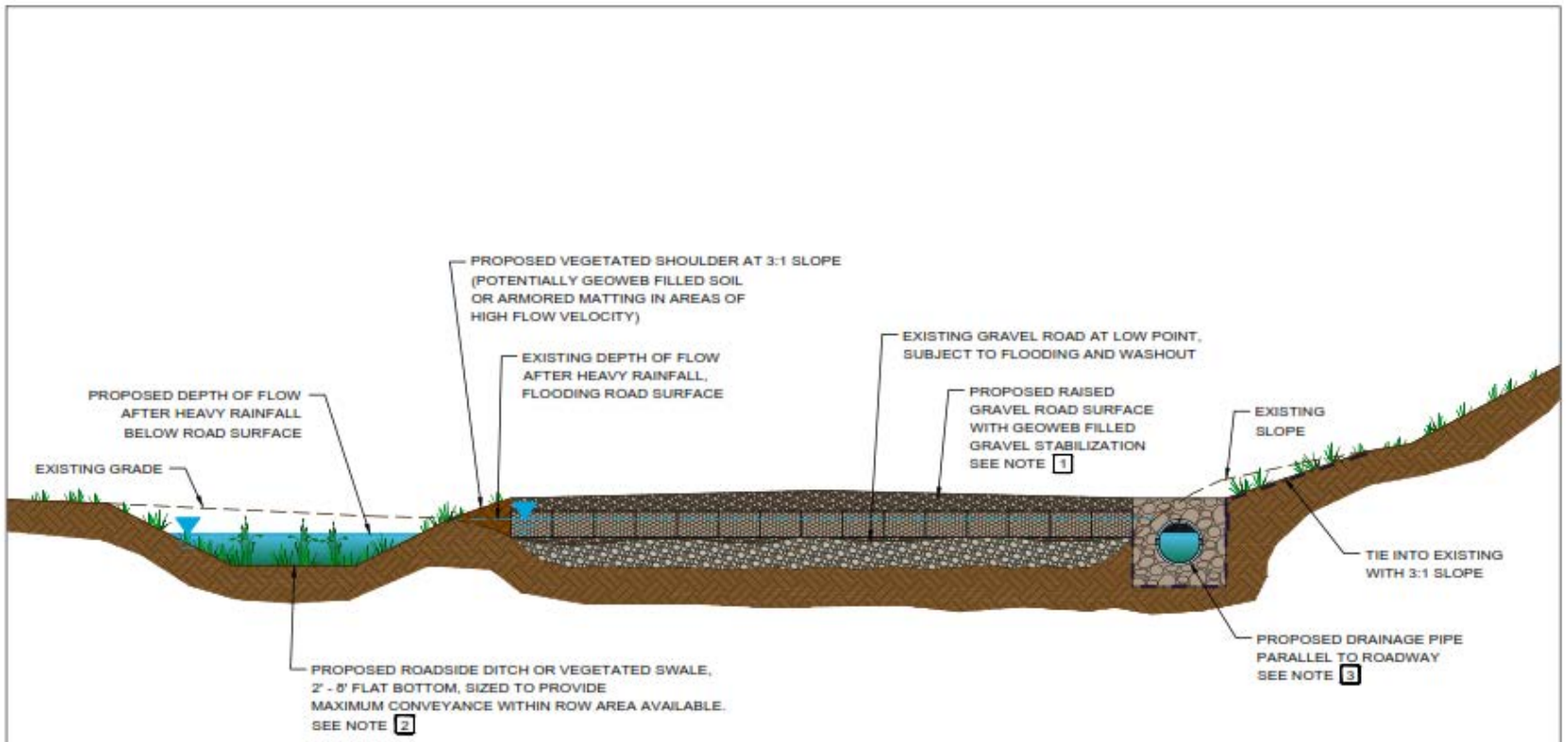
15 Year Goals and Actions

- Become recognized as a State leader for Stormwater Management activities.
- Complete design and implementation of projects 33 - 48 from Table 8, totaling approximately $2.9 Million
- Identify additional projects to be implemented in the next 5 years beyond year 25.

20 Year Goals and Actions

- Complete design and implementation of projects 49-60 from Table 8, totaling approximately $1.9 Million
- Review and update the Long Range Stormwater Management Plan for the next 20 years.

APPENDIX A – TYPICAL DETAILS



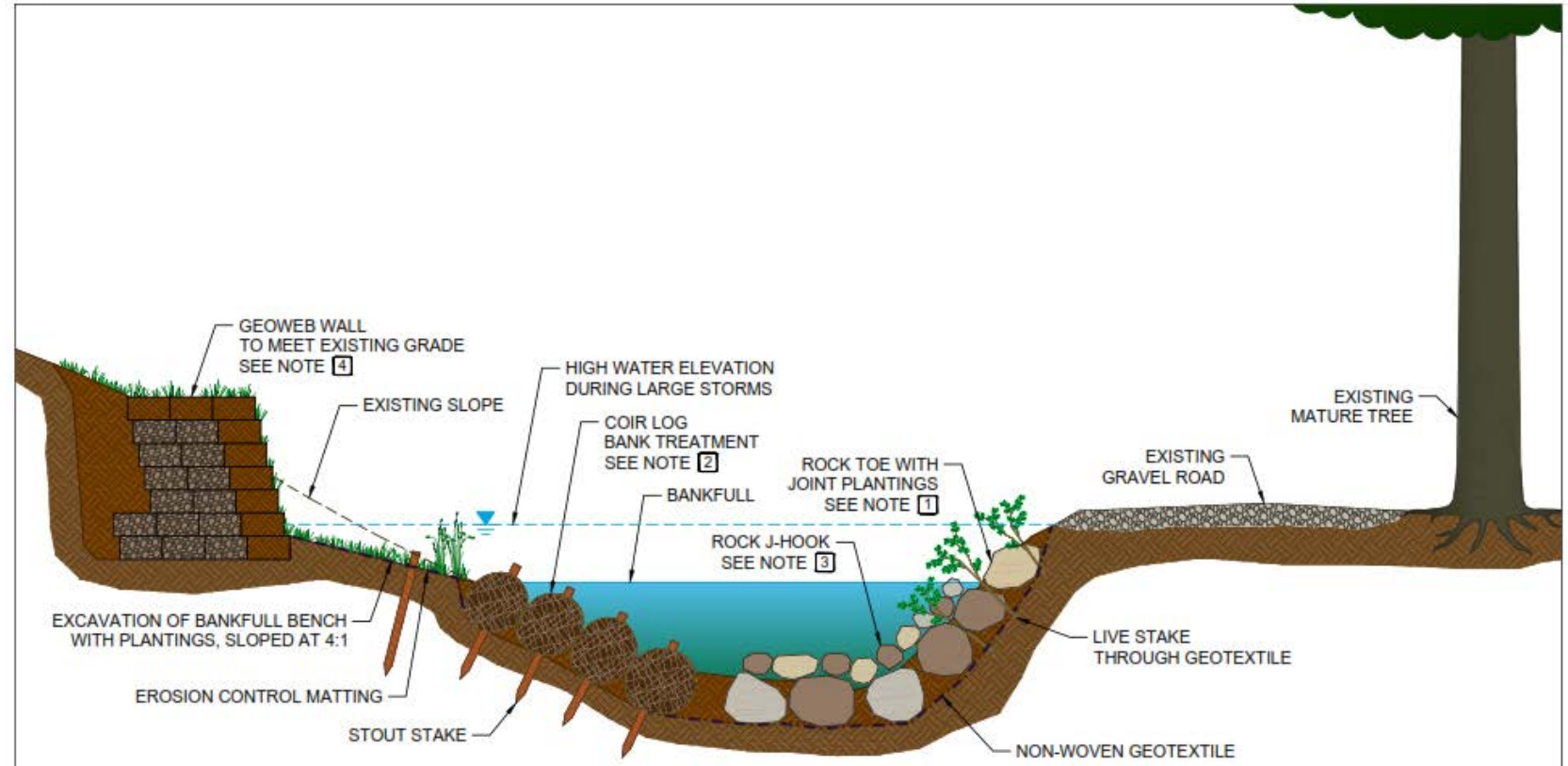
NOTES

1 FOR GEOWEB FILLED GRAVEL STABILIZATION:
- LEVEL EXISTING ROADBED WITH PAVEMENT BASE STONE PRIOR TO PLACING GEOWEB.
- PLACE GEOWEB AND FILL WITH CRUSHED STONE PER MANUFACTURER'S SPECIFICATIONS.
- MINIMUM PAVEMENT WEAR SURFACE 2" OF CRUSHED STONE.
- CONSULT MANUFACTURER'S SPECIFICATIONS FOR COMPATIBILITY WITH PAVEMENT BASE STONE, DRAINAGE REQUIREMENTS, AND MAINTENANCE REQUIREMENTS.

2 FOR VEGETATED SWALE:
- SOIL INFILTRATION BETWEEN 0.5 AND 3.0 IN./HR.
- SLOPE OF 1% TO 2" RECOMMENDED.
- VEGETATION SHOULD BE PERENNIAL GRASSES AND GRASS-LEGUME MIXES THAT ARE ABLE TO TOLERATE EXTENDED PERIODS OF FLOODING.

3 FOR DRAINAGE PIPE:
- PROVIDE PIPE BEDDING AND DRAINAGE MATERIAL SURROUNDING PIPE.
- PROVIDE ADEQUATE COVER TO PROTECT PIPE.
- IF LARGE AMOUNTS OF SEDIMENT AND SAND ARE PRESENT, WRAP NON-WOVEN FILTER FABRIC AROUND PIPE TO PREVENT CLOGGING.
- VERIFY ADEQUATE OUTLET LOCATION AND ELEVATION.

CONDITION 1 - SURFACE DRAINAGE CROSSES ROADWAY
ROADWAY IS LOW POINT OR INTERSECTS SLOPE, NO DITCHES



NOTES

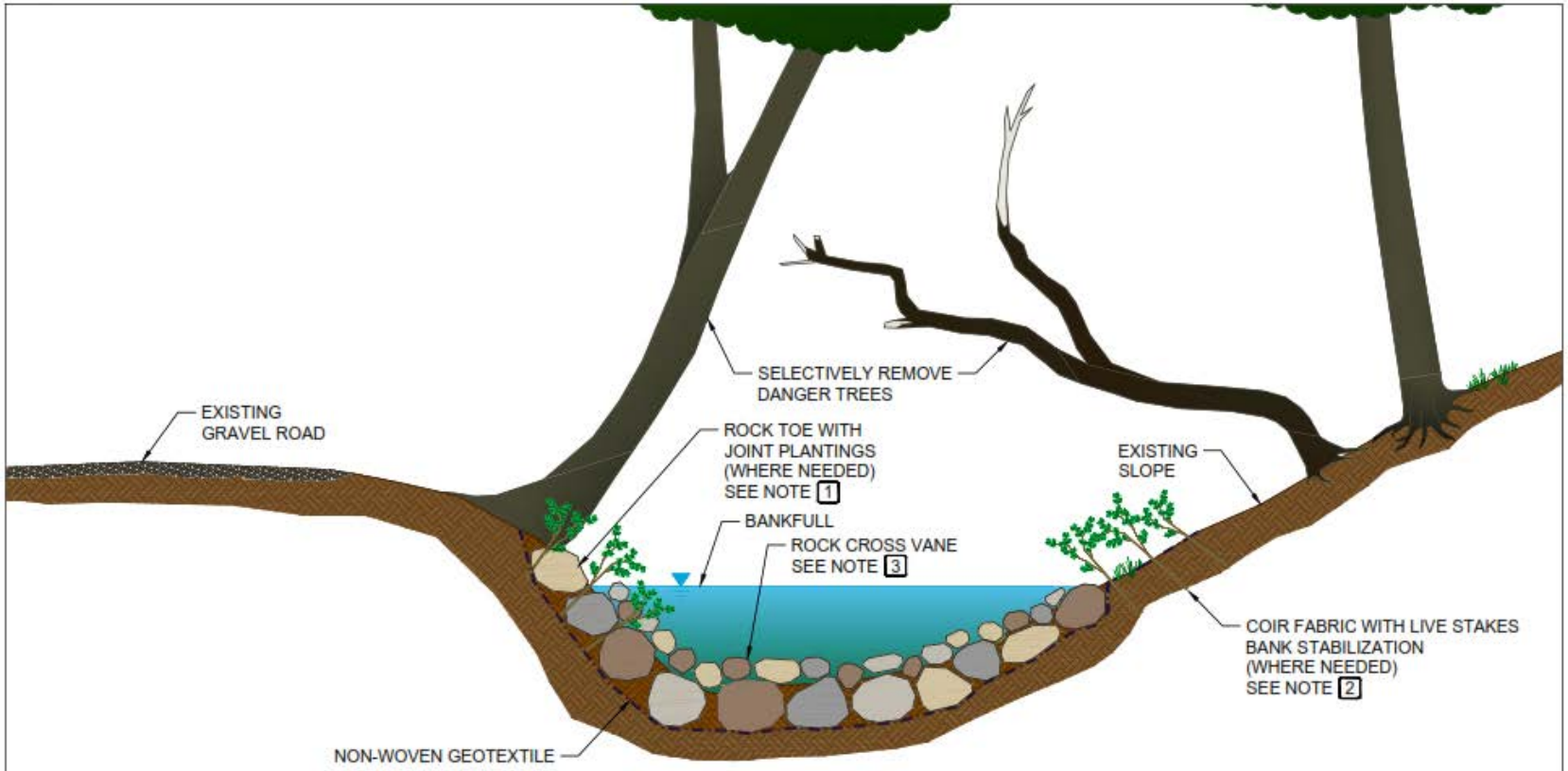
1 FOR JOINT PLANTINGS AT ROCK TOE:
- PROCURE LIVE STAKES 24"-36" IN LENGTH, 3/8"-3" IN DIAMETER.
- INSERT 2/3 LENGTH OF LIVE STAKE INTO SOIL AND INSERT THROUGH GEOTEXTILE.
- INSERT LIVE STAKES BETWEEN RIPRAP 3' ON CENTER.
- USE STINGER TO CREATE PILOT HOLE THROUGH GEOTEXTILE.

2 FOR COIR LOG BANK TREATMENT:
- RECOMMENDED COIR LOG SIZE IS 20" DIAMETER.
- EMBED LOWEST COIR LOG A MINIMUM OF 10" BELOW CHANNEL BED. STACK COIR LOGS ALONG BANK UNTIL THE TOP OF THE UPPERMOST LOG REACHES THE BANKFULL ELEVATION. OVERLAP COIR LOGS 4-6".
- FOLLOW MANUFACTURER'S RECOMMENDATIONS FOR STAKING PATTERN AND SPLICING.
- USE ROPE TO SECURE COIR LOGS TO ADDITIONAL STAKES IN THE BANKFULL BENCH, AND TO TIE STAKES TOGETHER IN A ZIG-ZAG PATTERN FOR ADDITIONAL SUPPORT.

3 FOR ROCK J-HOOK (OR VANE):
- FOOTER AND HEADER ROCKS SHOULD BE 30-40" DIAMETER.
- ROCKS CLOSEST TO STREAM BANK SHOULD BE KEYED INTO EXISTING GROUND.
- VANE WILL EXTEND INTO THE CHANNEL A TOTAL OF 1/3 OF THE BANK FULL WIDTH FLOW, AND WILL BE ANGLED FROM THE STREAMBANK BETWEEN 20° AD 30°.
- THE TOP OF THE VANE WILL HAVE A SLOPE BETWEEN 4° AND 7°.

4 FOR GEOWEB WALL:
- GEOWEB STACKED WITH GRANULAR INFILL IN INTERIOR CELLS AND VEGETATED TOPSOIL INFILL IN OUTER CELLS.
- GEOWEB WALL MAY NEED COMPACTED STONE LEVELING PAD BASED ON SITE CONDITIONS.
- GEOWEB WALL MAY NEED A PERFORATED SUBDRAIN BASED ON SITE CONDITIONS.

CONDITION 2 - ERODING STREAM PARALLEL TO ROADWAY



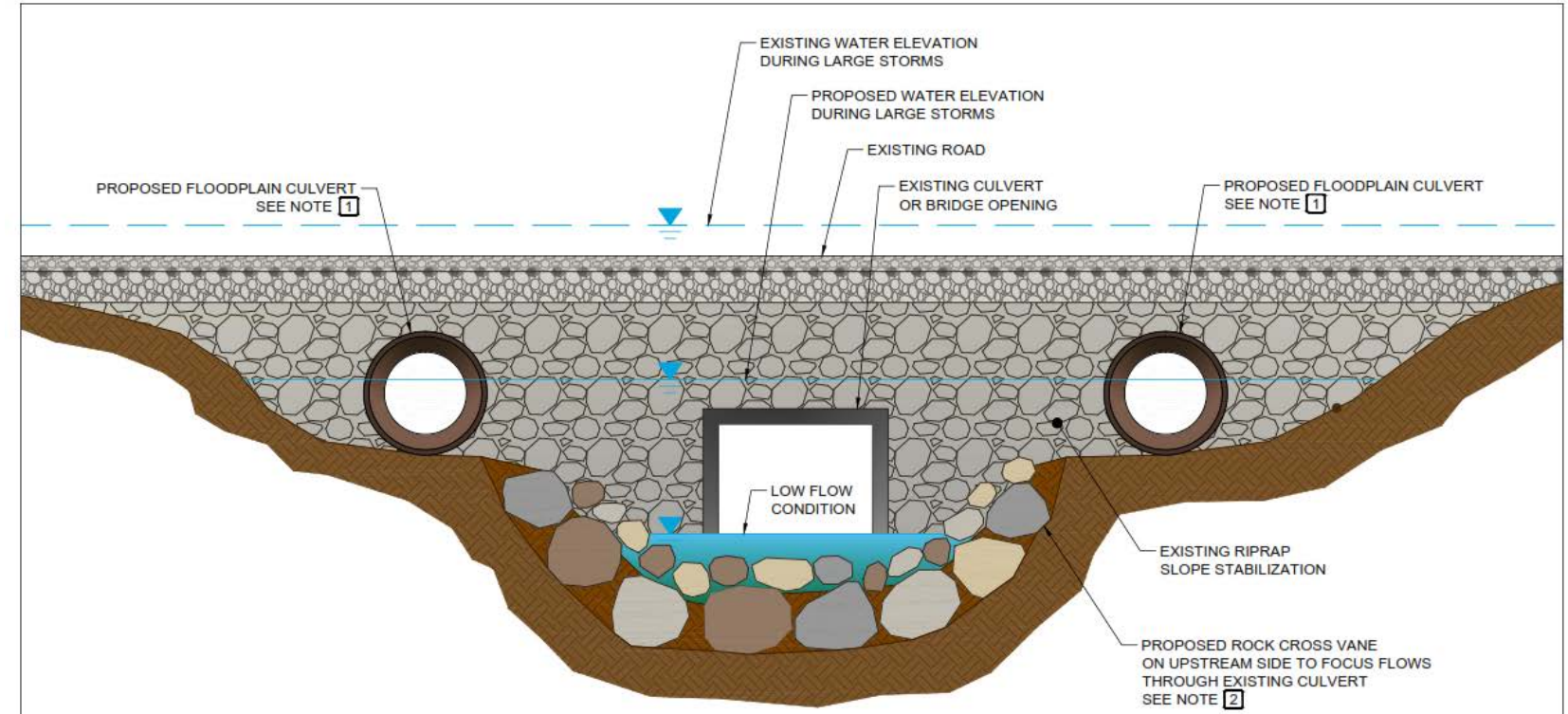
NOTES

1 FOR JOINT PLANTINGS AT ROCK TOE:
- PROCURE LIVE STAKES 24"-36" IN LENGTH, 3/8"-3" IN DIAMETER.
- INSERT 2/3 LENGTH OF LIVE STAKE INTO SOIL AND INSERT THROUGH GEOTEXTILE.
- INSERT LIVE STAKES BETWEEN RIPRAP 3' ON CENTER.
- USE STINGER TO CREATE PILOT HOLE THROUGH GEOTEXTILE.

2 FOR COIR FABRIC WITH LIVE STAKES:
- FOLLOW MANUFACTURER'S RECOMMENDATIONS FOR STAKING PATTERN AND SPLICING.
- PROCURE LIVE STAKES 24"-36" IN LENGTH, 3/8"-3" IN DIAMETER.
- INSERT 2/3 LENGTH OF LIVE STAKE INTO SOIL AND INSERT THROUGH GEOTEXTILE.
- SPACE LIVE STAKES 3' ON CENTER.
- USE STINGER TO CREATE PILOT HOLE THROUGH GEOTEXTILE.

3 FOR ROCK CROSS VANE:
- FOOTER AND HEADER ROCKS SHOULD BE 30-40" DIAMETER.
- ROCKS CLOSEST TO STREAM BANK SHOULD BE KEYED INTO EXISTING GROUND.
- VANE WILL EXTEND ACROSS THE ENTIRE CHANNEL SYMMETRICALLY, AND WILL BE ANGLED FROM THE STREAMBANK BETWEEN 20° AND 30° EACH SIDE.
- THE TOP OF THE VANE WILL HAVE A SLOPE BETWEEN 4° AND 7°.

CONDITION 3 - FALLING TREES AT STREAM PARALLEL TO ROADWAY

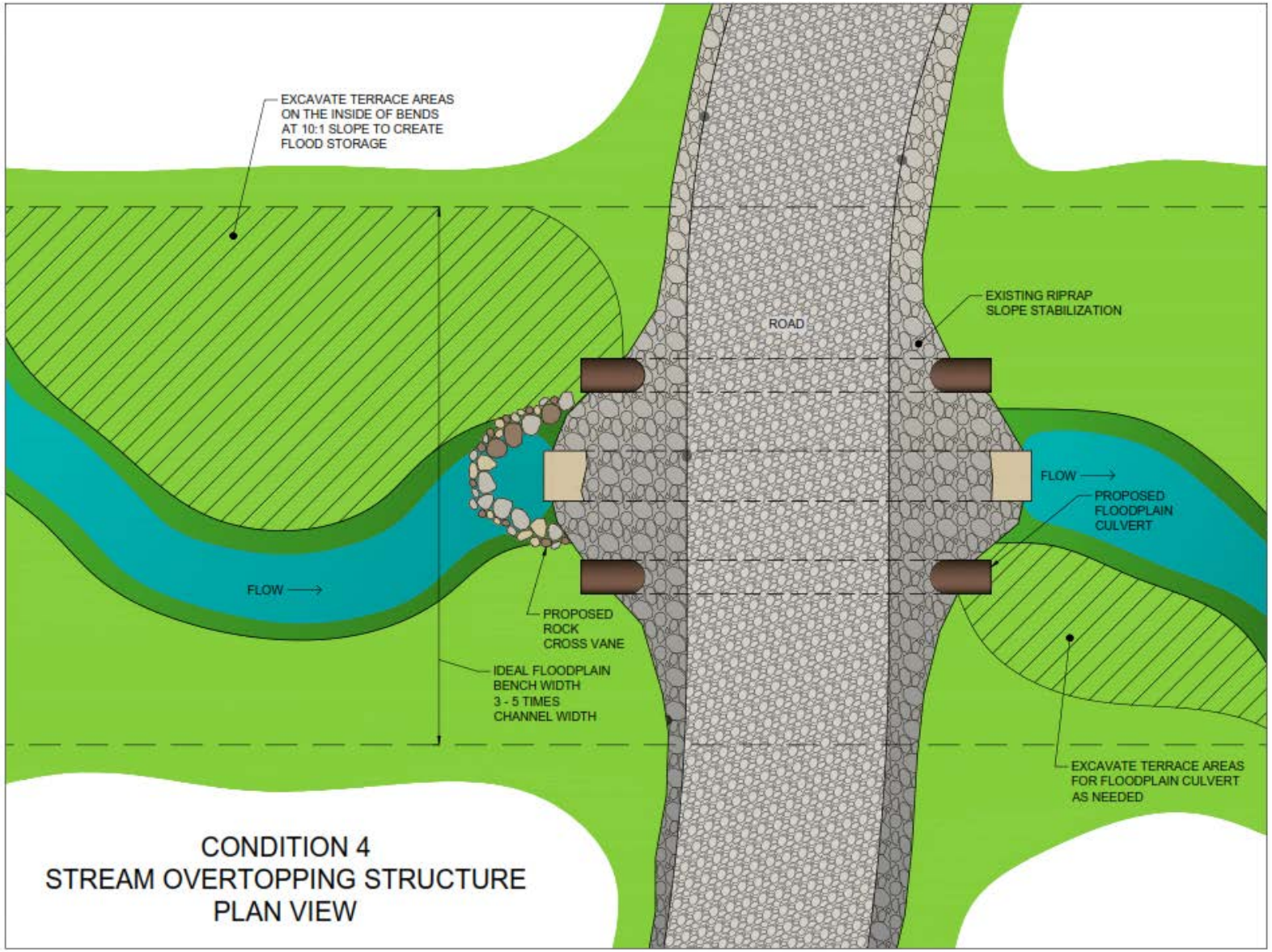


NOTES

1 PROPOSED CULVERTS:
- INSTALL ALL FLOODPLAIN CULVERTS AT SAME ELEVATION AND AT THE ELEVATION OF THE BANKFULL BENCH.
- FLOODPLAIN CULVERTS SHOULD NOT CONVEY FLOW DURING LOW FLOW CONDITIONS.
- FLOODPLAIN CULVERTS CAN BE INSTALLED BY THE JACK AND BORE METHOD, OR BY OPEN CUT IF ROAD IMPROVEMENTS ARE OCCURRING SIMULTANEOUSLY.
- FLOODPLAIN CULVERTS MAY BE INSTALLED ON THE LEFT BANK, RIGHT BANK, OR BOTH (AS SHOWN).
- EXCAVATION OF FLOODPLAIN UPSTREAM OR DOWNSTREAM OF STRUCTURE MAY BE REQUIRED IN SOME LOCATIONS.
- PIPE MATERIAL MUST BE COMPATIBLE WITH INSTALLATION METHOD, DEPTH OF COVER AND TRAFFIC LOADING.
- CULVERTS TO BE SIZED TO CONVEY VOLUME ADEQUATE TO ADJUST ELEVATION OF HIGH FLOW CONDITIONS BELOW ROADWAY.
- THESE CULVERTS MAY BE PLACED OUTSIDE OF ZONED FLOODPLAINS AND MAY NOT SOLVE TAILWATER FLOODING.

2 FOR ROCK CROSS VANE:
- FOOTER AND HEADER ROCKS SHOULD BE 30-40" DIAMETER.
- ROCKS CLOSEST TO STREAM BANK SHOULD BE KEYED INTO EXISTING GROUND.
- VANE WILL EXTEND ACROSS THE ENTIRE CHANNEL SYMMETRICALLY, AND WILL BE ANGLED FROM THE STREAMBANK BETWEEN 20° AND 30° EACH SIDE.
- THE TOP OF THE VANE WILL HAVE A SLOPE BETWEEN 4° AND 7°.

CONDITION 4 - STREAM OVERTOPPING STRUCTURE
SECTION VIEW LOOKING DOWNSTREAM


EXCAVATE TERRACE AREAS
ON THE INSIDE OF BENDS
AT 10:1 SLOPE TO CREATE
FLOOD STORAGE
ROAD
EXISTING RIPRAP
SLOPE STABILIZATION
FLOW
PROPOSED
FLOODPLAIN
CULVERT
FLOW
PROPOSED
ROCK
CROSS VANE
IDEAL FLOODPLAIN
BENCH WIDTH
3 - 5 TIMES
CHANNEL WIDTH
EXCAVATE TERRACE AREAS
FOR FLOODPLAIN CULVERT
AS NEEDED
CONDITION 4
STREAM OVERTOPPING STRUCTURE
PLAN VIEW

APPENDIX B –PUBLIC INVOLVEMENT SUMMARY AND SURVEYS

Monroe County Long Range Stormwater Improvement Plan- Community Questionnaire

The Monroe County Long Range Stormwater Questionnaires were developed to gather input for the Monroe County Long Range Stormwater Improvement Plan. There were three questionnaires developed for the following groups: the Monroe County Board of Commissioners, county employees, and the general public. Each questionnaire is further described below.

Board of Commissioners
The questionnaire was distributed to the Board of Commissioners during the board meeting on October 9th, 2014. The key information gathered from the questionnaire included drainage project ranking metrics that were discussed during the presentation and that were used to prioritize potential projects. These comments were integrated into the final project ranking matrix.

County Employees
The questionnaire was distributed to county employees at the various county garages on October 9th, 2014. The key information gathered from the questionnaire included stormwater problem collection process information, available equipment to handle stormwater complaint projects, and the importance and familiarity (providing repairs/solutions) of various stormwater projects. These comments were integrated into the final project ranking matrix.

General Public
The general public questionnaire was distributed by using a form hosted on the County website and was also made available at the Public Meeting held on January 15th, 2015. A total of 10 surveys were completed.

The results of these surveys are further described below.

The first section of the survey determined how long the resident has lived at the property and how often flooding has been noticed during that time. The average length of ownership was 16 years with the maximum being 30 years and the shortest was 5 years. Fifty percent of the respondents indicated that they have had flooding in their yard, while only 2 people provided information that their basement had flooded. Another respondent indicated that their crawl space had been flooded once during a heavy storm. Each person that responded to the survey with flooding problems had some type of evidence, like a photograph, water line or other, to show the extent of these flood events.

Each respondent was asked if they were part of the National Flood Insurance Program (NFIP) and if they had taken any personal measures to control the flooding on their property. Forty percent of those who responded said they were part of the NFIP. Many people had already taken measures to protect their property. Some example of control measures given in the survey were:

- Trenching around house
- Installing flood walls
- Installation of a sump pump

- Install drains around house

A majority of the respondents indicated that they had experienced erosion becoming worse along the streets and the banks of streams on their property. Others reported sink holes on their property getting larger, gravel on driveway washed out and the dirt around drain pipes being washed away. A few respondents had taken the following actions: purchasing gravel for along the roadways, filling holes in their yard where it had been washed away and installing drains and trenches with riprap on their property to control the flooding.

Questions were also asked about the age and type of foundation of the house of the residence. The average age of the houses from the people filling out the questionnaire was 43 years old with the oldest being over 100 years old and the most recent build being just 9 years old. The supporting structure under the houses were as follows:

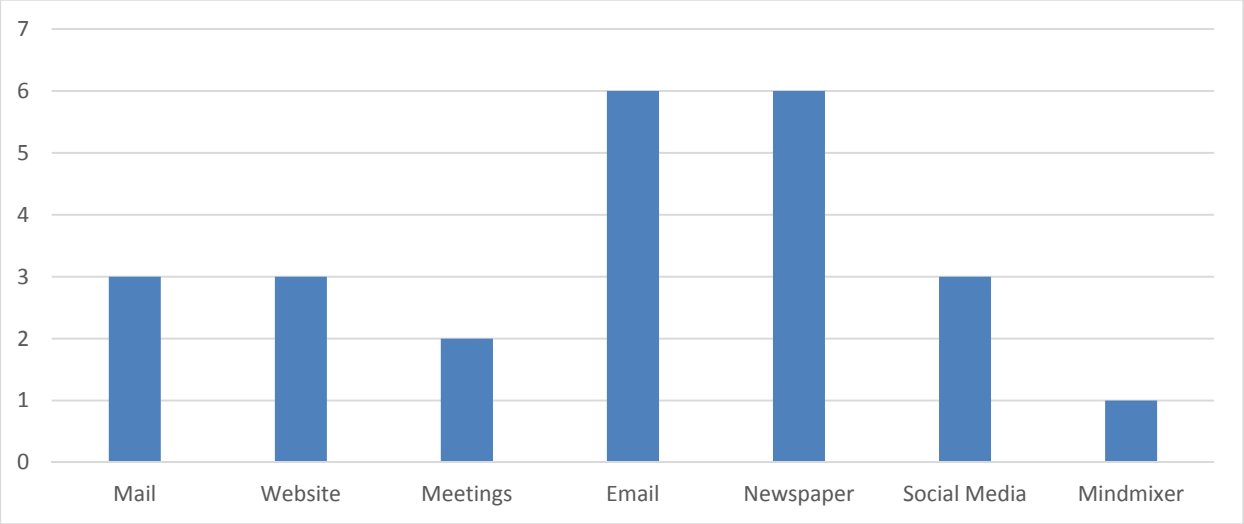
- 2 split level with crawl space
- 5 crawl space only
- 2 slab only
- 1 with basement only

Of the respondents, only three people had sump pumps and none of those had led to any flooding due to failure of the pumps. Sixty percent of the respondents reported having private septic systems and the other forty percent are on public systems. Three respondents reported that during some of the rain events they have been blocked from gaining access to their homes due to flood waters.

The survey also gathered information on how the public learns of flooding in the area and how the communications could improve. All of the respondents to the survey marked that they learned of the flooding by their own observations and by obtaining information on television and radio.

When given options on the best methods to distribute or share information with the public, the results were as follows:

Table 1.B: Best Method (s) for the Public to Receive Information



The survey asked for final thoughts and additional comments. Below are the summaries of those that responded:

- Wants the city to put storm sewers throughout town. Since they have to pay for the service each, they should get the service that they currently don't receive.

- The city has known about their issue for years and when they complain the city comes out each time. The city will make some marks in the yard and the street, but nothing is ever resolved with the issue. The water continues to not go into the drain and will sit in the street and in front of their house.

- Has complained and shared videos of the problem on Rockport Road. The highway department has cleaned the ditched on both side of Rockport road. Last year the department installed a drainage culvert across Stansifer Lane. Respondent told the city that it would not fix the problem and there needed to be an east/west drainage on the north side of Stansifer Lane. Currently the respondent has a large rut or crevice running across the gravel driveway in front of his house. Every rain gravel is removed from the driveway and it has to be shoveled back into the driveway.

- Has talked with the airport about their problem and they offered to help the situation, but nobody else he has contacted believes he has a problem. The city has been out to the area but don't seem to want to be involved with the fix. A simple culvert upgrade would eliminate the issue.

- According to the surveyors and mortgage people the house is not located in a flood area. The house sits on higher ground and isn't threatened but there is a large sink hole that is located close to the path of the culvert that exits from under SR 45. The storm water was brown in early January so it contained soil. Photographs can be provided to show the water breeching the access road during the storm.

- Jack's Defeat Creek bisects his property with the floodplain on one side. No damage has been experienced, but the biggest issue was from FEMA replotting the floodplain. Respondent had to pay for a LOMA so he wasn't paying for flood insurance on his property unnecessarily.

APPENDIX C – PROJECT CONCEPT PLANS

APPENDIX D – AUTOMATED MONITORING MEMO

Memo

To: Todd Stevenson, Monroe County Public Works

From: Danny Ketzer, P.E., Amec Foster Wheeler

CC: Jean Ramsey, P.E., Amec Foster Wheeler

Re: Remote Flood Monitoring

Amec Foster Wheeler conducted research to determine a few options available to Monroe County to establish an advanced flood warning system. These sensors would be installed at bridges or culverts and are capable of measuring water depth and sending electronic warnings at predetermined water elevations. Depending on the setup, this data can be available online in real time. There are several components to the flood monitoring setup:

Data Logger ($1,420-$1,780 each)
The data logger is the computer that the water elevation sensor and any other sensors (eg. rainfall gage) connects to. These data loggers run on batters, with some batter lives recorded as lasting up to 5 years. Batteries can also be supplemented with mounted solar panels at additional cost.

Housing ($400 each using commercial products)
The data logger needs to be housed to protect it from the elements and vandalism. Commercially available houses made of fiber glass are available, though these houses are not always durable enough to withstand vandalism. The project team has used corrugated plastic piping and sheet metal to construct rugged houses in the past.

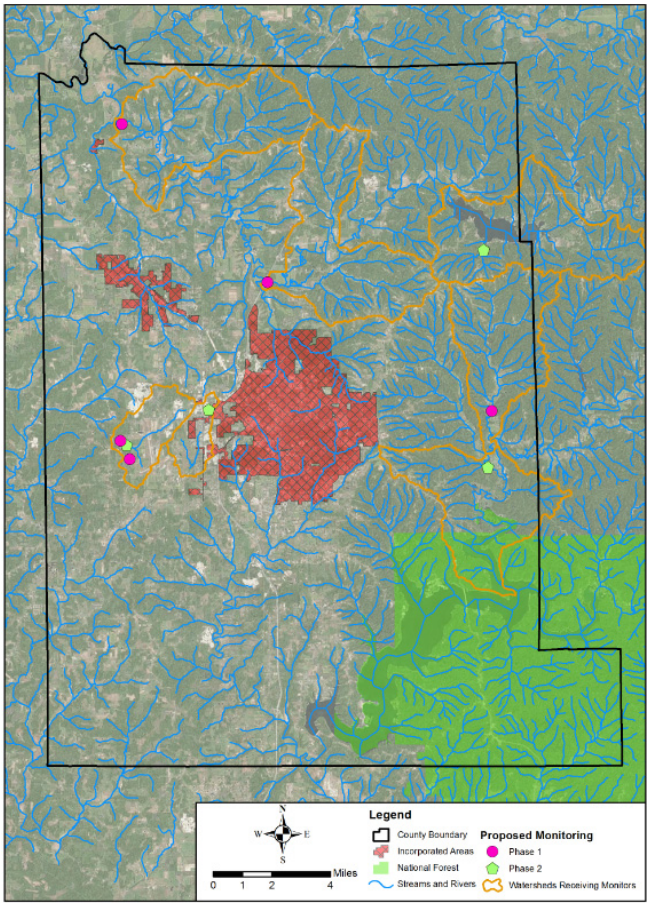
Sensors ($800 each)
A sensor is used to physically measure the water depth. The sensor is connected with a cable to the data logger and will be mounted outside of the housing unit to a bridge, culvert, or in a stream bed. The sensor may need to be mounted inside of a piece of piping for additional protection. There are two main types of depth sensors: pressure transducers and radar sensors. Pressure transducers are mounted in the stream bed and measure the water pressure above them. They are often out of sight but need to be adjust seasonally as frozen water can damage the sensor. Radar sensors are mounted at the crown of culverts or the low chord of bridges and measure the distance the water surface elevation is below the sensor. These sensors are often high enough to avoid ice and debris, but are visible to the public. The radar sensors also cannot measure the water elevation once the sensor is flooded.

Communication Device ($682 each)
The data logger will need to be attached to a communication device for incoming and outgoing signal exchange. This is often a cellular modem as priced here, but can be a radio or other transmission device.

Software ($600+ one time purchase)
The data logger and sensor are managed using proprietary software. This software is capable of sending out electronic warnings over text and email and often allows users or the public to view the data in real time. The software license only needs to be purchased once and is capable of managing all of the deployed sensors and data loggers. Advanced versions of the software can manage electronic warning signs remotely, though these signs are not available commercially from the vendors contacted.

Maintenance
According the vendors, each sensor typically requires maintenance once to twice per year. Typical maintenance involves clearing the sensor of debris, checking its functionality, changing batteries, and moving the position of pressure transducers to avoid ice. A faulty or blocked sensor can often be detected from its data, which can help determine if additional maintenance visits are required.

Summary ($3290+ per site plus $600+ software)
The quoted price for a single sampling station was $3290 plus the software license and maintenance. This price may vary depending on choice of sensor, housing, and communication device. Some data loggers are cable of using water quality sensors, which may allow the deployment to be paired with water quality grants and funding sources. Amec Foster Wheeler can coordinate with vendors to tailor a deployment strategy that best meets Monroe County's needs and resources.



APPENDIX E – STORMWATER REVIEW PROCESS FOR CIPs

Integrating comprehensive stormwater planning into the capital improvement project process from the onset is the most effective approach for reducing and preventing potential pollution and flooding problems. Early stormwater management planning will generally minimize the size and cost of structural and nonstructural solutions. Interdepartmental coordination, communication, and collaboration is recommended for the most cost effective design solution and can also identify overlapping projects to help minimize overall County costs. The flow chart below outlines the process for inclusion/integration of Stormwater review for capital improvement projects.