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Watershed Management Plan

For the Lost River Watershed

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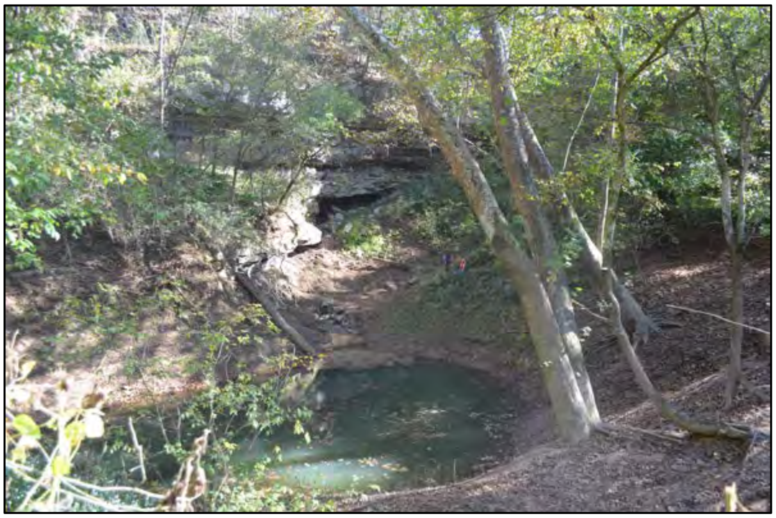

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Watershed Management Plan for:
Lost River & Dry Branch Lost River Watersheds
(Hydrologic Unit Code 0512020812 & 0512020813)

Section1 - Executive Summary

Orange County Soil and Water Conservation District (SWCD) retained Water Ways Consulting to conduct field data collection and write a Watershed Management Plan (WMP) for Lost River Watershed. The project was funded by the Indiana Department of Environmental Management through the Environmental Protection Agency (EPA) 205 (j) Program grant with a cash and in-kind services match provided by Orange County SWCD and partners.

Lost River flow comes from land that is part of Washington, Orange, Lawrence, Martin, and Dubois Counties in Indiana. The headwaters of Lost River originate in western Washington County, Indiana. Lost River generally flows west into Orange County to a point where it sinks underground into the karst caverns below. Lick Creek and French Lick Creek join Lost River once it reemerges from the cave system though a series of springs. The water movement continues in the westward direction where it bisects the landscape with narrow meandering valleys through Martin County. Many small side tributaries contribute to Lost River as it traverses this terrain. Lost River completes its journey to the East Fork of White River. Many karst springs keep water flowing year-round within many portions of the watershed.

Lost River is part of the Mississippi River Basin. Lost River Watershed Project area is comprised of two 10-digit hydrologic unit code (HUC) watersheds. They are Lost River Watershed (0512020813) and Dry Branch Lost River Watershed (0512020812). These two watersheds make up land that is comprised of 234,162 acres. These two drainage areas are composed of fourteen, 12-digit HUC subwatersheds including: Stampers Creek Subwatershed (051202081201), Orleans Karst Area Subwatershed (051202081202), South Fork Lost River Subwatershed (051202081203), Carters Creek-Lost River Subwatershed (051202081204), Lost River Sink Subwatershed (051202081205), Mt. Horeb Drain-Lost River Subwatershed (051202081206), Headwaters Lick Creek Subwatershed (051202081301), Log Creek-Lick Creek Subwatershed (051202081302), Scott Hollow-Lick Creek Subwatershed (051202081303), French Lick Creek Subwatershed (051202081304), Sulphur Creek-Lost River Subwatershed (051202081305), Sams Creek-Lost River Subwatershed (051202081306), Big Creek-Lost River Subwatershed (051202081307), and Grassy Creek-Lost River Subwatershed (051202081308).

Natural area including forest, scrub/shrub areas, and grassland comprise 48.4% of the total watershed area. Cultivated cropland is the next most predominant land use type comprising just over 26.2% of the total watershed area. An additional 15.7% of the watershed is pasture or hay fields making the total agricultural land use percentage almost 42% of the watershed. A total of 5.6% of the watershed is developed commercial, industrial, and residential areas as well as developed open space such as parks and golf courses. Lost River Watershed is seeing an increase in development due to the revitalization of French Lick. Tourism in the area is also increasing with this revitalization and the draw to Hoosier National Forest in the area.

A total of 27 sample sites were established within the watershed as part of this study. Data collected included temperature, pH, specific conductivity, dissolved oxygen, biochemical oxygen demand, total phosphorus, orthophosphate phosphorus, nitrate, total suspended solids (TSS), turbidity, discharge, E. coli, macroinvertebrate communities, and habitat data.

High nutrients, high E. coli levels, unstable and eroding stream banks, and poor aquatic communities are some of the biggest concerns in Lost River Watershed. Of all samples tested for E. coli 62.5% exceeded the state water quality standards for recreational use purposes. In addition, 49% of nitrate samples and 42% of total phosphorus samples exceeded recommended maximum targets set by the Lost River Watershed Steering Committee. TSS and turbidity samples exceeded water quality targets at rates of 21.4% and 18%, respectively. These targets for nutrients are set at a level to reduce the amount of overproduction of algae within a waterbody. Fifty-eight percent of streams tested had macroinvertebrate counts below levels required for a healthy aquatic ecosystem despite the fact that only one quarter of the sample sites lacked suitable habitat for aquatic life use. The habitat should be supporting more quality life. Likely nonpoint source pollutants are affecting the populations.

Stakeholder water quality concerns were collected at public and steering committee meetings and solicited by steering committee members. The steering committee determined whether each concern was supported by available data. The steering committee identified specific problems relating to each concern that was supported by data and on which the group wished to focus. Problems were defined as issues that exist due to a concern. Specific problems were consolidated into problem categories. Identified problem categories include high stream nutrient levels, high TSS and turbidity levels, high stream E. coli levels, low oxygen levels, low pH levels, degraded aquatic habitat, flooding, trash, reduced aquatic recreation, and decreased aquatic biodiversity.

Goals were developed to address the identified problem categories and improve water quality in Lost River Watershed. Seven primary goals selected include reducing E. coli concentrations to below the state standard, reducing sediment to below the water quality target, reducing nutrient loads to below water quality targets, increasing public awareness of water quality issues, improving aquatic life, increasing stream buffers, and decreasing stormwater runoff. The steering committee determined sub-goals to work toward with timelines in order to achieve each primary goal as well as indicators that can be used to determine if progress is being made toward achieving the goal.

A critical area is a place where implementation of watershed management plan guidance can remediate nonpoint source pollution in order to improve water quality or mitigate future pollutant sources to protect water quality. Critical areas were determined based on a grading system that took into account water quality, highly sensitive areas, and areas with higher potential to contribute nonpoint source pollution. Best management practices (BMPs) were selected to implement in critical areas to remediate nonpoint source pollution in order to improve water quality or mitigate future pollutant sources to protect water quality. Site-specific critical areas identified include areas lacking filter strips or riparian buffers whether that be on streams or karst features. The steering committee selected the subwatersheds that scored 13-27 as non-site specific critical areas based on grading sheet.

Recommended BMPs to address critical areas on agriculture and livestock land include no-till conservation tillage; cover crops; drainage water management; grass waterways; livestock fencing, stream crossings, alternative watering facilities, rotational grazing; nutrient and pest management plans; and waste utilization. BMPs recommended to address critical areas in urban settings include pervious pavement; pet waste receptacles; rain barrels; and stormwater management practices such as infiltration gardens, stormwater swales, and stormwater planters. BMPs such as riparian restoration and streambank stabilization including natural channel restoration are recommended for site-specific critical areas in both rural and urban areas. In addition to structural BMPs, multiple topics for educational programming and potential new ordinances as well as updates to existing local ordinances were also recommended.

An Action Register was developed to facilitate implementation of the WMP. It includes specific objectives to be carried out in the process of working toward accomplishing each water quality improvement goal for Lost River Watershed. Also included in the Action Register is the target audience for each water quality improvement objective, objective milestones, estimated costs for implementing each objective, and possible partners as well as technical assistance resources that may be beneficial for objective implementation. WMP implementation progress will be tracked using a combination of social indicators, administrative indicators, and environmental indicators.

Several well-known cost-share programs are offered by the United States Department of Agriculture (USDA) Natural Resource Conservation Services (NRCS), Indiana State Department of Agriculture (ISDA), Indiana Department of Natural Resources (IDNR), Indiana Department of Environmental Management (IDEM), and other less well-known programs that could be used to provide financial support for the implementation of recommended BMPs. A large variety of established institutional resources and other potential institutional resources exist to aid in water quality improvement efforts. The Orange County SWCD and steering committee will be seeking grants and assistance from institutional resources to move forward with implementation of the WMP.

Section 2 - Introduction

According to the Indiana Natural Resources Commission, Lost River is one of nine exceptional use waters from Indiana's Outstanding Rivers and is designated as such because the river has particular environmental and aesthetic interest. It is the desire of the community to protect our water resources for future generations. The Lost River Watershed system is a very diverse and unusual system within Indiana and should be maintained and improved for long-term enjoyment.

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The Environmental Protection Agency (EPA) is the federal entity that enforces the CWA. The 303(d) list is the record of impaired waters that the Clean Water Act requires all states to submit for EPA approval every two years. Some of the waters in the Lost River and Dry Branch Lost River watersheds are considered impaired for recreation and aquatic life according to Indiana's 2008 303 (d) list. EPA defines impaired waters as any waterbody (i.e., stream reaches, lakes, waterbody segments) with chronic or recurring monitored violations of the applicable numeric and/or narrative water quality criteria. In Indiana, impaired waters do not meet water quality standards set by the State of Indiana for that water's designated uses. These water quality standards are set in Indiana Administrative Code 327 Article 2. Appropriate or designated uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes.

Pollutant sources to waters degrading the quality of the waters are considered either point or non-point sources. Point sources are discrete conveyances such as pipes or man-made ditches. Point source pollutants contaminate the ground or surface waters through discharges traced back to a specific source such as a factory or sewage treatment plant. Non-point source (NPS) pollution, on the other hand, is contamination of ground and surface waters from more wide spread sources. Soil particles, fertilizers, animal manure, pesticides, oil, road salt, fecal material from failing septic systems, pet waste, and debris from paved areas are transported over the landscape by storm run-off, snowmelt, and wind. Eventually entering streams, wetlands and lakes, or penetrating into ground water, these pollutants damage aquatic habitats, harm aquatic life, and reduce the capacity of water resources to be used for drinking water and recreation. Because NPS pollution does not come out of a pipe that is easily located, it has to be managed differently than facilities with site-specific permits. That is why so many of the measures directed at controlling NPS pollution are voluntary, and why so many people need to be involved. Point sources of discharge into waters are regulated under the National Pollutant Discharge Elimination System (NPDES) permit program. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. CWA Section 205(j) requires States to determine the nature, extent, and causes of water quality problems in various areas of the State and interstate region, and report on these annually. The federal Clean Water Act Section 205(j) provides funding for water quality management planning, which is then allocated by each state. Under Section 205, state, territories, and tribes receive grants to support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects.

In November of 2010, the Orange County Soil and Water Conservation District (OC SWCD) received CWA Section 205 (j) grant to develop a watershed management plan, conduct education and outreach on non-point source (NPS) pollution concerns, and monitor the water bodies within the Lost River and Dry Branch Lost River Watersheds. The NPS pollution program developed within this document addresses water quality impairments within the Lost River and Dry Branch Lost River watersheds. Orange County SWCD was concerned that waters of these watersheds may be unsafe due to the water quality impairments listed on the 303 (d) list. Specifically, seven stream segments are listed as impaired on the 2008 303(d) list due to unacceptable levels of *Escherichia coli (E. coli)*. The draft 2012 303 (d) list includes two additional segments impaired for *E.coli*. This list also includes two stream segments in the watershed that have impaired biotic communities, one with dissolved oxygen levels below state standards.

This document will address the continued discussions on flooding issues, point source pollution (NPDES), and determine whether reduction of pollutant loading to the system is necessary. The Watershed Management Plan for the Lost River and Dry Branch Lost River watersheds will help with future planning and development within this area. We hope that behaviors and processes developed within this watershed management plan will allow for the enhancement of opportunities within these watersheds for residents, industry, agriculture, and recreation. The flora and fauna within the Lost River watershed is unique. In part, this is due to the vast underground cave system within this area. The goals set forth within this plan will help to protect the unique wildlife of the area. The plan within this document will help to restore and protect habitat including animal migration, forested lands, and stream buffers. Habitat restoration and protection can be a vital component of the watersheds' healthy ecosystem. The plan will address techniques to incorporate within the community that will address these concerns and promote healthier watersheds. The program design is to develop a proactive response to potential future threats, source water protection, wildlife habitat pressure, and other likely risks within the watersheds.

2.1 Document Overview

The initial sections of this document contain the Executive Summary and Introduction to the Lost River Watershed Management Plan. The remainder of the Lost River Watershed Management Plan is organized to go from a broad perspective down to the specifics of the water quality concerns and the actions planned to address those concerns. Section 3 gives a description of the watershed as a whole including the physical and natural features, the land use and land cover, and the demographic characteristics. Section 4 includes the water quality data with both a current and historical perspective. A more detailed investigation of the subwatersheds is provided in Section 5. This section divides the watersheds into subsections that are analyzed and investigated on a level that is more manageable. Section 6 summarizes the watershed inventory data and analyzes stakeholders concerns. The water quality problems identified and their associated causes are addressed in Section 7. Section 8 links the pollutant loads to their potential sources. Section 9 includes a summary of the watershed goals and objectives produced to address water quality concerns. Section 10 identifies the management strategies enacted to achieve the goals and objectives of the watershed management plan. Lastly, Section 11 describes the specifics to implementing the management strategies along with actions, milestones, and costs associated with each strategy.

2.2 Watershed Management Plan Purpose and Process Used

For the successful development of a Watershed Management Plan for the Lost River area, a partnership between community members needs to be fostered and facilitated. The members should represent all aspects of a watershed including agricultural producers, forest landowners, recreational enthusiasts, regulatory representatives, government landowners, conservation district representatives, and local residents. This section describes how a group of individuals representing these areas met and formed a partnership to address water quality issues within the area. It also describes the concerns that were gathered from stakeholders of the area to include the community into the process and give them a voice.

2.2.1 Watershed Management Team

Local leaders in the community are concerned about the health of the local waters, wildlife, and community, which has led leaders to initiate a project to address these concerns. Local leaders include members of the Soil and Water Conservation Districts (SWCD), Federal employees from Natural Resource Conservation Services (NRCS) and Farm Service Agency (FSA), state government employees from Department of Natural Resources (DNR), local government representatives, local landowners and farmers, and concerned citizens. They decided to work together to increase the quality of life for the community, increase recreation potential within the watershed, and decrease our negative impacts on water quality. They have come together to form a steering committee to give direction to the project and this plan (Table 1).

Table 1: Steering Committee Members

First Name	Last Name	Title
Don	Brewer	County Commissioner District I
Jim	McDonald	Farmer/ County Council Member
Rick	Emerick	Orange County Director of Emergency Management
Lee	Schnell	NRCS District Conservationist
Michael	Wilhite	SWCD Coordinator
Danny	Orr	SWCD Sponsoring Board Representative
Barry	Daughtry	Farmer
Jim	Daughtry	Farmer
Sandy	Clark-Kolaks	DNR-Southern Fisheries Research Assistant Biologist
Beth	Skees	Resident
Chad	Goldman	Teacher/ Resident
Bob	Houndshell	Teacher/ Resident
Russ	Apple	Pete Dye Golf Course Manager
Micheale	Porter	Trustee/Hobby Farmer
Michael	Porter	Local Youth- Concerned Citizen
Michael	Baker	Rents land for farming/ enrolled in timber stand projects
Clarence	Dillon	Former Resident- Professional Geologist/Hydrogeologist
Tom	Godfrey	Washington County SWCD Board Representative
Pete	Isom	Lawrence County SWCD Board Representative
Teresa	Harder	Martin County SWCD Representative
Bobby	Busic	White River Co-op

2.2.2 Public Participation

Stakeholder involvement was generated through a series of publications in the local newspaper, including press releases and advertisements; attendance at various town meetings and civic engagements, where brochures and flyers were distributed along with a verbal introduction to the project; and personally contacting landowners and stakeholders in the area. A local radio station donated a spot to the project coordinator for outreach and education via airwaves. A Kick-Off meeting was held on February 15, 2011 at 6:30 pm at the Orange County Community Center as an opportunity for community members to gather and share ideas and concerns on the water, land, caves, wildlife habitat, forest management, and other environmental concerns.

Additional stakeholder concerns were gathered through various face-to-face interactions, stakeholder meetings, and general polling of stakeholders of the area. Conversations over the water quality, wildlife habitats, maintaining greenspaces, and flooding concerns within the area took place with the start of this project.

2.2.3 Stakeholder Concerns

Concerns arose surrounding the quality of the water for recreational purposes, wildlife habitat, and drinking water sources. People also have concerns with the flooding that occurs in the area. Flooding is quick and lasts for weeks at a time due to the underground cave system. There is a strong concern about drinking water from the karst aquifers and numerous springs in the area. Many people rely on water from shallow aquifers and from springs, which often get muddy after heavy rains, or have high levels of Nitrogen. The quality of this water is a concern for those who rely on it as their only source of drinking water.

Many stakeholders in the area are anglers, and they have noticed that the fish population of certain species is declining. Several anglers have noticed that some fish pulled from streams within the watersheds have parasites attached to them. Within the distinctive cave system in the area, there are unique species that live solely in underground conduits. Some of these species are rare, threatened, or endangered and people are concerned with protecting these species.

Swimming in some of the deep pools of the rivers is a tradition for the youth in the area. People are concerned that their children may be swimming in waters that contain pollutants that could be harmful to them. People are concerned with becoming sick from swimming or coming in contact with the water.

Farming in the area can be very difficult due to the vast amounts of sinkholes. Livestock farmers have lost animals to sinkhole collapses, while row crop farmers have had problems with equipment loss within newly formed sinkholes. The concerns that these sinks are sometimes locations where water rises during large storms, only compounds the problems of farming within the karst area delaying spring plantings and causing some to double up on pesticide and fertilizer applications due to their late start.

Sinkholes are local dumping grounds for many people due to their deep holes, and out of sight characteristics. Many people fill sinkholes with refuse to “fill” the holes making the land usable again. This only compounds the problems of potential pollution of both our underground and surface streams in the area.

A full list of concerns incorporating many of the major issues suggested above is listed here.

- Water contact is unhealthy reducing the availability for recreational options within the waterbodies of the Lost River and Dry Branch Lost River watersheds.
- The general public lacks knowledge about the river and its tributaries’ water quality.
- The public does not feel a sense of ownership or pride for the streams, rivers, karst areas or the Lost River and Dry Branch Lost River watersheds.
- Historic pre-law practices and early post-law practices have harshly altered stream channel morphology, severely distorting natural erosion and deposition mechanics.
- Streambank stabilization, in-channel stabilization, and soil erosion controls are needed to improve water clarity and reduce sediment accumulation.
- Excess sediment depositing as bars within channels causing widening and bank erosion at channels edge.
- Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes.
- Spring and well water after heavy rains will be muddy or have high levels of Nitrogen making it unsafe for drinking water.
- Individuals are unaware of pollution prevention options; demonstration sites should be available for education and outreach opportunities.
- Too much physical waste, or refuse, is entering the river and its tributaries.
- Illegal dumping along roadsides and directly into waterways creates biological, environmental, and safety hazards.
- Sinkholes have been historically used as trash receptacles for household and hazardous materials.
- Collections of vehicles and refuse on private property can be a source of surface soil and water contaminants and lower surrounding property values.
- Too much untreated stormwater enters the streams within the watersheds.
- Imperviousness of parking lots, roofs, streets, and sidewalks does not allow absorption of rain or melting snow, increasing run-off, which results in negative impacts on surface water and habitat quality.
- Municipal stormwater systems cannot handle the amounts of surface run-off, resulting in flooding during heavy rain events and subsequent negative impacts on surface water, subsurface water, and habitat quality.
- Combined Sanitary and Storm Sewer systems (CSOs) within Paoli cannot handle current population densities along with the stormwater causing the release of pollutants, including E. coli, chlorine, and suspended solids into surface waters during rain periods.
- Septic systems are old, incorrectly installed, or improperly maintained to control sewage releases into the watersheds.
- Individuals use too much fertilizer and pesticide and are unaware available alternatives.
- Pharmaceuticals and personal care products may be affecting wildlife populations and contaminating drinking waters.

- Acid mine drainage (AMD) enters surface waters, lowering pH levels and raising metals content, severely diminishing water quality and aquatic habitat.
- Partnerships between existing organizations are under-utilized.
- Private landowners are unaware of their obligations related to streams running through their property (log jam preventive maintenance, who to contact for permit assistance, etc.)
- Poorly planned and conducted logging or land clearing activities contribute to stream bank destabilization, log jams, stream turbidity, and elevated water temperatures.
- Areas of unrestricted stream access by domestic animals such as horses, cattle, and goats destabilize stream banks, contributes to pesticide and manure additions to the streams.
- Poor pasture management contributes to increased run-off of nutrients, E. coli, and erosion.
- Tile drainage into sinkholes and streams may be negatively influencing water quality and water flow in caves and streams alike.
- Artificial draining of wetted lands may be reducing the presence of natural wetland filtration within the agricultural landscapes.
- Winter applications of manure may be contributing to nutrient loading of surface waters.
- Manure and other fertilizers applied without the use of soil tests, lead to over application; this can cause nutrient loading to streams and aquifers.
- Encroachments of agricultural fields into riparian buffer zones and transitional areas have severely diminished natural cooling and filtering systems.
- Farm chemicals have the potential to enter creeks and sinkholes, possibly degrading water quality.
- Nutrient and algae concentrations are too high within the Lost River and some of its tributaries.
- Soil erosion resulting from conventional cropping practices contributes heavily to increased sedimentation, turbidity, nutrient, and pesticide loads.
- Collapsing sinkholes make terrain unusable; as a result filling of sinkholes is a common practice reducing the storage of the underground system. This may be increasing flooding in other portions of the watersheds.
- Continued farming on improperly filled sinkholes likely results in higher contribution of fertilizers, pesticides and soil to the subsurface system. Lack of soil filtration occurs in these unnaturally filled areas.
- Small homestead farms are overlooked for traditional conservation programs and are greatly in need of conservation planning.
- Off-road vehicles enter streams regularly destroying habitats and natural stream channels.
- Off-road vehicles rut and destroy natural soils making erosion and limited infiltration a concern in some areas.
- Invasive and exotic species are present throughout the watersheds.
- Natural areas are not contiguous limiting the corridors for wildlife population
- Density and diversity of fish in the Lost River is lower than historical levels.
- Unique aquatic species within the cave system within watersheds are threatened by poor water quality.
- Natural and wildlife areas should be protected.
- There are not enough trails along the Lost River karst corridor.
- Access to the Lost River and unique cave system is limited by lack of parking, publicly available boat ramps, and access sites.
- Road salts negatively affect stream and cave biota.
- Flooding occurs frequently and in longer duration resulting in unpredictable water levels.

Each of the concerns listed previously pointed to at least one major category, or source, of problem, and most were directed at a specific area within that category where assistance and focus would like to be placed within the watershed management plan. Table 2 below lists some of the specific concerns stakeholders mentioned as sources to water pollution within the Lost River Watershed. Causes of concerns were gathered through the various venues were grouped into similar major sources. The specific area of concerns was then associated to the major area of concern. These sources of pollutants and concerns address the overall concerns that stakeholders have over drinking water resources, recreation opportunities, and protection of wildlife within the Lost River and Dry Branch Lost River watersheds.

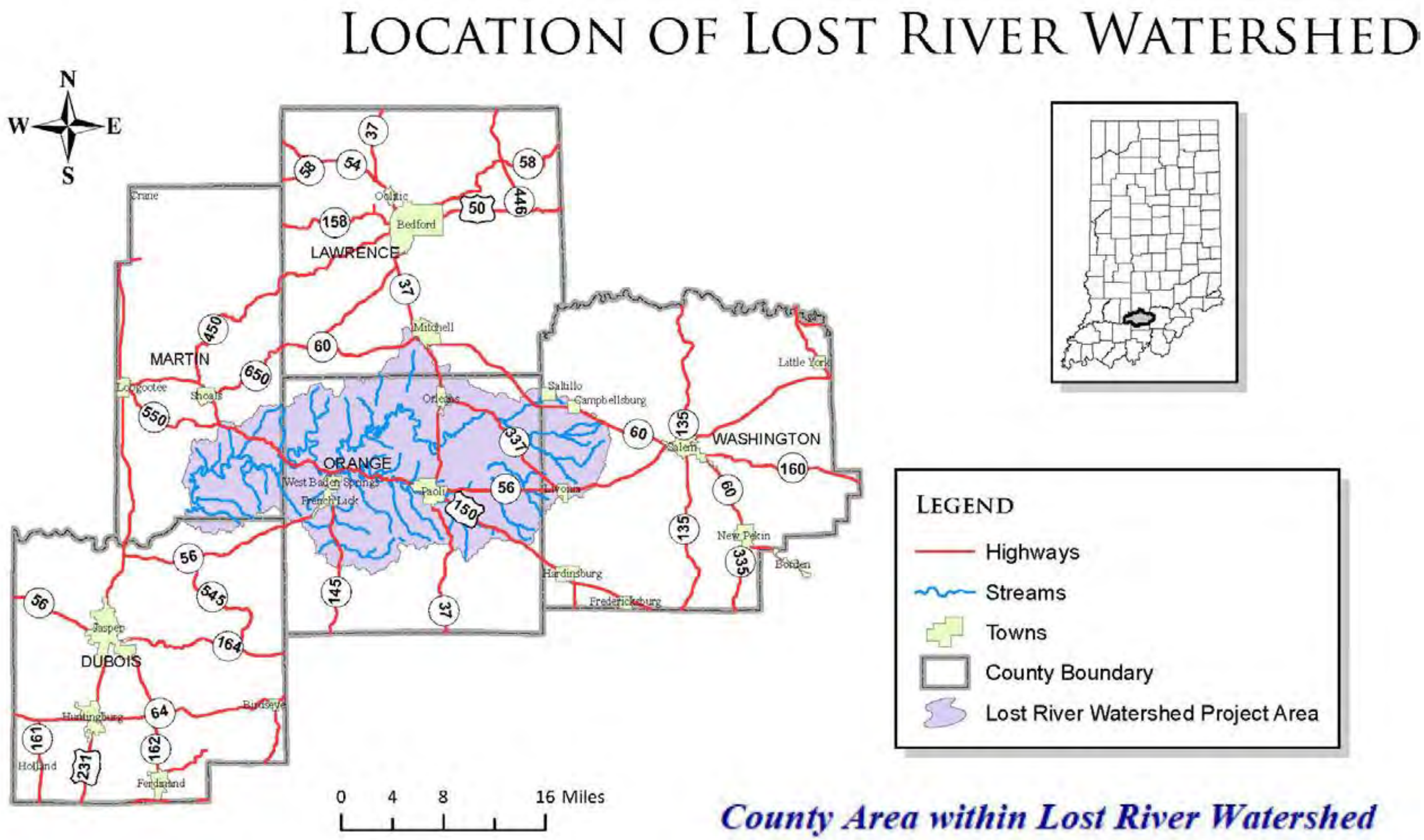
Table 2: Areas of Concern

Major Source	Specific Area	Concerns
Trash	sinkholes roadsides streams junk yards landfills/dumps	• Too much physical waste, or refuse, is entering the river and its tributaries. • Illegal dumping along roadsides and directly into waterways creates biological, environmental, and safety hazards. • Sinkholes have been historically used as trash receptacles for household and hazardous materials. • Collections of vehicles and refuse on private property can be a source of surface soil and water contaminants and lower surrounding property values.
Erosion & Deposition	along creek banks in channel within sinkholes sheet and rill (erosion) bars in channels (deposition) head cutting (erosion) ATV grubbing (off- road & off-trail)	• Historic pre-law practices and early post-law practices have harshly altered stream channel morphology, severely distorting natural erosion and deposition mechanics. • Too much untreated stormwater enters the streams within the watersheds. • Streambank stabilization, in-channel stabilization, and soil erosion controls are needed to improve water clarity and reduce sediment accumulation. • Excess sediment depositing as bars within channels causing widening and bank erosion at channels edge. • Poor pasture management contributes to increased run-off of nutrients, E. coli, and erosion. • Areas of unrestricted stream access by domestic animals such as horses, cattle, and goats destabilize stream banks, contributes to pesticide and manure additions to the streams. • Off-road vehicles enter streams regularly destroying habitats and natural stream channels. • Off-road vehicles rut and destroy natural soils making erosion and limited infiltration a concern in some areas. • Continued farming on improperly filled sinkholes likely results in higher contribution of fertilizers, pesticides and soil to the subsurface system. Lack of soil filtration occurs in these unnaturally filled areas. • Soil erosion resulting from conventional cropping practices contributes heavily to increased sedimentation, turbidity, nutrient, and pesticide loads. • Poorly planned and conducted logging or land clearing activities contribute to stream bank destabilization, log jams, stream turbidity, and elevated water temperatures. • Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes. • Imperviousness of parking lots, roofs, streets, and sidewalks does not allow absorption of rain or melting snow, increasing run-off, which results in negative impacts on surface water and habitat quality.
Chemical additions	herbicides insecticides fungicides vehicle associated salts from roadways metals/acidity from abandoned mine land pharmaceuticals and personal care products (PPCP)	• Combined Sanitary and Storm Sewer systems (CSOs) within Paoli cannot handle current population densities along with the stormwater causing the release of pollutants, including E. coli, chlorine, and suspended solids into surface waters during rain periods. • Tile drainage into sinkholes and streams may be negatively influences water quality and water flow in caves and streams alike. • Too much untreated stormwater enters the streams within the watersheds. • Pharmaceuticals and personal care products may be affecting wildlife populations and contaminating drinking waters. • Acid mine drainage (AMD) enters surface waters, lowering pH levels and raising metals contents, severely diminishing water quality and aquatic habitat. • Farm chemicals have the potential to enter creeks and sinkholes, possibly degrading water quality. • Road salts negatively affect stream and cave biota. • Continued farming on improperly filled sinkholes likely results in higher contribution of fertilizers, pesticides and soil to the subsurface system. Lack of soil filtration occurs in these unnaturally filled areas. • Soil erosion resulting from conventional cropping practices contributes heavily to increased sedimentation, turbidity, nutrient, and pesticide loads. • Individuals use too much fertilizer and pesticide and are unaware available alternatives. • Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes.
Fecal matter & Bacteria	excess manure residential septic systems (or lack) wastewater plants	• Poor pasture management contributes to increased run-off of nutrients, E. coli, and erosion. • Septic systems are old, incorrectly installed, or improperly maintained to control sewage releases into the watersheds. • Combined Sanitary and Storm Sewer systems (CSOs) within Paoli cannot handle current population densities along with the stormwater causing the release of pollutants, including E. coli, chlorine, and suspended solids into surface waters during rain periods. • Areas of unrestricted stream access by domestic animals such as horses, cattle, and goats destabilize stream banks, contributes to pesticide and manure additions to the streams. • Manure and other fertilizers applied without the use of soil tests, lead to over application; this can cause nutrient loading to streams and aquifers. • Water contact is unhealthy reducing the availability for recreational options within the waterbodies of the Lost River and Dry Branch Lost River watersheds. • Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes.

Major Source	Specific Area	Concerns
Excess Nutrients	excess fertilizer residential septic systems (or lack) excess manure	• Poor pasture management contributes to increased run-off of nutrients, E. coli, and erosion. • Septic systems are old, incorrectly installed, or improperly maintained to control sewage releases into the watersheds. • Areas of unrestricted stream access by domestic animals such as horses, cattle, and goats destabilize stream banks, contributes to pesticide and manure additions to the streams. • Manure and other fertilizers applied without the use of soil tests, lead to over application; this can cause nutrient loading to streams and aquifers. • Winter applications of manure may be contributing to nutrient loading of surface waters. • Continued farming on improperly filled sinkholes likely results in higher contribution of fertilizers, pesticides and soil to the subsurface system. Lack of soil filtration occurs in these unnaturally filled areas. • Soil erosion resulting from conventional cropping practices contributes heavily to increased sedimentation, turbidity, nutrient, and pesticide loads. • Nutrient and algae concentrations are too high within the Lost River and some of its tributaries. • Individuals use too much fertilizer and pesticide and are unaware available alternatives. • Manure and other fertilizers applied without the use of soil tests, lead to over application; this can cause nutrient loading to streams and aquifers. • Artificial draining of wetted lands may be reducing the presence of natural wetland filtration within the agricultural landscapes. • Encroachments of agricultural fields into riparian buffer zones and transitional areas have severely diminished natural cooling and filtering systems. • Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes.
Wildlife Habitat Protection	forestlands grasslands streams ponds/lakes caves	• Natural areas are not contiguous limiting the corridors for wildlife population • Natural and wildlife areas should be protected. • Unique aquatic species within the cave system within watersheds are threatened by poor water quality. • Artificial draining of wetted lands may be reducing the presence of natural wetland filtration and habitat within the agricultural landscapes. • Density and diversity of fish in the Lost River is lower than historical levels. • Invasive and exotic species are present throughout the watersheds. • Buffers and transitional natural areas are lacking along some of the Lost River, some tributaries, and some sinkholes. • Imperviousness of parking lots, roofs, streets, and sidewalks does not allow absorption of rain or melting snow, increasing run-off, which results in negative impacts on surface water and habitat quality.
Flooding	farmland residential floodplains roadways log jams sinkholes	• Flooding occurs frequently and in longer duration resulting in unpredictable water levels. • Poorly planned and conducted logging or land clearing activities contribute to stream bank destabilization, log jams, stream turbidity, and elevated water temperatures. • Collapsing sinkholes make terrain unusable; as a result filling of sinkholes is a common practice reducing the storage of the underground system. This may be increasing flooding in other portions of the watersheds. • Municipal stormwater systems cannot handle the amounts of surface run-off, resulting in flooding during heavy rain events and subsequent negative impacts on surface water, subsurface water, and habitat quality. • Imperviousness of parking lots, roofs, streets, and sidewalks does not allow absorption of rain or melting snow, increasing run-off, which results in negative impacts on surface water and habitat quality. • Tile drainage into sinkholes and streams may be negatively influences water quality and water flow in caves and streams alike.
Lack of Knowledge	general public landowners farmers residence interagency	• The general public lacks knowledge about the river and its tributaries' water quality. • The public does not feel a sense of ownership or pride for the streams, rivers, karst areas or the Lost River and Dry Branch Lost River watersheds. • Individuals are unaware of pollution prevention options; demonstration sites should be available for education and outreach opportunities. • Partnerships between existing organizations are under-utilized. • Private landowners are unaware of their obligations related to streams running through their property (log jam preventive maintenance, who to contact for permit assistance, etc.) • Small homestead farms are overlooked for traditional conservation programs and are greatly in need of conservation planning. • Muddy spring and well water after heavy rains, or have high levels on Nitrogen in this water may indicate unsafe drinking water. • There are not enough trails along the Lost River karst corridor. • Access to the Lost River and unique cave system is limited by lack of parking, publicly available boat ramps, and access sites.

Section 3 - Watershed Description

The following sections will describe the physical and natural features, the land use and land cover, and demographic characteristics of the Lost River watershed and Dry Branch Lost River watershed. For ease in discussion and due to the fact that the management plan is written for these two watersheds, the Lost River watershed and Dry Branch Lost River watershed are combined and referred to as the Lost River watershed from here on. The Lost River watershed is located in south central Indiana. It crosses five counties within Indiana (Orange, Martin, Washington, Lawrence, & Dubois Counties). Figure 1 shows the location of the Lost River watersheds within the state and the area of land within each county. Lost River starts in Washington County and then it flows west through Orange County into Martin County. Dubois County provides some drainage into Simmons Creek, a tributary that drains to the Lost River watershed. Lawrence County provides some drainage to an unnamed sinking stream and sinkholes that drain to the underground system within the watershed.



County Area within Lost River Watershed

County	Acre		Sq. Miles
ORANGE	166,701		260
MARTIN	34,986		55
WASHINGTON	23,064		36
LAWRENCE	6,947		11
DUBOIS	2,464		4
Total Acres	234,162	Total Sq. Miles	366

LOST RIVER WATERSHED PROJECT

Figure 1: Location and County Areas of Lost River watershed project area.

3.1 Physical and Natural Features

3.1.1 Watershed Boundary

A watershed is an area of land that drains by a river, river system, or other body of water. A watershed is bound by a line that connects high points in elevation, or ridges, around a specific river system ending in the outlet of that river system. Drawing this boundary is called delineating the watershed (Figure 2). For the case of the Lost River project area, the watershed boundary can be delineated by starting at the highest elevation in Washington County at 962.2 feet (293.3 meters) east of the town of Livonia on Highway 56. To the North, a high point line can be followed north in Washington County toward the populated area of Campbellsburg and Highway 60. One can follow the crest of the hill line up into the southern side of the Town of Mitchell in Lawrence County. The ridge then runs down into Orange County for a brief extent while it travels over into Martin County. In Martin County, the ridge turns to the south where the northern boundary ends at the outlet of Lost River into the White River at an elevation of 419.6 feet (127.9 meters). The southern boundary runs from the high in Washington County through the town of Livonia to the West where it crosses into Orange County. The ridge follows through the middle of Orange County where it drops to the south a bit to pick up ridges around the French Lick Creek system. The high ridge then goes to Martin County near the Martin/ Orange/ Dubois County lines, then drops south again into Dubois County for a short period before turning back north to meet up with the southern bank at the outlet into the White River in Martin County. The Lost River watershed drains land that crosses the political boundaries of Washington, Lawrence, Orange, Martin, and Dubois Counties in Southeastern Indiana.

Subwatershed delineation is performed in the same manner by connecting high points around smaller tributaries. Fourteen subwatersheds within the Lost River watershed are listed later in the Hydrology Section (Section 3.1.4). Figure 6 shows these watersheds and their boundaries. The boundaries to these subwatersheds are the ridgelines around the smaller tributaries that feed into Lost River. Even small ditches along roads will have a watershed boundary. These small watersheds may not have a defined name or be noted anywhere, but they still exist in the fact that they are bounded by high points. In the case of a small ditch, the watershed boundary may follow a hillside and may only be an acre in size, but that acre will directly influence the quality of water that runs in that ditch. Just like the ditch, the Lost River watershed influences the quality of water that flows in the Lost River.

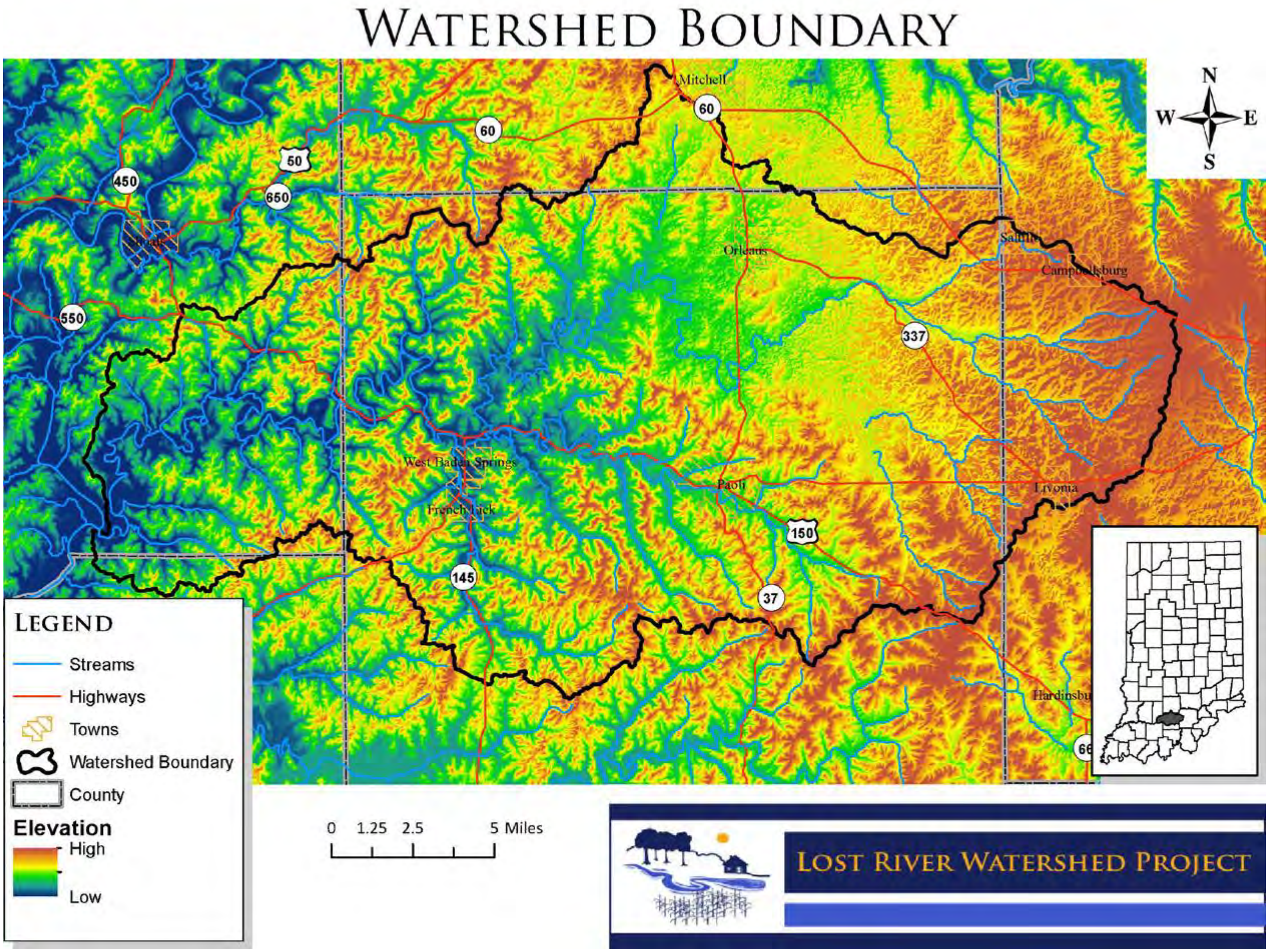


Figure 2: Watershed Boundary Delineation

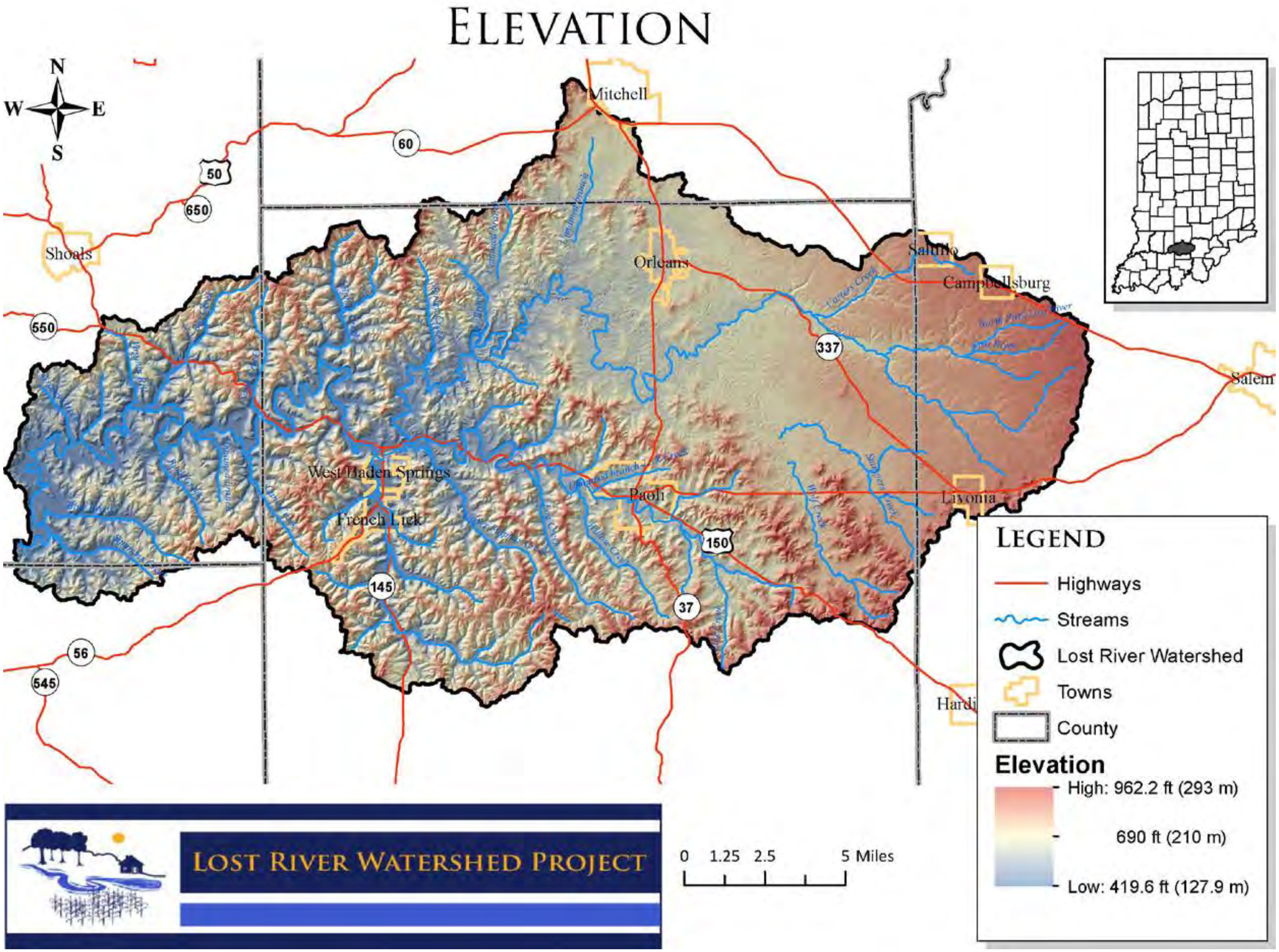


Figure 3: Topography- Digital Elevation Model (DEM) with hillshade of the Lost River Watershed Project area

3.1.2 Topography/Elevation

In the unglaciated south of Indiana, hills, ridges, knolls, caves and waterfalls abound. Topography, or the surface shape, of the Lost River watershed is controlled by the geology of the area (See Geology Section below). Figure 3 shows the topography of the Lost River watershed study area. Higher elevations are pink in color while lower elevations are blue in color.

The US Forest Service and Bureau of Land Management resource planning is considering the potential addition of Lost River to the National Wild and Scenic Rivers System. Largely, this status has been given to Lost River due to its unique hydrological setting in a karst system. The river's unusual hydrology has led to two of its features being designated as National Natural Landmarks. The Lost River watershed sits in a unique setting between the Mitchell Plain, which is littered with sinkholes, depression basins, and sinking streams, and the Crawford Upland, which is characterized by steep terrain, springs, and highly erodible lands. Sinkhole densities within the watershed are upwards of 155-310 per square mile with an extremely high probability of continued sinkhole development (Lestinger & Olyphant, 2011). In 1922, Malott mapped one square mile within the watershed where 1022 sinkholes exist. Many unique features, landforms, and sinking streams occur within this system. Unfortunately, karst sinkholes, epikarst, and sinking streams make the quality of the water that much more sensitive to point and non-point source pollution. Surface water is rapidly channeled into the subsurface in the karst landscapes via sinkholes without the benefit of extensive filtration or exposure to sunlight, which reduces contaminants. Groundwater is easily contaminated before reemerging as springs.

The watershed crosses the physiographic units of the Mitchell Plain and the Crawford Upland (Figure 4). Karst topography characterizes the Mitchell Plain. Karst topography is a geologic formation shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonate rock such as limestone. In many karst aquifers a large percentage of the water that is stored underground is perched, or suspended, above the main part of the aquifer in the "epikarst." The epikarst ("upon the karst") is the uppermost weathered zone of carbonate rock between the lower bedrock and the topsoil. The water in the epikarst is stored in enlarged joints and bedding planes, spaces around pieces of float (rocks that have been detached from the bedrock), porosity within residual chert rubble, and the smaller conduits in the bedrock. Sinkholes are a reflection of the development of the epikarst. Sinkholes are often sites of active transport of contaminants, insoluble sediment, and dissolved rock into the subsurface. Epikarst is of concern in the area due to its ability to hold contaminants within the fractures, only to release a portion of the contaminants during the next rain event. It has been seen that epikarst can hold contaminants for long periods, slowly re-releasing them over subsequent rains (Talarovich and Krothe, 2008). Epikarst is known to be present and can be seen within the Lost River watershed at sites within streambeds and where the soil, or overburden, has been removed.

Karst topography controls the movement of water within the Lost River watershed. Streams and their channels within these two different areas are vastly changing across the landscape. The upper segment of the watershed appears as a normal surface-flowing stream crossing the eastern part of the Mitchell Plain. In this portion of the watershed, the topography is mostly flat with some karst features like sinkholes dotted across the landscape. The middle section or western portion of the Mitchell Plain shows a more karst-influenced topography. This is the segment where water actively sinks into the subsurface. This is the area where the highest densities of sinkholes exist. The karst features litter the landscapes with sinkholes, estevelles, dry beds, epikarst, and swallow holes. The topography in this area looks undulating, but is in fact a series of sinkhole depressions creating the hilly terrain. Looking westward from the Mitchell Plain, one can see the sharp change into taller steeper hills of the Crawford Upland. The water movement in the Crawford Upland bisects the landscape with a narrow meandering valley through which the Lost River flows. The movement of water is normal surface flow in partially filled, deeply cut, or entrenched, valleys through the Crawford Upland. Many karst springs keep water flowing year-round within this portion of the watershed.

Dye tracing results from studies performed on the Lost River karst system to determine the drainage patterns of the underground conduits and groundwater divides are in Figure 4. Flourescein dye was injected 23 times into swallow holes, sinkholes, storm infiltration wells, the Orleans's sewage treatment facility, and caves. The results from this tracing gave scientists important information about low flow, normal flow, and high flow within the karst system as well as direction of drainage. The results showed that water sinking into swallow holes and sinkholes in the northern section of the watershed as well as some areas to the north outside of the watershed boundary would rise at the Orangeville Rise spring. Other areas to the north outside the watershed along State Highway 60 would rise in Sulphur Creek Spring. They also showed that water sinking in the Lost River and Stampers Creek would rise at the True Rise of Lost River spring just southwest of Orangeville Rise. Water sinking from Wolf Creek and other portions of Western Stampers Creek subwatershed would be released in springs draining to the Lick Creek area to the west.

Watershed boundaries within normal flowing rivers can predict where surface water will flow. However, in a karst watershed, the boundaries of surface flow are blurred with the boundaries of subsurface, or groundwater flow even more so than in a "typical" watershed landscape. This makes monitoring and determinations of non-point source influence on water quality that much more difficult than in typical watersheds.

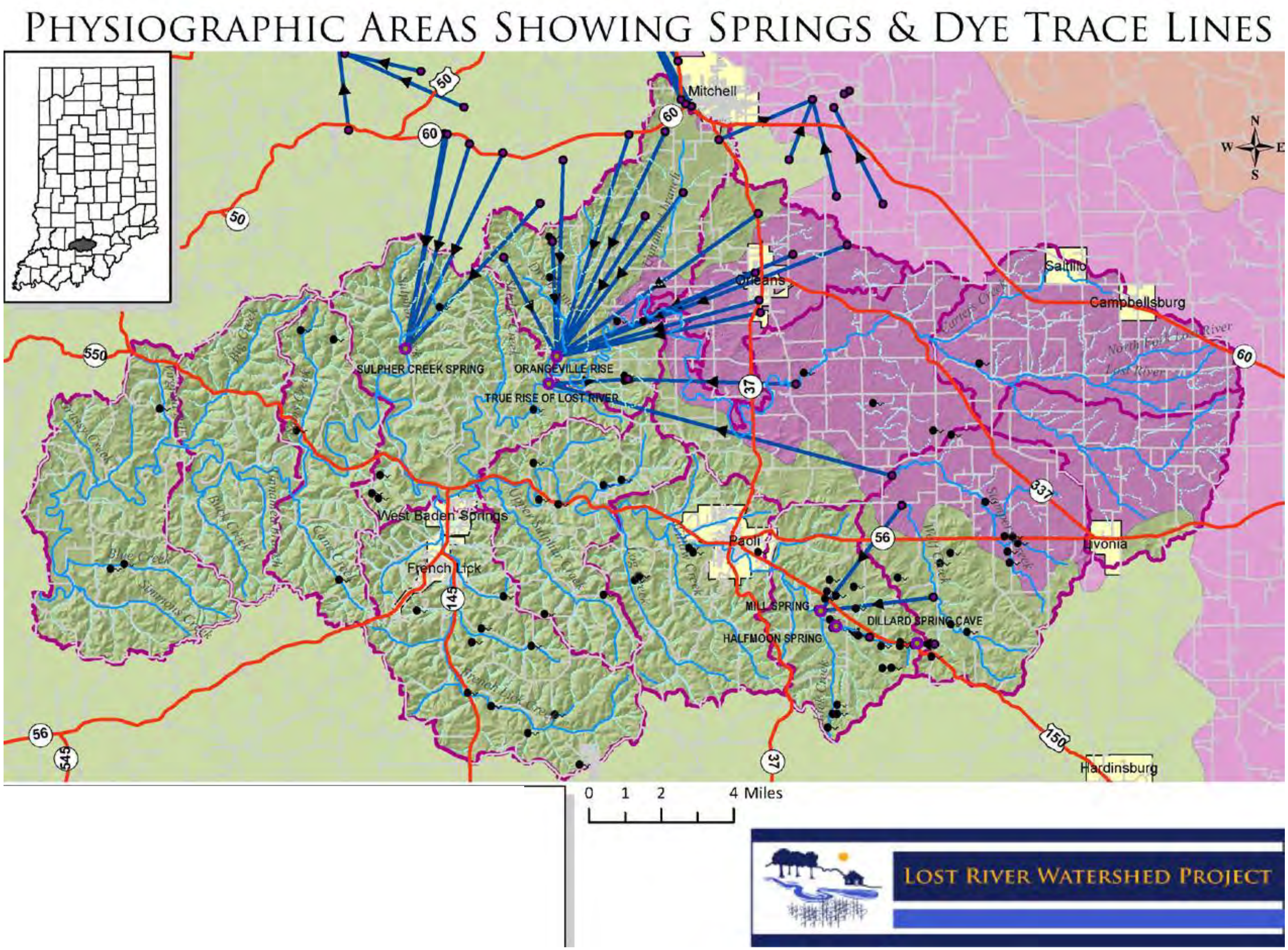


Figure 4: Physiographic Regions showing Spring locations along with Dye Tracing results.

3.1.3 Geology

Five major geologic units are present within the watershed (Figure 5). They represent rock units of the Mississippian and Pennsylvanian time periods. Older units outcrop in the east, and younger units outcrop to the west. These units are the Blue River Group, West Baden Group, Stephensport Group, Buffalo Wallow Group, and Raccoon Creek Group. These rock units were formed when empirical seas covered much of the Midwest. They are composed of alternating carbonates, like limestone and dolomite, with shale and sandstone from the advance and retreat of the seas.

Blue River Group

The oldest outcrops in the watershed are from the Blue River Group. This geological unit is formed largely of carbonate rocks but has significant amounts of gypsum, anhydrite, shale, chert, and calcareous sandstone. The three component formations of the group in ascending order are the St. Louis, Ste. Genevieve, and Paoli Limestones. The combined thickness of the constituent formation is about 400 feet (122 m) in northwestern Orange County (Gray, Jenkins, and Weidman, 1960, p. 48). The limestone from this group is the primary culprit of the karst topography in the area.

West Baden Group

The West Baden group consists dominantly of gray to varicolored shale and mudstone, thin-bedded to crossbedded sandstone, and limestone in beds of variable thickness (Gray, 1962). Total thickness along the outcrop ranges from 100 to 140 feet (30 to 43 m). A major feature of the West Baden Group is a southwestward-trending belt about six miles (10 km) wide across which the limestone was not deposited and instead sandstone dominates the entire thickness of the group. The group consists in descending order of the Elwren Formation (sandstone, shale, and mudstone, 20-60 ft thick), the Reelsville Limestone (skeletal limestone, 2-20 ft thick), the Sample Formation (shale and sandstone, 15-50 ft thick), the Beaver Bend Limestone (limestone, 10-14 ft thick), and the Bethel Formation (shale, sandstone, and thin coal, 1-42 ft thick).

Stephensport Group

The Stephensport group, named for Stephensport, Breckinridge County, Ky., consists of about equal parts of limestone, shale, and cliff-forming sandstone (Gray, 1962). The total thickness of the Stephensport Group is 130 to 230 feet (40 to 70 m). The Stephensport group consists in descending order of the Glen Dean Limestone (thick-bedded skeletal to oolitic to biomicritic limestone, 9 to 31 ft thick), the Hardinsburg Formation (shale and sandstone, 20-62 ft thick), the Golconda (now Haney) Limestone (skeletal limestone, dolomite, and minor shale, 20-40 ft thick), the Big Clifty Formation (shale, limestone, mudstone, and siltstone, 30-70 ft), and the Beech Creek Limestone (limestone, 8-33 ft thick).

Buffalo Wallow Group

The Buffalo Wallow Group is dominantly shale, mudstone, and siltstone, but it also contains prominent beds of sandstone and limestone, some of which are laterally extensive. The group exhibits its maximum surface thickness of about 270 feet (82 m) near Tobinsport on the Ohio River in the subsurface its maximum thickness is about 750 feet (200 m) in Posey County.

Raccoon Creek Group

Shale and sandstone compose more than 95 percent of the Raccoon Creek Group, and clay, coal, and limestone make up nearly all the rest; small amounts of chert and sedimentary iron ore are in the lower part of the group. The Raccoon Creek Group generally thickens toward the southeast but in some places has thickness variations of more than 300 feet (91 m) because of irregular unconformity on the surface of underlying rocks. The Raccoon Creek Group consists in ascending order of the Mansfield (sandstone, shale, and mudstone, 50-185 ft thick), Brazil (shale, sandstone, clay, and coal, 40-90 ft thick), and Staunton Formations (sandstone, shale, and as many as 8 coal beds,70-150 ft thick. Rocks ranging in age from Middle Devonian to Late Mississippian in age underlie it.

Bedrock Geology

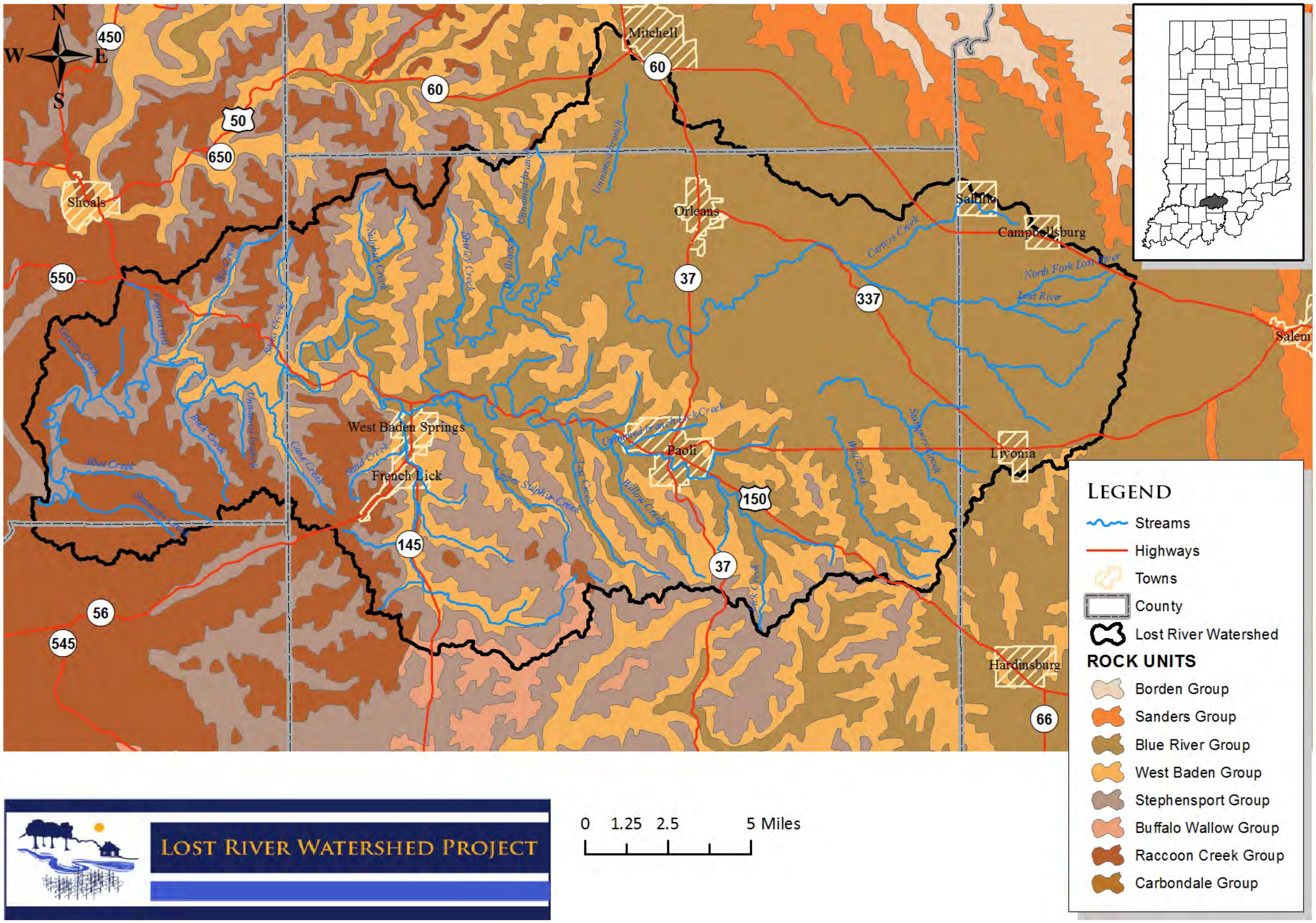


Figure 5: Bedrock Geology

3.1.4 Hydrology

Watersheds are divided into units, called Hydrologic Units, by the United States Geological Survey, and are coded into Hydrologic Unit Codes (HUC). Every watershed in the nation whether large or small has a unique HUC. The Lost River and Dry Branch Lost River watersheds drain a portion of the Lower East Fork White River Cataloging Unit (HUC 05120208), and are part of the Ohio River Basin Region (HUC 05). The HUC's for different sized watersheds associated with the Lost River are listed in Table 3 below and can be seen in Figure 6. Two digit HUC's have the largest size and are a regional code category, while 12-digit HUC's are smallest in size and are a subwatershed unit category. Larger digit HUC's will fit into smaller digit HUC's. For example, Stampers Creek Subwatershed, HUC number 051202081201, is part of the Dry Branch Lost River Watershed, HUC number 0512020812. These are also part of the Lower East Fork White River, HUC number 05120208.

Table 3: Hydrologic Unit Codes (HUC)

Unit Category	HUC	Name	Size (Acres)
Regional code	(2-digit HUC)		
	05	Ohio River Basin Region	130.83 million
Subregional code	(4-digit HUC)		
	0512	Wabash River Basin Subregion	20.86 million
Accounting unit code	(6-digit HUC)		
	051202	Patoka & White River Basins Accounting Unit	7.74 million
Cataloging unit code	(8-digit HUC)		
	05120208	Lower East Fork White Cataloging Unit	1.30 million
Watershed unit code	(10-digit HUC)		
	0512020812	Dry Branch Lost River Watershed	103,700.7
	0512020813	Lost River Watershed	130,460.8
Subwatershed unit code	(12-digit HUC)		
	051202081201	Stampers Creek Subwatershed	20,405.9
	051202081202	Orleans Karst Area Subwatershed	12,198.2
	051202081203	South Fork Lost River Subwatershed	11,980.8
	051202081204	Carters Creek-Lost River Subwatershed	16,284.0
	051202081205	Lost River Sink Subwatershed	23,013.3
	051202081206	Mt. Horeb Drain-Lost River Subwatershed	19,818.5
	051202081301	Headwaters Lick Creek Subwatershed	12,087.5
	051202081302	Log Creek-Lick Creek Subwatershed	15,913.7
	051202081303	Scott Hollow-Lick Creek Subwatershed	13,870.0
	051202081304	French Lick Creek Subwatershed	21,927.5
	051202081305	Sulphur Creek-Lost River Subwatershed	20,855.6
	051202081306	Sams Creek-Lost River Subwatershed	12,151.6
	051202081307	Big Creek-Lost River Subwatershed	13,780.5
	051202081308	Grassy Creek-Lost River Subwatershed	19,874.3

The Lost River Watershed (HUC 0512020813) and Dry Branch Lost River Watershed (HUC 0512020812) and the associated subwatersheds are the area of interest within this Watershed Management Plan. Like previously mentioned, the combination of the Dry Branch Lost River Watershed and Lost River Watershed are referred to as the Lost River watershed, or simply the watershed, from here on within this document. The total size of the watershed project area is 365.9 square miles, or 234,161.4 acres.

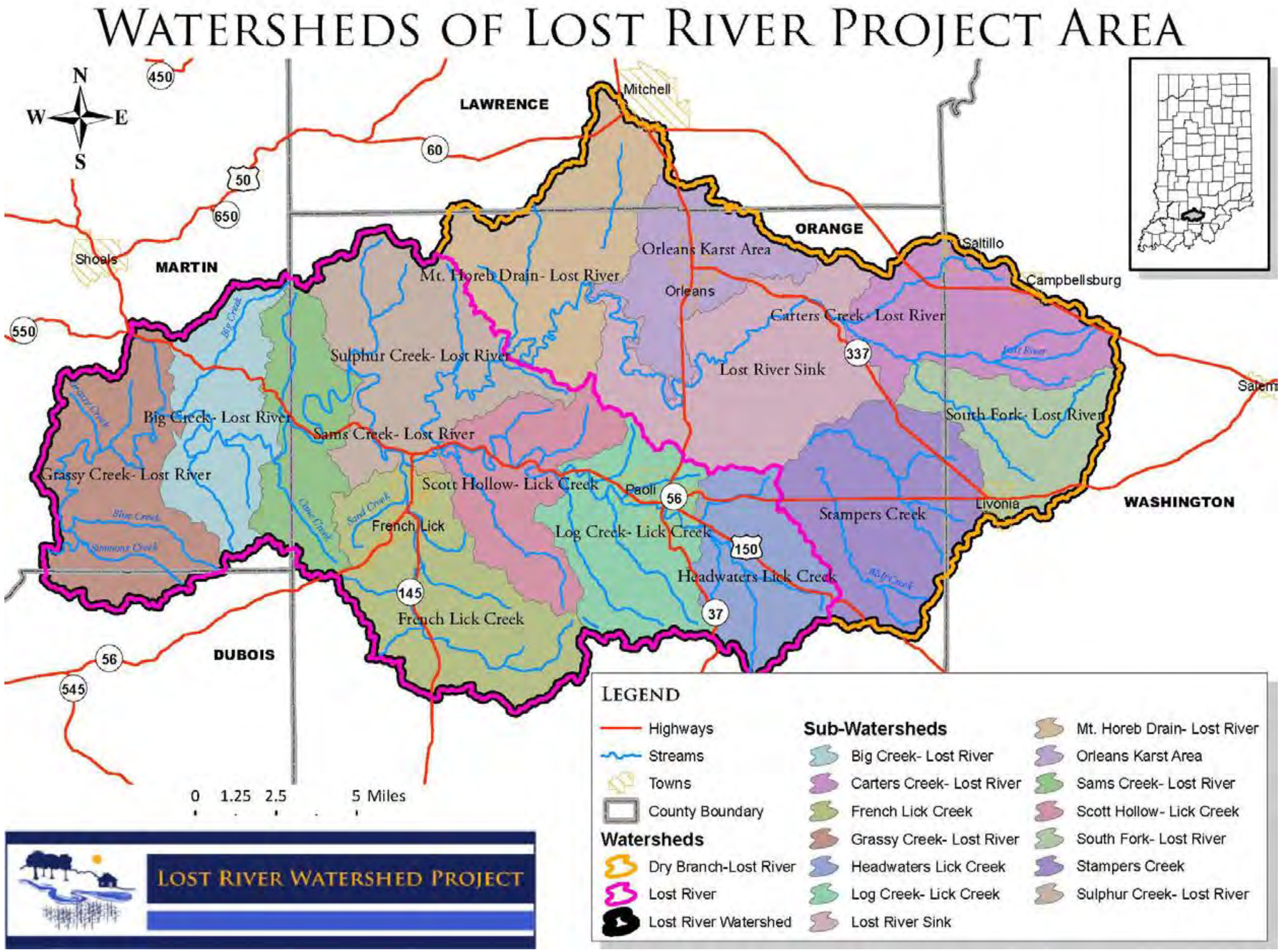


Figure 6: Subwatersheds- 12-Digit Hydrologic Unit Code Subwatersheds for the Lost River Watershed Project Area

3.1.5 Surface Water Resources

The overall flow direction of the Lost River is generally in the westward direction. Smaller tributaries will generally flow to the north in the southern half of the watershed, and to the south in the northern half of the watershed before meeting up with the Lost River, see Figure 7. The outlet of the watershed is into the White River near the Martin and Dubois County boundary. The watershed is home to many perennial, intermittent, and ephemeral streams. A perennial stream is a stream or river (channel) that has continuous flow in parts of its bed all year round during years of normal rainfall. These are often called blue line streams because they are represented by solid blue lines on topographic maps. Intermittent streams normally cease flowing for weeks or months each year, and ephemeral channels will have flow in them only for hours or days following rainfall. During unusually dry years, a normally perennial stream may cease flowing, becoming intermittent for days, weeks, or months depending on severity of the drought. The boundaries between perennial, intermittent, and ephemeral channels are indefinite, and subject to a variety of identification methods. For purposes of the Watershed Management Plan, the United States Geological Survey (USGS) National Hydrography Dataset is used to determine whether a stream is intermittent or perennial, see Figure 7. There is no clear demarcation between surface runoff and an ephemeral stream in many areas. For this reason, ephemeral streams are grouped with intermittent streams, if a defined channel exists. If a defined channel does not exist, the ephemeral stream is not included in calculations and cannot be seen in Figure 7.

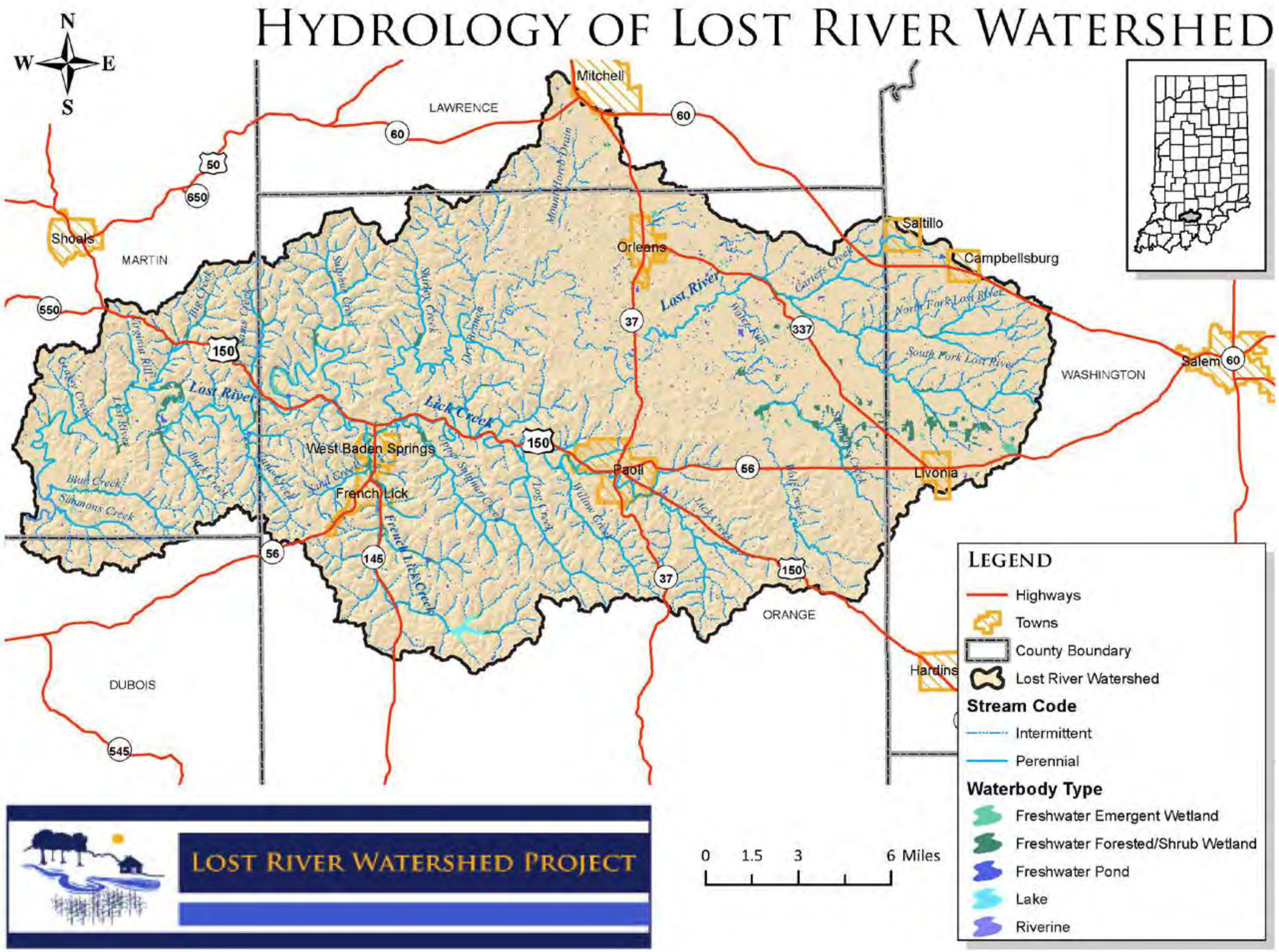


Figure 7: Hydrology- Water features of the Lost River Watershed Project Area

There are approximately 697 miles (1122 kilometers) of perennial and intermittent stream channels within the watershed. Of the total miles of stream channels, 219.2 miles (352.8 km) are perennial in nature. There is an unusual feature of an intermittent dry bed between two perennial sections of Lost River, 22.2 miles (34.1 km). This is because the intermittent section only contains flow during wet weather events when the groundwater system is saturated with water. The strong karst influence on this section makes it dry for the majority of the year. The upstream perennial flow continues its journey underground in a cavern before rising again at a natural spring called True Lost River Rise. The flow in the underground cavern may be only as long as 6 miles (9.7 km) as it can take a more direct route to the spring than does the dry branch. The Lost River area contains the second and third largest springs in Indiana, Orangeville Rise and the True Rise of the Lost River, respectively (Powell, 1961).

According to the Indiana Natural Resources Commission, Lost River is one of nine exceptional use waters from Indiana's Outstanding Rivers and is designated as such because the river has particular environmental and aesthetic interest. Specifically, Lost River has been identified by state natural heritage programs as having outstanding ecological importance. According to Indiana Administrative Code, waters classified for exceptional uses warrant extraordinary protection. Unless criteria are otherwise specified on a case-by-case basis, the quality of all waters designated for exceptional use shall be maintained without degradation. Lost River and all surface and underground tributaries upstream from the Orangeville Rise (T2N, R1W, Section 6) and the Rise of Lost River (T2N, R1W, Section 7) and the mainstream of the Lost River from Orangeville Rise downstream to its confluence with the East Fork of the White River are included as an Outstanding River, see Figure 8. Protection and education of the unique characteristics of this stream system are of interest to the stakeholders of the watershed. They would like to see the streams of the area more utilized for recreation potentials. However, stakeholders are also concerned about the possible health risks associated with swimming and wading in the streams.

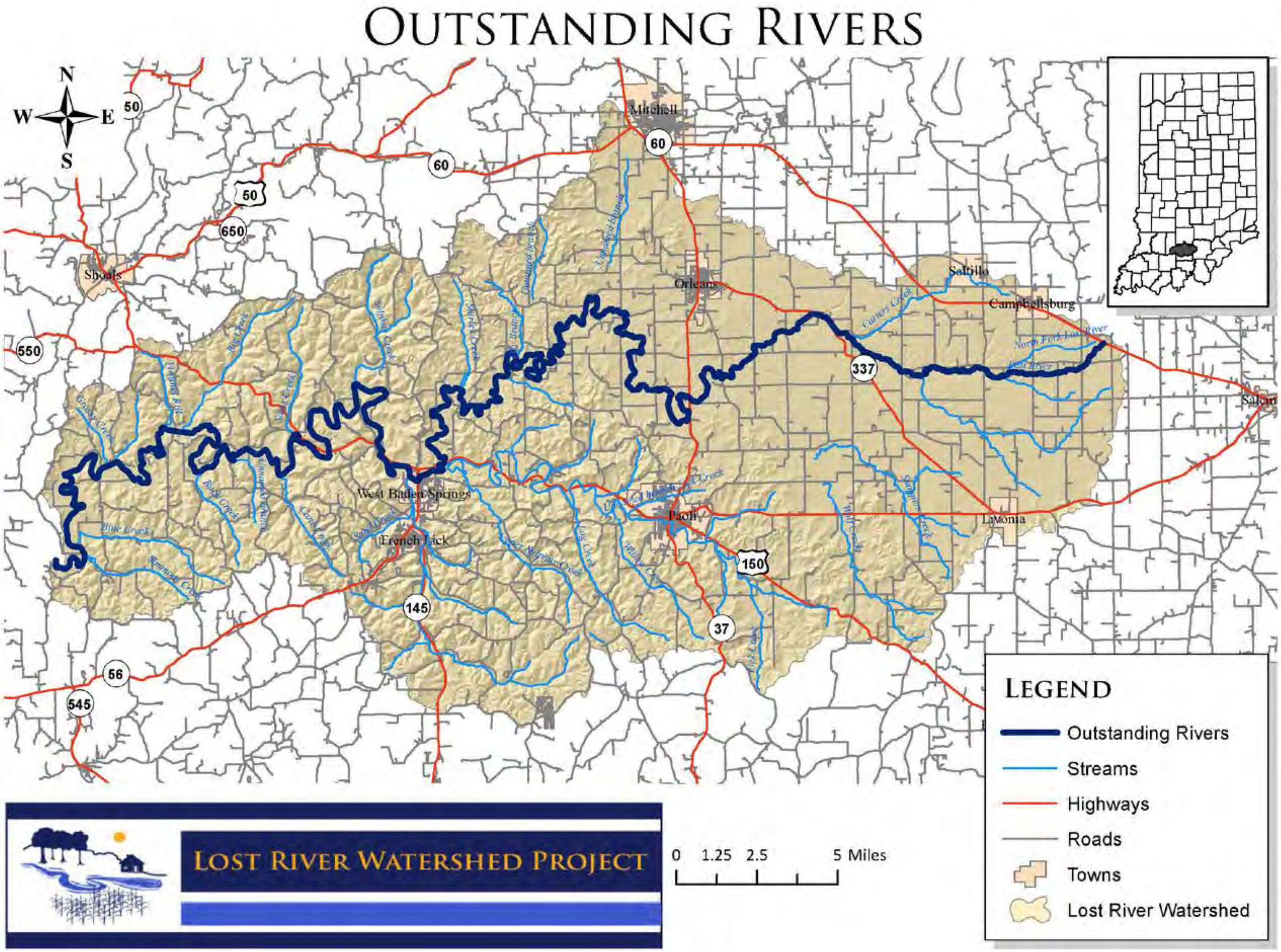


Figure 8: Location of Outstanding River set by Indiana Natural Resources Commission in the Lost River Watershed Project Area

The stream topography within the Lost River watershed can be divided up into three segments based on the karst influence in the area. The upper segment appears as a normal surface-flowing stream crossing the eastern part of the Mitchell Plain. This segment carries the streams known as Carter Creek, South Fork Lost River, and North Fork Lost River before converging into Lost River. The middle segment makes it clear where Lost River namesake comes from with the loss of water to subterranean, or underground, drainage. Lost River, Stampers Creek, Flood Creek, all of the area surrounding the Town of Orleans, and Wolf Creek drain into the underground karst system in this area, making it seem as though all of the streams have disappeared. The downstream western segment returns as normal surface flow in a partially filled, deeply cut, or entrenched, valley through the Crawford Upland. As mentioned before, many springs rise in this segment of the watershed giving way to many small tributaries and large springs. This is the re-emergence of the water previously lost in streams above along with infiltration from landscapes throughout the eastern portion of the watershed.

Surface streams such as Lost River, Stampers Creek, Wolf Creek, Mt. Horeb Drain, and Flood Creek in Orleans sink at multiple swallow holes along their channels. This is due to the underground cave system in the area. Water in these streams will flow to underground, or subsurface, conduits through these swallow holes. The swallow holes and subsurface conduits can only hold limited amounts of water, or have limited capacity. When the subsurface conduits fill, the surface water bypasses upstream swallow holes and flows downstream in the surface channel to the next downstream swallow hole. In several locations, Orleans for example, a downstream channel does not exist and so flooding occurs in this area for weeks at a time until the subsurface water can drain allowing for surface drainage. After large storms, stormwater rises, or overflow springs may discharge subsurface water into the lower portions of the Lost River dry bed, and bypass the downstream portions of the subsurface flow system. Depression springs, or estevelles, occur in a number of locations within the Lost River watersheds. Estevelles discharge groundwater when the water table is high and become a sink for surface water when the water table is low. Some estevelles can be responsible for intermittent lakes or wetlands known as Turloughs. Turloughs have not been officially defined in the area, but many likely exist due to the high number of estevelles in the area and associated seasonally standing water.

According to the US Fish & Wildlife National Wetlands Inventory Database, there are 3,084 acres of wetlands, lakes, ponds, and reservoirs within the watershed (Figure 7). There are five types of waterbodies found in the watershed. They are freshwater emergent wetlands (588.0 acres), freshwater forested/shrub wetlands (1,561.5 acres), freshwater ponds (762.3 acres), lakes (131.6 acres), and riverine wetlands (40.6 acres). Wetlands can be an important component to a watershed. They are nature's water filters and water storage facilities. Orleans Water Works Reservoir, Sleepy Hollow Lake, Tucker Lake (Springs Valley Lake), and Wildwood Lake are the only named lakes, reservoir, or ponds on record in the area. There are 1886 lakes and ponds with three reservoirs noted in the watershed, and they total 898 acres (3.63 km^2). Stakeholders are concerned with protecting these valuable resources for wildlife habitat and recreation within the watershed.

Recreation on the streams, lakes, and wetlands includes hunting, fishing, boating, and hiking. Canoeing and kayaking is a common use of the rivers and streams for viewing the unusual karst features. Ponds and wetlands are watering holes for livestock and wildlife in the area. Legal drains that would fall under Indiana Code 36-9-27 Chapter 27- Drainage Law are not present within the watershed. Ditches maintained by the counties are only present along roadways, with the exception of the ditch to drain West Washington Elementary School onsite treatment system effluent. These ditches are not mapped in the area, but estimates from personal conversations with the Counties Highway Department put the total miles of ditches at approximately 1,400 miles in the watershed. Ditches along roadways are for drainage of the roads. Maintenance, including cleaning debris, is performed as often as per rainstorm to every five years. Road miles within the watershed total 894 miles.

3.1.6 Groundwater Resources

Reliable groundwater withdrawals in the Lost River watershed are from the Blue River and Sanderson Group bedrock aquifer system. Detailed information on bedrock aquifer systems for the area can be found on the Indiana Department of Natural Resources Division of Water website. The hydraulic characteristics of limestone in this area are vastly different from other limestone areas in Indiana due to the dissolution of soluble beds of gypsum and widening of fractures and joints. Wells are generally contained in the St. Louis and Ste. Genevieve limestone units. These units may have horizontal conductivity up to 10^{3} ft/sec in the karst areas where normally limestone will have horizontal conductivity of 10^{-4} to 10^{-1} ft/sec (Freeze and Cherry, 1979). The system holds enough water for domestic uses, however the capacity for industrial uses is limited. The registered significant ground-water withdrawal facilities with wells completed in this system are reported to have pumping capacity ranging from 100 to 135 gallons per minute.

Many residences in the area depend on groundwater from the area for fresh water to their homes and farms. Many reports from residents in the area suggest that their water seems clean until it rains. After heavy rains, many wells and streams will go muddy. This indicates the strong connection between surface waters that carry sediments and the groundwater system in the area. Residents are concerned that their wells and springs are unsafe for drinking water. The population that rely on wells or springs for their water should test their spring and well waters for contaminants during both normal and muddy periods. Well drillers in the area have indicated that the surface aquifer in the area have shown high levels of Nitrogen. Levels of nitrate in water above 10 mg/L are considered toxic to both the elderly and young. Blue baby syndrome is an illness that is caused by babies consuming waters with high levels of nitrogen.

3.1.7 Navigation Channels

Lost River is considered navigable from near Orangeville rise to the outlet of Lost River into the White River. Lick Creek is navigable from the old mill site near Mill Spring down to the outlet of Lick Creek into Lost River. Log jams and low head dams disrupt the current navigability of these waterways. There are five known low head dams in upper Lick Creek (See Section 3.1.9). Large log jams along the Lost River have been the cause of flooding and channel bank erosion. Dredging regularly occurred at one time along the Lost River to make the channel navigable for shipping of goods and lumber in and out of the area. This previous dredging has caused channelization of portions of the river and may be responsible for head cutting seen along the river. Currently, Lost River is not navigable by motored or non-motored boats due to the significant number of log jams blocking the channel. The availability of recreation potential along the Lost River is reduced due to the significant number of log jams in the area. The concern over the limited recreational use of the streams and rivers is partly due to the log jam blockage. Log jams are a constant battle for the stakeholders within the watershed. Several grants have been awarded for removal of logjams over the years. Log jams were removed from Lost River and Lick Creek in 2008 through a program offered by the Orange County Soil and Water Conservation District. By 2009, new log jams had formed and were removing large amounts of sediments from the banks of Lost River. Martin and Orange Counties obtained a Disaster Relief grant through the Office of Community and Rural Affairs to remove seven Type 3 and Type 4 log jams in 2012. The Type 3 log jam consists of more than two logs within the channel and is causing significant blockage to channel flow. The Type 4 log jam consists of more than three logs and is causing significant enough blockage within the channel that flood waters will be forced to extend beyond the top of bank of the channel. There is a desire among stakeholders to develop a preventative log jam maintenance plan that will address the risk of log jams while still maintaining habitat function of downed trees and the functions of a riparian corridor.

3.1.8 Floodplains

Flooding within the watershed distributed through all four major town centers, Orleans, Paoli, French Lick, and West Baden, is a major concern for the residents of the area. The flooding often affects travel and businesses within the watershed. Current floodplain areas determined by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) do not encompass the true area of flooding within the watershed. FIRM maps show the area of one percent annual chance of a flood hazard. This was previously known as the 100-year flood, but since a 1% flood could happen every year FEMA adopted the 1% annual chance of flood hazard description instead to avoid confusion. Indiana State Department of Natural Resources is currently updating these maps for Orange, Martin, Washington, and Dubois Counties, but the new proposed boundaries are only preliminary and cannot be included in figures at this time. Instead, the Interim Digital FIRM (2004), or DFIRM, is shown in Figure 9. Lawrence County has an updated map and none of the areas within the Lost River watershed are considered in the 1% annual chance of flood hazard. Only areas along major streams and rivers show up on the FIRM maps, current or proposed. They do not incorporate areas of flooding due to subsurface water backing up onto the land surface in karst locations. For example, the Town of Orleans does not have any area that is considered floodplain according to the FIRM maps. Talk to anyone who lives in the area and they will tell you that the Town of Orleans floods on a regular basis. There is a desire for these areas to be more precisely mapped by the community and Emergency Managers.

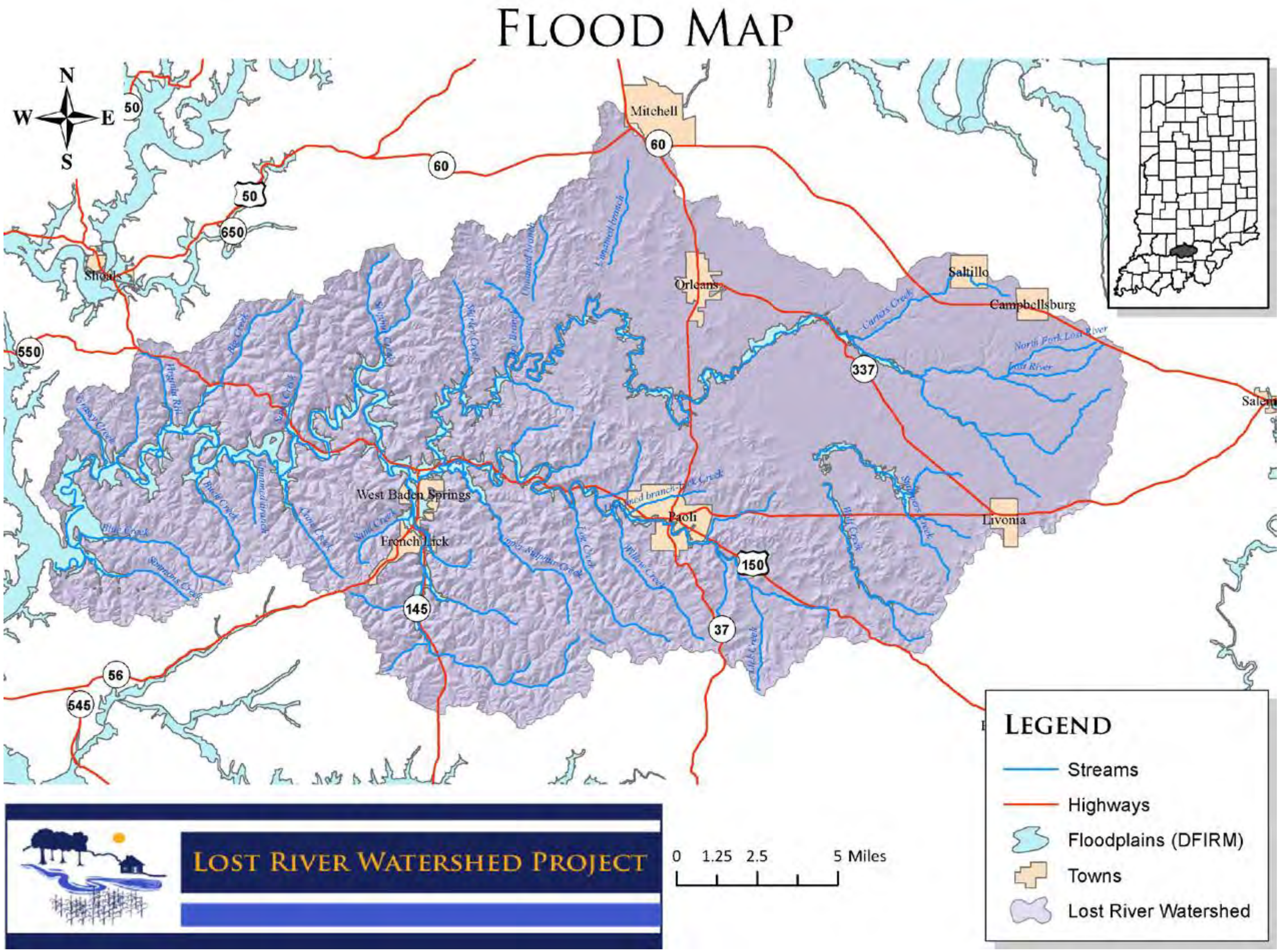


Figure 9: Floodplain boundaries from FEMA Flood Insurance Rate Maps (FIRM)

3.1.9 Dams

Several low head dams have been constructed in the watershed for a variety of purposes. Low head dams are one of the mysterious and frustrating features of our local rivers. These are artificial structures of stone, concrete, timber or other material, which are less than 15 feet in height and extend across the channel. A normal unobstructed river naturally meanders on its bed course within a floodplain, with the passage of time. However, each artificial low head dam turns the river into a stagnant small lake in the impounded area, which may stretch for a mile or more upstream. The water passing over a dam can pose lethal safety hazards, and they have been referred as "drowning machines". At least six low head dams are known to exist in Lick Creek. Some of these dams are designed to alter the flow characteristics within the town of Paoli for flood control.

The low head dam off Gospel Street in Paoli provided a pool for the city's water intake; another small dam on the creek has a utility pipe crossing under it. Several other low head dams are located along the stretch of Lick Creek as it makes it way to Paoli. These dams limit Lick Creek for navigation of small canoes and kayaks. The stagnant water behind them is not suitable for most fish and other diverse life that a healthy river normally can support.

Flood control is a major purpose for other impoundments in the area. Numerous small-scale dams constructed in water and sediment control basins (WASCOB) are in the agricultural region of the watershed. Other DNR regulated dams are located within the watershed for flood control and recreational purposes. Tucker Lake, or Springs Valley Lake, is the result of a DNR regulated dam along the upper portions of French Lick Creek. In 2011, another dam was constructed on Sand Creek, a tributary to French Lick Creek, within French Lick for irrigation of the Pete Dye Golf Course on the French Lick Resort Property.

3.1.10 Soils

Seven soil associations make up the land surface of the watershed. They are shown in Figure 10 and Table 4 below. These can be broken into 51 different soil map units. Three of these soil associations make up 97.9% of the watershed. The Crider-Bedford-Baxter (s2379) association is the most abundant soil association within the watershed. It makes up nearly half of the soils within the watershed and is the most farmed soil association. It is nearly level to very steep, deep to moderately deep, well drained to somewhat poorly drained soils that formed in loess or in silty and clayey sediment and in the underlying residuum of limestone. Zanesville-Wellston-Gilpin (s2371) is the second most predominant soil. It is deep and moderately deep, well drained to moderately well drained soils that formed in loess and in the underlying residuum of sandstone, siltstone, and shale. Wellstone-Weikert-Gilpin-Berks (s2372) is deep to moderately deep, gently sloping to very steep, well drained soils formed in loess and weathered material from sandstone, siltstone, and shale on uplands. Wilbur-Wakeland-Haymond (s2356) is deep, nearly level, somewhat poorly drained to well drained soils formed in alluvium on bottom lands. The surface texture of all the soil associations is silt loam with the exception of the Princeton-Bloomfield-Ayrshire-Alvin (s2361) which is a fine sandy loam. The Princeton-Bloomfield-Ayrshire-Alvin (s2361), Uniontown-McGary-Markland-Henshaw (s2369), and the Petrolia-Nolin-Haymond (s2328) make up less than 0.2% of the watershed soils. More specific soil units can be identified for the area using Web Soil Survey a NRCS product.

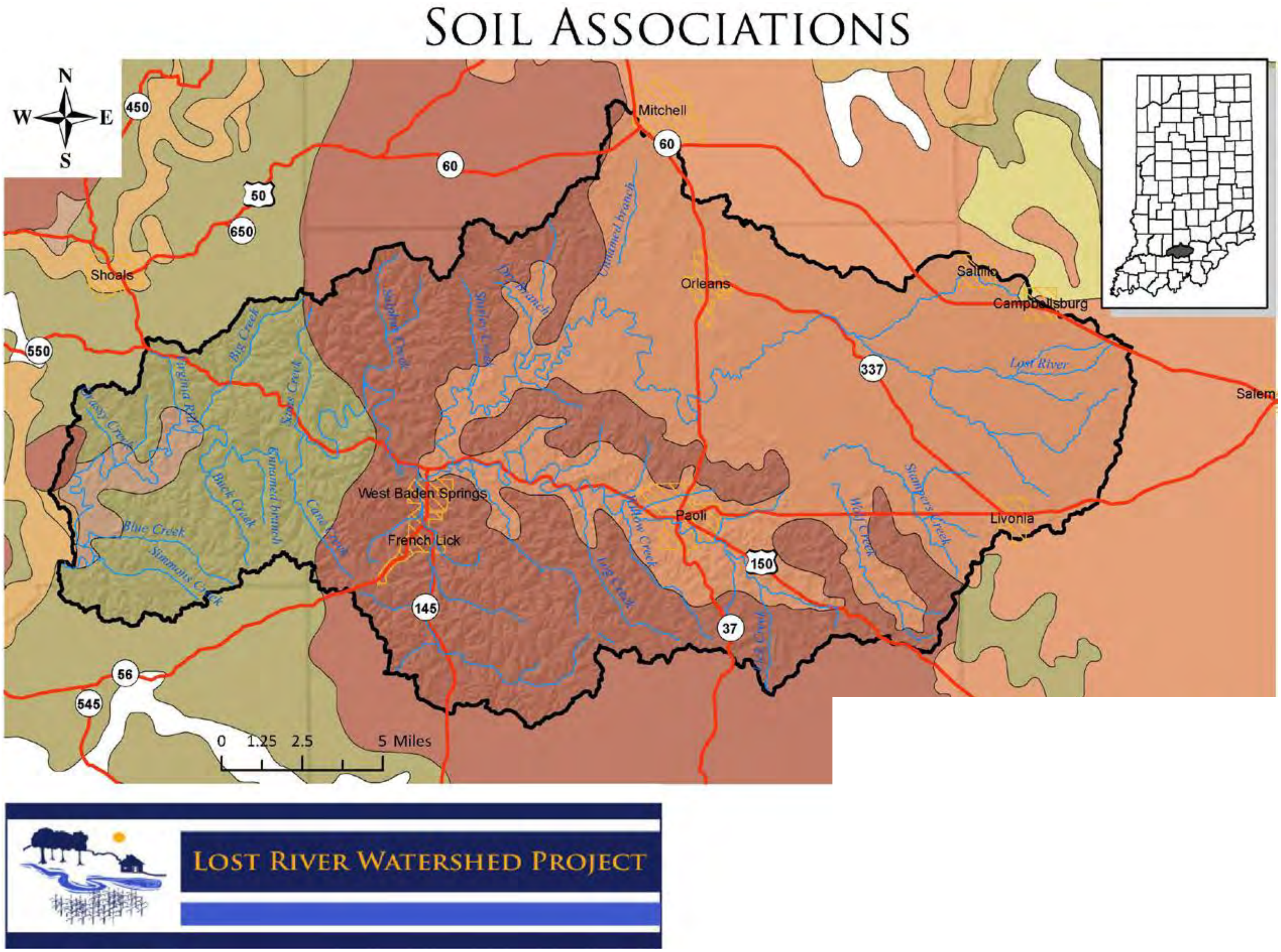


Figure 10: Soils associations from the U.S. General Soil Map.

Table 4: Soil Associations in the Lost River Watershed.

Soil Association	Area (acres)	Percent of Watershed
Crider-Bedford-Baxter (s2379)	110,336.6	47.1%
Zanesville-Wellston-Gilpin (s2371)	81,356.2	34.7%
Wellston-Weikert-Gilpin-Berks (s2372)	37,193.1	15.9%
Wilbur-Wakeland-Haymond (s2356)	4,856.5	2.1%
Princeton-Bloomfield-Ayrshire-Alvin (s2361)	263.0	0.1%
Uniontown-McGary-Markland-Henshaw (s2369)	111.5	<0.1%
Petrolia-Nolin-Haymond (s2328)	44.6	<0.1%
Total	**234,161.5**	**100.0%**

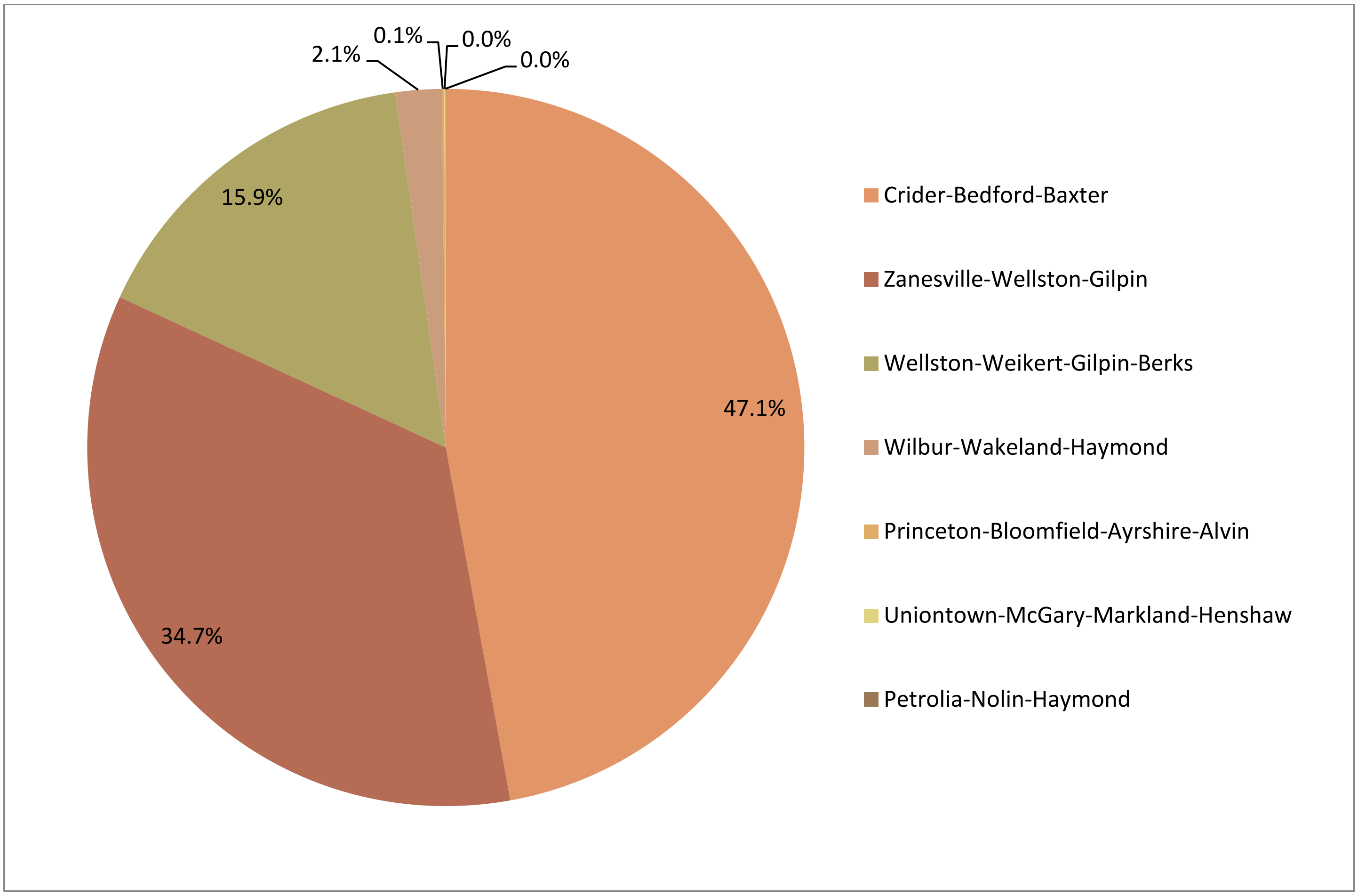


Figure 11-Lost River Watershed Soil Associations Percentage Graph

Hydric soils are those that remain saturated for a sufficient period generating a unique series of chemical, biological, and physical processes. These soils maintain the hydric characteristics even after draining or use modification occurs. Watershed stakeholders are concerned about the reduction of wetlands by draining for the conversion into agricultural land uses. A total of 3,105.9 acres (4.9 square miles), or 1.3% of the watershed, is covered by hydric soils (Figure 12). The hydric soils found in the watershed are located along Stampers Creek and South Fork Lost River in the eastern portion of the watershed, in the headwaters of Flood Creek in the Northern portion of the watershed, and in the bottomlands of the main trunk of Lost River near the outlet into the West Fork of the White River. Likely, these soils developed under wetland conditions and they are a good indicator of historic or current wetland locations within the watershed. Draining of these areas is a concern for stakeholders in the watershed.

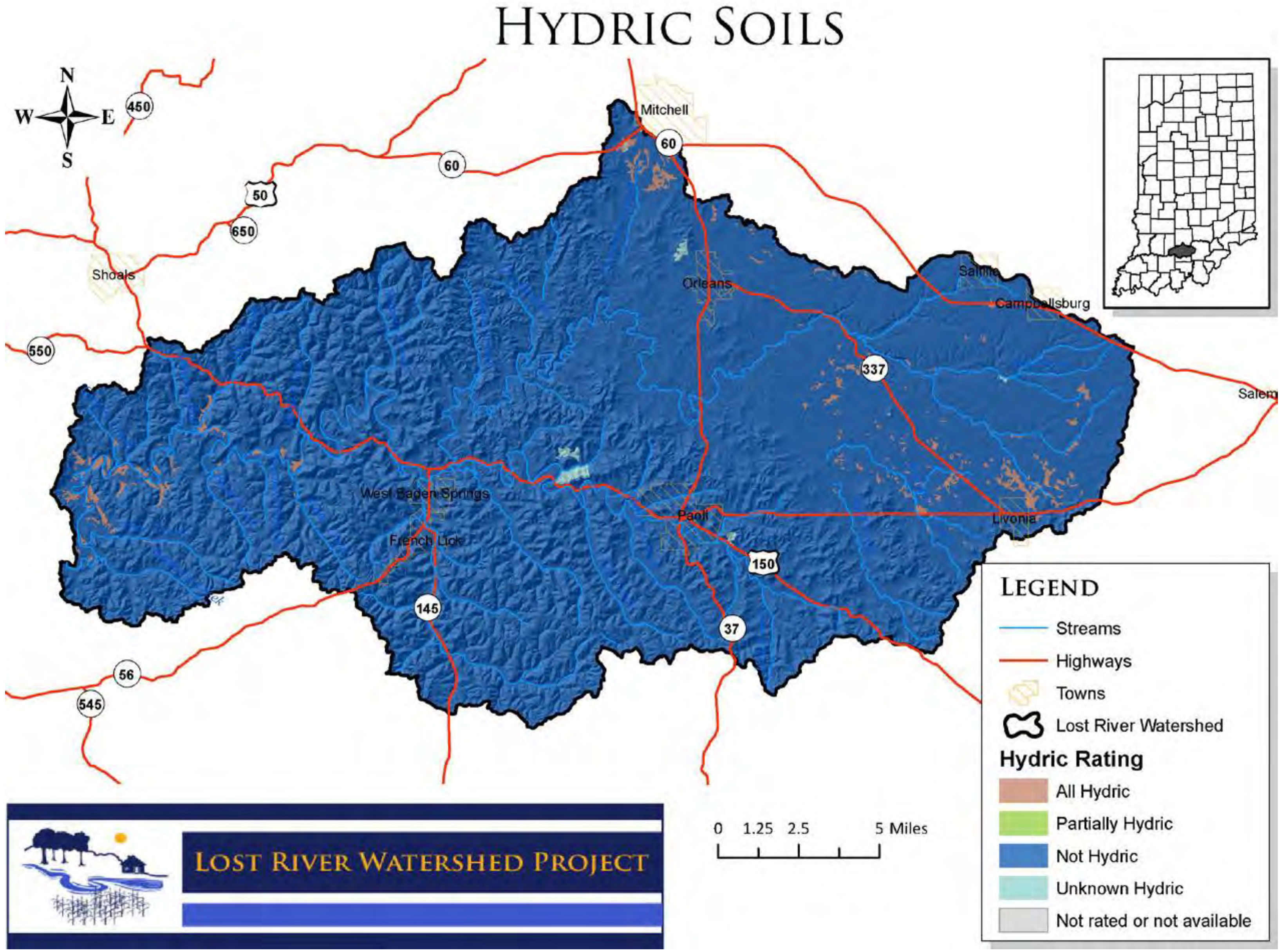


Figure 12: Hydric Soils

Throughout Indiana, households depend upon septic tank absorption fields in order to treat wastewater. Seven soil characteristics, including position in the landscape, soil texture, slope, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table, determine suitability for on-site septic treatment. Septic tank absorption fields require soil characteristics that allow for gradual movement of wastewater from the surface into the groundwater. A variety of characteristics limits the ability for soils to adequately filter and treat wastewater. In the watershed, soils with high water tables, shallow bedrock, shallow limiting layer (fragipan/hardpan), and high clay content all limit a soil's ability to work as absorption fields. Specific system modifications are necessary to address soil limitation. The karst system also causes many areas to be inadequate for use in septic tank absorption fields. In many cases, soils that would normally work as absorption fields are too close to sinkholes and other karst features. These features cause drainage to occur too rapidly for proper treatment.

Until 1990, residential homes located on 10 acres or more and occurring at least 1,000 feet from a neighboring residence were not required to comply with any septic system regulations. In 1990, a new septic code corrected this loophole. Current regulations address these issues and require that individual septic systems be examined for functionality. Additionally, newly constructed systems cannot be placed within the 100-year floodplain and systems installed at existing homes must be placed above the 100-year flood elevation. However, many residences grandfathered into this code throughout the area have not upgraded or installed fully functioning systems (personal communication with local health officials, 2011). In these cases, septic effluent discharges into field tiles or open ditches and waterways and will likely continue to do so due to the high cost of repairing or modernizing systems. Repairing and modernizing systems can cost anywhere from $4,000 to $15,000 depending on the upgrades needed. Likely, there is degraded water quality from the influence of septic systems in the Lost River watershed; however, it cannot be determined without a complete survey of systems.

The Natural Resources Conservation Service (NRCS) ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is considered very limited, somewhat limited, or not limited based on characteristics of the soil unit. Some soils are not rated for their absorption field suitability. Very limited, or severe limitation, areas are areas whose soil properties present serious restrictions to the successful operation of a septic tank absorption field. Using soils with a severe limitation increases the probability of the system's failure and increases the costs of installation and maintenance. Areas designated as having moderate limitations have soil qualities, which present some drawbacks to the successful operation of a septic system; correcting these restrictions will increase the system's installation and maintenance costs. Slight limitations delineate locations whose soil properties present no known complications to the successful operation of a septic tank absorption field. Uses of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function.

Watershed stakeholders are concerned about the lack of maintenance associated with septic tanks, the use of soils or karst features that are not suited for septic treatment, and the presence of straight pipe systems within the watershed. These concerns are compounded by the fact that severely limited soils cover a majority of the watershed (Figure 13). In total, over 163,080 acres or 69.9% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. An additional 69,823.5 acres or 29.9% of the watershed soils rate as somewhat limited. None of the area falls into the not limited category meaning that there is some limitation throughout the watershed for septic tank absorption fields. The remaining 1,257.5 acres are not rated. Of those 627 acres are covered by water, and 568 acres are located within the 100-year floodplain of the Lost River watershed. These locations would not be suitable for septic tank absorption fields either, due to their proximity to water.

The majority of the watershed is unsewered. The exceptions lie within the town boundaries of the major towns within the watershed. The Town of Orleans, The Town of Paoli, the town of Campbellsburg, and the adjoining towns of French Lick and West Baden are sewered. The Town of Orleans system is badly in need of repairs. The collection system, or sewer pipes, within the area are severely degraded and may be nonexistent in some locations due to complete dissolution of old clay pipes. The underlying karst in this area makes this situation more concerning because of the inherent connection between the karst and rising streams within the watershed. The majority of the watershed's 228,539 acres is unsewered. People in these areas rely on traditional septic systems, mounding systems, and straight piping to sinkholes and creeks to dispose of waste. Many accounts from landowners have indicated that many old systems likely drain into sinkholes bypassing normal soil filtration in many of the areas. Several populated areas that are unsewered include Greenbrier, Chambersburg, Millersburg, Saltillo, Pumpkin Center, Leipsic, Orangeville, Rusk, and Natchez.

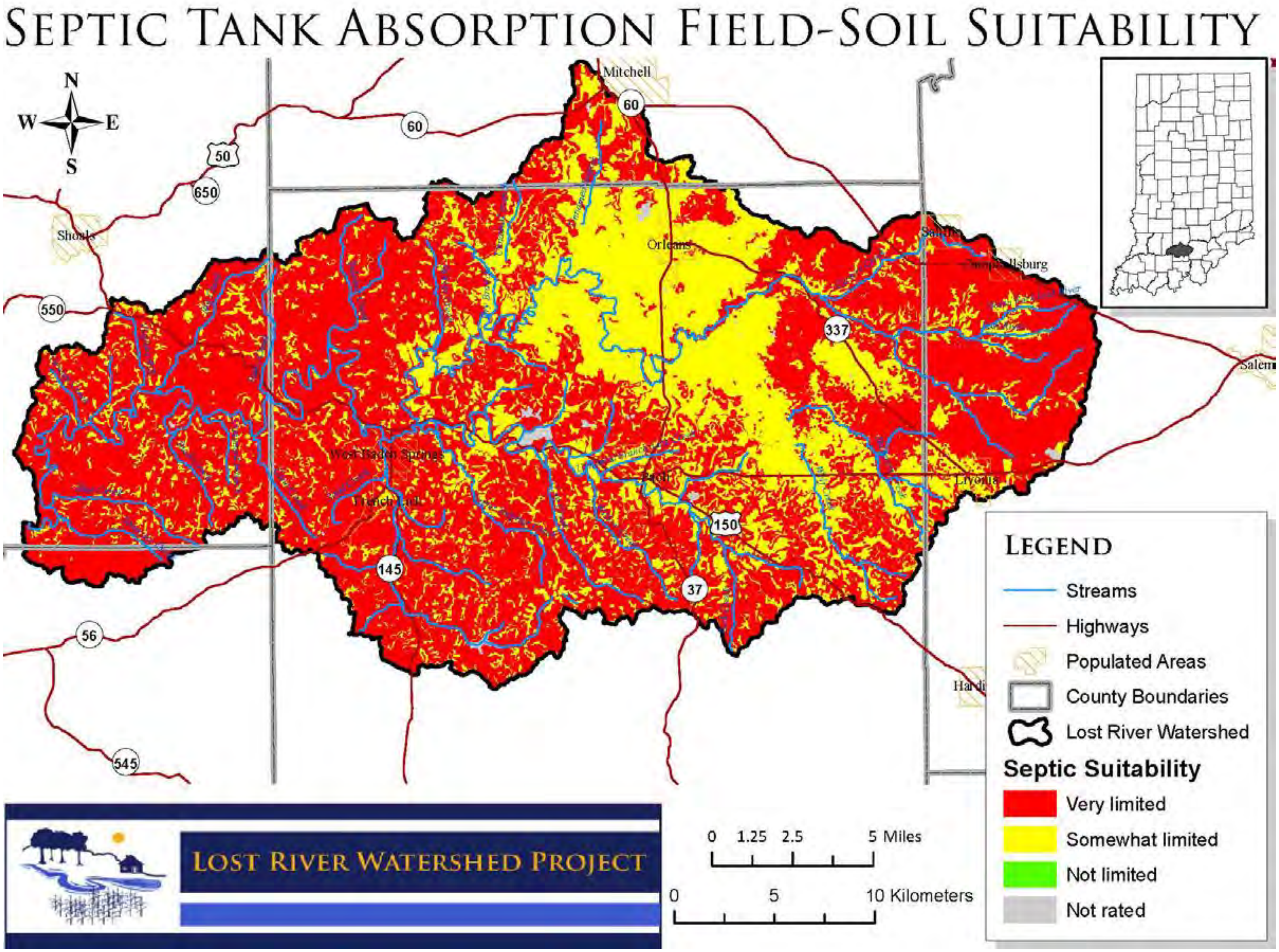


Figure 13: Septic Tank Absorption Field Suitability

- This map shows where soils are limited for standard septic tank absorption fields based on soil characteristics.

The ability of soil to move from the landscape to waterbodies is rated by the Natural Resources Conservation Service (NRCS). The NRCS uses soil texture and slope to classify soils into Highly Erodible Land (HEL) or not based on whether they are highly erodible, potentially highly erodible, or not highly erodible. The classification is calculated using an erodibility index. This index is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss T value or tolerance value. The T value is the maximum annual rate of erosion that can occur for a particular soil type without causing a decline in long-term productivity. Potentially highly erodible soil determinations are based on the slope steepness and length in addition to the erodibility index value. Soils that move from the landscape to adjacent waterbodies result in degraded water quality, limited recreational use, and impaired aquatic habitat and health. Soils carry attached nutrients, pesticides, and herbicides. These can result in impaired water quality by increasing plant and algae growth or can kill aquatic life or damage water quality.

Watershed stakeholders are concerned about soil erosion in many different forms. As detailed above, soils that are located on steep slopes and are easily moved by wind, water, or land uses are considered highly erodible and are a concern for watershed stakeholders. Figure 14 shows the classification of soils based on these characteristics within the Lost River watershed. In total, highly erodible soils cover 43% of the watershed or approximately 99,750 acres, while potentially highly erodible soils cover 41% of the watershed or approximately 95,075 acres. Highly erodible soils are found throughout the watershed, but are more concentrated in the Crawford Uplands in the southern and western portion of the watershed.

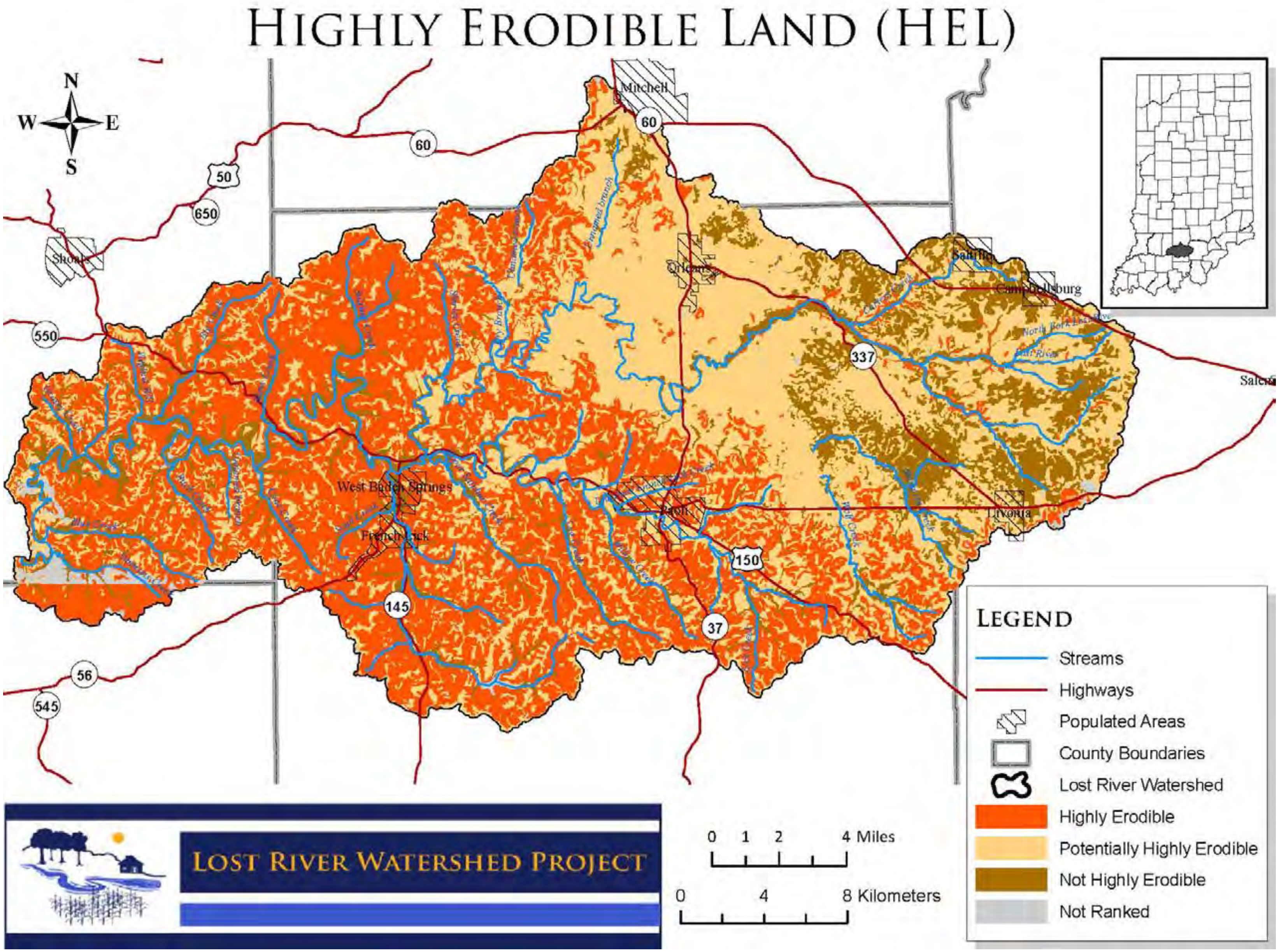


Figure 14: Highly Erodible Land (HEL) - Natural Resources Conservation Services (NRCS) rated soils.

Erosion hazards caused by off-road vehicles, or All Terrain Vehicles (ATVs), are a concern for watershed stakeholders. Off-road motorcycle or ATV trails do not exist in the watershed, however many people ride ATVs or motorcycles recreationally on abandoned county roads and along other trails. Improper use of these areas results in areas that are devoid of vegetation. Another concern is the considerable compaction of the soil material from this type of activity. Logging, mining, and other disturbances to the land causing high amounts of soil erosion and vegetation removal are also of concern to watershed stakeholders. Figure 15 indicates the hazard of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface. The ratings are based on slope and soil erosion factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance. The hazard is described as "slight," "moderate," "severe," or "very severe." A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions. Within the Lost River watershed, 58% of the land has a slight hazard for erosion in these areas. "Moderate" indicates that some erosion is likely and that erosion-control measures may be needed. The Lost River watershed has 17.5% of the land considered moderate for this type of erosion. "Severe" indicates that erosion is very likely and that erosion-control measures, including re-vegetation of bare areas, are advised. Within the Lost River watershed, 16.7% of the land has a severe hazard for erosion in these areas. "Very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures may be costly and generally impractical. Lost River watershed has 7.23% of its land rated as very severe and off road vehicles should not be used in these areas because of the extensive erosion that would occur. A total of 41.4% of the watershed is rated from moderate to very severe for erosion hazard. Unfortunately, the area where most off-road activities occur is in the western portion of the watershed, where erosion hazards from moderate to very severe are more prevalent.

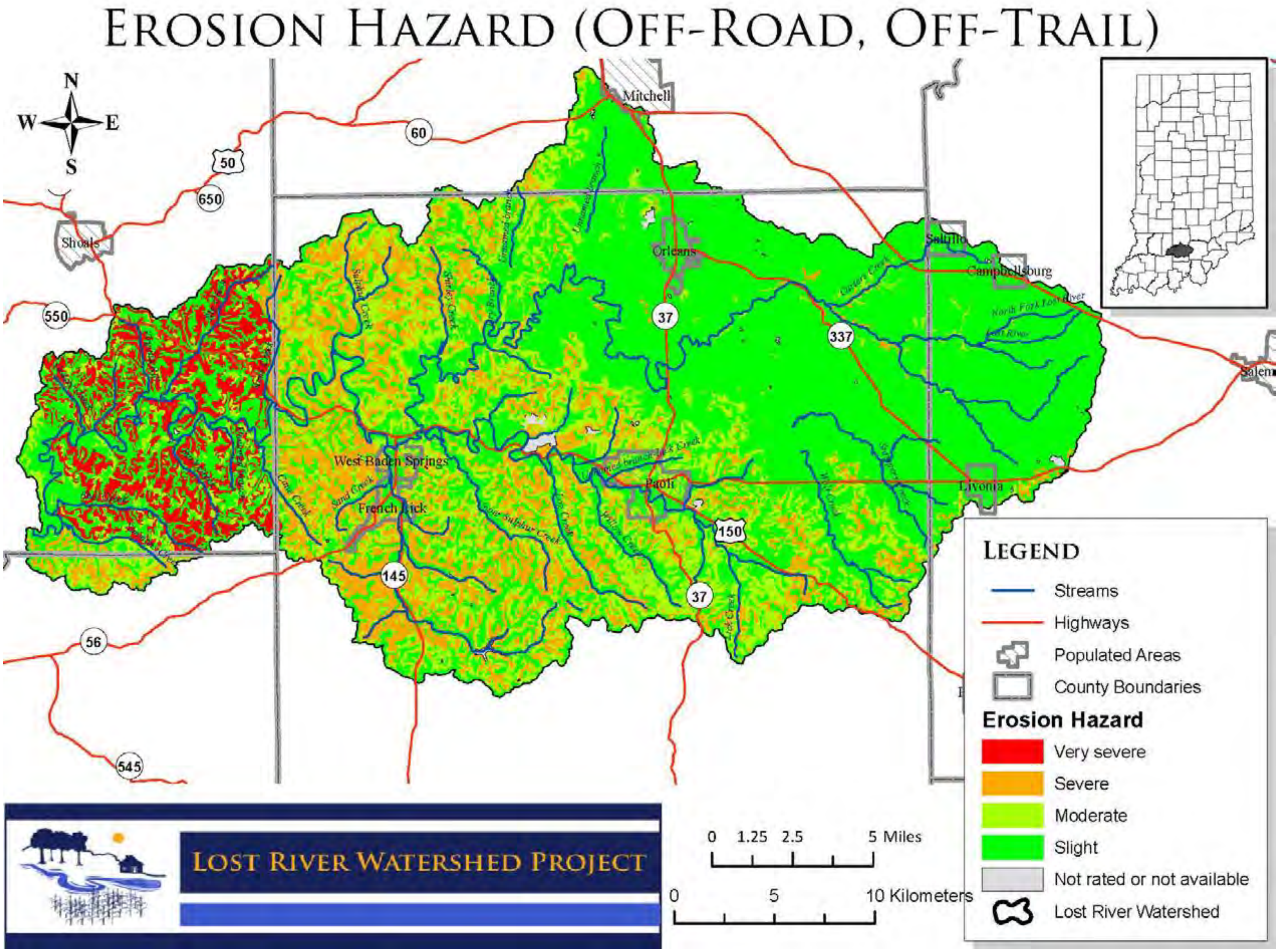


Figure 15: Erosion Hazard from Off-Road & Off-Trail Uses

3.1.11 Climate/Precipitation

Indiana has an invigorating climate with strongly marked seasons. Winters are often cold, sometimes bitterly so. The transition from cold to hot weather can produce an active spring with thunderstorms and tornadoes. Oppressive humidity and high temperatures arrive in summer. Autumn is favored by many residents as a pleasant time of the year with lower humidity than the other seasons, and mostly sunny skies.

Indiana's location within the continent highly determines this cycle of climate. The Gulf of Mexico is a major player in Indiana's climate. Southerly winds from the Gulf region readily transport warm, moisture laden air into the state. The warm moist air collides with continental polar air brought southward by the jet stream from central and western Canada. A third air mass source found in Indiana originates from the Pacific Ocean. Due to the obstructions posed by the Rocky Mountains, however, this third source arrives less frequently in the state.

A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The interaction between these two air masses of contrasting temperature, humidity, and density favors the development of low pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana. Weather changes occur every few days as surges of polar air move southward or tropical air northward. These changes are more frequent and pronounced in winter than in summer.

Average annual precipitation is 47 inches in southern Indiana. May is the wettest month of the year with average rainfall between 4 and 5 inches. Average rainfall decreases slightly as summer progresses. Autumn months are drier with 3 inches of rainfall typical in each month. Indiana winters are the driest time of year with less than 3 inches of precipitation commonly received each month. February is the driest month of the year statewide, then precipitation increases in March and April as the spring soil moisture recharge season begins. On average precipitation occurs every third day in Indiana.

Annual precipitation is adequate, but an uneven distribution in the summer occasionally limits crops. Mild droughts occasionally occur in the summer when evaporation is highest and dependence on rainfall is greatest for crops. In 2012, the area had one of the most severe droughts on record affecting many crops in the area. Approximately one-third of the annual rainfall flows to the Mississippi or Great Lakes, mainly during cool weather. The soil usually becomes saturated with water several times during the winter and spring. An underlying bed of limestone with shallow soils limits ground water storage in much of south central Indiana.

Floods occur in some part of the state nearly every year and have occurred in every month of the year. The months of greatest flood frequency are from December through April. The primary cause of floods is prolonged periods of heavy rains, although rain falling on snow and frozen ground is a contributing factor. In 2011, rainfall amounts hit all time records with over 63 inches in the area. The spring of 2011 saw several floods that inundated the area for many days.

Average annual snowfall is around 14 inches in southwest Indiana. Snowfall amounts vary greatly from year to year depending on both temperature and the frequency of winter storms. Measurable snow typically begins in late November and ends by early April although the season can begin as early as mid October and end as late as early May. In warm years snow may not begin until mid December. At a given latitude in central and southern Indiana snowfall amounts increase toward the east because of the higher elevation.

Figure 16 shows the average temperature, precipitation, humidity, wind speed, snowfall and sunshine for Paoli, Indiana.

Based on data reported by over 4,000 weather stations

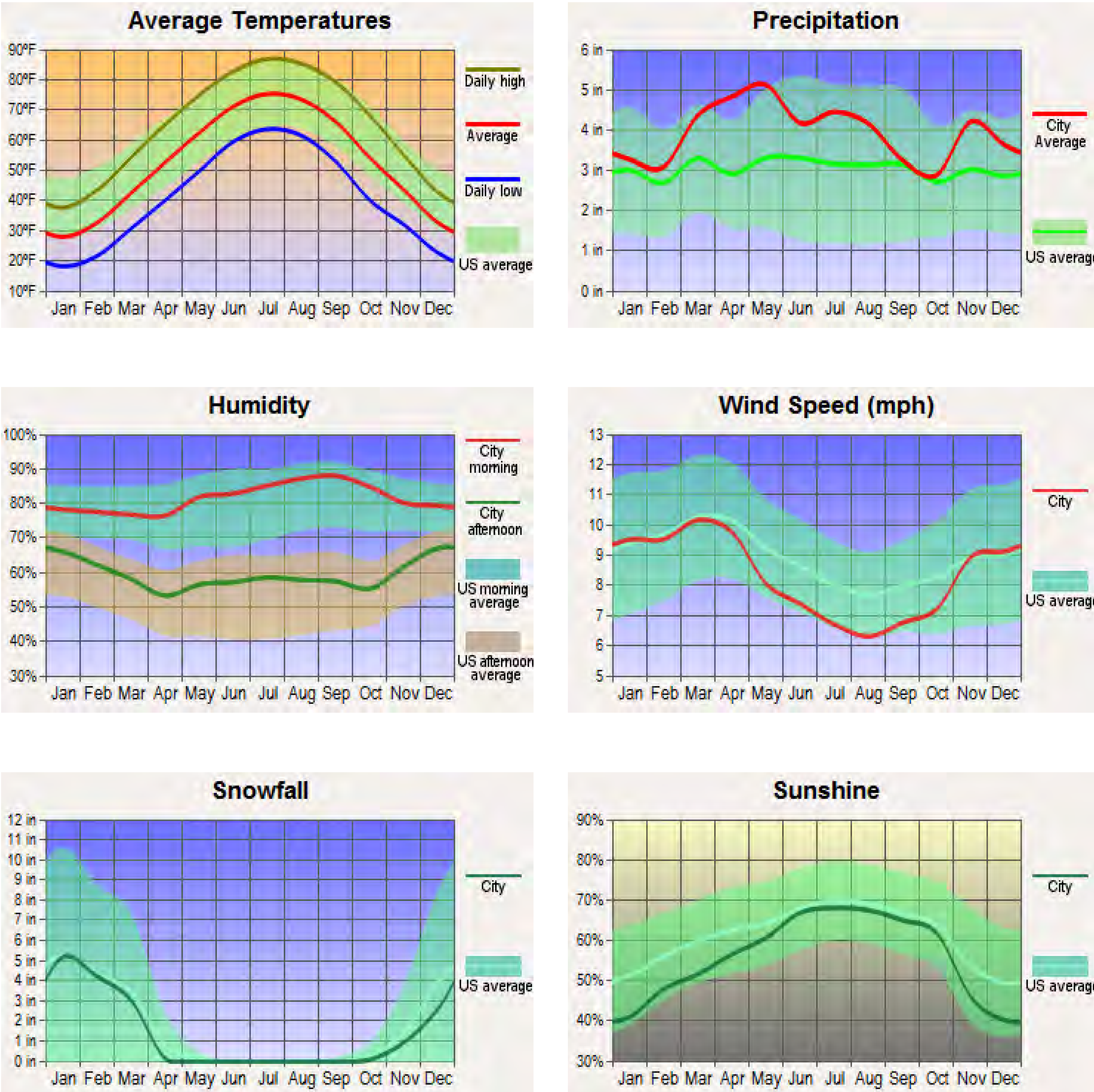


Figure 16: Comparison of average precipitation, temperature, wind speed, snowfall and sunshine in Paoli, Indiana to US averages. (Average climate in Paoli, Indiana taken from City-Data.com)

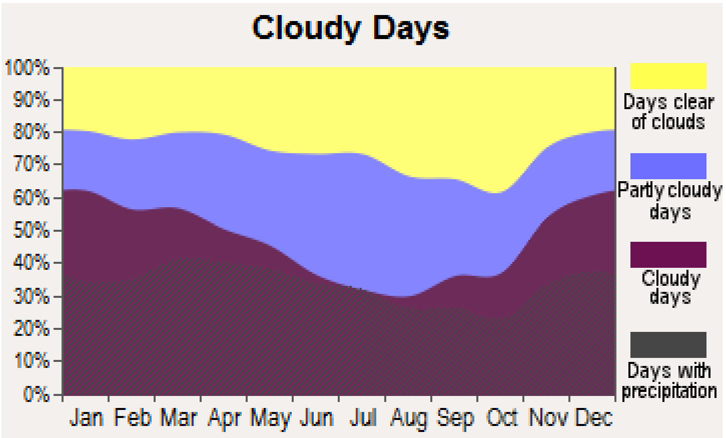


Figure 17: Amount of days with clear, partly cloudy, cloudy, or precipitation (Average climate in Paoli, Indiana taken from City-Data.com)

Figure 17 indicates the amount of cloudy days in Paoli, Indiana. The amount of precipitation is an important component to water quality and runoff rates. Figure 18 shows the amount of precipitation that was recorded in Oolitic, Indiana (just north of the study area in Lawrence County) for the period of June 2011 through July 2012. This information is used to determine whether samples collected during water monitoring were taken at base flow or storm flow within the watershed. Intense rainfall was seen in mid-June 2011.This event caused flooding within the watershed due to the high intensity of rain following previous high rainfall events. Due to the geology of the watershed rainfalls like this will flood the area because previous rains have saturated the cave system leaving no room for additional water. This phenomena is only witnessed in karst landscapes. High intensity rains like the one seen in July 2011 will also cause high runoff rates within the watershed because water does not have time to soak into the soils before more water is added to the area. Flooding from this event lasted weeks.

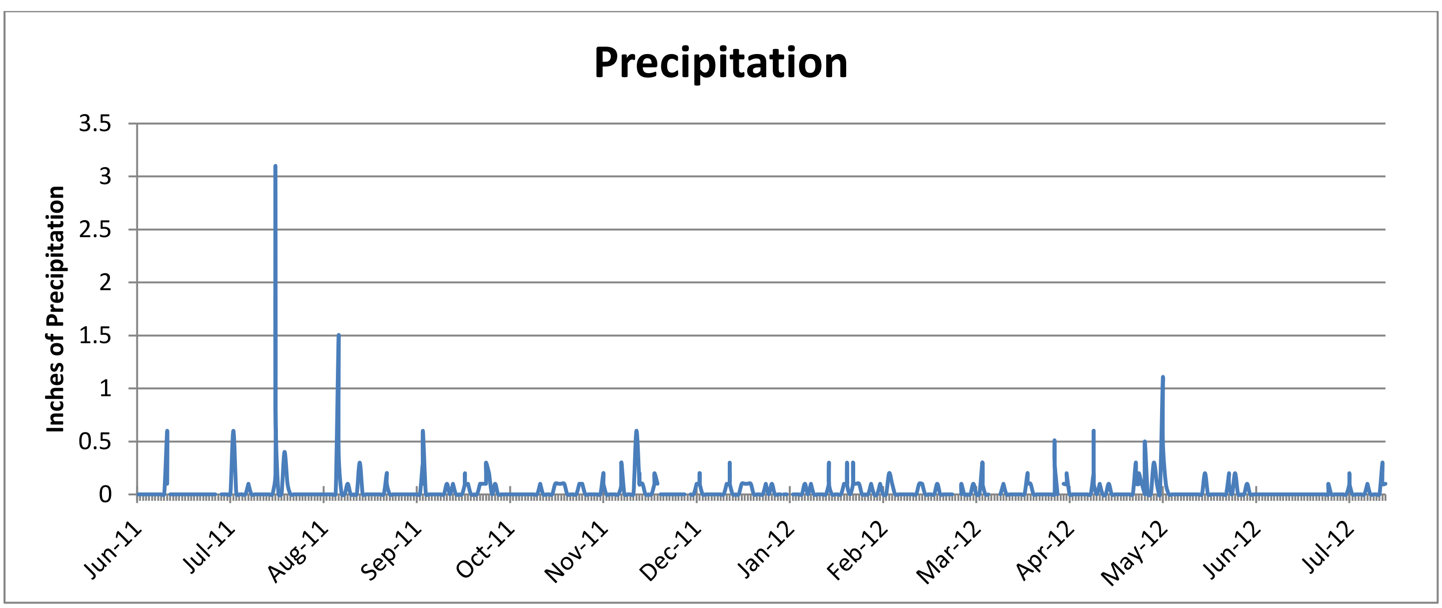


Figure 18: Precipitation during the 2011-2012 sampling period (Oolitic Purdue Experiment Farm Station, COOP:126580)

3.1.12 Ecoregion

The Lost River watershed is in the Interior Plateau (Level III) of the Southeastern Temperate Forested Plains and Hills (Region IX). Two ecoregions within the Interior Plateau dissect the watershed and are the most specific to the area. They are the Mitchell Plain (Level IV) and the Crawford Uplands (Level IV).

According to EPA, there are eleven Level III ecoregions contained within Aggregate Ecoregion IX. Aggregate Ecoregions will often cover several states is size. Region IX is composed of irregular plains and hills. Originally, the Southeastern Temperate Forested Plains and Hills (IX) was mostly forested in contrast to the South Central Cultivated Great Plains (V); areas of savannah and grassland also occurred. Region IX is a mosaic of forest, cropland, and pasture. The Southeastern Temperate Forested Plains and Hills (IX) is not as arable as the South Central Cultivated Great Plains (V) or the Corn Belt and Northern Great Plains (VI). However, there is much more cropland than in the more rugged Central and Eastern Forested Uplands (XI). Lateritic soils are common and are a contrast to the soils of the surrounding regions. Areas of depleted soils are found in Region IX. Major poultry and aquaculture operations occur locally in the Southeastern Temperate Forested Plains and Hills (IX). Stream quality in the Southeastern Temperate Forested Plains and Hills (IX) has been significantly affected by urban, suburban, and industrial development as well as by poultry, livestock, silviculture, and aquaculture operations. Downstream of sewage treatment plants, poultry farms, and hog operations, nutrient levels and fecal coliform bacteria concentrations can be very high. There are a large number of intensive chicken, turkey, and hog operations in Region IX; effluent from intensive livestock production poses a substantial eutrophication threat to surface waters. In contrast, streams draining relatively undisturbed and forested watersheds have low median concentrations of fecal coliform bacteria, sulfate, dissolved solids, and phosphorus. Silviculture, agriculture, and urban development have impacted suspended sediment levels in streams especially where soils are highly erodible. Coal mining has degraded water quality and affected aquatic biota in several areas including southern Iowa, northern Missouri, Indiana, and eastern Pennsylvania.

The Interior Plateau Ecoregion IV, Ecoregion 71 is a diverse ecoregion extending from southern Indiana and Ohio to northern Alabama. Rock types are distinctly different from the coastal plain sands and alluvial deposits to the west, and elevations are lower than the Appalachian ecoregions to the east. Mississippian to Ordovician-age limestone, chert, sandstone, siltstone, and shale compose the landforms of open hills, irregular plains, and tablelands. The natural vegetation is primarily oak hickory forest, with some areas of bluestem prairie and cedar glades. The region has a diverse fish fauna.

The Crawford Uplands and the Mitchell Plain, Level IV Ecoregions, divide the Lost River watershed. The Crawford Uplands ecoregion is heavily dissected by medium to high gradient streams and is more rugged and wooded than the Mitchell Plain Ecoregion. Oaks are found on well-drained upper slopes; mixed mesophytic forest occurs in coves as well as on north facing slopes, and specialized plant communities dominate the eastern sandstone-limestone cliffs. General farms occur especially in the west and in the wider valleys. Table 5 has some general descriptions of the Crawford Uplands.

The Mitchell Plain is differentiated from adjacent ecoregions by its karst topography, low relief, residential-urban areas, and limestone quarries; its peripheral hills are wooded. The north experienced pre-Wisconsinan glaciation and is flatter and more poorly-drained than the unglaciated part, which is dominated by sink holes, underground drainage, and terra rosa soils. Soils are leached and largely developed from loess and limestone. Western mesophytic forests were once dominant; karst wetland communities and limestone glades also occurred and were the major examples of these communities in Indiana. Table 5 has some general descriptions of the Mitchell Plain.

Table 5: Ecoregion General Descriptions

Level IV Ecoregion		Physiography		Geology
	Area (square miles)		Elevation/ Local Relief (feet)	Surficial material and bedrock
Crawford Uplands	2363	Unglaciated. Heavily dissected hills with narrow valleys and medium to high gradient channels. Terrain is especially rugged in the east and cliffs occur.	350-1000 / 300-350+	Quaternary loess or colluvium may overlie Mississippian and Pennsylvanian shale, sandstone, and limestone (Raccoon Creek and West Baden Groups are common).
Mitchell Plain	1555	Unglaciated, except in extreme north. Gently rolling plains, karst terrain with entrenched streams, and wooded hills on periphery. Stream density is low where sinkholes and underground drainage are present.	380-960 / 50-350+	Quaternary colluvium and Mississippian limestone of, primarily, the Blue River Group.

Ecoregion	Soil			Climate		
	Order (Great Groups)	Common Soil Series	Temperature /Moisture Regimes	Precipitation Mean annual (inches)	Frost Free Mean annual (days)	Mean Temperature January min/max; July min/max, (°F)
Crawford Uplands	Inceptisols (Dystrochrepts), Ultisols (Hapludults), Alfisols (Hapludalfs, Fragiudalfs)	Zanesville, Ebal, Wellston, Gilpin, Berks, Stendal, Haymond.	Mesic/Udic	41-46	170-200	23-27/40-45; 64/91
Mitchell Plain	Alfisols (Paleudalfs, Hapludalfs, Fragiudalfs), Mollisols (Argiudolls), Ultisols (Paleudults)	Crider, Hagerstown, Bedford, Caneyville, Baxter, Frederick, Haymond.	Mesic/ Udic	41-45	170-200	23-27/40-45; 64/90

Ecoregion	Potential Natural Vegetation	Land Use and Land Cover
Crawford Uplands	Mostly oak-hickory forest on uplands; also beech forest in north and a few barrens.	Mostly forests; some general farming especially in the west and in wider valleys.
Mitchell Plain	Western mesophytic forest. Also, karst wetlands; limestone glades on stony Corydon soil.	General farming and residential-urban development; also woodland in rugged areas and many limestone quarries.

3.1.13 Exotic/Invasive Species

Over the last few years, there has been an ever increasing emphasis on invasive species. Our surroundings are changing because of them. Not only are invasive species threatening our agriculture and our forests, they are also causing major impacts to our back yards.

So just what is an invasive species? An unofficial definition could be that an invasive species is a species that does not naturally occur in a specific area and whose introduction does or is likely to cause economic or environmental harm or harm to human health. Official U.S. definitions regarding invasive species were provided in Executive Order 13112 signed by President William Clinton on February 3, 1999. "Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. “Alien species” means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem. “Species” means a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms. “Ecosystem” means the complex of a community of organisms and its environment.

In the Lost River watershed, there are threats from many invasive species. They include terrestrial and aquatic vertebrates, invertebrates, plants, and pathogens. In our area several terrestrial plants have been added to the invasive species list for the watershed. Invasive species of concern include Zebra Mussel, Hydrilla, Nutria, Tree of Heaven, Asian Bush Honeysuckle Autumn Olive, Miltifloral Rose, Garlic Mustard, Japanese Stiltgras, Emerald Ash Boar, Gypsy Moth, and Brown Headed Cowbird. These plants, animals, and insects are of concern for their aggressive control of habitat, food sources, and competition for erosion control in understory of forests.

3.1.14 Wildlife

Just like humans, wildlife require food, water, and shelter in order to survive. Though native wildlife species evolved in this area over time, the landscape has changed so dramatically that wildlife are often more challenged to meet their basic needs. The stream environment is in an integral part to wildlife’s survival. This area is located within the Central Hardwoods Bird Conservation Region (BCR 24) as well as the Appalachian Landscape Conservation Cooperative (LCC). Both of these plans focus on forest interior and early successional bird species, such as the Kentucky Warbler, Worm-eating Warbler, Wood Thrush, Prairie Warbler, and Blue-winged Warbler. In addition, the Lost River watershed contains important riparian species, such as the Louisiana Waterthrush, Acadian Flycatcher, and the federally endangered Indiana Bat. Wetland restorations in Lost River floodplain habitats benefit the Copperbelly Water Snake and Wood Duck, and also help improve water quality for aquatic species.

The aquatic ecosystem can be seen within the streams and lakes of a watershed. They are home to beaver, otter, and muskrats along with fish, mussels, and insects. Disturbances within the watershed environment may be affecting biodiversity within the watershed. The variety of species and level of populations can indicate the health of a stream for wildlife. Overabundance of nutrients, particularly phosphorus and nitrogen, can lead to an enrichment of plant and other organic productivity in fresh water. This eutrophication process often results in enhanced rates of decomposition and in chemical conditions that greatly reduce or eliminate suitable habitat for many species of plants and animals. People are concerned that increased chemical inputs into this ecosystem may be causing a decline in aquatic species including the bass populations, which historically created a draw to anglers from around the state. In recent years, there have been many reports from anglers that fish populations are in decline and that ick, a parasite that effects fish populations, has been seen in the area.

3.1.15 Endangered and Threatened Species

The Indiana Natural Heritage Data Center, part of the Indiana Department of Natural Resources, Division of Nature Preserves, maintains a database documenting the presence of endangered, threatened, or rare species; high quality natural communities; and natural areas in Indiana. The database originated as a tool to document the presence of special species and significant natural areas and to assist with management of said species and areas where high quality ecosystems are present. The database is populated using individual observations, which serve as historical documentation, or as sightings occur; no systematic surveys occur to maintain the database.

The state of Indiana uses the following definitions to list species:

- Endangered: Any species whose prospects for survival or recruitment within the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants currently known to occur on five or fewer sites in the state are considered endangered.
- Threatened: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants currently known to occur on six to ten sites in the state are considered threatened.
- Rare: Plants and insects currently known to occur on eleven to twenty sites.

Appendix 1 details the Indiana Natural Heritage Data Center Endangered Threatened and Rare species rank database results for the Lost River watershed.

The Lost River watershed ranks among the top 10 caves in the country for species richness. It is home to at least 24 cave species of them five are known to only exist within the Lost River Cave System. In total, 243 observations of special species and/or high quality natural communities occurred within the Lost River watershed. Of these observations, five federally threatened species have been observed in the watershed. These listings include three mussel species, one mammal, and one bird. They are Eastern Fanshell Pearly Mussel, Clubshell, Rabbitsfoot, Indiana Bat, and Bald Eagle. On a state listing basis, 23 species listed in the Natural Heritage Database as state endangered have been observed within the Lost River Watershed including the Northern Cavefish. Many of these species depend on a healthy aquatic system to survive. Several of these species are unique to this area because they live, hunt, seek shelter, or hibernate within the local cave system. Species that live within the cave system often do not have the ability to migrate to an alternative area if the habitat they reside in becomes too polluted to sustain life. Stakeholders have voiced their concern for preservation of habitat for endangered, threatened, or rare species.

On a state listing basis, 23 species listed in the Natural Heritage Database as state endangered have been observed within the Lost River watershed including:

- Mussels: Clubshell, Eastern Fanshell Pearlymussel, Longsolid, Rabbitsfoot;
- Reptiles: Kirtland's Snake and Timber Rattlesnake;
- Fish: Northern Cavefish;
- Invertebrates: Appalachian Cave Spider, Indiana Cave Pseudoscorpion, Packard's Cave Pseudoscorpion, Southeastern Wandering Spider, Springtail, and Truncated Springtail;
- Birds: Bald Eagle, Barn Owl, King Rail, Loggerhead Shrike, and Yellow-crowned Night-heron;
- Mammals: Eastern Woodrat, Evening Bat, Indiana Bat or Social Myotis; and
- Vascular plants: Appalachian Quillwort, and Gray Beardtongue.

State threatened species include any animal species likely to become endangered within the foreseeable future. State threatened species include five invertebrates and two vascular plant species. They include the Golden Cave Harvestman, Jeannel's Cave Copepod, Lewis' Cave Springtail, Fountain Cave Springtail, and Carrion Beetle. The vascular plants that are included on the state threatened list are Roundleaf Water-hyssop and Eastern Featherbells.

The Lost River watershed contains important habitats due to the unusual Karst topography in the region, including caves and their associated rare biota. These rivers support high biodiversity and provide habitat for State and Federal threatened and endangered species such as cave biota, fish and mussel species. Lost River is unusual because a large part of it flows underground. Habitat preferences for the state and federally listed species vary. For instance, the cave dwelling aquatic organisms prefer slow flowing with relatively clear water. For example, the Northern “blind” Cavefish feed on shrimp, gammarus and arachnids falling into the water, using the vibrations of it to orient themselves to prey. They are blind and depigmented. Despite the lack of eyes it does respond to light and moves away from it, a behavior known as scotophilia, or being fond of darkness. All of the fish and mussel observations included in the Heritage Database occurred within the Lost River, which offers high mussel diversity. Mussels feed by filtering water and are sensitive to impurities in the water or increases in water temperature. They also require specific fish species in order for reproduction cycles to occur. Warm water temperatures, high turbidity, and loss of habitat can all impact fish and mussel diversity. Deforestation or forest fragmentation likely affect the bald eagle, barn owl, loggerhead shrike, and evening and Indiana bat species. These species require large hunting areas where dense forests are present and small stream corridors with well-developed riparian forests. The elimination of these habitats could result in the loss of roost and hunting habitat thus eliminating these species. Other listed species, including Eastern Woodrat, and vascular plant species rely on prairie habitat. Some plant and bird species, like the yellow-crowned night heron, king rail, are found in wetland habitats. Again, the fragmentation and loss of wetland habitat likely affected the diversity and density of these listed species.

Finally, one species listed in the Heritage Database is on the state extirpated list. Any animal species that has been absent from Indiana as a naturally occurring breeding population for more than 15 years is put on the state extirpated list. In the Lost River watershed, the Eastern Spotted Skunk is on this list. It was last observed in the area in 1979. Eastern Spotted Skunks seem to prefer forest edges and upland prairie grasslands, especially where rock outcrops and shrub clumps are present.

3.1.16 Sensitive Areas

According to the Indiana Natural Resources Commission, Lost River is one of nine exceptional use waters from Indiana's Outstanding Rivers and is designated as such because the river has particular environmental and aesthetic interest. Specifically, Lost River has been identified by state natural heritage programs as having outstanding ecological importance. Largely, this status has been given to Lost River due to its unique hydrological setting in a karst system, and it even has two features that are National Natural Landmarks. Sinkhole densities here are upwards of 155-310 per square mile with an extremely high probability of continued sinkhole development (Lestinger, 2011). In 1922, Malott mapped 1,022 sinkholes in one square mile just southwest of Orleans. This area boasts many unique features, landforms, and creatures that live in this area as a direct result of the karst system. However, it needs special consideration because karst sinkholes, epikarst, and sinking streams make water more susceptible to non-point source pollution. People that live in these areas consider the sinkholes a pain because all of the associated loss that occurs due to their existence. The community as a whole does not perceive sinkholes and karst grounds as sensitive areas that need special consideration when deciding how to manage sinkholes and the land over karst ground. Stakeholders of the watershed desire special consideration by landowners when managing these areas.

Surface water is rapidly channeled into the subsurface in karst landscapes via sinkholes without the benefit of extensive filtration or exposure to sunlight, which reduces contaminants from water. In a typical surface water system, nutrients within the water may be removed when flooding takes sediment and nutrient rich waters onto floodplains and water is allowed to slow down and spread out. This decrease of speed in the water flow allows nutrient laden sediment to settle out of the water and remain on the floodplains. In other areas, floodwater may be held on floodplains by natural levees or wetlands. In these areas, pollutants are filtered out as water slowly soaks through soils and into groundwater. This process both filters pollutants and recharges aquifers. This is why floodplain soils are so fertile. In a cave there is no floodplain for water to slow down. Because of this, sediments and nutrients are quickly carried through the underground system into all cracks and crevices. Most will reemerge as springs still holding contaminated water, while other portions will remain in pockets within the system. The portion in these pockets now has direct connection to the underground aquifer system which are often directly connected to many wells drilled in the area. Water will take the path of least resistance and often that is directly into a well. Groundwater is easily contaminated in karst areas due to the lack of filtration and direct connection.

The Lost River cave system ranks among the top 10 caves in the country for species richness. It is home to at least 24 cave adapted animals. Many of these species depend on a healthy aquatic system to survive. Species that live within the cave system often do not have the ability to migrate to an alternative area if their habitat becomes too polluted to sustain life. Land that overlies the karst system within the watershed are considered sensitive areas due to the direct connection to the underground system. Sinkholes, especially, need special consideration in order to protect the subsurface habitat. Stakeholders have voiced their concern over historic and current use of sinkholes as trash receptacles. They are concerned that hazardous trash placed in sinkholes may be toxic to the species that live in these unique areas and the contamination of groundwater for human and animal consumption.

3.2 Land Use and Land Cover

Land use data were obtained from the 2001 and 2006 National Land Cover Database (NLCD) available from IndianaMap (IGS, 2011). These data were originally produced using a combination of Landsat imagery and ancillary data. Figure 19 shows the relative percentage of each different type of land use in the watershed. Figure 20 depicts the distribution of land use types throughout the watershed.

Natural area including forest, scrub/shrub areas, and grassland comprise 48.4% of the total watershed area. Hoosier National Forests (HNF) makes up a considerable portion of these natural areas. The HNF owns approximately 22,116 acres of land within the Lost River watershed, or 18% of the natural area. Indiana Department of Natural Resources (DNR) helps landowners manage another 23,302 acres within the watershed. Total managed land is more than 37% of the natural areas. Managed areas have signs of abuse by all terrain vehicles (ATV) as seen by HNF employees and steering committee members. Woodland managers are concerned over the effects of off-trail ATV use is having on water resources and habitat. The other 63% of natural areas are at risk of poor management decisions. Logging activities occur within the watershed. Stakeholders are concerned that some forests are being harvested without consideration of its effect on water quality. Forested watersheds are frequently used for defining stream reference conditions and loss of forested cover in watersheds correlates with declining water quality (Center for Watershed Protection, 2003).

Cultivated cropland is a major land use type comprising just over 26.2 % of the total watershed area (Figure 19 & 20 and Table 7). An additional 15.7% of the watershed is pasture or hay fields making the total agricultural land use percentage almost 42% of the watershed. Agricultural practices significantly influence water quality. Factors such as the timing, quantities, and methods of fertilizer application on cropland influence nutrient loading in streams. Manure applications to the fields are increasing with the increase of manure sources within the watershed. Nutrients and pathogens can make their way from pastures and manure applied fields to the waterways in these areas. Nutrients as well as pathogens and sediments from degraded banks enter surface water when livestock have direct access to streams. Sediment erodes from fields and enters streams when soils are disturbed for cultivation. High nutrient levels, sediment, and pathogens such as E. coli in streams in Lost River watershed are all concerns expressed by stakeholders.

A total of 5.6% of the watershed is developed including commercial, industrial, and residential areas as well as developed open space such as athletic fields and golf courses. Lost River watershed is trending toward more rapid development due to the revitalization of French Lick and West Baden Springs, especially with the placement of State Rd 145 and increased width of State Rd 37 which offer convenient access from the north and south. Development increases impermeable surface in the watershed consequently resulting in greater runoff volumes and possible higher pollutant concentrations. Notable impacts to water quality occur with as little as 10% watershed impervious cover, which can be obtained with as little as one house per 2 acres. Watershed impervious cover greater than 25% indicates a high probability that streams will be impaired for aquatic life use (Center for Watershed Protection, 2003). It is anticipated that total impervious cover as a component of developed land will exceed 10% in Lost River watershed in coming years.

Urban and suburban fertilizer application poses another threat to water quality. Public perception of the beauty of green, well-manicured lawns frequently results in significant quantities of fertilizer being applied by homeowners and managers of recreational facilities such as golf courses and athletic fields. These fertilizers often contain phosphorus and are likely applied by homeowners adjacent to streams as well as recreational facilities directly adjacent to Lick Creek and Lost River and its tributaries.

Increasing numbers of homestead farms with small numbers of livestock such as cattle, horses, goats, and sheep that may be given direct access to streams. Such animals currently contribute to nutrient and E. coli loading in the watershed and may become more problematic as development increases.

All land uses have an effect on water quality, whether positive or negative. In forests and other areas with good vegetation cover and little disturbance from humans, most rainfall soaks into the soil rather than running off the ground, stream flows are fairly steady, and water quality is good. In built-up areas with pavement and buildings, little rainfall soaks into the soil, causing high runoff, stream flows with high peaks and low flows in between, and poorer water quality. In fact, land use and practices are probably the most important factor in determining water quality in most Indiana landscapes.

The fate of rain that falls on the land is strongly affected by land use as seen in Table 6. In a forest or grassy area, most rain soaks into the soil (infiltrates), where it eventually is used by growing plants or percolates to ground water. Ground water flows slowly into streams, usually over a period of months, providing steady base flow (flow in streams in times without rainfall) that fish and other aquatic life need. By contrast, most rain that falls on a parking lot runs off immediately, often draining into storm sewers that transport it to a stream or ditch. The most common land use in Indiana is agriculture, which lies somewhere between these two extremes. On agricultural land, some rainfall runs off, while some infiltrates into the ground where it can be used by plants or provide base flow for streams.

Table 6: Runoff Expected from Four Types of Land Use

Land uses	Runoff from a 4-inch rainfall (inches)	Runoff volume from 4-inch rainfall on 1 acre (gallons)	Average yearly runoff* from this land use in southern Indiana
Forest	0.5 inch	13,600	0.3 inches
Grass (meadow, lawns, parks)	0.8 inches	21,700	0.4 inches
Corn/soybeans	2.0 inches	54,300	1.1 inch
Roofs/pavement	3.9 inches	105,900	19 inches

**NRCS "Curve Number" method of estimation; Hydrologic soil group B; Corn/soybeans have 30% residue coverage; Curve numbers are 55 (forest), 61 (grass), 75 (corn/soybeans), and 98 (roofs/pavement). Soil moisture before storm is average.*

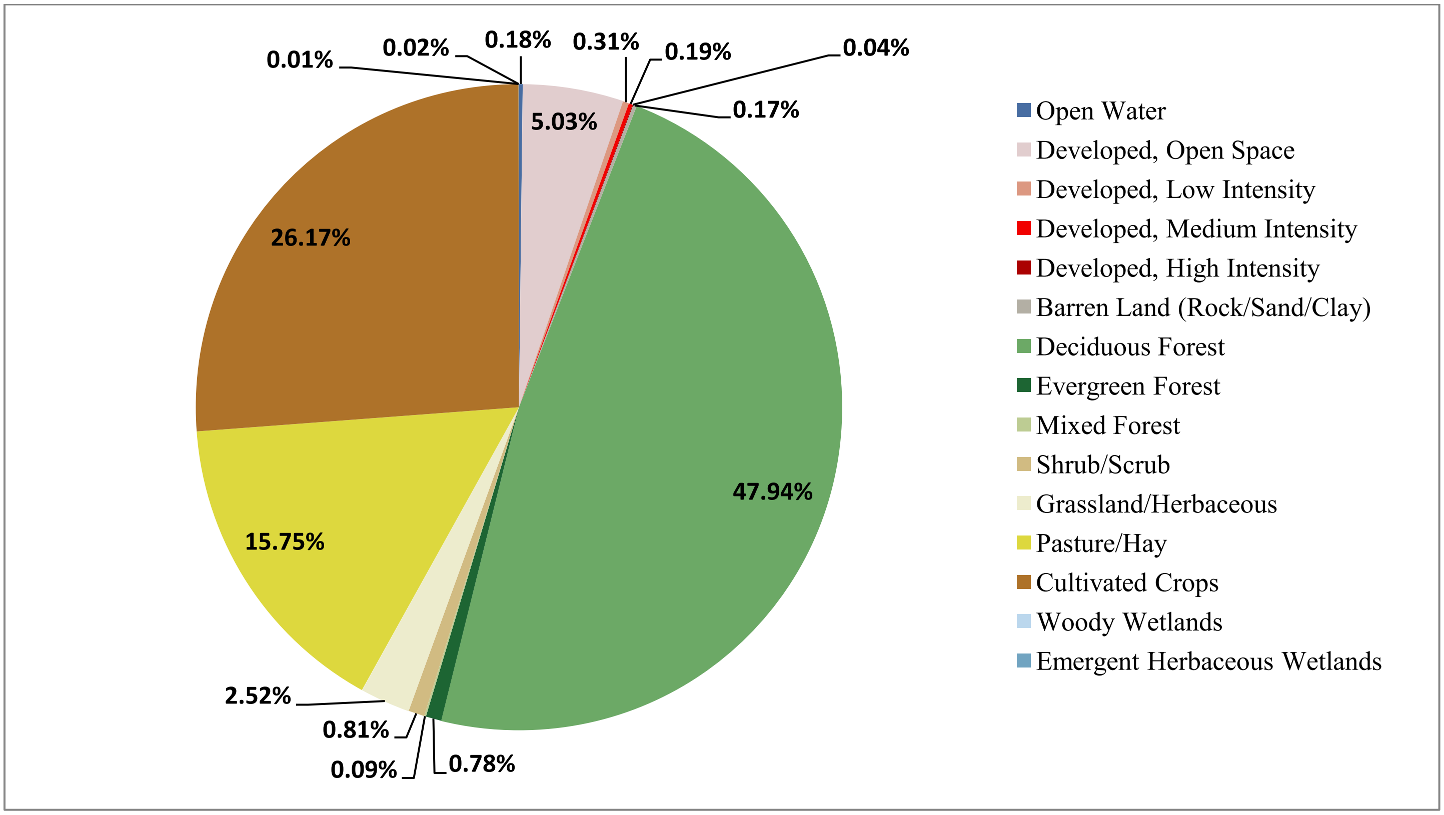


Figure 19: Lost River Watershed Land Use Percentage Graph

Table 7: Land Use Acreage and Percentage- Values from in 2001 and 2006 plus land use change

	2001		2006		Change	
	(acres)	% of total	(acres)	% of total	(acres)	↑ or ↓
Open Water	371.4	0.2%	432.3	0.2%	60.9	gain ↑
Developed, Open Space	11,762.8	5.0%	11,788.1	5.0%	25.3	gain ↑
Developed, Low Intensity	733.4	0.3%	716.1	0.3%	17.3	loss ↓
Developed, Medium Intensity	424.2	0.2%	444.9	0.2%	20.7	gain ↑
Developed, High Intensity	93.7	<0.1%	90.8	<0.1%	2.9	loss ↓
Barren Land (Rock/Sand/Clay)	358.0	0.2%	405.3	0.2%	47.3	gain ↑
Deciduous Forest	111,623.2	47.7%	112,262.9	47.9%	639.7	gain ↑
Evergreen Forest	1,897.8	0.8%	1,833.0	0.8%	64.8	loss ↓
Mixed Forest	239.8	0.1%	202.5	0.1%	37.3	loss ↓
Shrub/Scrub	2,073.3	0.9%	1,888.9	0.8%	184.3	loss ↓
Grassland/Herbaceous	6,008.9	2.6%	5,899.4	2.5%	109.5	loss ↓
Pasture/Hay	37,479.9	16.0%	36,871.1	15.7%	608.8	loss ↓
Cultivated Crops	61,057.6	26.1%	61,269.3	26.2%	211.7	gain ↑
Woody Wetlands	24.0	<0.1%	20.4	<0.1%	3.6	loss ↓
Emergent Herbaceous Wetlands	13.6	<0.1%	36.4	<0.1%	22.9	gain ↑
Total	**234,161.5**		**234,161.5**		**0.0**	

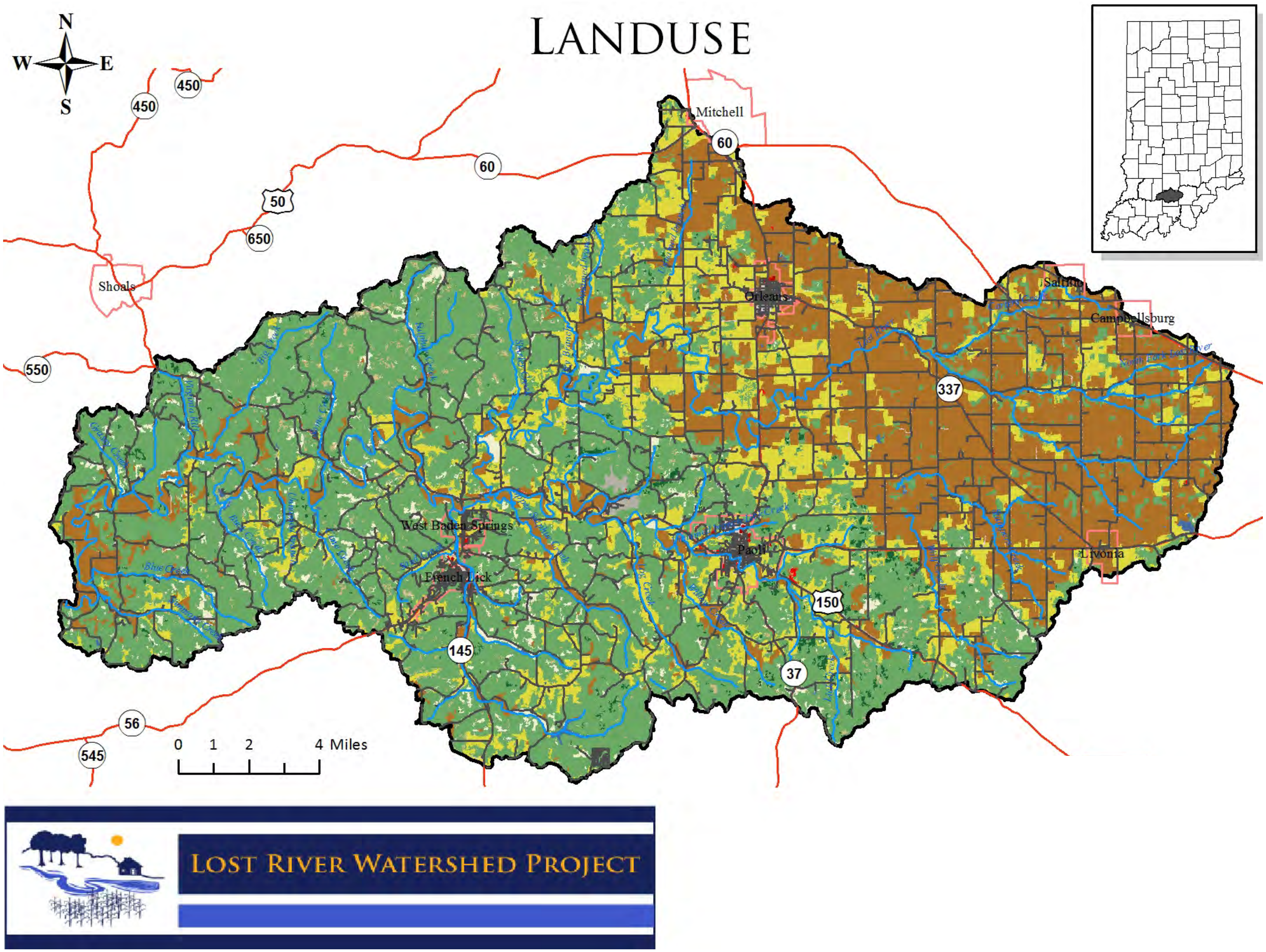


Figure 20: Landuse in Lost River Watershed (2006)

3.2.1 Open Space

Open space makes up 11,788.13 acres within the watershed. This area includes roads and paved areas along with areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes. These areas are increasing in the watershed. From 2001 to 2006, 25.3 acres of the watershed transitioned to open space. Watershed stakeholders are concerned with increasing the amount of urban and open spaces developing in the watershed without practices in place to control increases in runoff from some of the new impervious surfaces.

3.2.2 Wetlands

Wetlands make up 20.44 acres classified as woody wetlands and 36.44 acres classified as emergent herbaceous wetlands. A total of 432.29 acres are open water in the 2006 National Land Cover Dataset (NLCD) of Lost River watershed. This is in sharp contrast to the 3,084 acres that US Fish and Wildlife National Wetland Inventory calculated as wetlands and waterbodies within the Lost River watershed. Likely, the National Land Cover Dataset is under calculating wetlands in the watershed. This may be due to the spatial resolution used within this dataset of 30 meters. Just under 50% of the emergent wetlands in the area are less than 30 meters squared in size. At least 46 acres of wetlands are missed in this dataset.

3.2.3 Forested Areas

Forested landuse makes up a total of 114,298.43 acres within the watershed. Of this, 112,262.90 acres is of the deciduous forest, or broadleaf type, 1,833.04 acres is evergreen forest, and 202.49 acres is mixed forest. From 2001 to 2006, deciduous forest grew by over 600 acres, this will likely help to improve both water quality and wildlife habitat. Forestland growth may be due to management and acquisition of lands by US Forest Service's Hoosier National Forest, but also likely to the increase of forestland due to other federal, state, and local programs. As of 2011, Hoosier National Forest owns and manages over 22,000 acres within the Lost River watershed. This land is mainly forested, but they also maintain wetlands, early habitat successions, along with recreational lands.

Tree species that are most common to the Lost River watershed area include white oak, red oak, black oak, shagbark hickory, pignut hickory, yellow poplar, black cherry, sugar maple, American beech, black walnut, black gum, sycamore, sassafras, and persimmon with minor amounts of species such as American elm, red elm, blue beech, boxelder, dogwood, REC, hackberry honeylocust, ironwood, mulberry, Ohio buckeye, paw paw pin oak, redbud, scarlet oak, shingle oak, spicebush sweet gum, and willow. White Ash is also common but under severe threat from the Emerald Ash Borer (EAB). Softwood species are not native to the area (except eastern red cedar and bald cypress), but have been planted on many old fields over the last 80 years and include white pine, red pine, shortleaf pine, and Scots pine.

The majority of the timber harvesting is done on private lands without the aid of a professional forester, and management work such as proper tree selection (for harvest) and Timber Stand Improvement (TSI) is not practiced on most of these woodlands. Most of the timber companies have had at least one crew member trained on proper felling and skidding techniques as well as Best Management Practices (BMP's), although not all companies utilize the training.

Forest management programs are available through DNR and other agencies to help people manage their forests for timber, wildlife, or recreation. Through government sponsored cost-share programs, private landowners are employing more TSI work such as thinning of stands and grapevine and invasives control. Tree planting is underutilized at this time, partly due to the increase in crop prices. Information is available to landowners about using BMP's, although it appears that most non-forester involved timber sales have BMP's used only when the harvester is conscientious about the work done in the woods. Trails may or may not be closed out properly depending on the harvester and the wishes of the landowner.

Lumber and logging is a major source of revenue to the people of the area. Watershed stakeholders are concerned about the mismanaged timber harvest in the area, and its effects on our forests, habitat, and water quality.

3.2.4 Agricultural Lands

Agricultural lands are primarily on the eastern portion of the watershed in the Mitchell Plain and along river and stream valleys. Agricultural lands make up 98,140 acres within the watershed. Cultivated crops take up 61,237 acres, while pasture and hay make up the other 36,856 acres. Twenty-six percent of the Lost River watershed is cultivated crop land. Farming within the watershed consists primarily of small grains along with some pasture and hay lands. As with most agriculture production in the Midwest, the diversity of crops grown has shrunk dramatically. Cultivated areas are typically kept in a corn-soybean rotation. A minor percentage of that area is kept in a corn-wheat-soybean rotation or corn-soybean-tobacco rotation.

Commercial fertilizer use in this area is split between the use of urea and liquid nitrogen at 32%. An average of 150-180 units per acre of nitrogen is applied in the spring or fall with sidedress use when needed. Phosphorus and Potassium is applied at an average rate of 250 pounds per acre. Approximately 15-20% of crop ground takes poultry litter or manure as the primary fertilizer with this number to likely increase to 40-50% in the next few years. The addition of poultry farms in the area make this a low cost alternative to increasing commercial fertilizer costs. Application of municipal wastewater sludge is restricted to one owner/operator in the Orleans area. This landowner uses the sludge from the Orleans Wastewater Treatment Plant for fertilizer additions to their operation.

Amish farming is prevalent in many areas within the watershed, as well. They are typically known for tilling in conventional fashion using a horse and till set-up. Amish croplands are grazed once a crop is harvested. There is a desire to teach these communities different practices to help diminish the concerns surrounding runoff from these fields. A more promising growing trend in the area is small homestead organic farms. These farmers use the sustainable diversified farm school of thought. They are interested in getting as much out of the land while putting as much back into the land as they take out. With the lack of programs to fund smaller farming operations, they are not as able to get monetary assistance for developing conservation plans on their farms. With growing numbers of smaller homestead farms, programs directed toward this under-represented niche is a concern of the watershed stakeholders. There may be some need for education on buffers and storage facilities for smaller farms in the area.

Local adoption of conservation tillage practices within the watershed is well above the Indiana median for three of the five counties (Table 8). Some of the larger farmers in this area that have moved into no-till farming have found the long term benefits to no-till. Others are still reluctant to adopt this method of planting. The farmers who do no-till are interested in sharing their knowledge with current 'non-believers' in the area to encourage more conservation minded farming.

Table 8: Tillage Practices- Tillage transects data for counties within Lost River watershed (Source: ISDA, 2011)

Crop	Conventional Tillage	Reduced Till	Mulch Till	No Till	No Till Acreage	Total Acreage	Cultivated Acreage in Lost R. Watershed
				Corn			
Orange	13%	6%	13%	69%	14,400	21,100	19,366.1
Washington	5%	6%	8%	82%	32,200	39,700	7,537.4
Martin	23%	17%	28%	32%	5,100	16,000	2,396.4
Lawrence	9%	3%	4%	84%	14,300	17,000	1,342.9
Dubois	44%	7%	9%	40%	21,800	54,500	27.9
				Soybean			
Orange	10%	3%	6%	80%	17,000	21,000	19,288.8
Washington	3%	9%	5%	84%	34,100	41,000	7,782.5
Martin	5%	5%	31%	59%	7,600	12,800	1,913.6
Lawrence	18%	14%	4%	63%	14,400	22,600	1,557.5
Dubois	26%	8%	12%	54%	25,300	46,800	23.9

3.2.5 Mining

Mining takes two forms within the watershed. Currently three gravel mines within the watershed occupy a total of 412.1 acres. Remnants from past coal mining is the second type of mining found in the area. This mining was in the past and the extent is unknown at this time. Coal mines took the form of backyard mines, or gopher holes, and most were likely not permitted through local agencies because of the location, the timing, or the small extents. There are 705.7 acres of known abandoned mined land that contribute to drainage within the Lost River Watershed. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 addresses the water-quality problems associated with acid mine drainage and requires that extensive information about the probable hydrologic consequences of mining and reclamation be included in mining-permit application so that the regulatory authority can determine the probable cumulative impact of mining on the hydrology. Acid mine drainage is a result of coal containing iron sulphates exposed to air and water. The air and water oxidize the iron sulphates in the coal and cause leaching of acidic water high in iron and sulphur. Water with these features are harmful to local stream ecology along with wildlife in the area. Acid mine drainage has been identified in two locations within the watershed. Stakeholders are concerned over the presence of acid mine drainage and its effect on the water quality and habitat in the watershed.

3.2.7 Recreation

Green spaces, golf courses, and athletic fields make up a fraction of a percent of the watershed. Most of these areas have lawn or turf that is highly managed greens with the use of chemical fertilizers and pesticides. There are three golf courses within the watershed. The Paoli Country Club Golf Course is located on the east side of Paoli and is within the Headwaters of Lick Creek subwatershed. The Donald Ross Course and Valley Links Course at French Lick Resort are located within the French Lick subwatershed along with the Pete Dye Golf Course.

One exception to the standard management of green space within the watershed is on the newly developed Pete Dye Golf Course. The Pete Dye Golf Course is working toward an Audubon Society Golf Course Certification Program to protect the environment, conserve natural resources, and provide wildlife habitats. Achieving certification demonstrates the course's leadership, commitment, and high standards of environmental management.

3.2.8 Developed Areas

Development increases impermeable surface in the watershed consequently resulting in greater runoff volumes and possible higher pollutant concentrations. Notable impacts to water quality occur with as little as 10% watershed impervious cover, which can be obtained with as little as one house per 2 acres. Watershed impervious cover greater than 25% indicates a high probability that streams will be impaired for aquatic life use (Center for Watershed Protection, 2003).

Officials from the towns and small communities in the area consider development stable in their communities, with the exception of the Town of French Lick. The addition of the Casino to the area has increased the diversity of businesses that have moved into the area. Many new businesses have started to build, or taken over old buildings. The local Rule 5 permitting process oversees this growth and measures are in place to protect the water and sediment on site. Continued expansion on the hilly terrain is of concern for watershed stakeholders, as they believe that the growth will encourage more logging of the area, and cause additional sediment to erode to the streams and basin. Also of concern is the additional flooding that occurs when growth takes place within a floodplain.

Towns in the area have a large amount of residential land along with businesses and some industry. Residential properties in these areas are typically ¼ to ½ acre in size with single-family residences. Most residences in the area take pride in well-maintained lawns and may be over using fertilizers to maintain these areas. There is a concern that most residences misuse fertilizer applications and may be contributing to high nutrient loads to the area streams. Domestic pets in the area may be contributing to high bacteria counts within local streams. Stakeholders are concerned that non-domesticated strays may be also contributing to problems. Reports of high amounts of stray dogs are present in the French Lick and West Baden Springs areas. Stray cats have been seen in many areas of Paoli and may be posing an issue there.

Towns in the area are not large enough in size or population density to be included in the Municipal Separate Storm Sewer System (MS4) program. Storm water runoff from urban areas is a concern of watershed stakeholders in the area. Current stormwater is not treated before discharge in most towns but are separate from the sewage water. The Town of Paoli is the only combined sewer system in the watershed. They have developed a long term control plan to upgrade their system and disconnect the storm and sewer system when funds become available.

Zoning only occurs within the town boundaries of Orleans, French Lick, and West Baden. Discussions have begun about zoning within Paoli and a planning board has been formed for the Town of Paoli. The rest of Orange County along with the surrounding Counties of Martin, Washington, and Lawrence have no zoning plans in place. There are no county master plans or any other planning efforts. The reasons surrounding the lack of zoning stem from projects proposed in the past that suggested eminent domain could be used to take peoples' land for the good of the community. This started a long-term feeling that government interference in the lands of the people was undesirable. Planning has a hard time getting past the stage of making suggestions at county and town meetings. No serious planning effort has been made in regards to land use or development within the watershed.

Even with the sensitive karst lands below, no groundwater protection plan or source water protection plan is in place in the area. Drinking water for many of the developed areas is obtained from Patoka Lake to the south. Drinking water for the towns of Paoli, Orleans, Orangeville and Livonia come from Patoka Lake. Water is piped far distances for use as drinking water. The Town of French Lick and West Baden did withdraw water from Lost River as a drinking water source until Fall of 2011. The town decided to switch to Patoka Water due to the lack of funds to update their outdated water treatment plant. They also saw that Lost River was degrading in quality and they needed to look for alternatives. The cost benefit of hooking up to water lines from Patoka Lake Regional Water and Sewer District outweighed the cost benefit of updating the old plant and treatment of a degrading Lost River. The towns of Saltillo and Campbellsburg both get their water from wells drilled south of town within the watershed. Groundwater protection is desired by the rural residences that are out of reach of the current water conveyance system. These landowners and residents rely on water from wells and springs. The water from wells and springs are intimately connected to the stream water and watershed in the area. Residents relying on spring water from this area should always have their water tested before using as drinking water.

3.2.9 Transportation

Transportation in and out of the watershed is mainly on state and interstate highways that cross the watershed from north to south and southeast to northwest. Five highways are present within the watershed. This includes U.S. Route 150 which runs from U.S. Route 6 outside of Moline, Illinois to U.S. Route 25 in Mount Vernon, Kentucky. Locally travelers from Shoals to Paoli and down to Palmyra take this route. Indiana State Road 56 is a route that travels the south central part of the state from west to east. It travels through Paoli, West Baden, and French Lick on its way to Salem in the east and Jasper in the west. US Route 150 and State Road 56 are the same road from Paoli to French Lick. Indiana State Road 37 is a major route in Indiana, running as a 4-lane divided highway until it reaches the watershed edge in Mitchell then it narrows down to a 2-lane highway for the rest of its journey south. As of 2011, State Road 37 is under construction and will be upgraded to a super 2 highway within 3 years. By 2014, the length of State Road 37 from Mitchell to Paoli will have extra wide shoulders to help improve mobility and improve safety. The stormwater runoff from this highway will be directed into in-sinkhole treatment areas and roadside ditches throughout the extent of the expanded roadway. The in-sink treatments are designed with reverse grade fill and filter fabric to reduce the contaminants from the roadways. The northern section of State Road 337 begins in Orleans, where it is concurrent with East Washington Street. Upon reaching the east edge of town, the road begins winding to the southeast. It passes through the small community of Bromer and terminates at State Road 56 just west of Livonia. It covers a distance of about 12 miles (19 km). State Rd 145 runs north from Tell City and terminates at State Road 56 in French Lick.

Section 4 – Current and Historical Data

To evaluate the watershed, an inventory and assessment of the watershed and existing water quality studies conducted within the watershed is necessary. Examining previous efforts allowed the project participants to determine if sufficient data was available or if additional data needed to be collected in order to characterize water quality problems. The following sections detail the water quality and watershed assessment efforts in a focused manner.

4.1 Water Quality Targets

When evaluating anything, standards have to be set in order to evaluate whether the target is acceptable or unacceptable. This is even more important if the evaluation is using data from various different sources. In evaluating the water quality in the Lost River watershed, a set of water quality standards need to be set that represent the desired outcomes. Concerns discussed previously surround three general themes: recreation potential, full body contact, wildlife habitat, and well and spring drinking water protection. These themes all require different levels of standards. Wells and spring water are intimately connected to surface waters in the watershed. The standard for this use is the most important, but also the most strict. Trying to clean the stream to a drinking water standard without the assistance of filtration is unlikely. Therefore, for developing target water quality levels, levels are set at a target that would be more representative of a full body contact or aquatic habitat standard. Benchmarks for indexes are set to represent the level wildlife need to thrive. Table 9 details the water quality targets and benchmarks utilized to evaluate collected water quality data.

Table 9: Water Quality Targets for Measured Parameters

Parameter	Target	Reference
pH	> 6 and < 9	Indiana Administrative Code (327 IAC 2-1-6)
Temperature	Monthly standard	Indiana Administrative Code (327 IAC 2-1-6)
Dissolved oxygen	> 4 mg/L and < 12mg/L	Indiana Administrative Code (327 IAC 2-1-6) & Consolidated Assessment and Listing Methodology (CALM)
Biochemical Oxygen Demand 5-day	< 2 mg/L	University of Wisconsin (2011)
E. coli	< 235 cfu (or MPN) /100 mL	Indiana Administrative Code (327 IAC 2-1.5-8)
Nitrate-nitrogen	< 1.5 mg/L	Dodds et al. (1998)
Nitrite	< 1 mg/L	Indiana Administrative Code (327 IAC 2-1-6)
Total phosphorus	< 0.07 mg/L	Dodds et al. (1998)
Orthophosphorus	< 0.05 mg/L	Dunne and Leopold (1978)
Total suspended solids	< 25 mg/L	Waters T.F. (1995)
Turbidity	< 25 NTU	Minnesota TMDL criteria (2001)
Salinity	< 2 ppt	Nielsen et al (2003)
Conductivity	> 150 and < 1500 µs/cm	US EPA (2011)
Qualitative Habitat Evaluation Index	> 51 points	IDEM (2008)
Index of Biotic Integrity	> 36 points	IDEM (2008)
Pollution Tolerance Index	>16 points	Hoosier Riverwatch (2012)

4.2 Available Monitoring/Resource Data

Water quality, habitat, physical and biological data used in the assessment of the Lost River watershed is from various sources, with varying degree of intensity. All data used to evaluate the watershed, followed Indiana State Standard Protocols for data collection. Historical data used to evaluate the watershed is limited to 15 years in age. Data older than that is eliminated from this evaluation because it does not represent current landuse, practices, or status of the watershed. Data older than 5 years is only used in trend or reference data.

Data used in the assessment and inventory of the watershed and water quality studies include findings from:

Current water quality Monitoring

- Lost River Watershed Team macroinvertebrate sampling, habitat assessment, physical and chemical monitoring;

And Historic water quality monitoring

- Indiana Department of Environmental Management (IDEM) water quality monitoring data;
- Indiana's 303(d) listing of impaired streams and waterbodies;
- NPDES violation data;
- USGS National Water Quality Assessment-National Water Information System;
- Lost River Watershed Final Water Quality Monitoring Study (2006, LARE study of Dry Branch Lost River);
- Watershed Diagnostic Study: Lost River Watershed (2010, LARE study of lower Lost River in Martin, Orange, and Dubois Counties); and
- Springs Valley Fish Management Report (2009, Indiana DNR, Department of Fish and Wildlife).

4.2.1 Current Water Quality Data

This section summarizes water quality data that was collected as part of the Watershed Management Plan development process. Factors influencing water quality in the watershed observed via windshield and desktop surveys as part of the Watershed Management Plan development process, as well as, through regulated land use activities are also discussed. Data presented and discussed here is for the entire Lost River watershed as a whole. Data analysis relevant to12-digit HUC subwatersheds can be found in Section 5.

Lost River Watershed Team Sampling

Macroinvertebrate collection, Habitat assessment, Physical and Chemical monitoring

Hoosier Riverwatch Lost River Team (HRLR) along with a contracted laboratory (Lab) collected water samples at 27 locations throughout the watershed (Figure 21). Water samples were collected on a monthly basis from June 2011 through May of 2012. Fourteen of the 27 sites, Site 1 through Site 14, the Lab monitored pH, dissolved oxygen, temperature, salinity, conductivity, nitrate (as N), turbidity, total suspended solids, total phosphorus, and *E.coli*. Of these parameters, temperature, dissolved oxygen, and pH were determined in the field using equipment designed to measure parameters in the field. The remaining parameters were analyzed in the professional laboratory. Meanwhile, HRLR Team collected data at 13 sites using alphabetic labels (Site A through Site M) for pH, dissolved oxygen, 5-day biochemical oxygen demand (BOD5), temperature, orthophosphate, flow, nitrate (NO3), nitrite (NO4), turbidity, *E.coli*, and general coliforms. These parameters were collected in the field, only BOD5 and E. coli required further analysis in the office lab.

Macroinvertebrates were collected once from 26 of the 27 stations. One station (Site M) was dry from July through October making it impossible to collect chemistry or macroinvertebrate data. Commonwealth Biomonitoring collected macroinvertebrates from 14 stations, and they analyzed the results using the mIBI index. At the other 13 stations, HRLR collected macroinvertebrates using Hester-Dendy's and dip nets in October of 2011. The HRLR Team using the Pollution Tolerance Index analyzed the macroinvertebrates to determine aquatic quality for each site. Habitat data collected at each sampling location was analyzed using some form of the Qualitative Habitat Evaluation Index QHEI method. HRLR Team used the Citizens QHEI while the contractor used the Ohio EPA method for QHEI.

Results from water quality sampling are compared at a watershed scale for baseflow and stormflow measurements in this section. Individual site data obtained through this monitoring study will be discussed in more detail within the subwatershed discussion in Section 5.

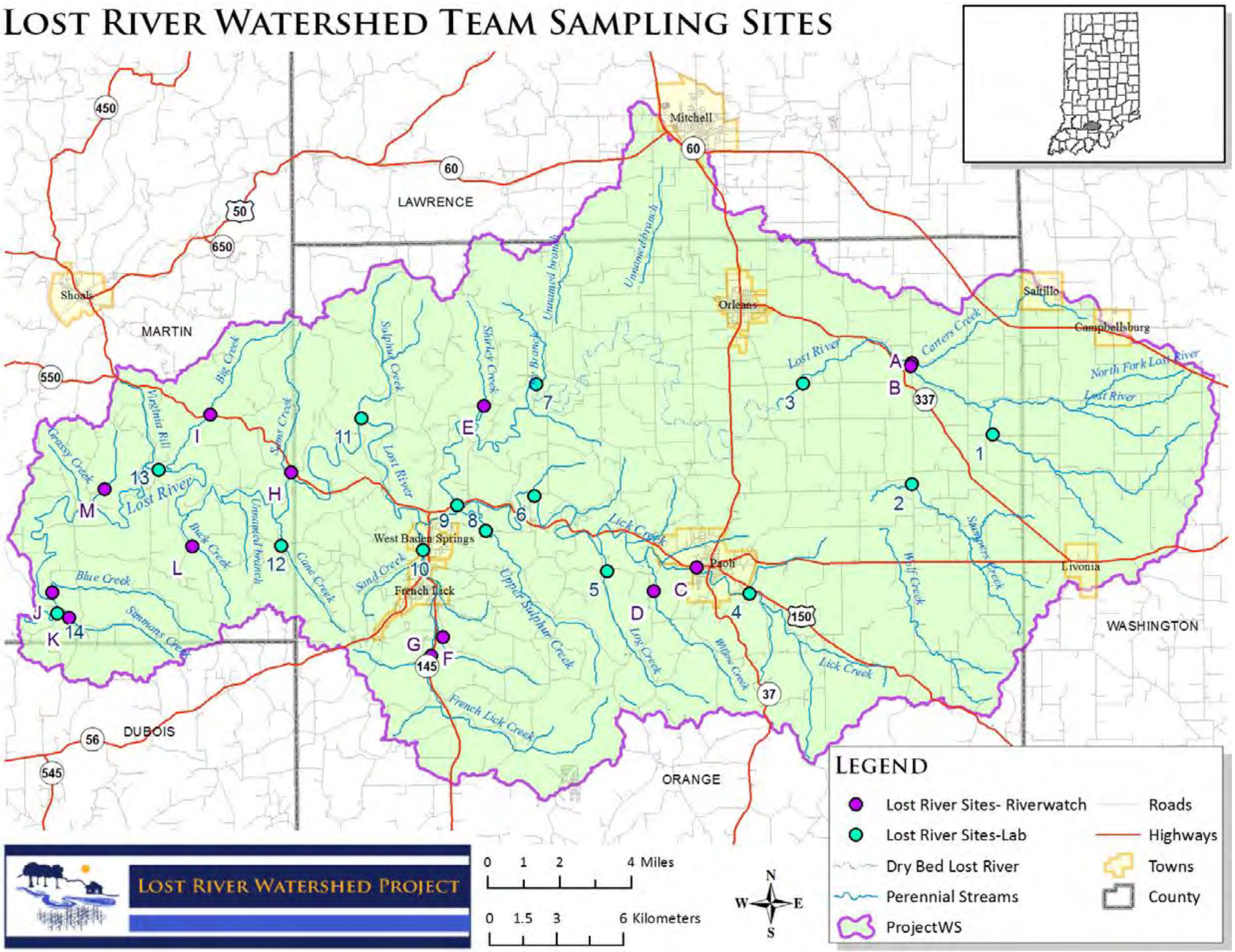


Figure 21: Lost River Watershed Team Sampling Locations for current monitoring

4.2.1.1 Nitrogen

Nitrogen is one of earth's atmosphere most abundant elements. About 80 percent of the air we breathe is nitrogen. It is found in the cells of all living things and is a major component of proteins. Inorganic nitrogen may exist in the free state as a gas N^2, or as nitrate NO^{3-}, nitrite NO^{2-}, or ammonia NH^{3+}. Organic nitrogen is found in proteins and is continually recycled by plants and animals. Bacteria in water quickly convert nitrites [NO2-] to nitrates [NO3-].

Nitrogen-containing compounds are part of the nutrient budget in streams and rivers. Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L). The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L.

Sources of nitrates include animal wastes (including birds and fish), wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, industrial discharges that contain corrosion inhibitors, and discharges from car exhausts.

Nitrates are highly mobile in water and may be carried through soil layers into underground waters. Nitrate derived from fertilizers applied at the surface can leach downwards and contaminate underlying aquifers. Percolating water containing nitrate can also be intercepted by shallow subsurface drainage pipe systems or cave systems and then discharged offsite into streams, rivers, and lakes. This has the potential of having adverse impacts on surface water quality at local, regional, and national scales.

Nitrites can produce a serious condition in fish called "brown blood disease." Nitrites also react directly with hemoglobin in human blood and other warm-blooded animals to produce methemoglobin. Methemoglobin destroys the ability of red blood cells to transport oxygen. This condition is especially serious in babies under three months of age. It causes a condition known as methemoglobinemia or "blue baby" disease. Water with nitrite levels exceeding 1.0 mg/l should not be used for feeding babies. Nitrite/nitrogen levels below 90 mg/l and nitrate levels below 0.5 mg/l seem to have no effect on warm water fish (Kneppa and Arkin, 1973).

There is no current standard for nitrate concentrations in surface water not used as a public water supply. Surface water in Lost River Watershed is no longer used as a public water supply. The only Indiana water quality standards available at this time state that nitrate+nitrite-nitrogen levels in surface water are not to exceed a 30-day average of 10 mg/L at a public water supply intake (327 IAC 2-1-6). The nitrate+nitrite reference condition for USEPA Aggregate Ecoregion IV, Ecoregion 71 is 1.2 mg/L and is based on median nitrate+nitrite concentrations for the top 25th percentile of streams sampled (2000). It has been shown that streams that have available phosphorous will go eutrophic when nitrate levels exceed 1.5 mg/L. For this reason, 1.5 mg/L was set as the upper limit for the nitrate water quality target.

Nitrate levels vary greatly throughout the watershed with lowest average levels occurring during low flow, or baseflow, periods in many of the smaller tributaries (Figures 22 & 23). The tributaries that have average concentrations below target levels during both baseflow and stormflow include:

- Shirley Creek – Site E (Sulphur Creek subwatershed),
- Unnamed Tributary to French Lick Creek – Site F (French Lick Creek subwatershed),
- French Lick Creek – Site G (French Lick Creek subwatershed),

- Sams Creek – Site H (Sams Creek subwatershed),
- Big Creek – Site I (Big Creek subwatershed),
- Blue Creek – Site J (Grassy Creek subwatershed),
- Buck Creek – Site L (Big Creek subwatershed),
- Unnamed Tributary to Lost River – Site M (Grassy Creek subwatershed),
- Log Creek – Site 5 (Log Creek – Lick Creek subwatershed),
- French Lick Creek – Site 10 (French Lick Creek subwatershed),
- Sulphur Creek – Site 11 (Sulphur Creek subwatershed), and
- Cane Creek – Site 12 (Sams Creek subwatershed).

The streams that have average nitrate levels that exceed target levels for both baseflow and stormflow include:

- Carters Creek – Site A (Carters Creek subwatershed),
- Lost River (near Leipsic) – Site B (Carters Creek subwatershed),
- Lick Creek (in Paoli) – Site C (Log Creek – Lick Creek subwatershed),
- Willow Creek – Site D (Log Creek – Lick Creek subwatershed),
- Simmons Creek – Site K (Grassy Creek subwatershed) (only stormflow),
- South Fork Lost River – Site 1 (South Fork subwatershed),
- Stampers Creek – Site 2 (Stampers Creek subwatershed),
- Lost River – Fishers Ford Bridge – Site 3 (Lost River Sink subwatershed)
- Lick Creek (in Pioneer Mothers) – Site 4 (Headwaters Lick Creek subwatershed),
- Lick Creek (near Abydel) – Site 6 (Scott Hollow – Lick Creek subwatershed),
- Orangeville Rise – Site 7 (Log Creek – Lick Creek subwatershed),
- Upper Sulphur Creek – Site 8 (Scott Hollow – Lick Creek subwatershed) (only baseflow),
- Lost River (near Prospect) – Site 9 (Sulphur Creek subwatershed),
- Lost River (Big Creek subwatershed) – Site 13 (Big Creek subwatershed), and
- Lost River (near Outlet) – Site 14 (Grassy Creek subwatershed).

Concentrations measured in the tributary of French Lick Creek (Sites F, G, & 10) generally measure below the target concentration (1.5 mg/L) with nitrate-nitrogen concentrations exceeding the target only once in June of 2011 at Site 10. In Lost River, nitrate-nitrogen concentrations exceed target concentrations at every location sampled (Sites B, 1, 3, 7, 9, 13, & 14) during the sampling period. Nitrate-nitrogen concentrations peaked at 20 mg/L on Lost River near Leipsic during baseflow, which is over ten times the target concentration and twice the level that is toxic to warm blooded animals. These peaks during low flow periods point to the influence that agricultural applications and tile drains may be having the nitrate levels within streams in the areas. Levels like this are of great concern and should be reduced to improve the health of the stream system.

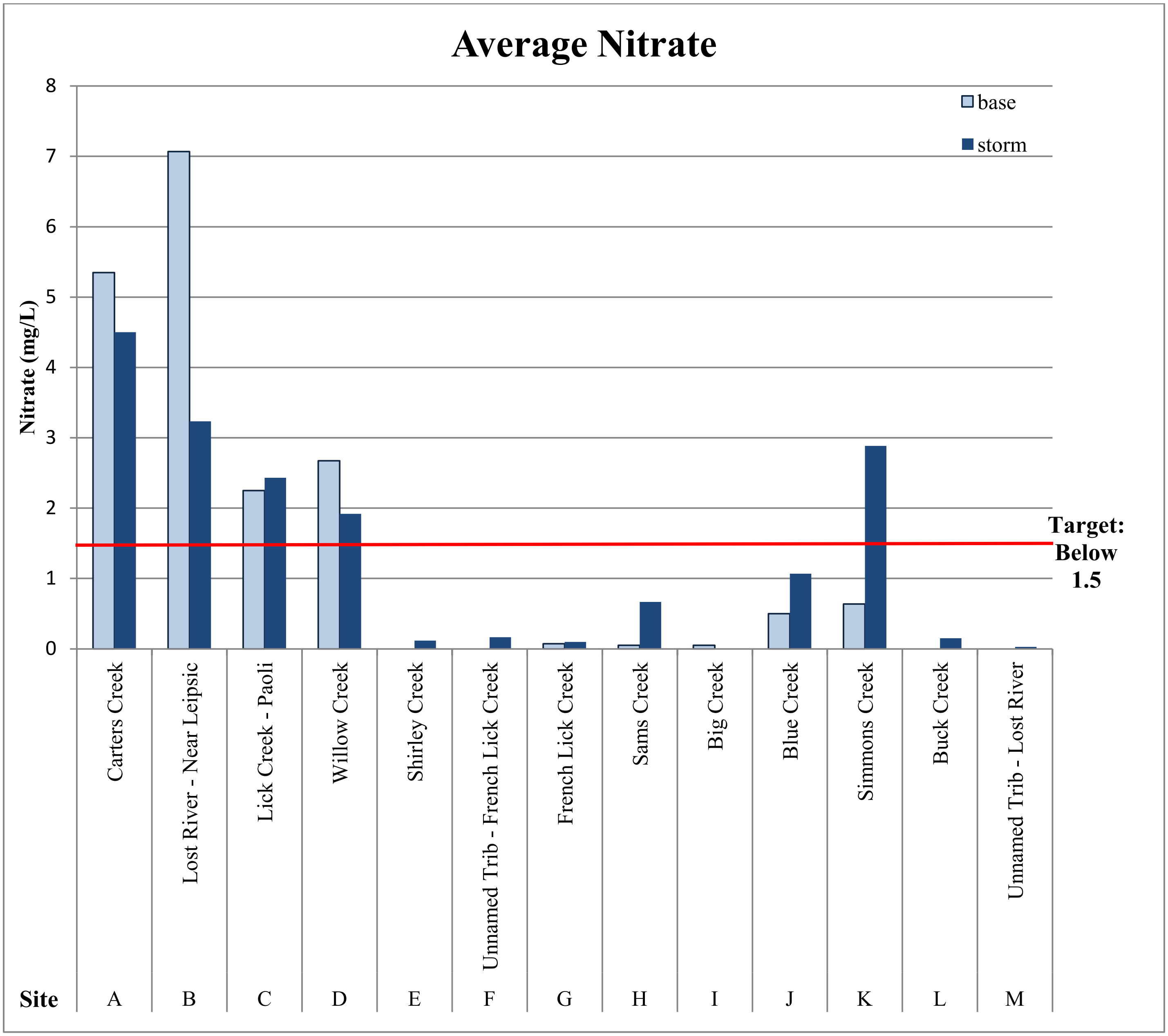


Figure 22: Average Nitrate values at HRLR team sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

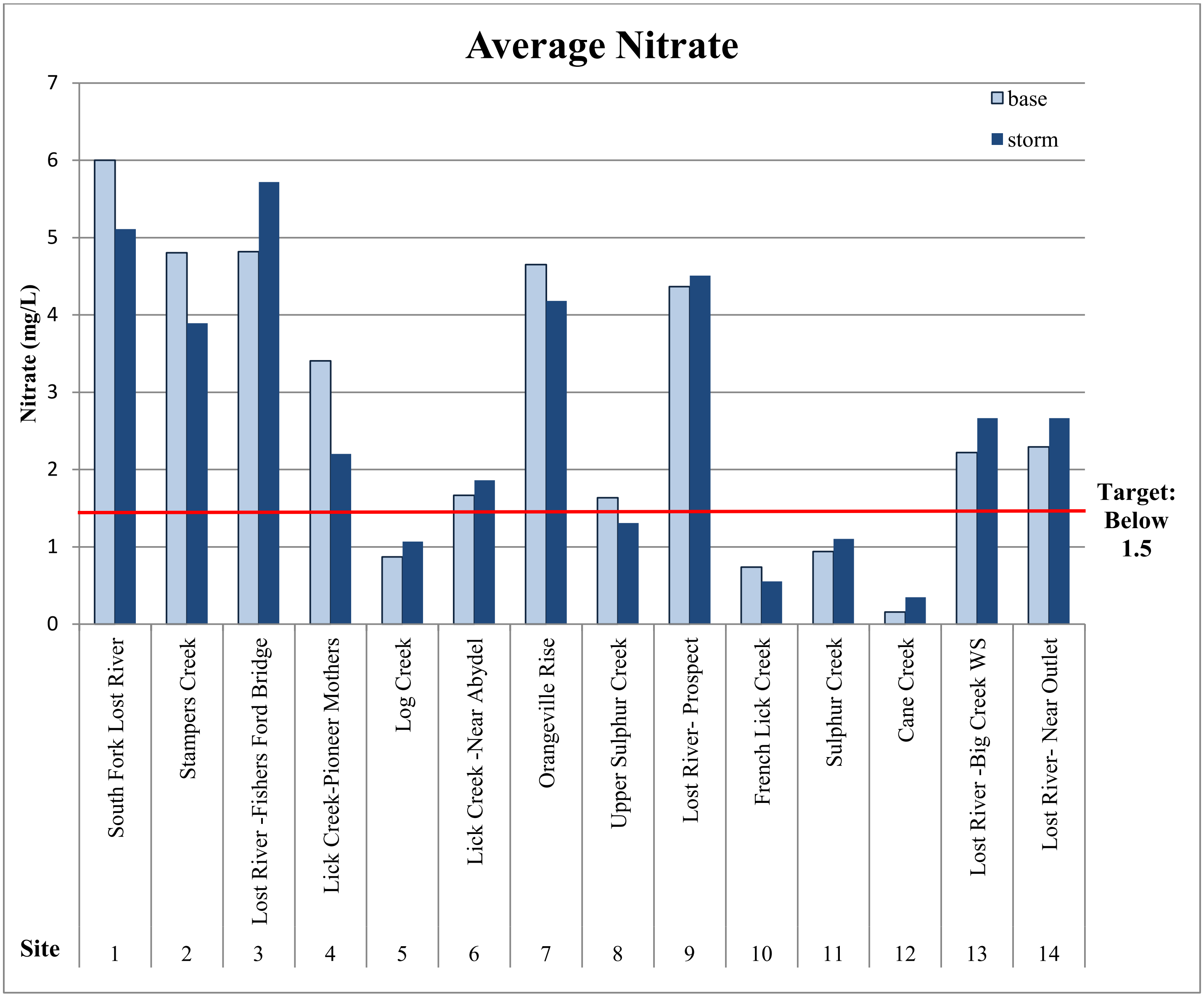


Figure 23: Average Nitrate values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.2 Phosphorus

Phosphorus is a naturally occurring nutrient in aquatic systems. Sources of additional phosphorus inputs include organic wastes such as human and animal wastes, fertilizers, detergents, and industrial wastes. Phosphorus gets into water in both urban and agricultural settings. Phosphorus tends to attach to soil particles and, thus, moves into surface-water bodies from runoff. Phosphorus is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes. This has been a very serious problem in many areas. In many urban areas, phosphorus coming into streams from point sources, primarily wastewater-treatment facilities, have caused many lakes and streams to become highly eutrophic ("enriched"). State laws to reduce phosphorus coming from wastewater-treatment facilities and to restrict the use of phosphorus detergents has caused large reductions in the amounts of phosphorus. Many areas will need to continually expand and upgrade existing wastewater-treatment facilities to handle the increasing volume of wastewater and sewage and to meet stiffer regulations on effluent and river quality. Additional control of phosphorus from non-point sources (such as applications of lawn fertilizers and disposal of animal wastes) may be useful to maintain or improve the water quality in streams and lakes near growing urban areas

Phosphorus is necessary for plant growth and is often the limiting growth factor in aquatic systems. The limiting factor indicates that all other nutrients needed for plant growth are usually readily available in water bodies. When the limiting agent, in this case phosphorus, is added to the system, the plants have all that is needed and start to grow. Excessive amounts of phosphorus result in algae blooms and eutrophication. In an aquatic system, phosphorus cycles through different forms. Analysis of total phosphate levels indicates the potential for future algal blooms and eutrophication by indicating the amount of phosphate that can convert to orthophosphate and be utilized by plants. Measurements of orthophosphate indicate the amount of phosphorus already available for plant growth. Figure 24 shows the breakdown of total phosphorus into its components.

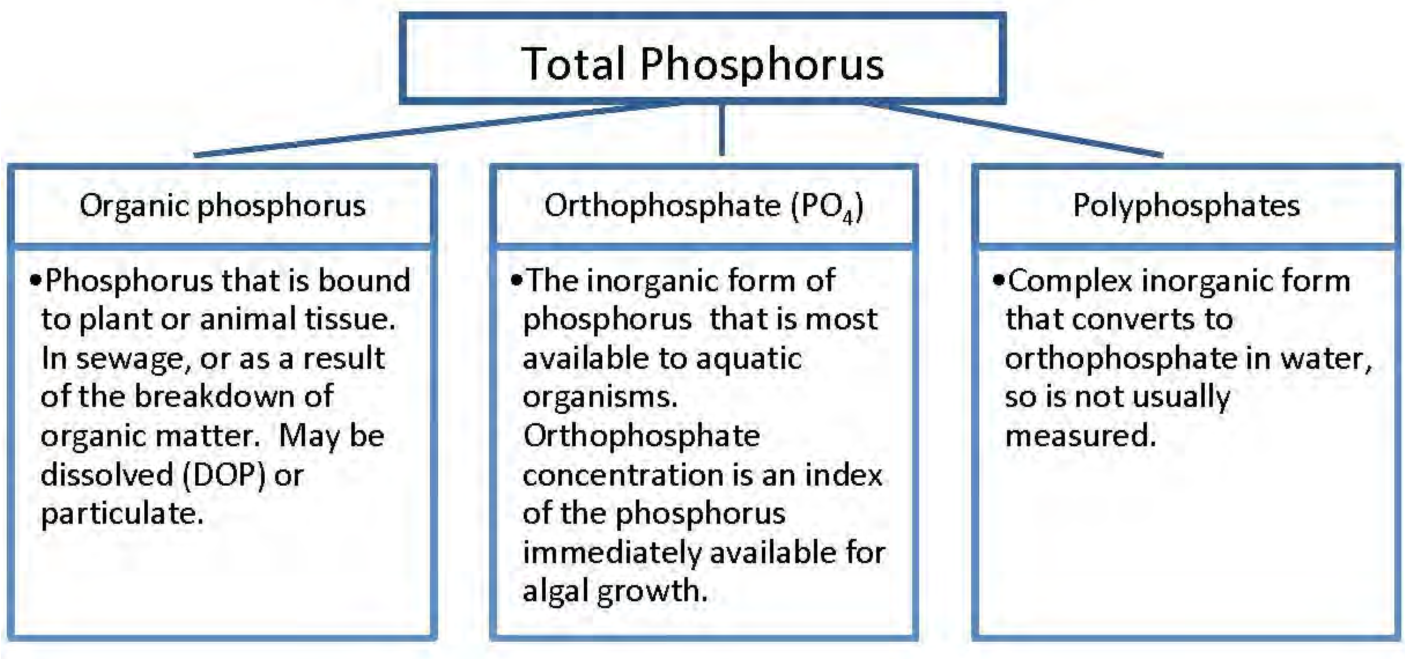


Figure 24: Chemical forms of phosphorus in water (taken from Frankenburger and Esman, 2012)

There is not currently an Indiana water quality standard for total phosphorus. The average total phosphorus value for Indiana waterbodies is 0.05 mg/L. A benchmark set by IDEM states that one or more measurements of total phosphorus greater than 0.3 mg/L coupled with another impairment on the same date allows the waterbody to be classified as impaired (IDEM, 2010c). Ohio Environmental Protection Agency (Ohio EPA) recommends a maximum total phosphorus concentration of 0.08 mg/L to protect aquatic biotic integrity in warm water habitat (IDEM, 2010e). The total phosphorus reference condition for United States Environmental Protection Agency (USEPA) Aggregate Ecoregion IV, Ecoregion 71 is 0.03 mg/L that is based on median total phosphorus concentrations for the top 25th percentile of streams sampled (2000). The dividing line between mesotrophic and eutrophic streams has a total phosphorus concentration of 0.07 mg/L (Dodds et al. 1998) or a orthophosphate concentration of 0.05 mg/L (Dunne and Leopold, 1978) . For this reason, 0.07 mg/L is set as the target concentration for total phosphorus, and 0.05 mg/L is set as the target concentration for orthophosphate in streams within Lost River watershed.

Orthophosphate levels were high in both the average baseflow and stormflow samples at Sites A, B, C, D, J, and K. Sites F, H, and L showed a slight increase during stormflow (Figure 25). When average baseflow levels of orthophosphate exceed average stormflow levels, assumptions can be made that there is some external influence like straight pipe septic systems, discharges by wastewater treatment facilities, chemical fertilizer application over the waterbody, or livestock access to stream channels.

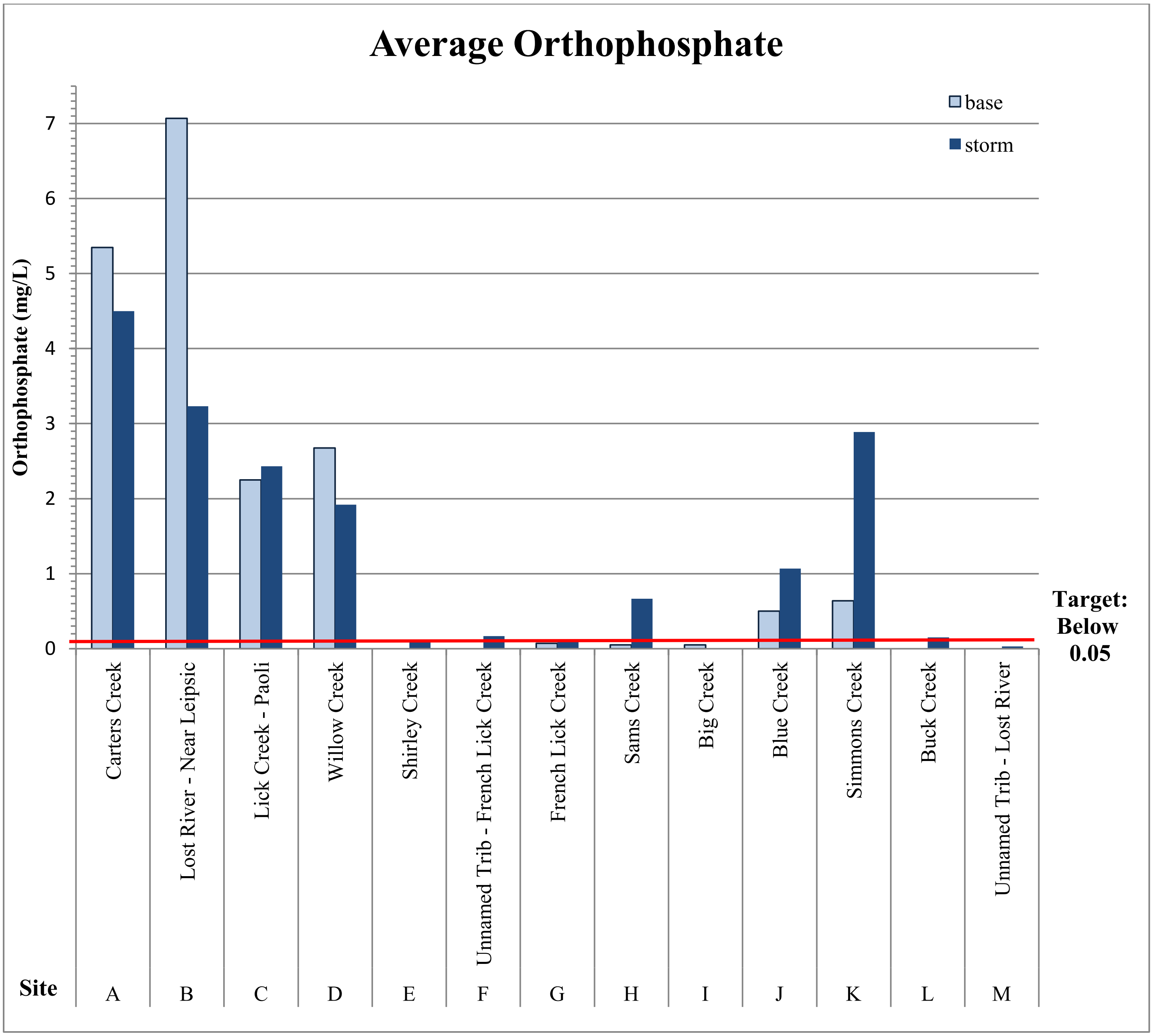


Figure 25: Average Orthophosphate values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

Average baseflow samples collected at Sites 7, 9, and 13 exceeded both target levels and the state average (Figure 26). All but two of the averaged storm flow samples exceeded the target levels for total phosphorus. Log Creek (Site 5) and Cane Creek (Site 12) showed low levels for both baseflow and stormflow. Stormflow levels throughout much of the watershed had high levels of total phosphorus. These values point to the non-point source nature of this nutrient. Phosphorus is carried with sediment into streams during rain periods.

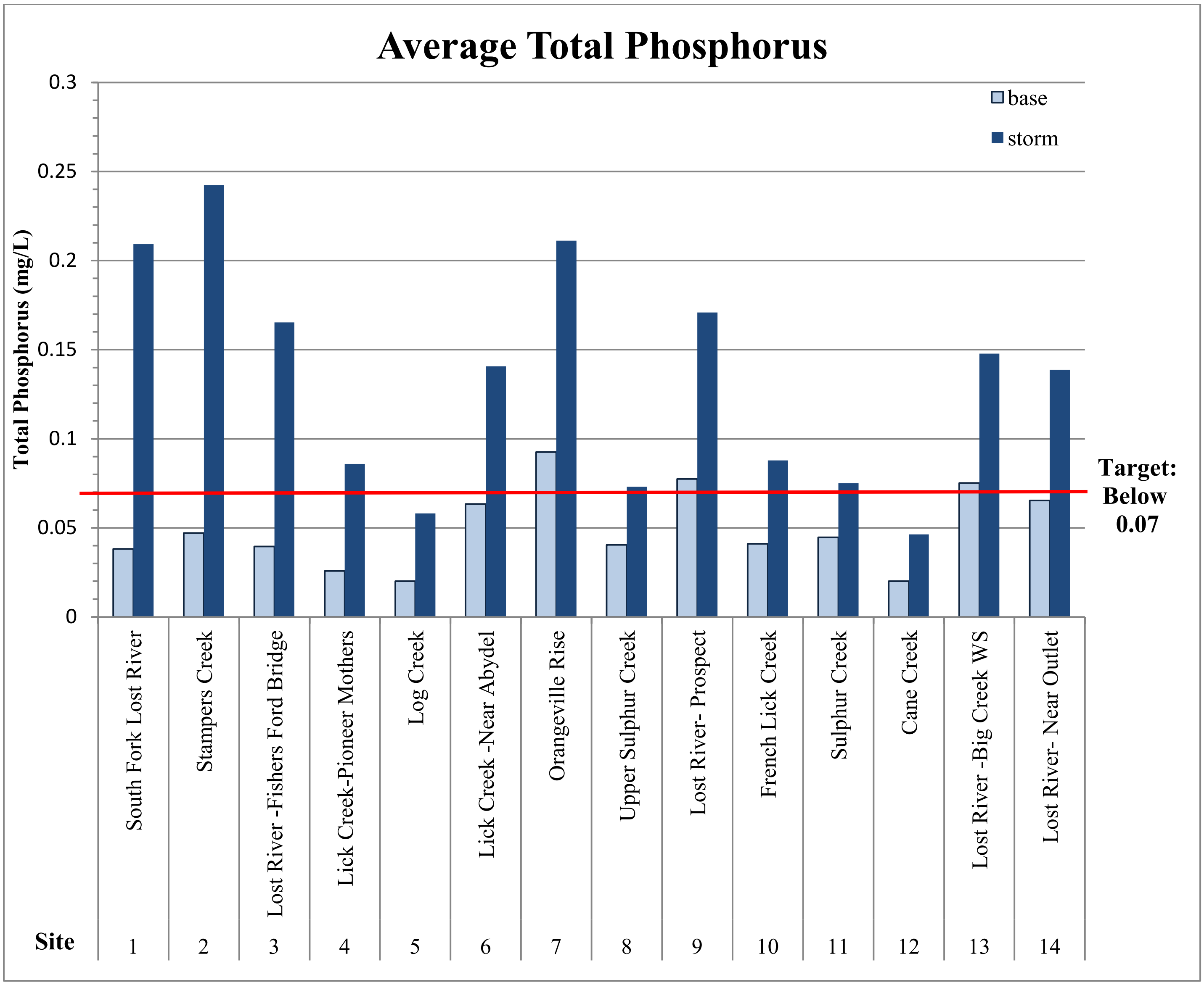


Figure 26: Average Total Phosphorus values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.3 Total Suspended Solids

Measuring the amount of suspended particulate matter in water is important when assessing impacts to aquatic life diversity and habitat. As suspended sediment concentration increases, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen (warmer water holds less oxygen than cooler water). Large quantities of suspended solids can also inhibit sunlight from reaching submerged plants and reduce photosynthesis resulting in less oxygen being released.

Suspended solids can also destroy fish habitat because they settle to the bottom and can eventually blanket the riverbed, smothering the eggs of fish and aquatic insects, and suffocating newly hatched insect larvae. Suspended materials can also harm fish directly by clogging gills, reducing growth rates, and lowering resistance to disease. Changes to the aquatic environment may result in diminished food sources, and increased difficulties in finding food. Natural movements and migrations of aquatic populations may also be disrupted.

The total suspended solids (TSS) measurement provides the weight of particulate material suspended in a water sample including sediment and other particles such as decaying organic matter. TSS concentrations are influenced by stream velocity. The higher the velocity, the larger and greater number of particles a stream can carry. As the velocity of water slows, TSS settle to the bottom of a stream where they can smother aquatic organisms. Solids suspended in the water column can originate from overland surface flow and streambank erosion. IDEM has established a maximum TSS concentration target of 30.0 mg/L; concentrations from 25.0-80.0 mg/L have been shown to reduce fish populations (IDEM, 2010e). Target values set for Lost River watershed are 25 mg/L for Total Suspended Solid concentrations.

TSS measurements were only conducted at the Lab sites. The HRLR team did not have the equipment available to make these kinds of measurements. Average TSS concentrations were below the target value at all sites at the time of baseflow sampling. Sites 3, 5, 8, and 12 were below target levels for baseflow and stormflow TSS, while all other sites exceeded target levels for average stormflow sampling (Figure 27). As the major tributaries, Lick Creek, Lost River upstream of Prospect, and French Lick Creek, are nearing their confluence all three see large spikes in TSS levels during stormflow. Water exiting the spring at Orangeville Rise also has high sediment levels during stormflow periods. The high levels of TSS are also seen at the outlet of Lost River into White River but are more diluted than further upstream.

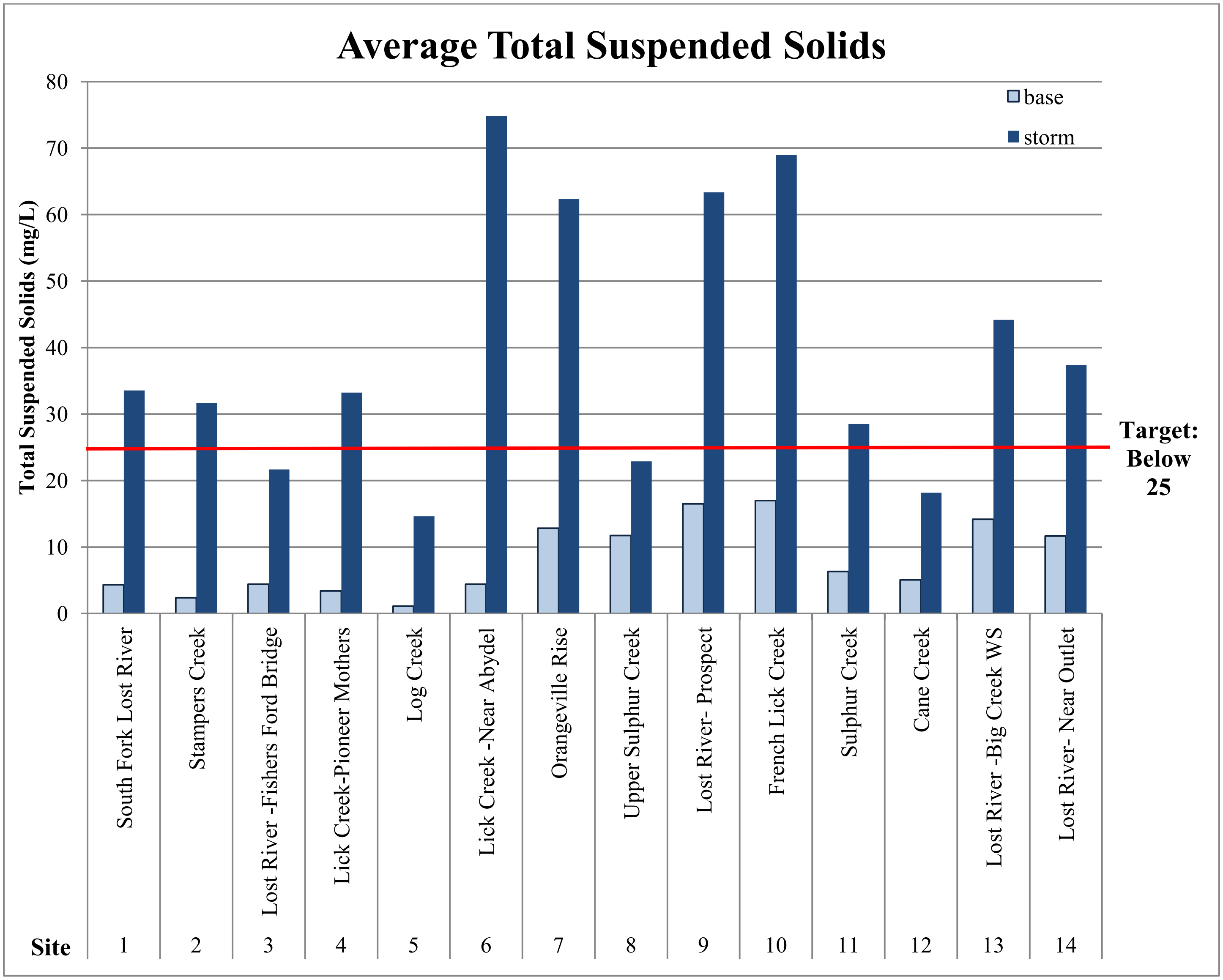


Figure 27: Average Total Suspended Solid values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.4 Turbidity

Turbidity and transparency are both measures of water clarity. Turbidity and transparency are not measures of the concentration of suspended materials in water, but rather their scattering and shadowing effect on light shining through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances, which are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Sources of turbidity include:

- Soil erosion,
- Waste discharge,
- Urban runoff,
- Eroding stream banks,
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments, and
- Excessive algal growth.

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources. Turbidity often increases sharply during a rainfall, especially in developed watersheds, which typically have relatively high proportions of impervious surfaces. The flow of stormwater runoff from impervious surfaces rapidly increases stream velocity, which increases the erosion rates of streambanks and channels. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in or near a stream without erosion control practices in place.

Turbidity is a measure of how much the material suspended in water decreases the passage of light through the water, and is generally measured using a turbidity meter. Transparency measures how far light can penetrate a body of water. Transparency is measured using a transparency tube. Unlike a measure of TSS, turbidity and transparency measurements do not often include heavier particles that settle out quickly. Turbidity is measured in Nephelometric Turbidity Units (NTU). Turbidity levels can be calculated by transforming transparency measurements using a pre-determined relationship to convert transparency results (cm) to units of turbidity (NTUs). The average turbidity value for Indiana surface water is 36 NTU (IDNR, 2008). The turbidity reference condition for USEPA Aggregate Ecoregion VI, Ecoregion 71 is 7.0 NTU, which is based on turbidity concentrations for the top 25th percentile of streams sampled (2000). The top 25th percentile consisted of streams with the lowest turbidity levels. Target levels for turbidity for this project were selected to be 25 NTU.

Turbidity measurements using transparency tubes at the HRLR team sites found only one site, Lick Creek in Paoli, to be above target levels for the average stormflow (Figure 28). All other sites collected by HRLR team were within or just met target levels for both average baseflow and stormflow. However, turbidity measured with a turbidity probe at the Lab sites found that most streams average stormflow was above target levels during the 2011-2012 sampling period (Figure 29). French Lick Creek was also above target levels for average baseflow. This discrepancy may be due to the methods used to measure turbidity, timing of sampling, or differences in streams sampled.

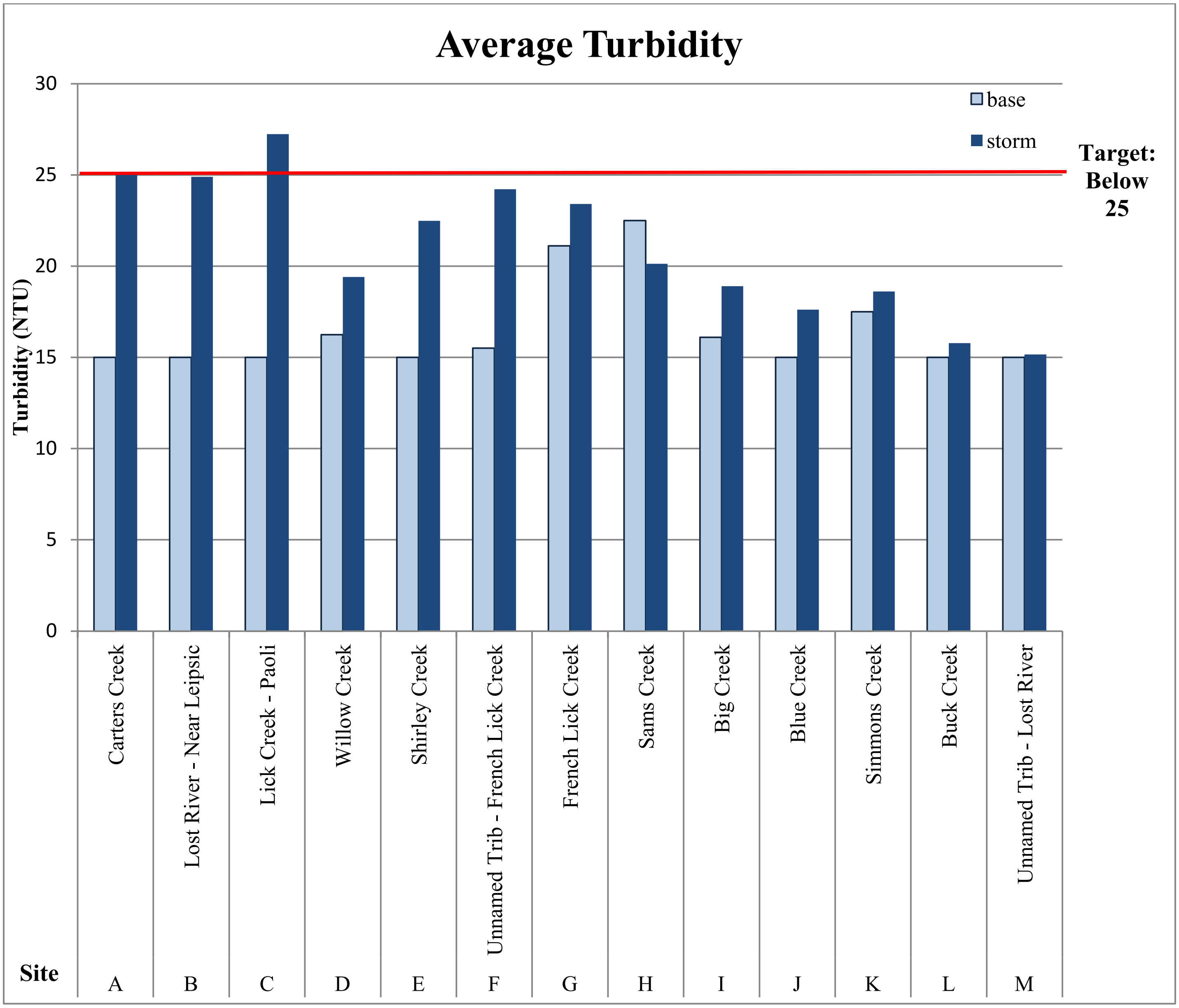


Figure 28: Average Turbidity values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

-Turbidity calculated from transparency measurements. Turbidity under 15 NTU could not be determined using this equipment.

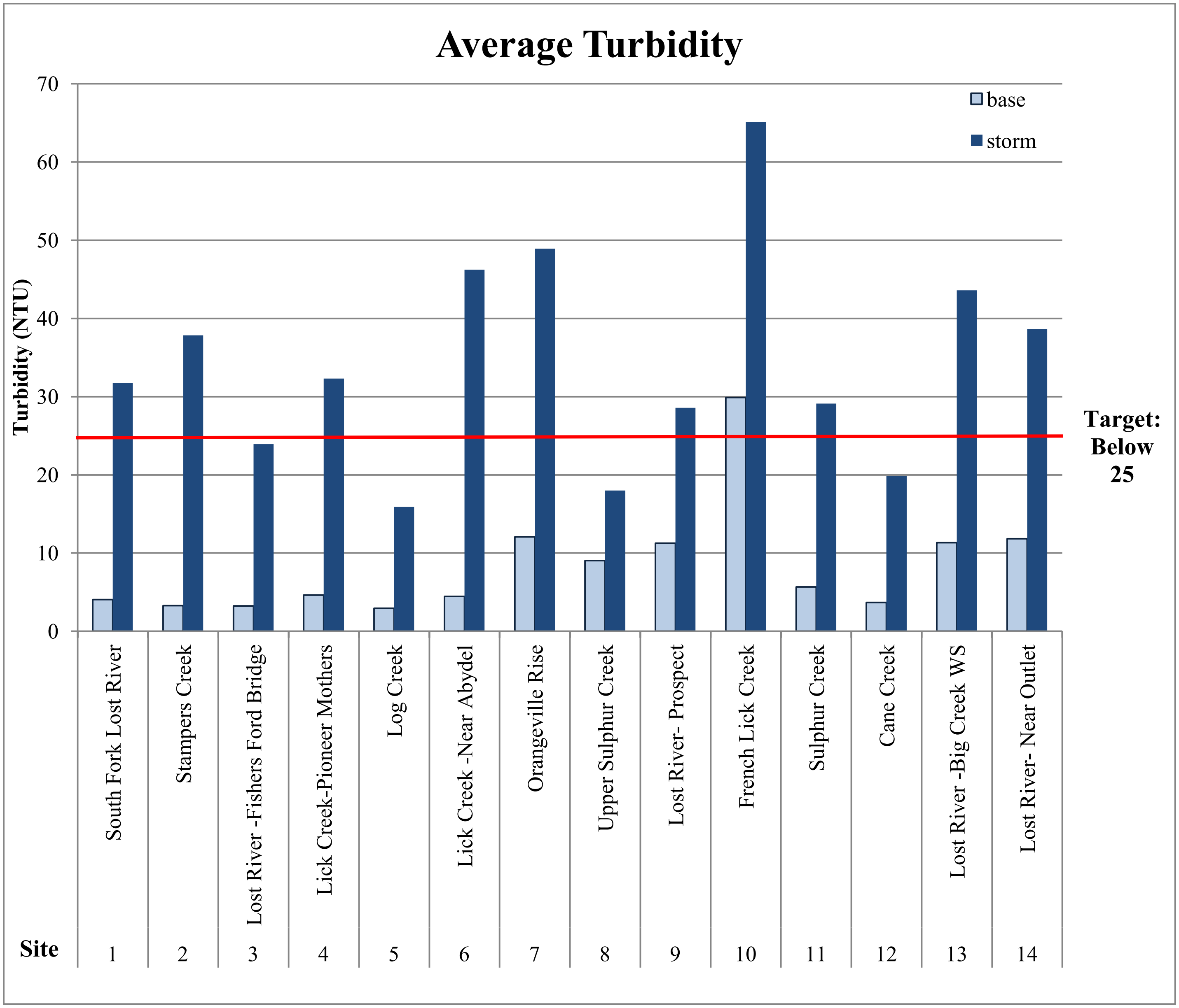


Figure 29: Average Turbidity values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season. (Data collected using the Nephelometric Method)

4.2.1.5 Escherichia coli (E. coli)

Fecal coliform bacteria are found in the feces of warm-blooded animals, including humans, livestock, and waterfowl. *Escherichia coli* (*E. coli*) is a specific species of fecal coliform bacteria used in many state's water quality standards, including Indiana. The US EPA has determined that *E. coli* bacteria counts above 235 colonies per 100 mL indicate that more than eight people out of 1,000 who come into contact with the water may become sick. The bacteria can enter the body through the mouth, nose, eyes, ears, or cuts in the skin. It is important to remember that as *E. coli* counts go up, the chance that someone will get sick goes up. There are many other things that determine if a person will become sick:

• How long someone is in contact with the water

• If water comes into contact with a person's eyes or mouth

• lf the person has skin abrasions or wounds

• The age and health of the person, as that can determine a person's susceptibility to illness.

Elevated *E. coli* levels can occur throughout the year; however Indiana's water quality standards for *E. coli* only apply in the recreation season (April to October) and therefore the water body is only considered "impaired" by *E. coli* if the high levels occur then. Sources of *E. coli* include:

- Human waste, which may reach water through poorly functioning septic systems, wastewater treatment plants during the winter or that are non-compliant, or combined sewer overflows; or
- Animal waste including waste from pets, wildlife/waterfowl, and livestock. Livestock waste most commonly reaches water bodies after having been applied to fields.

Many attempts have been made to differentiate *E. coli* from humans and animals, but it remains uncertain and requires resources far beyond this nonpoint source project. Total coliforms were also monitored during this study, but at this time do not indicate anything more than the presence of fecal coliforms. Past studies have suggested that the ratio of total coliforms to E.coli may give clues to the originating source of E.coli. At this time the data on total coliforms will be given in hopes that it can give a clue to the source with further research.

Streams usually contain a variety of microorganisms including bacteria, viruses, protozoa, fungi, and algae. Most of these occur naturally and have little impact on human health. If fecal pollution is present, there is greater potential for microorganisms that can cause illness and disease in humans.

Monitoring *E. coli* in winter is not generally done by state agencies because the water quality standard only applies to the recreation season. Winter testing is used to gain insight into sources of *E. coli* by monitoring throughout the year. Point sources (NPDES dischargers) do not chlorinate during the winter, which will influence *E. coli* levels near these discharge points. The 2011-2012 sampling year had a very mild winter with temperatures well above freezing most of the season. This data was going to be looked at in detail but the warm temperature may have skewed results and so are not discussed here, but will be mentioned in individual discussions of subwatersheds in Section 5.

E. coli measurements at the HRLR team sites found four sites, Lost River near Leipsic, Lick Creek in Paoli, Willow Creek, and Big Creek where average *E. coli* baseflow levels were above target levels (Figure 30). Figure 30 shows that 11 out of the 13 sites had average stormflow *E. coli* levels above target levels at the HRLR sites. Six of those sites had average *E.coli* stormflow concentrations over 1,000 CFU/100mL, which is a serious problem for the area. *E. coli* measurements at the Lab sites found nine sites had average *E. coli* baseflow levels were above target levels (Figure 31). All 14 sites had average stormflow *E. coli* levels above target levels at the Lab sites. The most wide spread impairment within the watershed is E. coli according to IDEM 303 (d) list. Current monitoring confirms this result and shows other areas that may also be considered impaired that are not currently on the list.

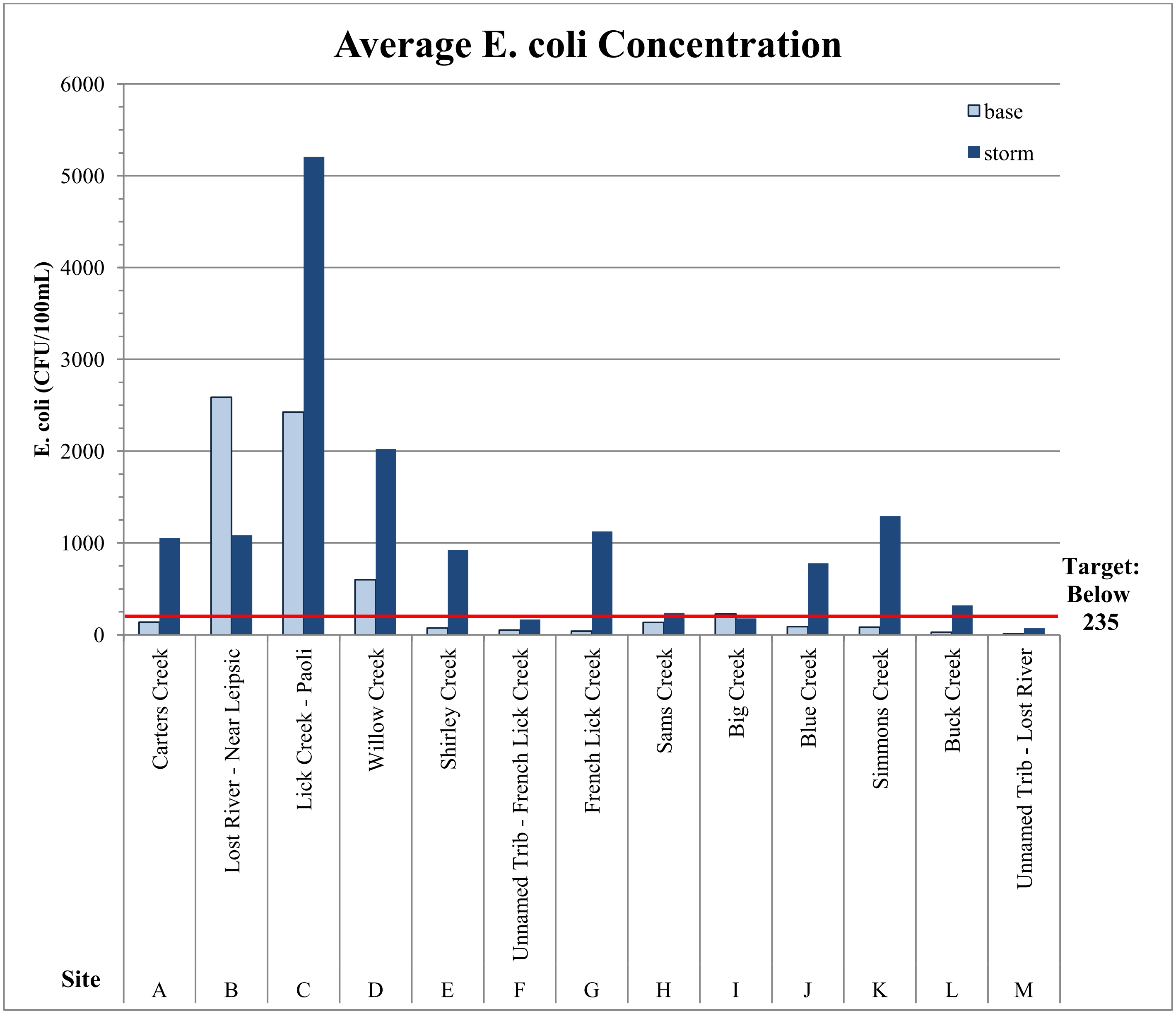


Figure 30: Average *E. coli* values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

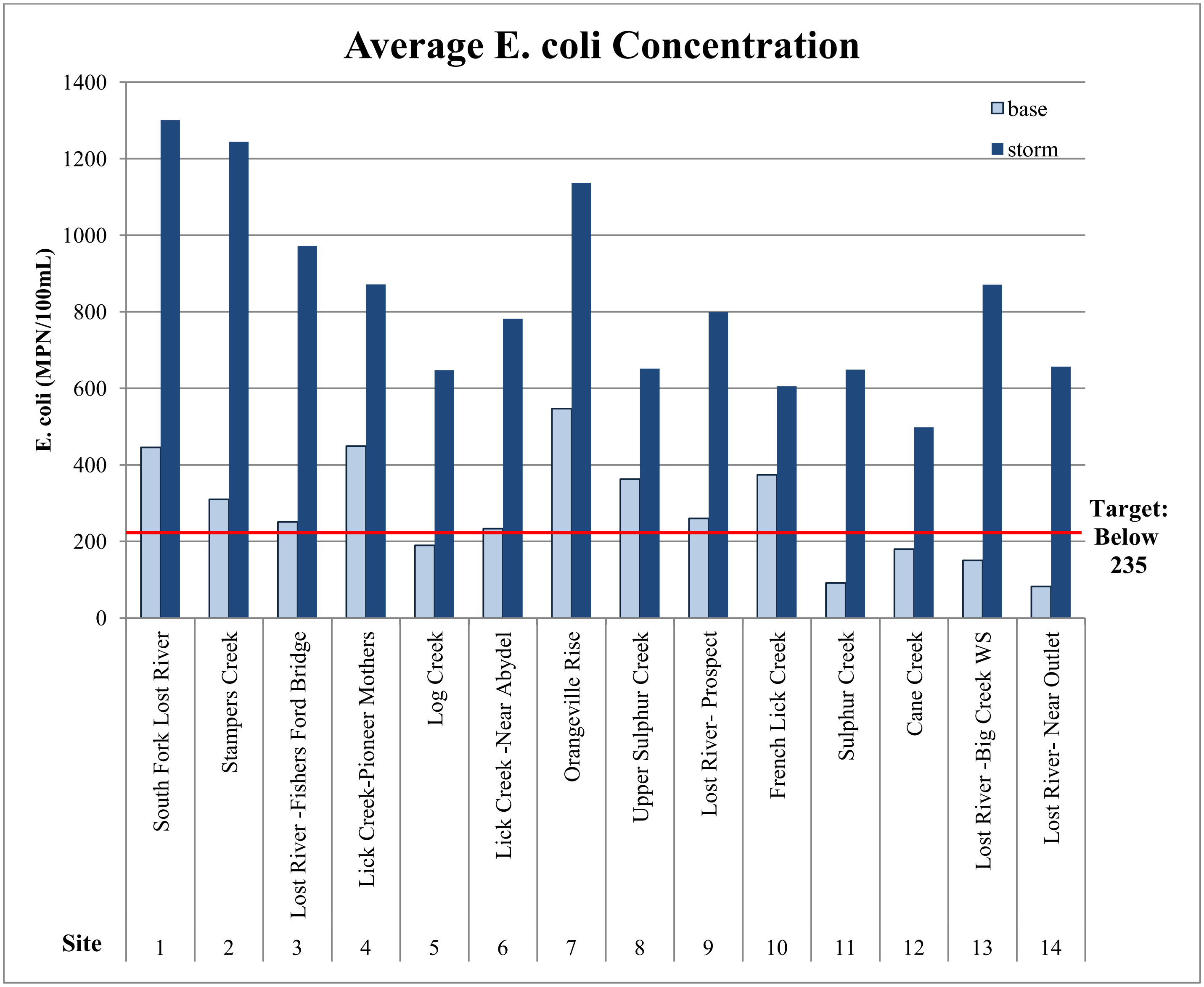


Figure 31: Average *E. coli* values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.5 Dissolved Oxygen and Biochemical Oxygen Demand

The stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as that in a reservoir behind a dam. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen.

Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process. The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand or BOD. Other sources of oxygen-consuming waste include stormwater runoff from farmland or urban streets, feedlots, and failing septic systems.

Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content. Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset.

Biochemical oxygen demand, or BOD, measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD also measures the chemical oxidation of inorganic matter (i.e., the extraction of oxygen from water via chemical reaction). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20 C). The rate of oxygen consumption in a stream is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. Target levels for BOD were set at less than 2 mg/L dissolved oxygen consumption over 5 days.

BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants; failing septic systems; and urban stormwater runoff.

Target levels set for the Lost River Watershed Management Plan are greater than 4 mg/L and less than 12 mg/L for dissolved oxygen. Average Dissolved oxygen levels fell within normal levels for both stormflow and baseflow at both HRLR sites and Lab sites (Figures 32 & 33, respecively). A few locations did drop below target levels, but on average the dissolved oxygen levels are good for the area. The locations with low levels will be discussed in detail in Section 5. On the other hand Biochmical Oxygen Demand tested at the HRLR team sites did have some average change in concentrations exceed target levels at Sams Creek, Big Creek, and Simmons Creek in baseflow samples (Figure 34). Lost River near Leipsic and the unnamed tributary to French Lick Creek stormflow average values exceeded target levels for BOD. These sites may have problems with dissolved oxygen in the early morning hours which can affect the aquatic life within the stream.

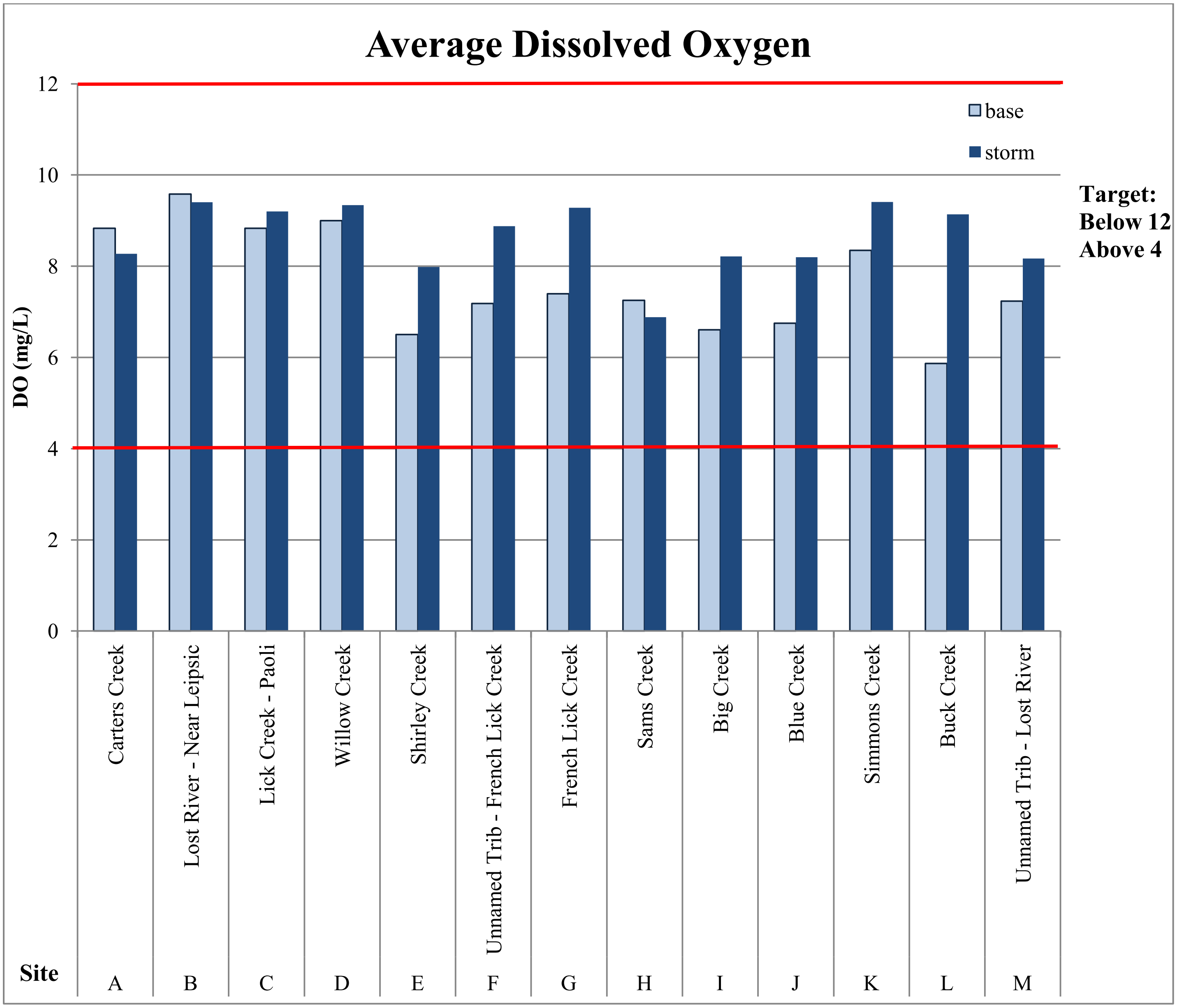


Figure 32: Average Dissolved Oxygen values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

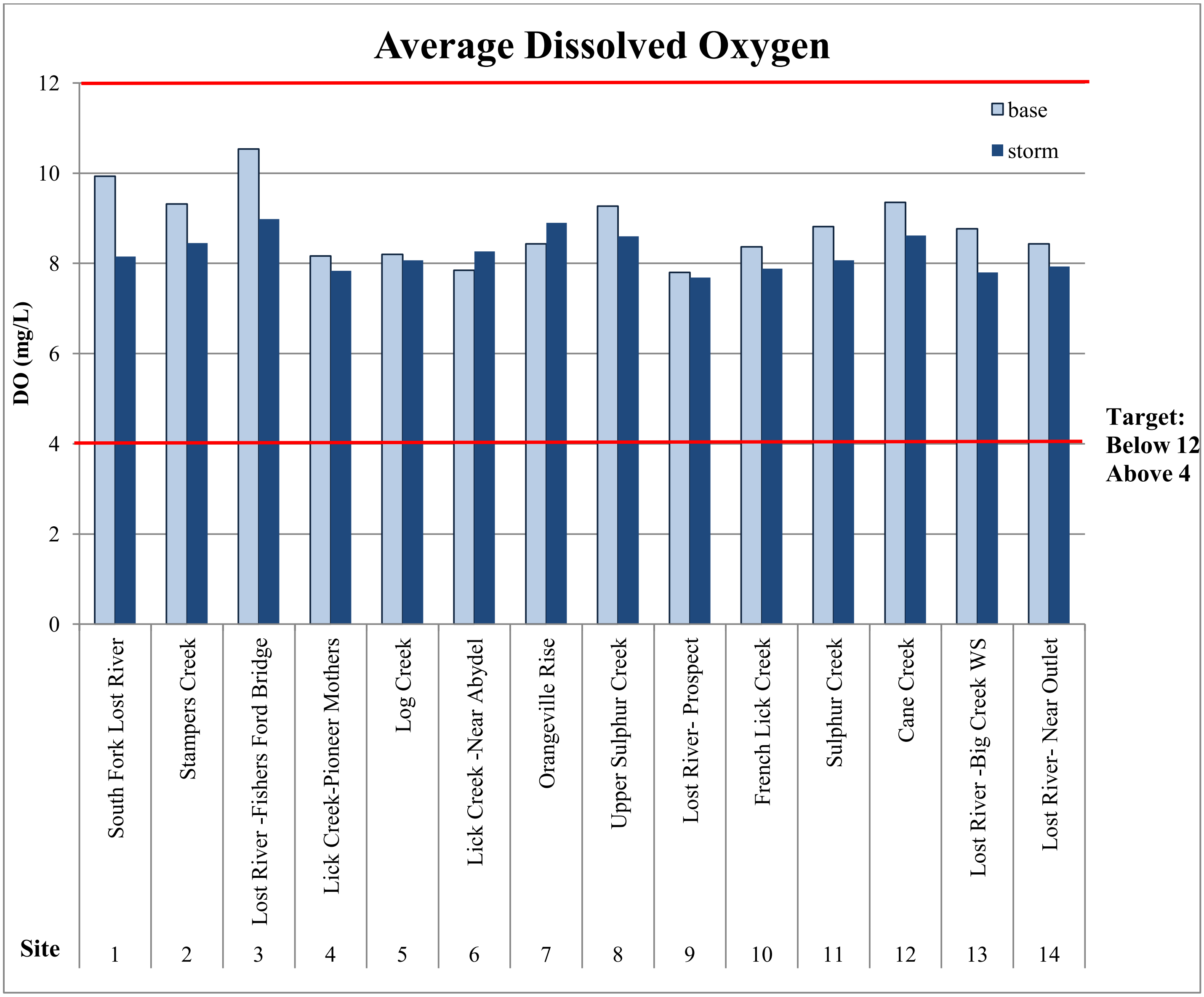


Figure 33: Average Dissolved Oxygen values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

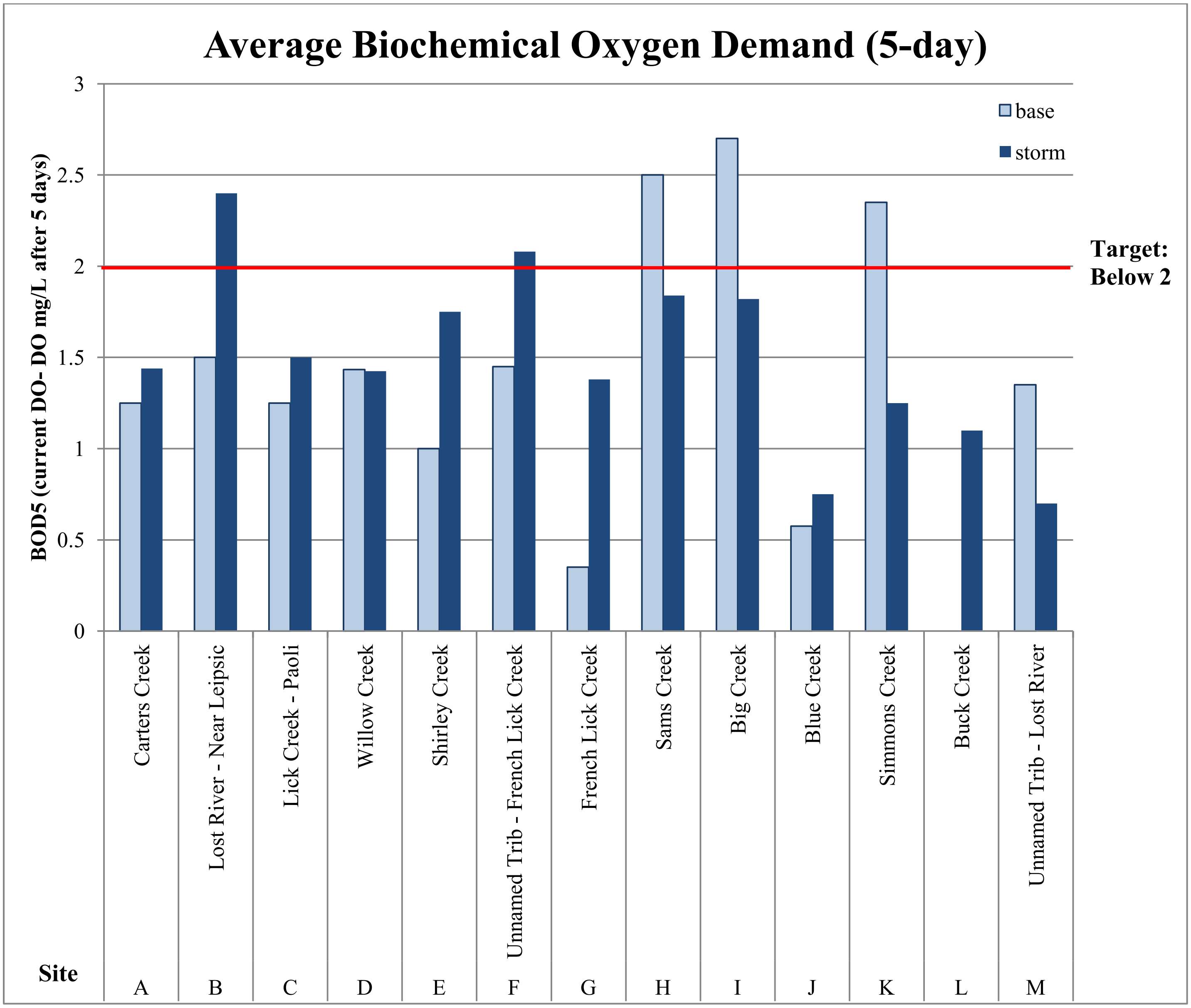


Figure 34: Average Biochemical Oxygen Demand (5-day) values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.7 pH

pH is a term used to indicate the alkalinity or acidity of a substance as ranked on a scale from 1.0 to 14.0. Acidity increases as the pH gets lower. pH affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a range of 6.5-8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, certain wastewater discharges, and abandoned coal mines.

The pH scale measures the logarithmic concentration of hydrogen (H^+) and hydroxide (OH^-) ions, which make up water ($H^+ + OH^- = H_2O$). When both types of ions are in equal concentration, the pH is 7.0 or neutral. Below 7.0, the water is acidic (there are more hydrogen ions than hydroxide ions). When the pH is above 7.0, the water is alkaline, or basic (there are more hydroxide ions than hydrogen ions). Since the scale is logarithmic, a drop in the pH by 1.0 unit is equivalent to a 10-fold increase in acidity. Therefore, a water sample with a pH of 5.0 is 10 times as acidic as one with a pH of 6.0, and pH 4.0 is 100 times as acidic as pH 6.0. Target levels for pH within the Lost River Watershed Management Plan were set at greater than 6 and less than 9.

Average pH levels at the HRLR sites were below target levels at eight sites and the Mine Drainage site (Figure 35). Baseflow samples collected had average levels of pH that were within target levels, except at site M and the Mine Drainage site. An extra set of measurements for the pH at the Mine Drainage site were collected due to the strong orange color of the river bottom. This site is upstream of Site M, which is the unnamed tributary of Lost River in Grassy Creek Subwatershed. After collecting pH values on site at this location, it was determined that the pH of the water was extremely low, or acidic. Average pH at this site was 2 during baseflow and 2.3 during stormflow. A gofer hole, or small abandoned underground mine was located within this area. Water within the creek flows from this identified area. The average pH at the Lab sites stayed between target values for all sampling locations (Figure 36).

Acid mine drainage impacts stream and river ecosystems through acidity, ferric ion (Fe^{3+}) precipitation, oxygen depletion, and release of heavy metals associated with coal and metal mining, such as aluminum (Al^{3+}), zinc (Zn^{2+}), and manganese (Mn^{2+}).

When mineral deposits that contain sulfides are mined, they have the potential to produce acid mine drainage. This includes the mining of coal, copper, gold, silver, zinc, lead, and uranium. The mineral pyrite, more commonly known as "fool's gold," is iron disulfide (FeS_2). Pyrite is one of the most important sulfides found in the waste rock of mines. When exposed to water and oxygen, it can react to form sulfuric acid (H_2SO_4).

Bright orange-colored water and stained rocks are usually tell-tale signs of acid mine drainage. The orange color is caused by ferric hydroxide ($Fe(OH)_3$) precipitating out of the water. The precipitate forms as the acid mine drainage becomes neutralized. At low pH values, the metal ions remain soluble. When the pH rises, the iron oxidizes and precipitates out. Depending on the conditions, the orange-colored precipitates may form inside the mine or several miles downstream. The precipitates can be harmful to aquatic life. The clumps reduce the amount of light that can penetrate the water, affecting photosynthesis and visibility for animal life. Furthermore, when the precipitate settles, it blankets the stream bed, smothering the bottom-dwellers and their food resources.

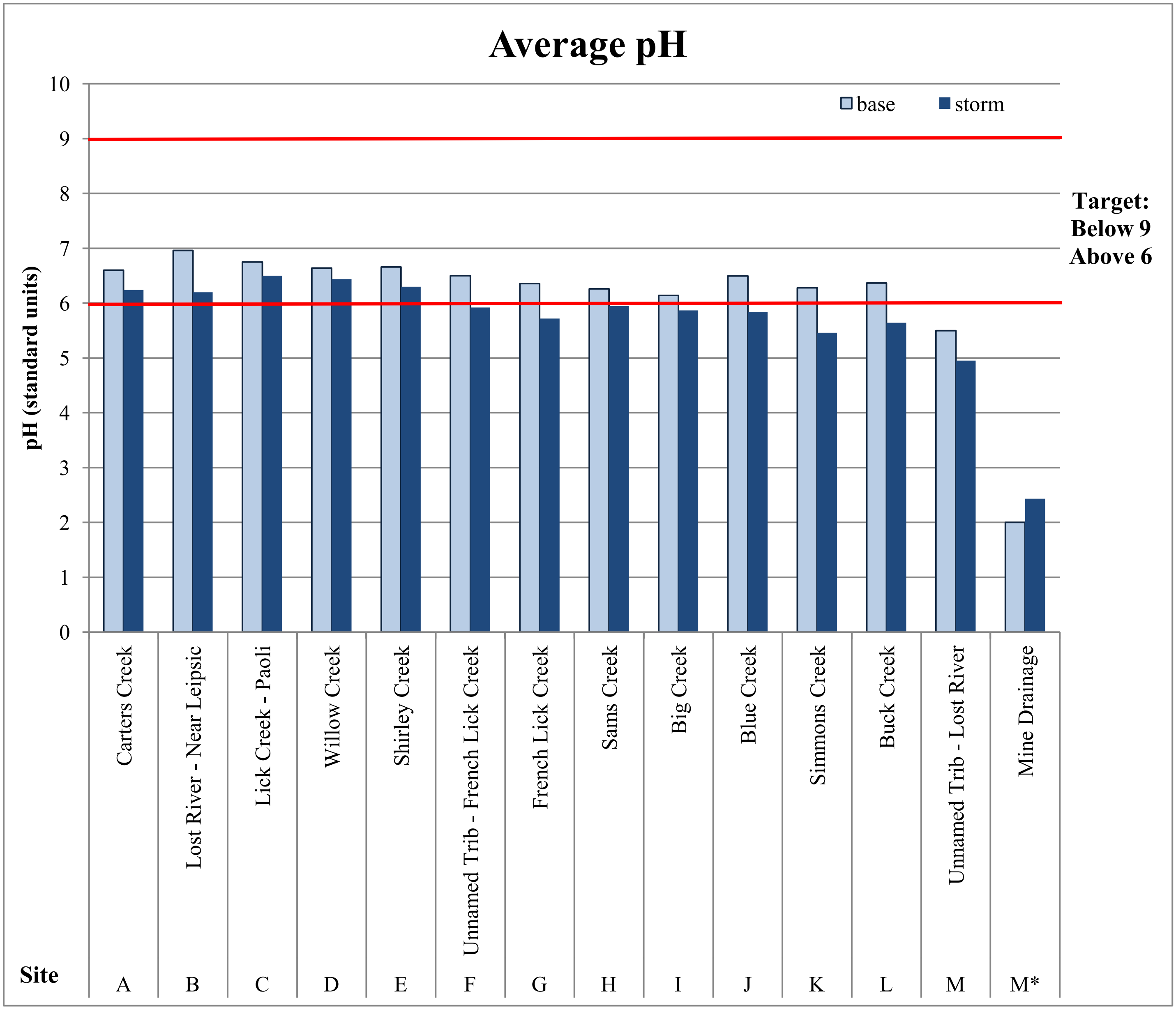


Figure 35: Average pH values at HRLR sampling locations for baseflow and stormflow during the 2011-2012 sampling season. Includes Site M* which is 2.5 miles upstream of Site M and drains from an abandoned underground coal mine.

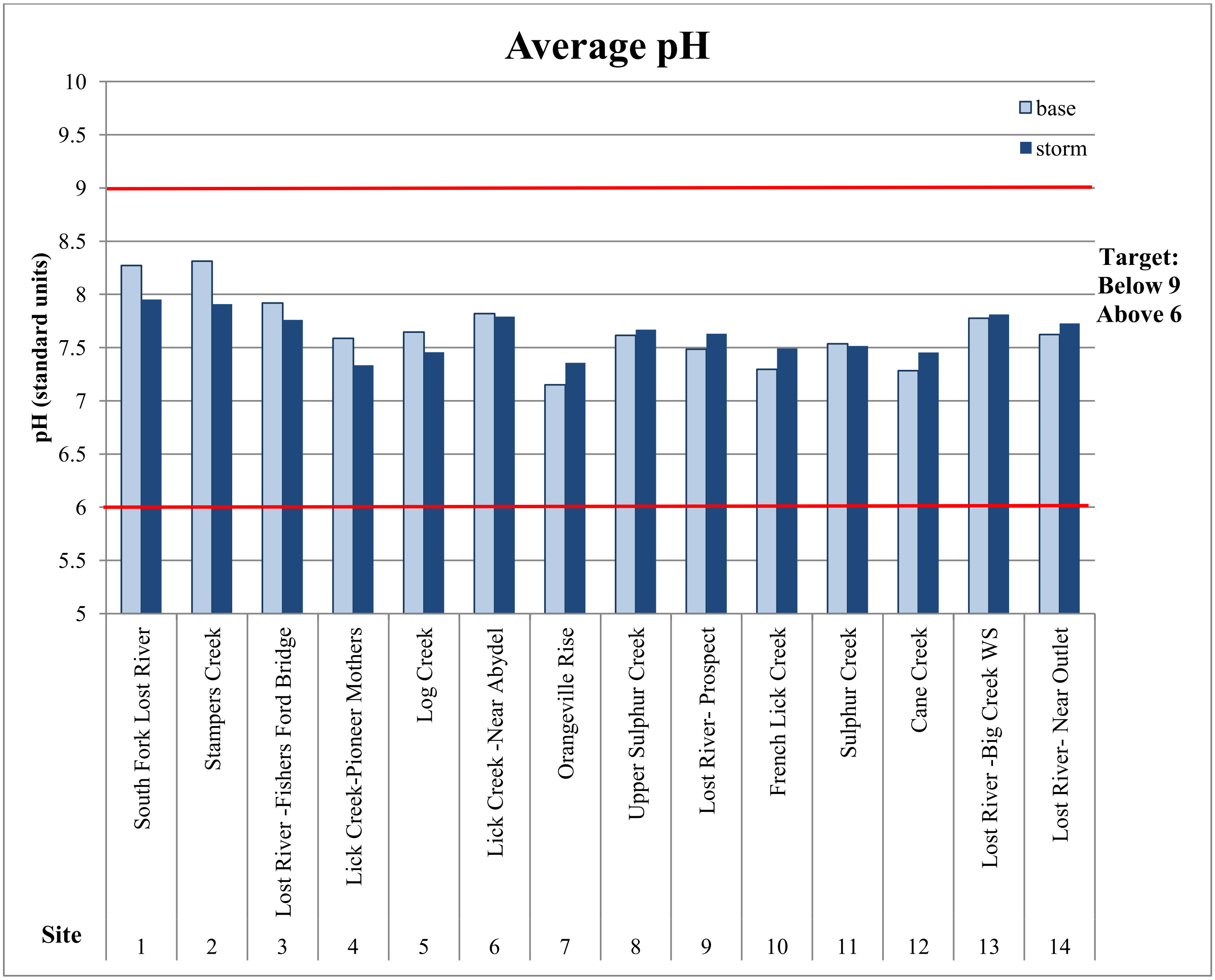


Figure 36: Average pH values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.8 Salinity

When snow and ice melts, the salt goes with it, washing into our lakes, streams, wetlands, and groundwater. It takes only one teaspoon of road salt to permanently pollute 5 gallons of water. Once in the water, there is no way to remove the chloride, and at high concentrations, chloride can harm fish and plant life. Less is more when it comes to applying road salt. Salinity is a measure of the mass of dissolved salts (ionic constituents) in a given mass of solution and usually expressed as parts per thousand (ppt). Ions commonly found in water include calcium, magnesium, potassium and sodium cations and bicarbonate, carbonate, chloride, nitrate, and sulfate anions. Conductivity can help determine the salinity of water.

Chloride salts are composed of approximately 60% chloride and 40% positive ion. Deicing operations use calcium, potassium, and magnesium chlorides, but to a lesser degree than sodium chloride (NaCl). These salts may be applied in liquid or crystalline form, either of which can be used in conjunction with abrasives. Liquid salt solutions provide immediate deicing upon application to roads and sidewalks. Crystalline forms are slower and longer acting than liquid solutions. Sodium ferrocyanide is added to chloride salts to prevent clumping during storage and application. In water, sodium ferrocyanide can be photolyzed to release approximately 25% cyanide ions (EPA, 1971).

Runoff to surface waters and percolation to groundwater are the most common mechanisms for road salts to enter water supplies. Infiltration is more common for groundwater-based supplies. In the Lost River watersheds, groundwater is a major contributor to streams. Typically, chloride concentration in groundwater supplies exhibits a relatively linear relation to road-salt application rate or two-lane road density throughout the year. In surface-water supplies, chloride concentration depends on salting intensity, soil type, climate, topography, and water volume, with larger water bodies exhibiting lower concentrations through the process of dilution. Deicing salts applied to roads during winter are the primary source of solutes to groundwater.

NaCl dissociates in aquatic systems into chloride ions (CL-) and sodium cations (Na+). While sodium may bond to negatively charged soil particles, or be taken up in biological processes, chloride ions are less reactive and can be transported to surface waters through soil and groundwater. Road salts applied to roadways can enter air, soil, groundwater, and surface water from direct or snowmelt runoff, release from surface soils, and/or wind-borne spray. These salts remain in solution in surface waters and are not subject to any significant natural removal mechanisms. Their accumulation and persistence in watersheds pose risks to aquatic ecosystems and to water quality. Approximately 55% of road-salt chlorides are transported in surface runoff with the remaining 45% infiltrating through soils and into groundwater aquifers (Church and Friesz, 1993). Target levels for salinity were set at less than 2 parts per thousand for the Lost River Watershed Management Plan.

Due to high temperatures in the winter of 2011-2012 road salts were not used in the area for deicing roadways. This is reflected in the measurements of salinity in Lost River’s streams and tributaries. At no point during sampling in the 2011-2012 monitoring cycle was salinity a concern and levels never exceeded target levels (Figure 37). This component should be measured again in a colder winter to truly determine whether it is a pollutant of concern.

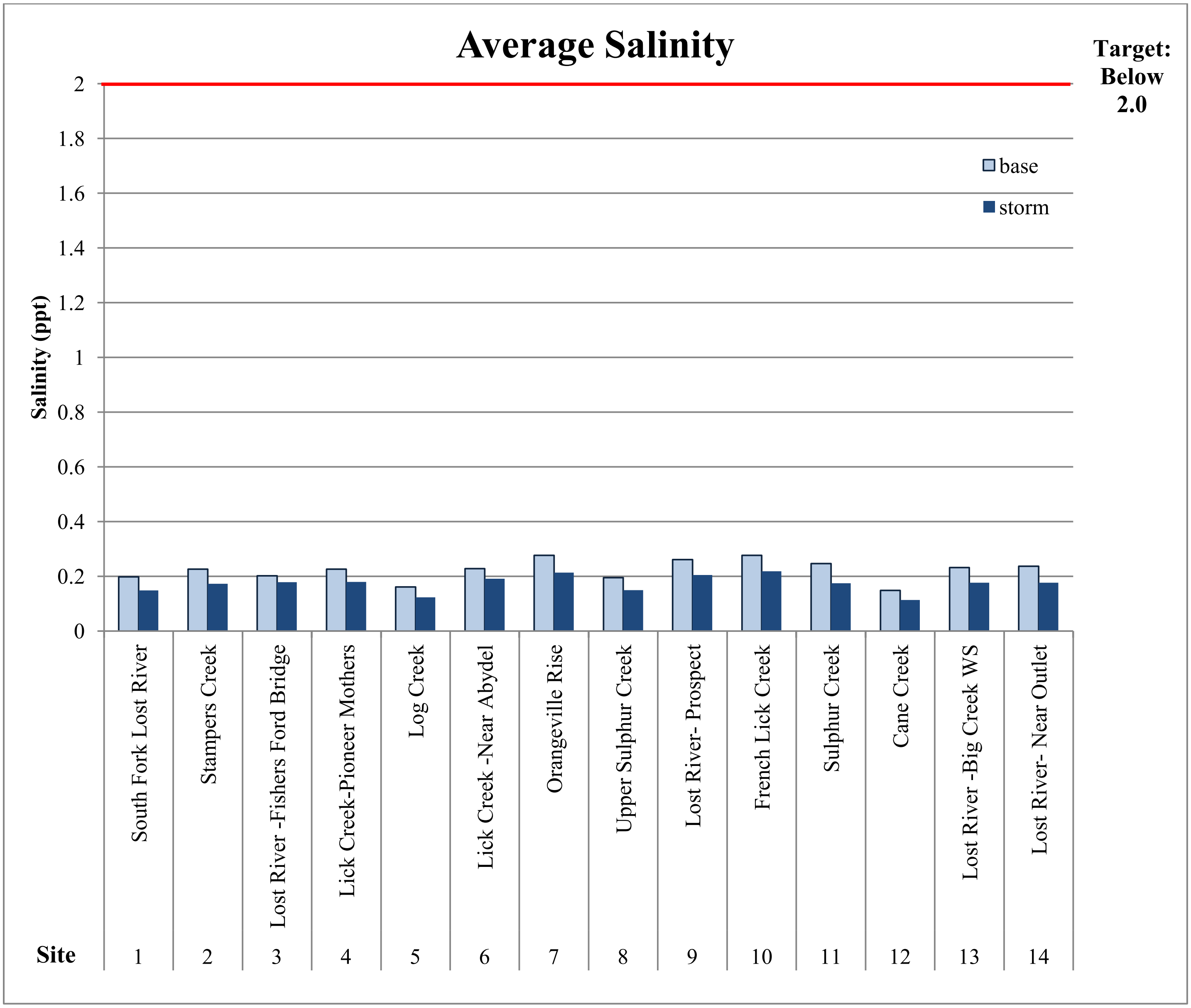


Figure 37: Average Salinity values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

4.2.1.9 Specific Conductivity

Specific conductance is a measure of the ability of water to conduct an electrical current. It is highly dependent on the amount of dissolved solids (such as salt) in the water. Pure water, such as distilled water, will have a very low specific conductance, and sea water will have a high specific conductance. Rainwater often dissolves airborne gasses and airborne dust while it is in the air, and thus often has a higher specific conductance than distilled water. Specific conductance is an important water-quality measurement because it gives a good idea of the amount of dissolved material in the water. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius (25 C).

High specific conductance indicates high dissolved-solids concentration; dissolved solids can affect the suitability of water for domestic, industrial, and agricultural uses. At higher levels, drinking water may have an unpleasant taste or odor or may even cause gastrointestinal distress. Additionally, high dissolved-solids concentration can cause deterioration of plumbing fixtures and appliances. Relatively expensive water-treatment processes, such as reverse osmosis, are needed to remove excessive dissolved solids from water.

Agriculture also can be adversely affected by high-specific-conductance water, as crops cannot survive if the water they use is too saline, for instance. Agriculture can also be the cause of increases in the specific conductance of local waters. When water is used for irrigation, part of the water evaporates or is consumed by plants, concentrating the original amount of dissolved solids in less water; thus, the dissolved-solids concentration and the specific conductance in the remaining water is increased. The remaining higher specific-conductance water reenters the river as irrigation-return flow.

Often in school, students do an experiment where they connect a battery to a light bulb and run two wires from the battery into a beaker of water. When the wires are put into a beaker of distilled water, the light will not light. However, the bulb does light up when the beaker contains salt water (saline). In the saline water, the salt has dissolved, releasing free electrons, and the water will conduct an electrical current.

Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity.

The basic unit of measurement of conductivity is the mho or siemens. Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm). Distilled water has a conductivity in the range of 0.5 to 3 µmhos/cm. The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can range as high as 10,000 µmhos/cm. Target levels for conductivity are greater than 150 µs/cm or less than 1500 µs/cm for the Lost River Watershed Management Plan.

Conductivity measurements made in the Lost River watershed were done at Lab sites (Figure 38).   All sites monitored showed an average concentration between water quality targets. These targets were set based on tolerance levels for fish and other aquatic life.

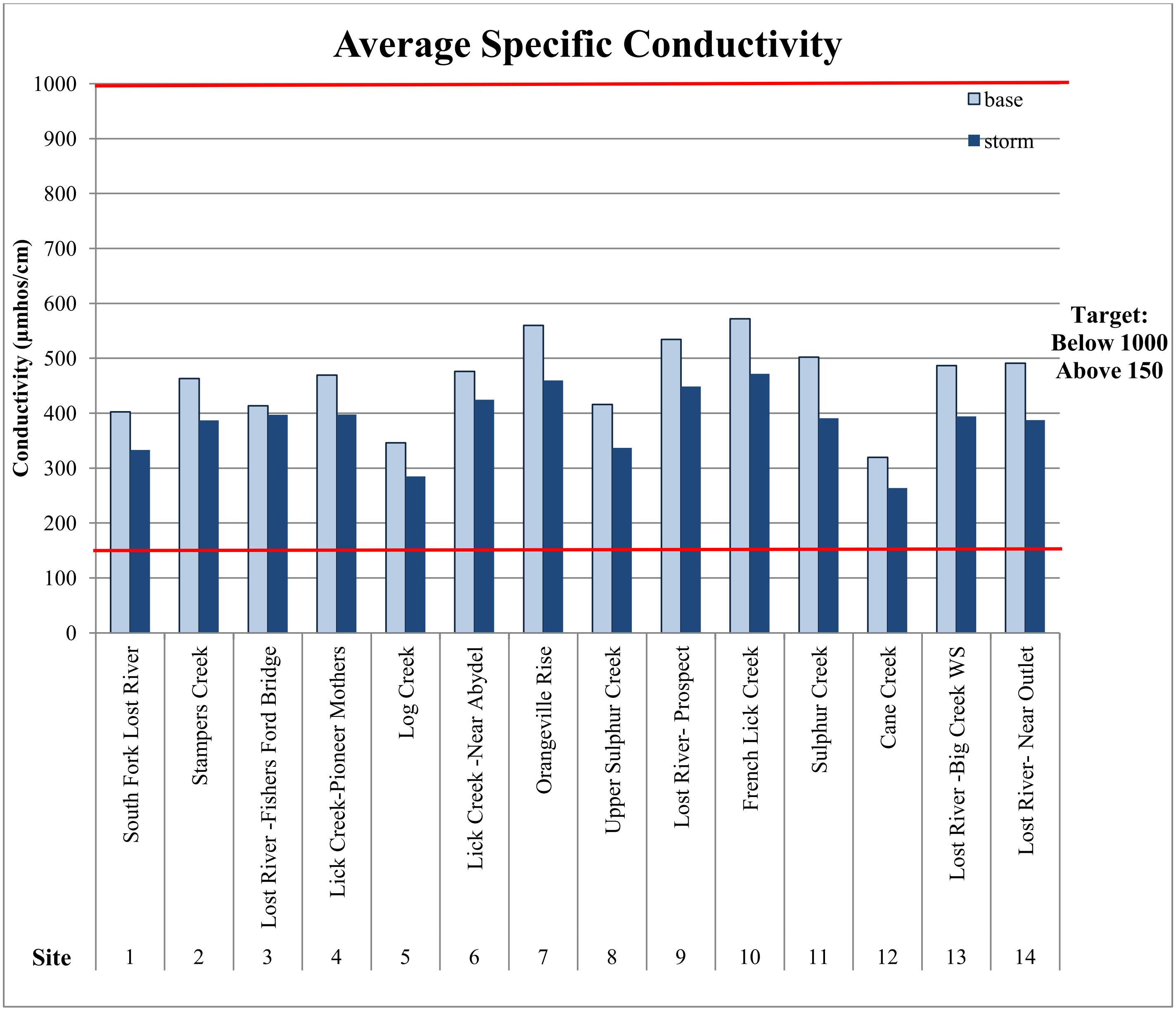


Figure 38: Average Specific Conductivity values at Lab sampling locations for baseflow and stormflow during the 2011-2012 sampling season.

Lost River Watershed Team Windshield Surveys

Windshield surveys were conducted during the initial stages of the project to ground truth data obtained from desktop surveys and other sources of information. Windshield surveys followed the Watershed Inventory Workbook for Indiana (2002) guidelines and forms for conducting watershed inventories. Observations were made of the streams to assess the current condition. Effects that adjacent lands may be having on the streams were documented and assessed for the watershed. Workbook forms were used in the field with site maps and GPS location units. Modified Bank Erosion Hazard Index (BEHI) data was also collected for most areas where roads crossed stream channels or ran adjacent to the channel. Channels were assessed for root depth to bank height ratio, root density on channel banks, the amount of surface protection of the banks, and the angle of the bank. This information can help determine how high of risk a particular length of channel has for eroding. Figure 39 shows the results of the modified BEHI collected during windshield surveys. From an analysis of channels near roads, the results indicated that 33.7 miles of channel are rated as high, very high, or extreme risk of erosion. Another 28 miles showed a moderate risk of erosion. Streambank erosion is a concern of stakeholders in the areas due to the associated loss of land and risks of damage to infrastructure and other structures. Additional data was collected from windshield surveys including areas where livestock have direct access to streams, tilled fields, pastures that are at risk of erosion, and residential areas. This data will be discussed in more detail at the HUC 12 level in Sections 5.

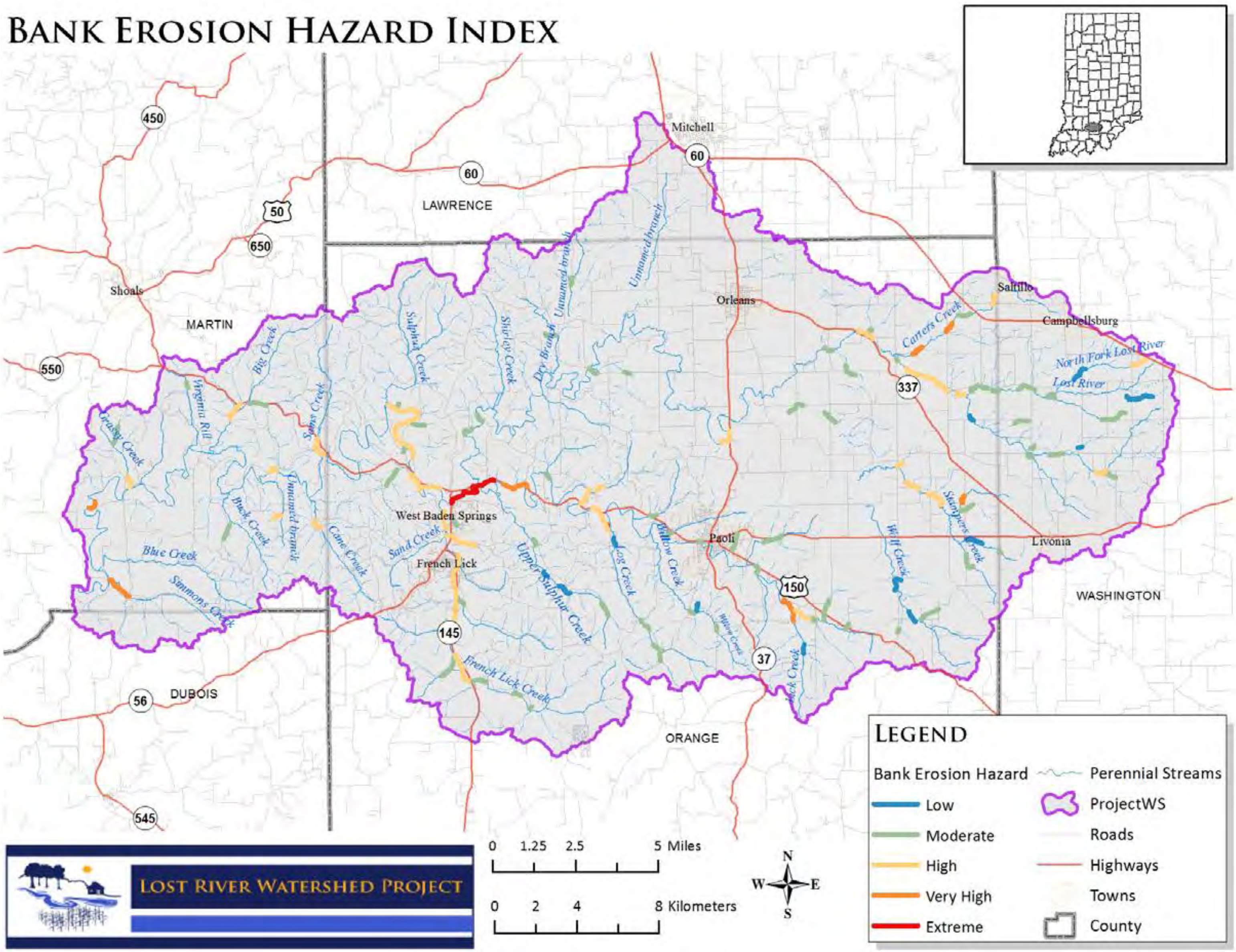


Figure 39: Modified Bank Erosion Hazard Index results on Lost River Watershed

4.2.1 Historic Water Quality Data

Water quality data and influencing factors collected by various organizations from as early as 1992 is discussed in this section.

Indiana's 2012 Integrated Water Monitoring and Assessment Report (IDEM)

Section 305(b) of the Clean Water Act requires the state to assess and report on how well the waters of Indiana support the beneficial uses designated in Indiana's water quality standards. Indiana's Integrated Water Monitoring and Assessment Report (IR) is developed every two years to fulfill this requirement and describes the condition of Indiana's lakes and streams, and ground water. The assessment rotated through watershed basins around the state on a five-year basis until 2011 when rotations changed to a nine-year rotation. The IR is submitted to the U.S. EPA in even-numbered years. In odd-numbered years, the IDEM sends a copy of its Assessment Database to the U.S. EPA as an electronic update.

The Lower Fork White River watershed Assessment Unit was monitored in 1997, 2002 and 2007 for water chemistry. Fifteen sites monitored were within the Lost River watershed. IDEM has collected 34 water chemistry parameters including heavy metals, hardness and alkalinity, nutrients, and other chemical and physical parameters. A total of 198 water chemistry samples have been collected in the watershed study area from 1997-2011. At these stations field parameters such as dissolved oxygen (DO), pH, Specific conductance (SC), temperature, and turbidity were collected from three to five times per sampling year. Chemical parameters collected at these stations were analyzed in a laboratory throughout these three sampling years. They include alkalinity and hardness, chloride, nitrate plus nitrite (nitrogen), total Phosphorus, total suspended solids (TSS), total solids, total dissolved solids (TDS), sulfate, Total Kjeldahl Nitrogen (TKN), total organic carbon, total coliform, and *Escherichia coli* (*E. coli*). Some of this data will be discussed further within each of the subwatershed discussions in the Pollutant Source Assessment in Section 5. Results of parameters tested at these sites are in Section 5.

Out of the total 198 samples collected 157 samples were collected at the Fixed Station (WEL160-0003) on Lost River. This station is located near the outlet of Lost River into White River at Able Hill Road and Simmons Creek Rd in Martin County. This is also Site 12 of the Lost River Watershed Team Sampling sites (See Figure 195 for location information). This site has been monitored monthly since April 1999 for chemical and field parameters. This site was monitored for 6 months in 1997, as well.

Table 10 lists selected parameter means, standard deviations, and whether or not the parameter means meet water quality standards or recommended targets. Turbidity, TSS, nitrogen, and total phosphorus mean values do not meet recommended water quality targets. Further discussion of water quality standards and recommended targets can be found in the Water Quality Targets section 4.1 of this report. Figures 40-45 depict trends in nitrogen (nitrate + nitrite, & TKN), total Phosphorus, turbidity, total suspended solids (TSS), and dissolved oxygen at Site12 from 1997-2011. Nitrogen in the form of nitrate plus nitrite and TKN values have slightly increased since 1997 indicating degradation in water quality in regards to these parameters. Phosphorus, turbidity, and TSS values have decreased indicating an improvement in water quality in relation to these parameters. Dissolved oxygen concentrations have increased in recent years which could indicate an improvement in water quality, or could indicate supersaturation do to nutrient overloads. No other parameters showed a notable increasing or decreasing trend.

The increase in dissolved oxygen concentrations can in part be attributed to a decrease in water temperatures over time. Factors such as precipitation and air temperature may be influencing the water temperature parameter. The decrease in Phosphorus, a limiting agent in algae growth, may also be in part responsible for the increase in dissolved oxygen levels over time. Decreasing turbidity values in conjunction with decreasing TSS concentrations suggest that there has been an overall decrease in the amount of sediment particles in the water column. Since Phosphorus often binds to sediment particles, a decreasing trend in Phosphorus coincides well to the decrease in sediment making its way into the streams. The decreasing trends in Phosphorus and sediment is likely due to the increasing amount of farmed ground moving to no-till or limited- till practices plus the recent addition of cover crops to many local cropping systems.

Table 10: Site 12 –Historic Parameters Means and Standard Deviations

Parameter	Mean	Standard Deviation	Sample Size	Water Quality Standard or Target	Mean Meets Target or Standard
Alkalinity (as CaCO3) (mg/L)	158.2	±35.2	157	-	
Chloride (mg/L)	14.15	±7.97	157	-	
COD (mg/L)	11.14	±5.15	148	-	
E. Coli (CFU/100mL)	110.00	± 0	2	Max: 235 CFU/100mL	Yes
E. Coli (MPN/100mL)	118.33	± 46.5	3	Max: 235 MPN/100mL	Yes
Hardness (as CaCO3) (mg/L)	219.90	±58.35	156	-	
Nitrogen, Ammonia (mg/L)	0.17	±0.04	151	Dependent on pH & Temperature	
Nitrogen, Nitrate+Nitrite (mg/L)	2.46	±1.21	157	Max: 1.5 mg/L	**No**
pH (Lab) (SU)	7.78	±0.20	144	Min: 6 Max: 9	Yes
Phosphorus, Total (mg/L)	0.084	±0.05	157	Max: 0.07 mg/L	**No**
Solids, Suspended Total, (TSS) (mg/L)	29.2	±40.6	157	Max: 25 mg/L	**No**
Solids, Total (TS) (mg/L)	324	±72	157	-	
Solids, Total Dissolved (TDS) (mg/L)	281	±76	157	Max: 750 mg/L	Yes
Sulfate (mg/L)	44.6	±25.3	157	Max: 250 mg/L	Yes
Total Kjeldahl Nitrogen (mg/L)	0.392	±0.217	156	Max: 0.591 mg/L	Yes
Total Organic Carbon (mg/L)	2.90	±4.90	156	-	
% Saturated Dissolved Oxygen (%)	86.4	±9.7	7	Min: 60% Max: 110 %	Yes
Dissolved Oxygen (mg/L)	8.91	±2.19	157	Min: 4.0 mg/L Max: 12.0 mg/L	Yes
pH (Field) (SU)	7.82	±0.20	157	Min: 6 Max: 9	Yes
pH (Lab) (SU)	7.77	±0.21	150	Min: 6 Max: 9	Yes
Specific Conductance (Field) (umho/cm)	448	±119	156	Max: 1,200 µS per cm at 25°	Yes
Temperature (°C)	14.4	±7.4	157	varies by sample date	
Turbidity (NTU)	27.4	±37.4	156	Max: 25 NTU	**No**

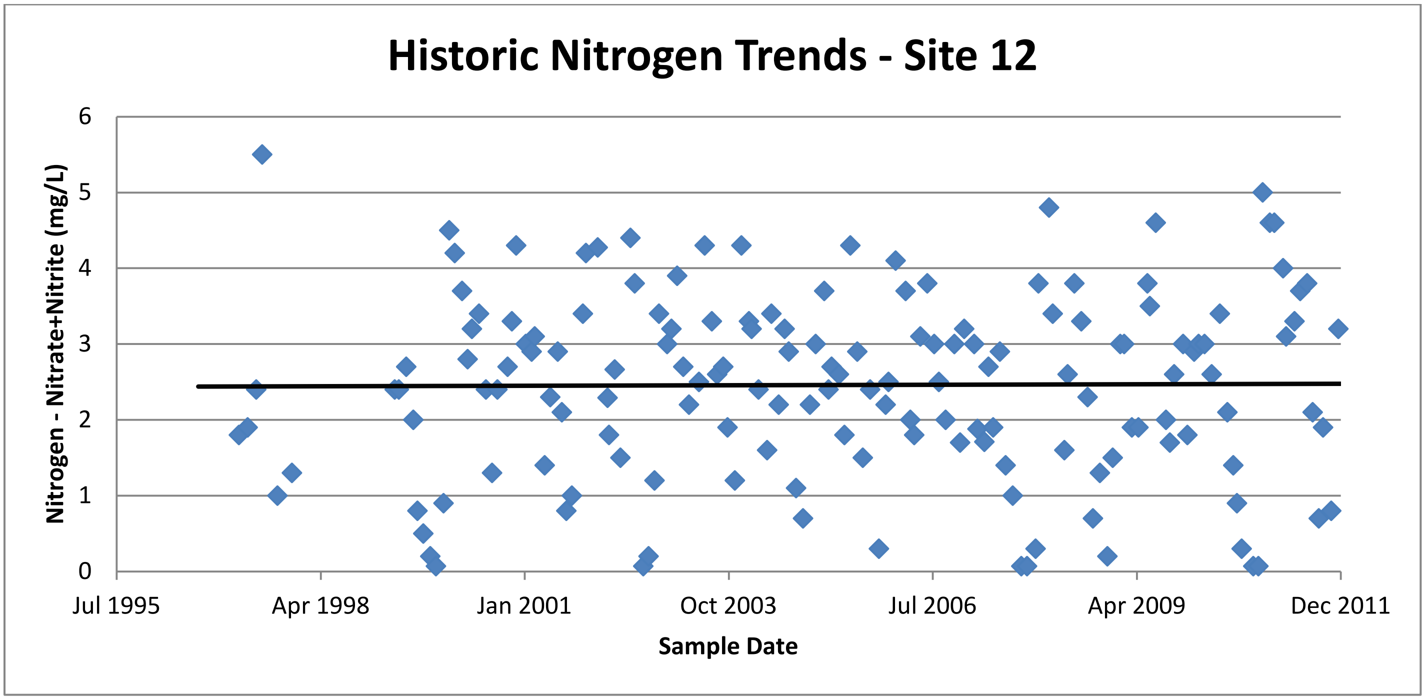


Figure 40: Historic Nitrogen Trends near Lost River Outlet

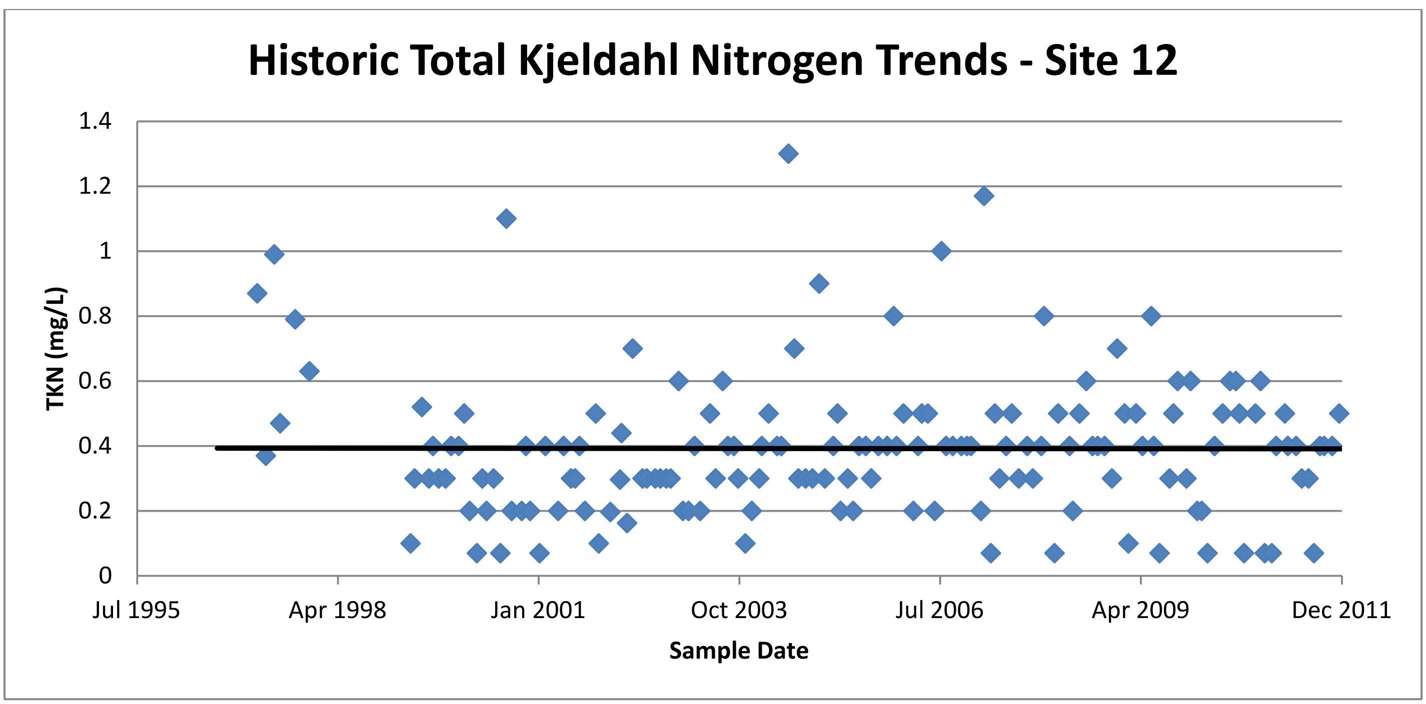


Figure 41: Historic Total Kjeldahl Nitrogen Trends near Lost River Outlet

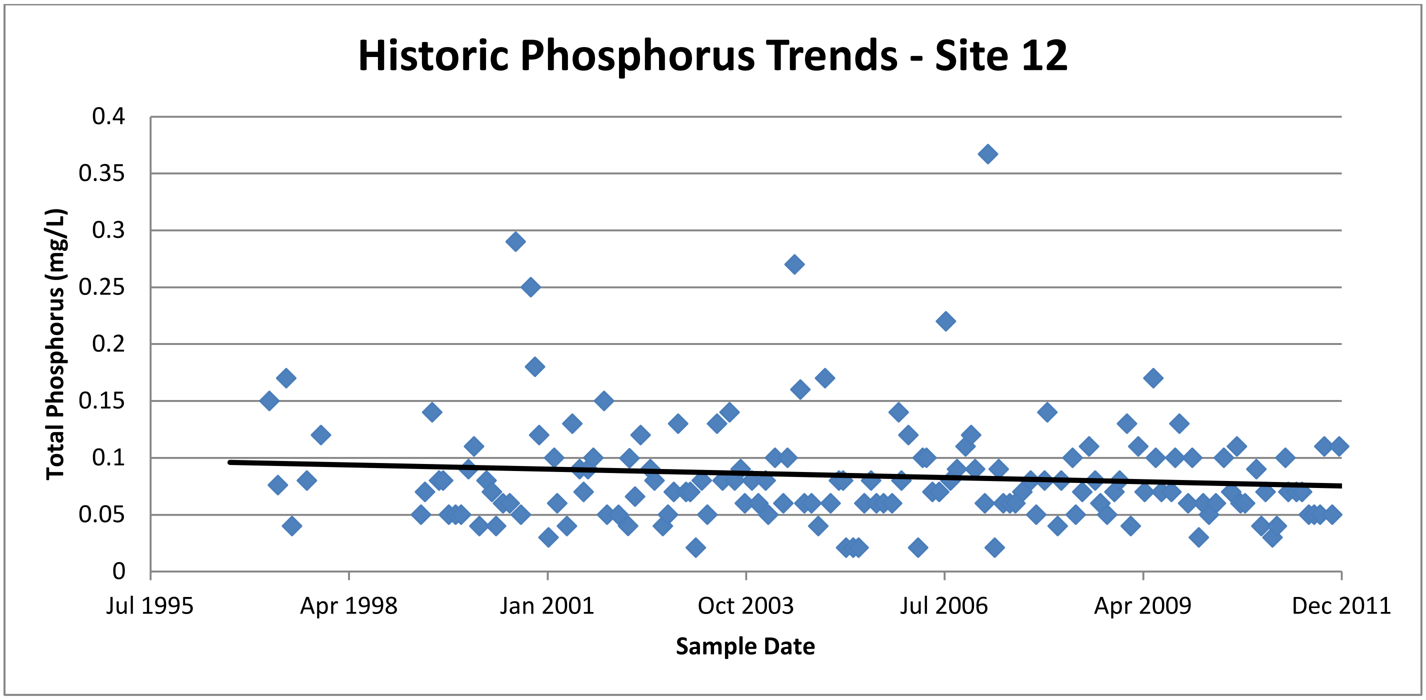


Figure 42: Historic Phosphorus Trends near Lost River Outlet

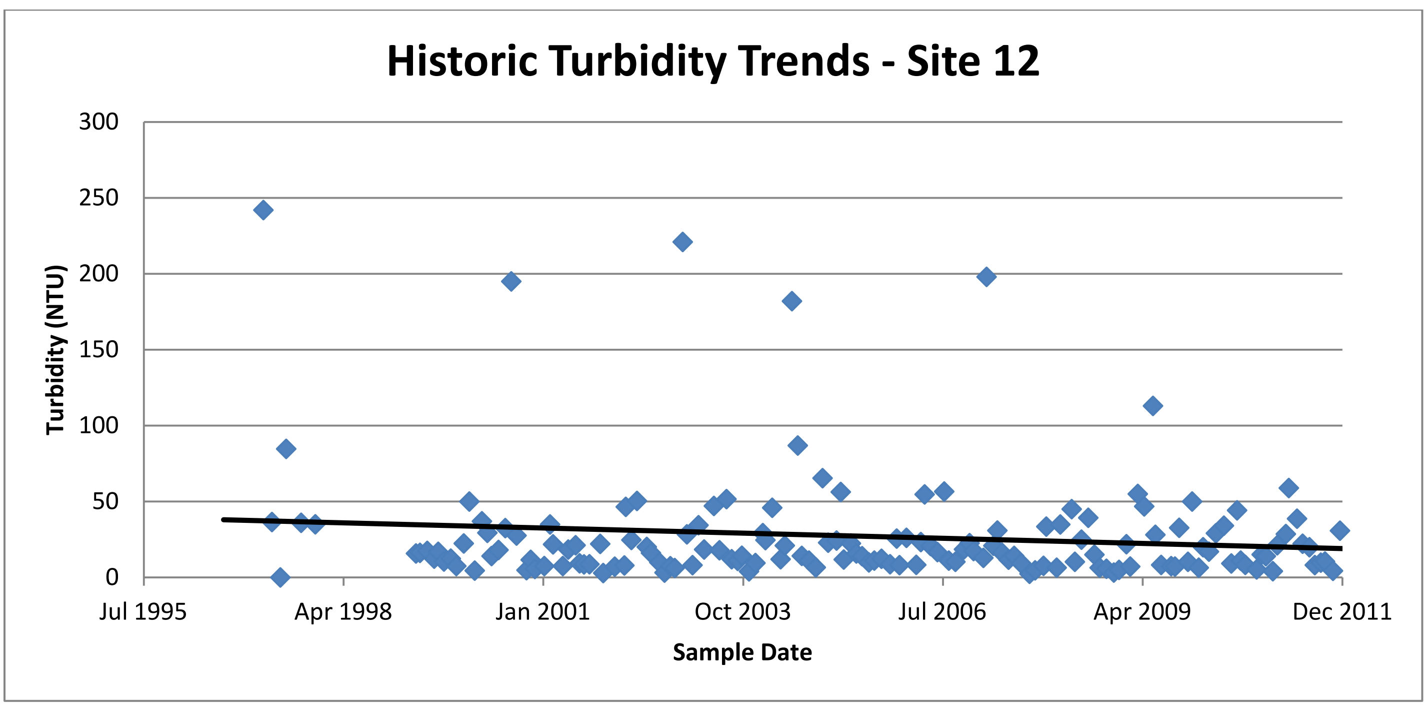


Figure 43: Historic Turbidity Trends near Lost River Outlet

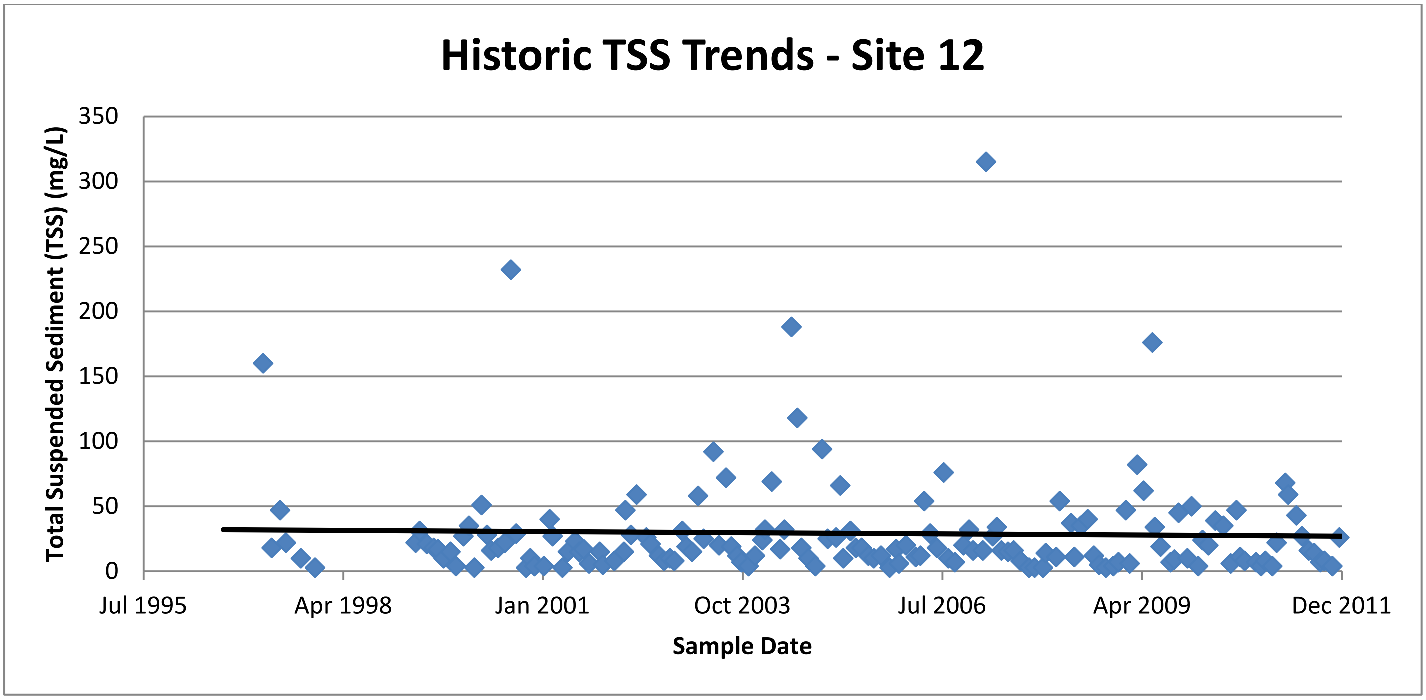


Figure 44: Historic Total Suspended Solids Trends near Lost River Outlet

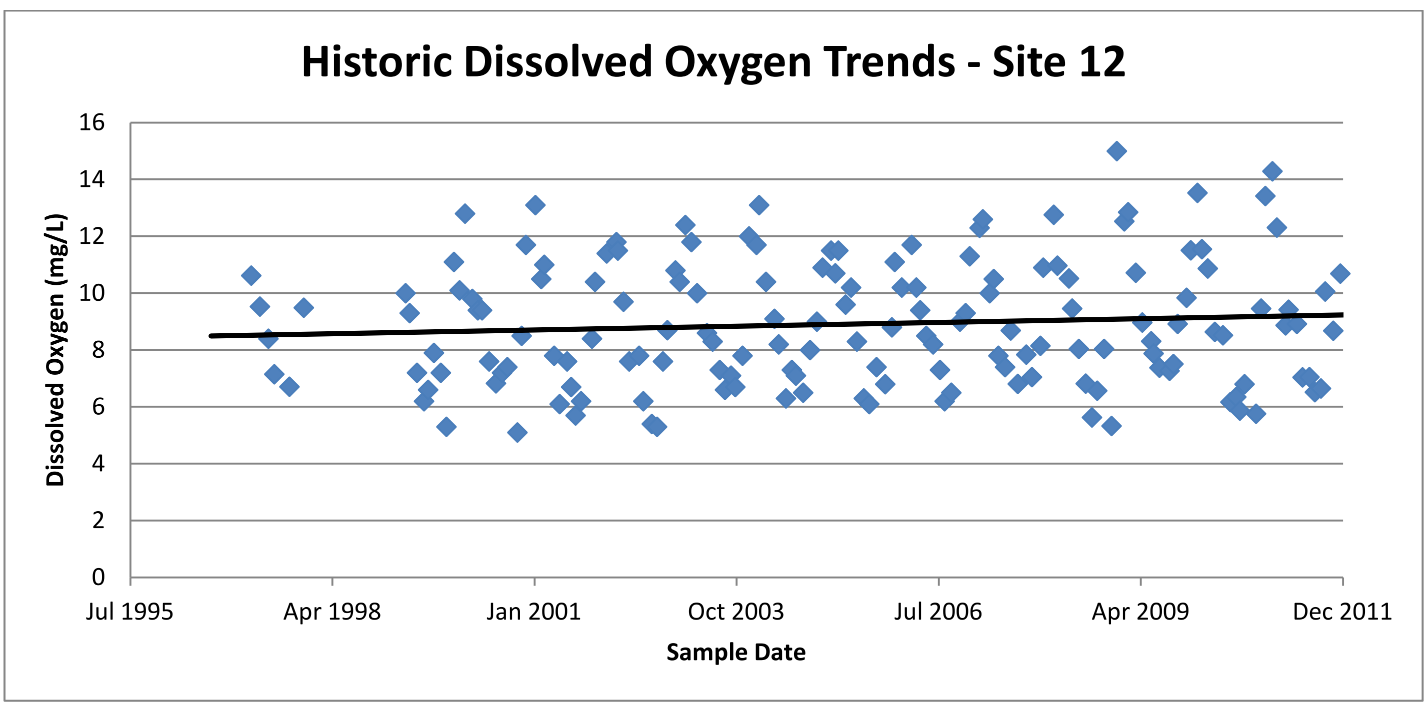


Figure 45: Historic Dissolved Oxygen Trends near Lost River Outlet

Indiana's 303(d) listing of impaired streams and waterbodies

The term "303(d) list" is short for the list of impaired and threatened waters (stream/river segments, lakes) that the Clean Water Act requires all states to submit for EPA approval every two years on even-numbered years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors. States then provide a long-term plan for completing load reductions within 8 to 13 years from first listing.

Table 11 is the 303 (d) list of impaired stream segments within Lost River watershed. Each entry has the impaired assessment unit IDs and assessment unit names for testing areas of Lost River watershed. The table also contains the cause of impairment for those testing areas and the category of impairment. The category of impairments are organized as follows:

- Category 1- Attaining the water quality standard and other applicable criteria for all designated uses and no use is threatened.
- Category 2- Attaining some of the designated uses; no use is threatened; and insufficient data and information are available to determine if the remaining uses are attained or threatened.
- Category 3- Insufficient data and information is available to determine if any designated use is attained.
- Category 4- Impaired or threatened for one or more designated uses, but does not require the development of a total maximum daily load (TMDL).
    - A. A TMDL has been completed that is expected to result in attainment of all applicable water quality standards and has been approved by U.S. EPA.
    - B. Other pollution control requirements are reasonably expected to result in the attainment of the water quality standards in a reasonable period of time.
    - C. Impairment is not caused by a pollutant.
- Category 5- The water quality standards or other applicable criteria are not attained.
    - A. The waters are impaired or threatened for one or more designated uses by a pollutant(s), and require a TMDL.
    - B. The waters are impaired due to the presence of mercury or PCBs, or both in the edible tissue of fish collected from them at levels exceeding Indiana's human health criteria for these contaminants.

Ten segments within Lost River watershed are listed on the draft 303 (d) list of impaired streams. Table 11 indicates that the 2012 draft 303(d) list has two reaches listed for impaired biotic communities. One reach was listed for low levels of Dissolved Oxygen. The list also indicates high levels of E.coli plague the area with nine reaches on the 2012 draft 303(d) list.

The goal of the Lost River Watershed Management Plan is to work toward a situation where all stream reaches are in Category 1. This can be accomplished by identifying the impairments and sources of those impairments. The work expressed within this document was work to try and identify impairments, identify sources and causes for those impairments, identify action strategies and management techniques to address these impairments.

Table 11: Waterbodies on the 2012 draft 303 (d) list within Lost River Watershed

ASSESSMENT UNIT ID	ASSESSMENT UNIT NAME	CAUSE OF IMPAIRMENT	CATEGORY
INW08F7_T1040	LOST RIVER-SINK	E. COLI	5A
INW08G5_T1062	LICK CREEK (SCOTT HOLLOW TO MOUTH)	E. COLI	5A
INW08G6_02	LICK CREEK	E. COLI	5A
INW08GE_T1033	LOST RIVER-SINK	E. COLI	5A
INW08G7_T1006	FRENCH LICK CREEK - UNNAMED TRIBUTARY	E. COLI	5A
INW08G7_T1006	FRENCH LICK CREEK - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A
INW08G7_T1063	FRENCH LICK CREEK (ABOVE FRENCH LICK WATER INTAKE)	E. COLI	5A
INW08GC_T1034	LOST RIVER	E. COLI	5A
INW08GE_T1002	LOST CREEK - UNNAMED TRIBUTARY (HARNER HOLLOW)	IMPAIRED BIOTIC COMMUNITIES	5A
INW08GE_T1002	LOST CREEK - UNNAMED TRIBUTARY (HARNER HOLLOW)	DISSOLVED OXYGEN	5A
INW08G8_T1036	LOST RIVER-WEST BADEN	E. COLI	5A
INW08G8_T1065	LOST RIVER (ABOVE SPRINGS VALLEY INTAKE)	E. COLI	5A

National Pollutant Discharge Elimination System (NPDES)

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. NPDES permits and programs include concentrated animal feeding operations (CAFOs), pesticide discharges, combined sewer overflows (CSOs), pretreatment, sanitary sewer overflows (SSOs), stormwater and whole effluent toxicity (WET).

There are several different types of permits that are issued in the NPDES permitting program. They are Municipal, Semi-Public or State (sanitary-type discharger), Industrial (Wastewater generated in producing a product), or Wet Weather which includes Storm Water-related (Wastewater resulting from precipitation coming in contact with a substance which is either dissolved or suspended in the water) or Combined Sewer Overflows (CSO) (Wastewater discharged from combined storm and sanitary sewers due to precipitation events).

Lost River watershed has or has had twelve NPDES permitted facilities. Five facilities, Campbellsburg Municipal WWTP, Essex Group Inc, Republic Services of IN LP Orleans Transfer Station, Rogers Group (Orleans Quarry) and Paoli Municipal

Water have since closed. A total of 7 facilities are currently active and shown in Table 12. They are mostly wastewater treatment facilities in the towns of Paoli, French Lick, Orleans, Campbellsburg, and the West Washington Jr. - Sr. High School. One of these facilities, Paoli Wastewater Treatment Plant (WWTP), is a Combined Storm and Sewer Treatment Facility. Calcar Quarries is a Dimension Stone Production Facility. Eight pipes discharge into our local streams and rivers from these facilities, two of which are from the Paoli WWTP.

Table 12: Active NPDES permitted Facilities in Lost River Watershed

NPDES ID	Facility Name
ING490041	CALCAR QUARRIES INC
IN0024023	PAOLI MUNICIPAL WWTP
IN0022489	CAMPBELLSBURG MUNICIPAL WWTP
IN0031577	WEST WASHINGTON JR-SR HS
IN0021601	ORLEANS MUNICIPAL WWTP
IN0022951	FRENCH LICK MUNICIPAL WWTP
IN0003247	SPRINGS VALLEY REGIONAL WASTE DISTRICT

The NPDES permitted facilities are required to report regularly to IDEM and report any unscheduled discharges due to overflow during rain periods. The compliance and violation data will be discussed later within the subwatershed discussions in Section 5.

USGS National Water Quality Assessment-National Water Information System

The USGS implemented the National Water-Quality Assessment (NAWQA) Program in 1991 to develop long-term consistent and comparable information on streams, rivers, ground water, and aquatic systems in support of national, regional, State, and local information needs and decisions related to water-quality management and policy. The NAWQA program is designed to address the following objectives and answer these questions:

1. What is the condition of our Nation's streams, rivers, and ground water?
2. How are these conditions changing over time?
3. How do natural features and human activities affect these conditions, and where are those effects most pronounced?

USGS scientists collect and interpret data about surface- and ground-water chemistry, hydrology, land use, stream habitat, and aquatic life in parts or all of nearly all 50 States using a nationally consistent study design and uniform methods of sampling analysis.

USGS monitored five stations within the Lost River watershed from 1992-1995 for water chemistry. USGS collected 390 water quality parameters including heavy metals, hardness and alkalinity, nutrients, and other chemical and physical parameters. A total of 41 sample collection events occurred at these five locations in the watershed study area from 1992-1995. The location of four of these stations are Lost River as it crosses under Windom Rd in Martin County, Upper Sulphur Creek at County R 100 S on Orange County, South Fork Lost River at County Rd 100 S in Orange County, and Lost River near Claysville in Orange County. These stations only collected data once or twice during this period and are not considered due to lack of substantial data. Of the sampling events, 35 were collected from Lost River near Leipsic, IN. This sample location corresponds to the location of the long term USGS Gage Station 03373530 and Site B of the Lost River Watershed Team Sampling sites (See Figure 71 for location information). Parameters comparable to current data collection are shown in Figures 46 through 51.

Table 13 lists selected parameter means, standard deviations, and whether or not the parameter means meet water quality standards or recommended targets. TSS, nitrogen, and total phosphorus mean values do not meet recommended water quality targets Figures 46 through 51 depict trends in nitrogen (nitrate + nitrite, & TKN), total Phosphorus, orthophosphate, total suspended solids (TSS), and dissolved oxygen at Site B from 1993-1995. Nitrogen in the form of nitrate plus nitrite and nitrate values have slightly decreased since 1993 indicating improvement in water quality during this period in regards to this parameters. Phosphorus and TSS values have increased indicating a degradation in water quality during this period in relation to these parameters, and dissolved oxygen concentrations have decreased in these years indicating an degradation in water quality.

The decrease in dissolved oxygen concentrations can in part be attributed to an increase in phosphorus, a limiting agent in the growth of algae. The potential increase in algae and associated algal decay will decrease the dissolved oxygen content. Increasing TSS concentrations suggest that there has been an overall increase in the amount of sediment particles in the water column. Since Phosphorus often binds to sediment particles, an increase trend in Phosphorus coincides well to the increase in amount of sediment making its way into the streams. The increasing trends in Phosphorus and sediment is likely due to the increasing amount of farmed ground within the watershed and lack of erosion control measures during this time.

USGS monitored one station within the Lost River watershed in 2002 for biochemistry and plant tissue. At this station Inorganic carbon, Organic carbon, total carbon (inorganic plus organic), particulate nitrogen, Chlorophyll a (phytoplankton), Pheophytin a (phytoplankton), and Ratio particulate nitrogen to organic carbon was collected three times in June, July, and September of 2002. Plant Tissue data collected at this site included biomass of periphyton, Pheophytin a (periphyton), and Chlorophyll a (periphyton). This data is beyond the scope of this investigation and will not be discussed further.

Table 13: Site B –Historic Parameters Means and Standard Deviations

Parameter	**Mean**	**Standard Deviation**	**Sample Size**	**Water Quality Standard or Target**	**Mean Meets Target or Standard**
Alkalinity (as CaCO3) (mg/L)	157.6	±39.8	31	-	
Chloride (mg/L)	11.8	±2.0	30	-	
Hardness (as CaCO3) (mg/L)	190.3	±52.4	31	-	
Nitrogen, Ammonia (mg/L)	0.05	±0.067	31	Dependent on pH & Temperature	
Nitrogen, Nitrate+Nitrite (mg/L)	6.21	±1.44	31	Max: 1.5 mg/L	**No**
Nitrogen, Nitrate (mg/L)	6.28	±2.16	31	Max: 1.5 mg/L	**No**
Nitrogen, Nitrite (mg/L)	0.03	±0.02	31	Max: 1 mg/L	Yes
pH (Lab) (SU)	7.76	±0.292	32	Min: 6 Max: 9	Yes
Phosphorus, Total (mg/L)	0.141	±0.208	31	Max: 0.07 mg/L	**No**

Parameter	Mean	Standard Deviation	Sample Size	Water Quality Standard or Target	Mean Meets Target or Standard
Orthophosphate (mg/L)	0.276	±0.400	31	Max: 0.05 mg/L	**No**
Solids, Suspended Total, (TSS) (mg/L)	45.0	±60.9	31	Max: 25 mg/L	**No**
Solids, Total Dissolved (TDS) (mg/L)	253.0	±45.8	31	Max: 750 mg/L	Yes
Sulfate (mg/L)	17.2	±4.75	30	Max: 250 mg/L	Yes
Total Organic Carbon (mg/L)	3.79	±4.24	31	-	
% Saturated Dissolved Oxygen (%)	92.3	±17.7	31	Min: 60% Max: 110 %	Yes
Dissolved Oxygen (mg/L)	9.3	±2.5	32	Min: 4.0 mg/L Max: 12.0 mg/L	Yes
Discharge (m3/s)	2.85	±6.14	32	-	
Specific Conductance (Field) (uS/cm)	421	±90	32	Max: 1,200 µS per cm at 25°	Yes
Temperature (°C)	15.1	±6.88	32	varies by sample date	

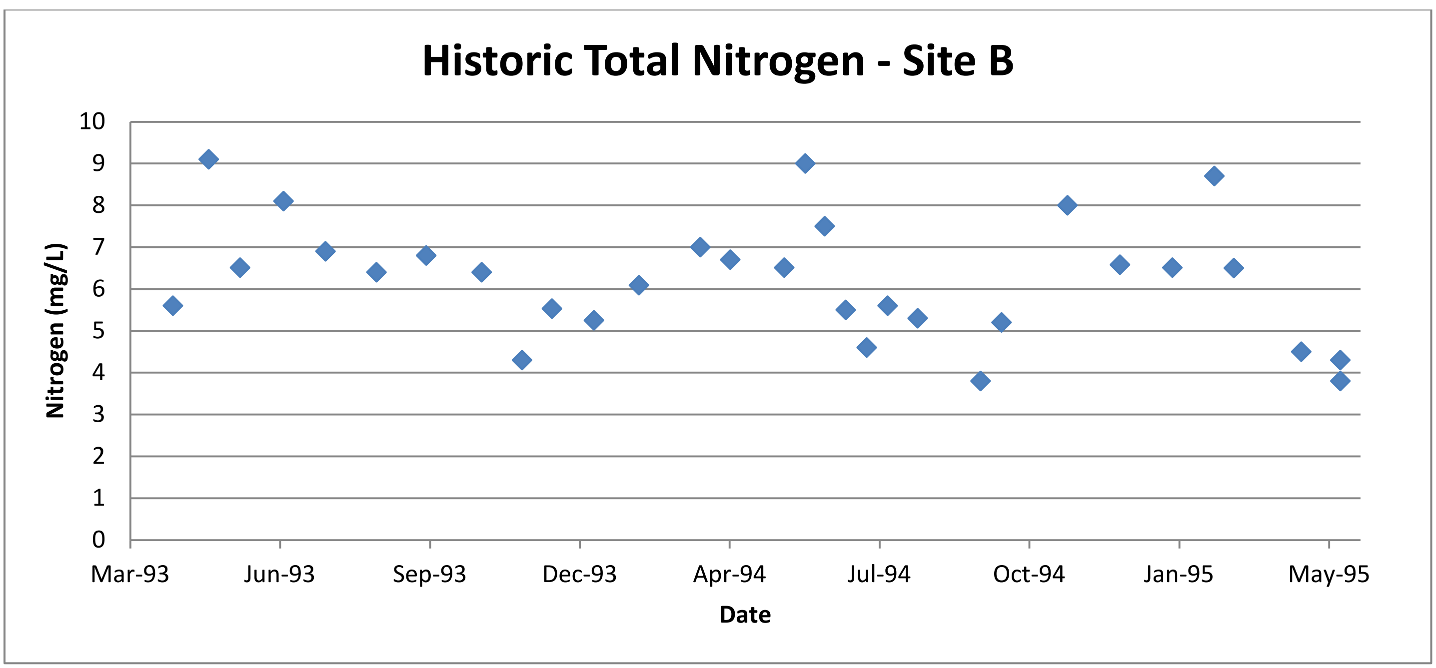


Figure 46: Historic Total Nitrogen Data on Lost River at Potato Rd (USGS, 1993-1995)

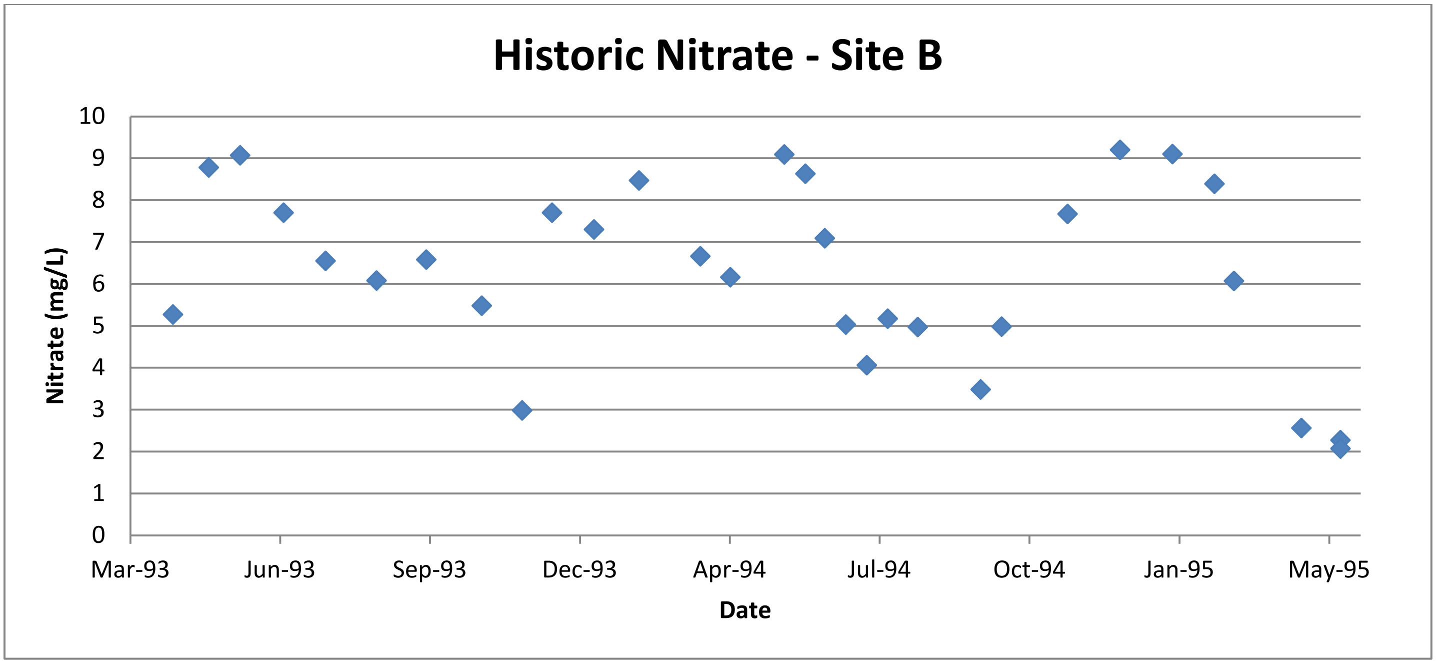


Figure 47: Historic Nitrate Data on Lost River at Potato Rd (USGS, 1993-1995)

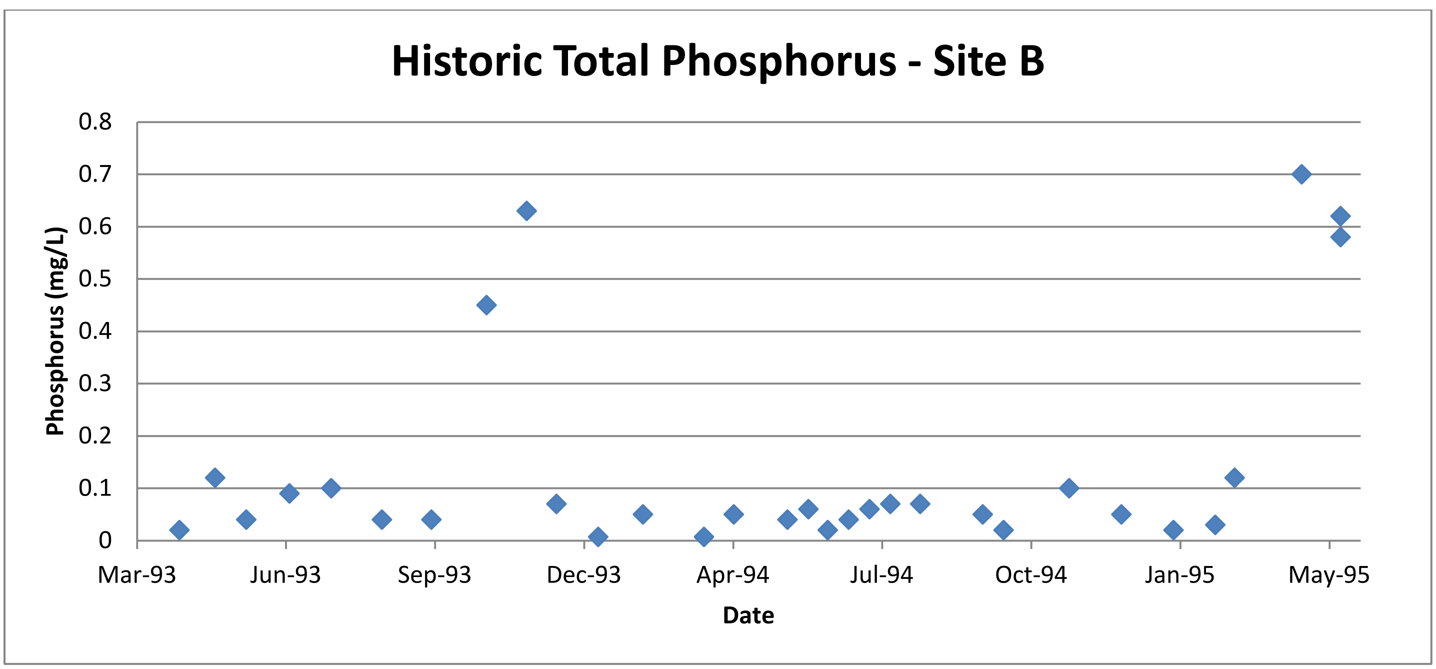


Figure 48: Historic Total Phosphorus Data on Lost River at Potato Rd (USGS, 1993-1995)

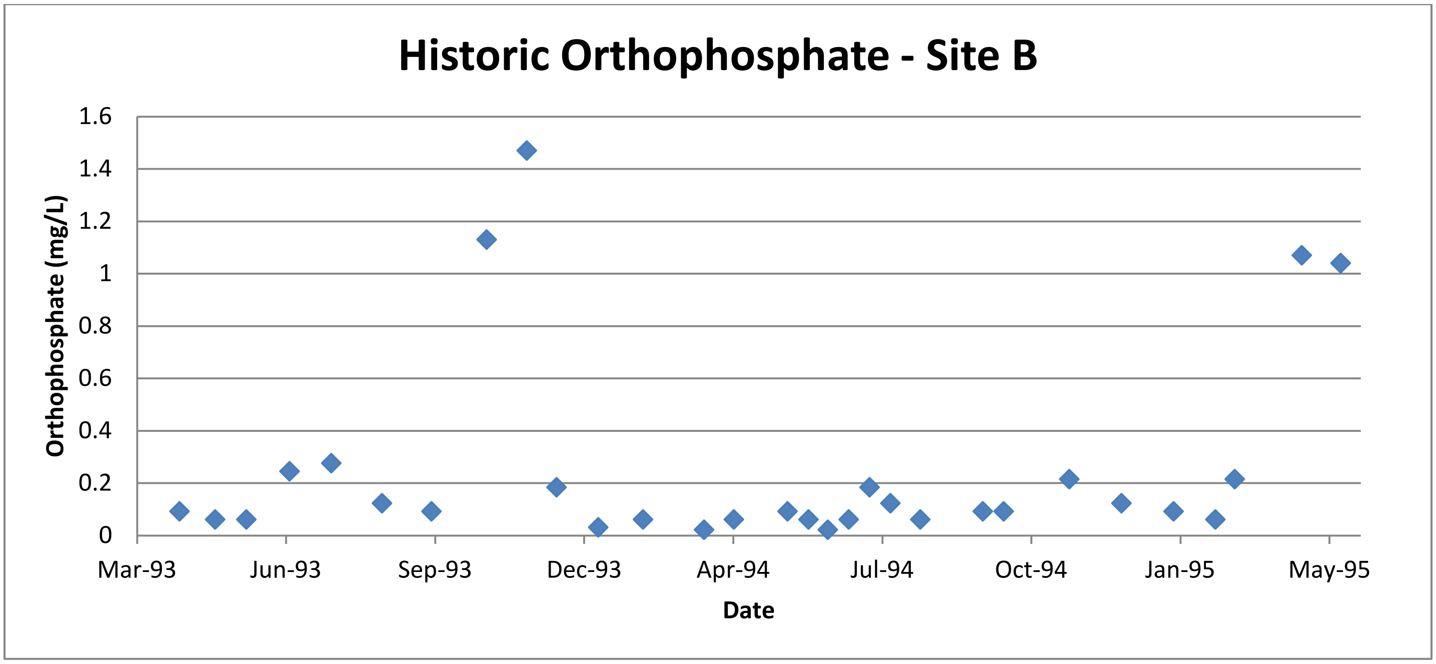


Figure 49: Historic Total Phosphorus Data on Lost River at Potato Rd (USGS, 1993-1995)

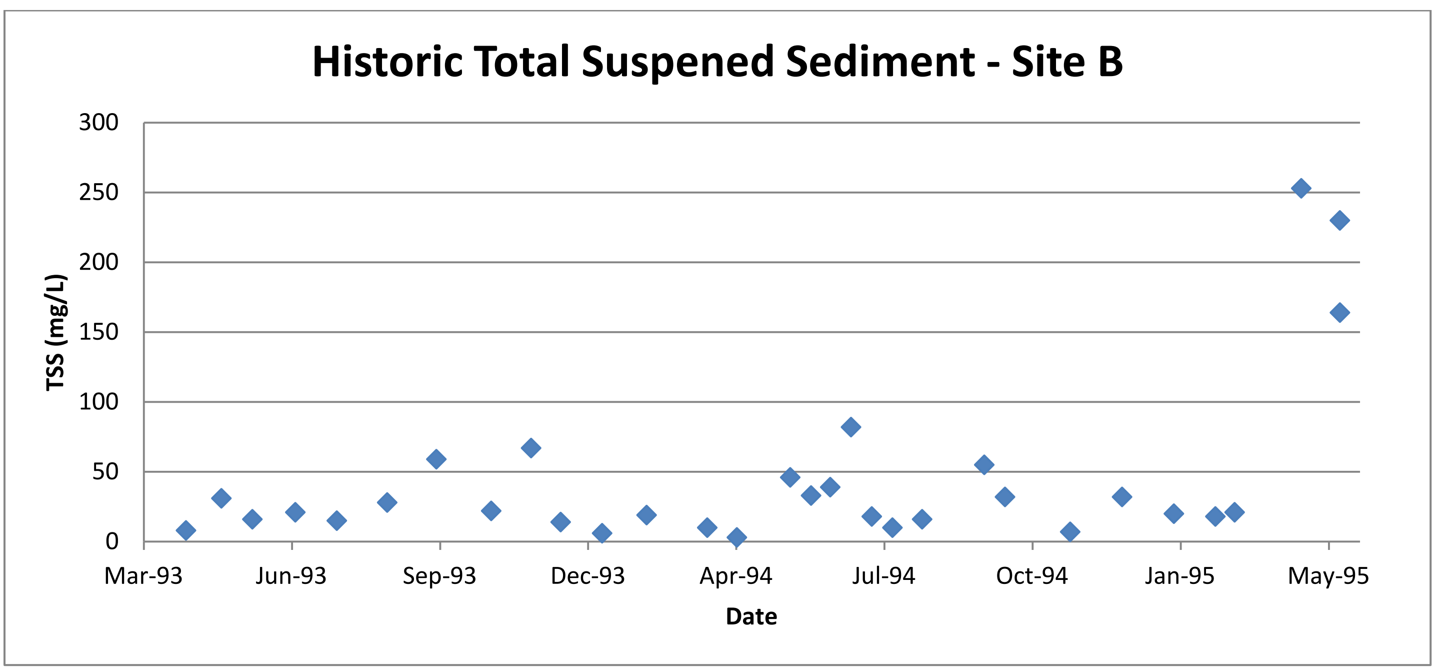


Figure 50: Historic Total Suspended Sediment Data on Lost River at Potato Rd (USGS, 1993-1995)

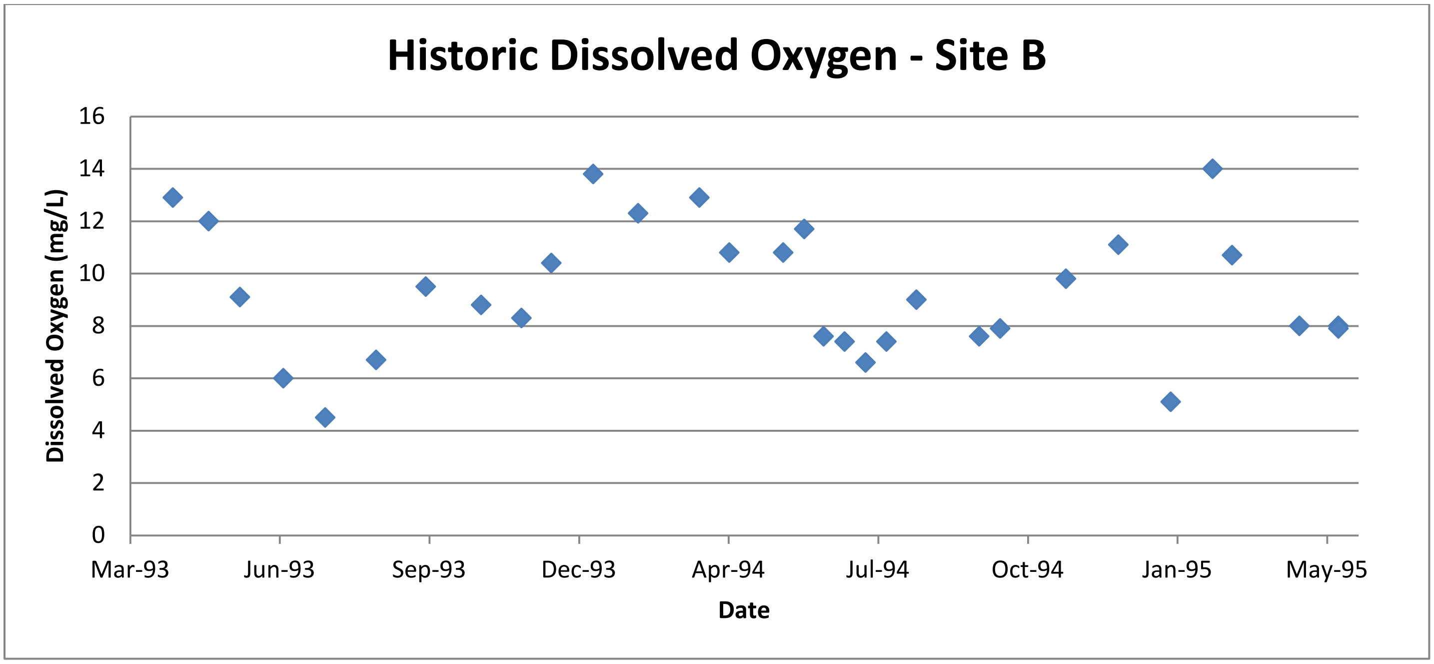


Figure 51: Historic Total Suspended Sediment Data on Lost River at Potato Rd (USGS, 1993-1995)

Lost River Watershed: Final Water Quality Monitoring Study (2006, LARE study of Dry Branch Lost River)

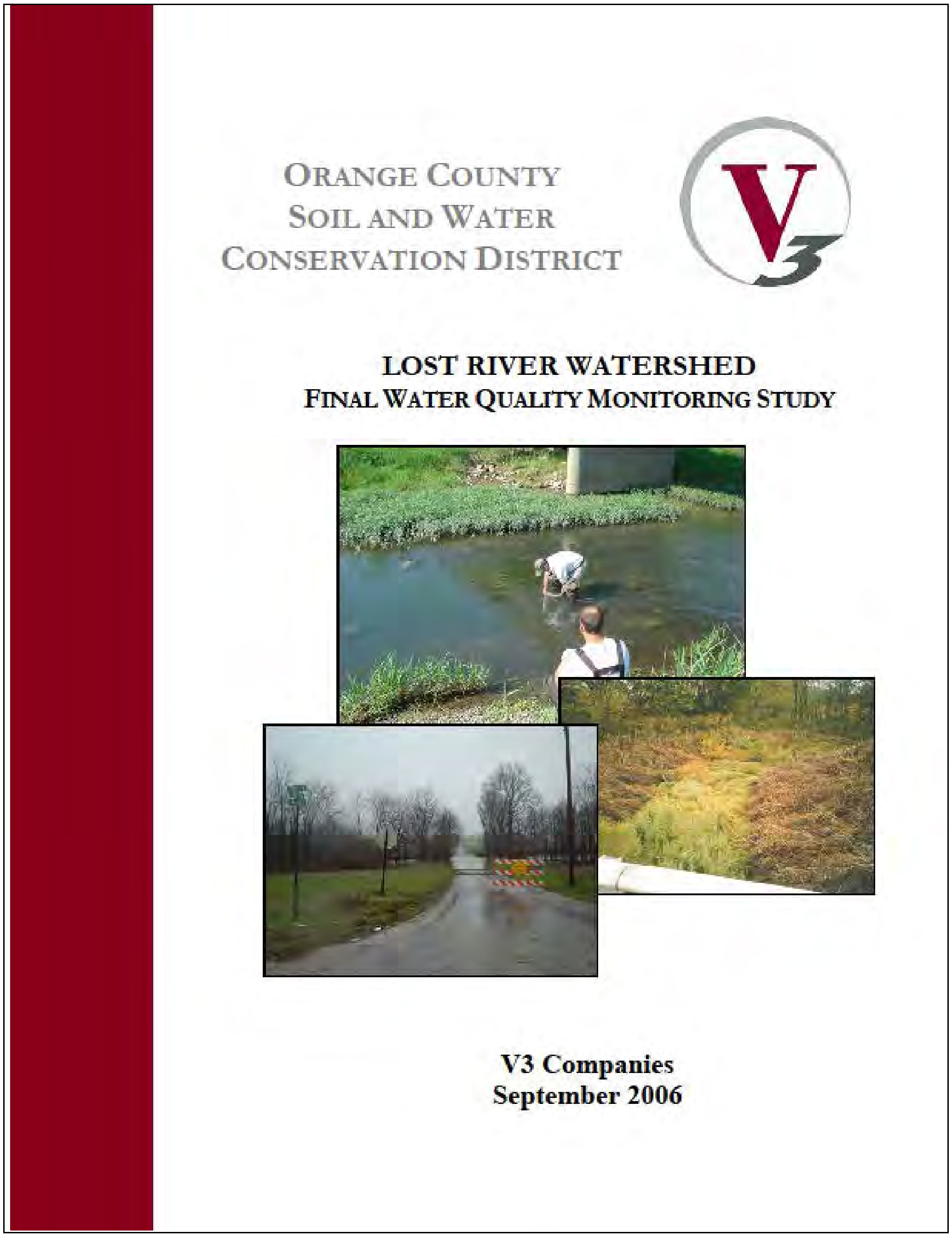


Figure 52: Report Cover (LARE 2006)

V3 Companies, Ltd conducted the Lost River Watershed: Final Water Quality Monitoring Study for the Orange County Soil and Water Conservation District (Figure 52). Ten sampling stations were used for evaluating the biological, physical, and chemical condition of Dry Branch Lost River watershed including macroinvertebrate communities, instream and riparian habitat and water quality parameters. This watershed study includes eight sampling stations on Lost River, one sampling station on South Fork Lost River and one on Carter's Creek. Of these locations, four were sampled for macroinvertebrates, eight were sampled for water quality during baseflow conditions, and nine were sampled for water quality during stormflow conditions (see Figure 53).

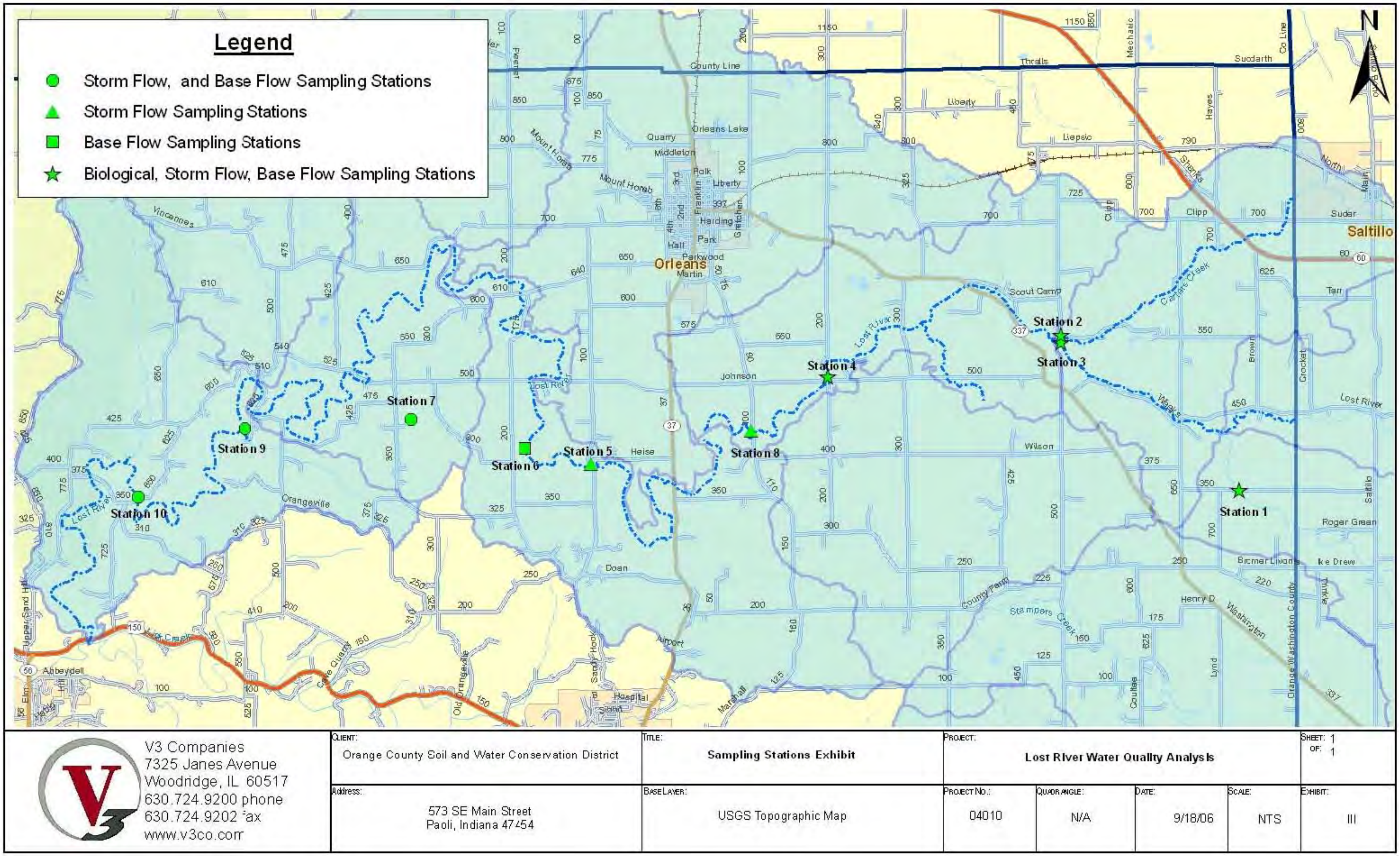


Figure 53: Sample Site Locations for the 2006 LARE Final Water Quality Monitoring Study for the Orange County (figure from Lost River Watershed Final Water Quality Monitoring Study, 2006)

Table 14: Site locations of LARE sampling sites with relation to current sampling sites.

(Sampling type: M= macroinvertebrate, S= Stormflow, B= Baseflow)

LARE 2006 Sample Site	Stream Name	Location	Location in Relation to Current Study Sample Sites	Sampling Type
1	South Fork Lost River	CR 350 N	Site 1	M, S, B
2	Carters Creek	Tater Road	Site A	M, S, B
3	Lost River	Tater Road	Site B	M, S, B
4	Lost River	Fishers Ford Bridge	Site 3	M, S, B
5	Lost River- Dry Bed	CR 100 W	7.4 miles downstream of Site 3	S
6	Lost River- Dry Bed	Tolliver Swallow Hole	8.6 miles downstream of Site 3	B
7	Lost River	Wesley Chapel Gulf	Subterraneous window	S, B
8	Lost River- Dry Bed	Roosevelt Road	1.5 miles downstream of Site 3	S
9	Lost River	True Rise of Lost River	downstream of Site 7	S, B
10	Lost River	Orangeville Road	upstream of Site 9	S, B

Water quality analysis of the watershed during baseflow and stormflow events showed acceptable parameter values with the following exceptions. Phosphorus levels were high at 1,2,3,4,5,7,8,9 and 10 during stormflow sampling in January 2005 and at 1,2,3,6,7,9 and 10 during baseflow sampling in June 2004. Nitrate was measured at high levels at both Stations 1 and 3 during the June 2004 sampling effort (Figure 54). The stations with the highest levels of E coli were baseflow conditions at Station 1 (6,300 cfu/100ml) along the South Fork Lost River and stormflow condition at both drybed sampling stations along Lost River, Stations 5 (4,800 cfu/100ml) and Station 8 (5,000 cfu/100ml) (Figure 55). Stations 5 and 8 also shared the highest turbidity levels, Station 5 (80 NTU) and Station 8 (85 NTU) (Figure 56).

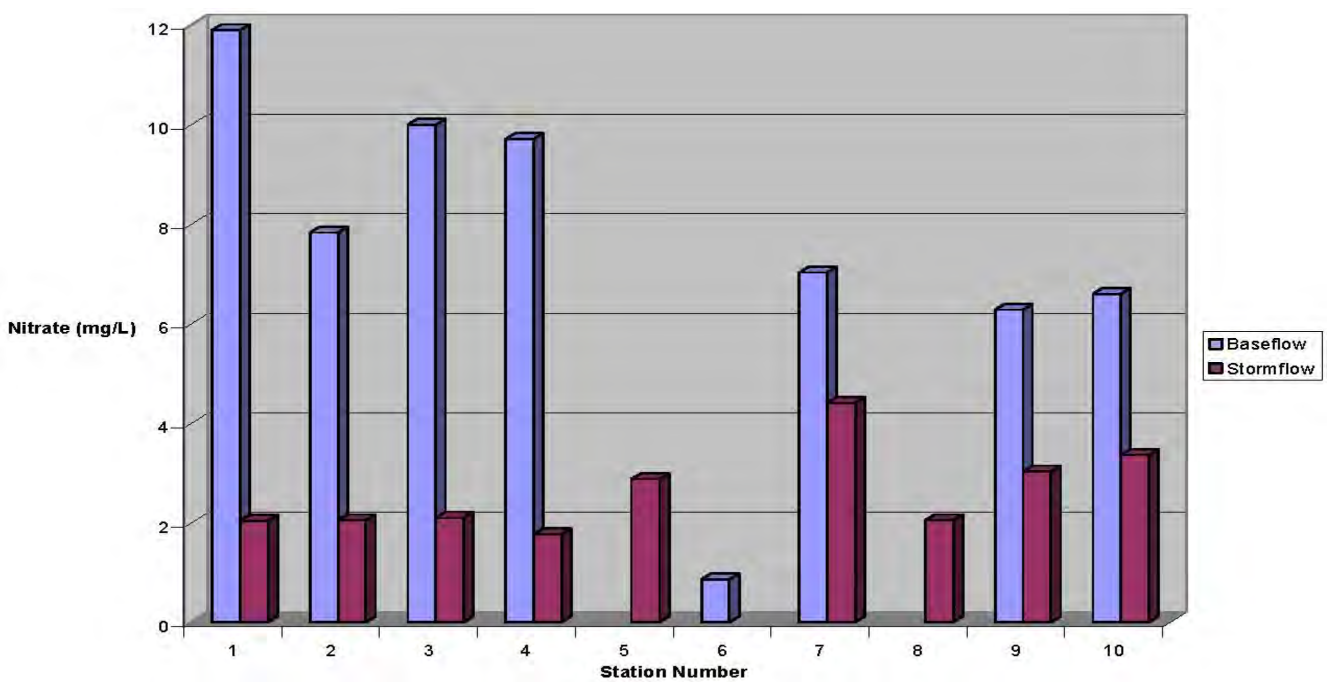


Figure 54: Nitrate levels at baseflow (June 2004) and stormflow (January 2005) sampling events (figure from Lost River Watershed Final Water Quality Monitoring Study, 2006).

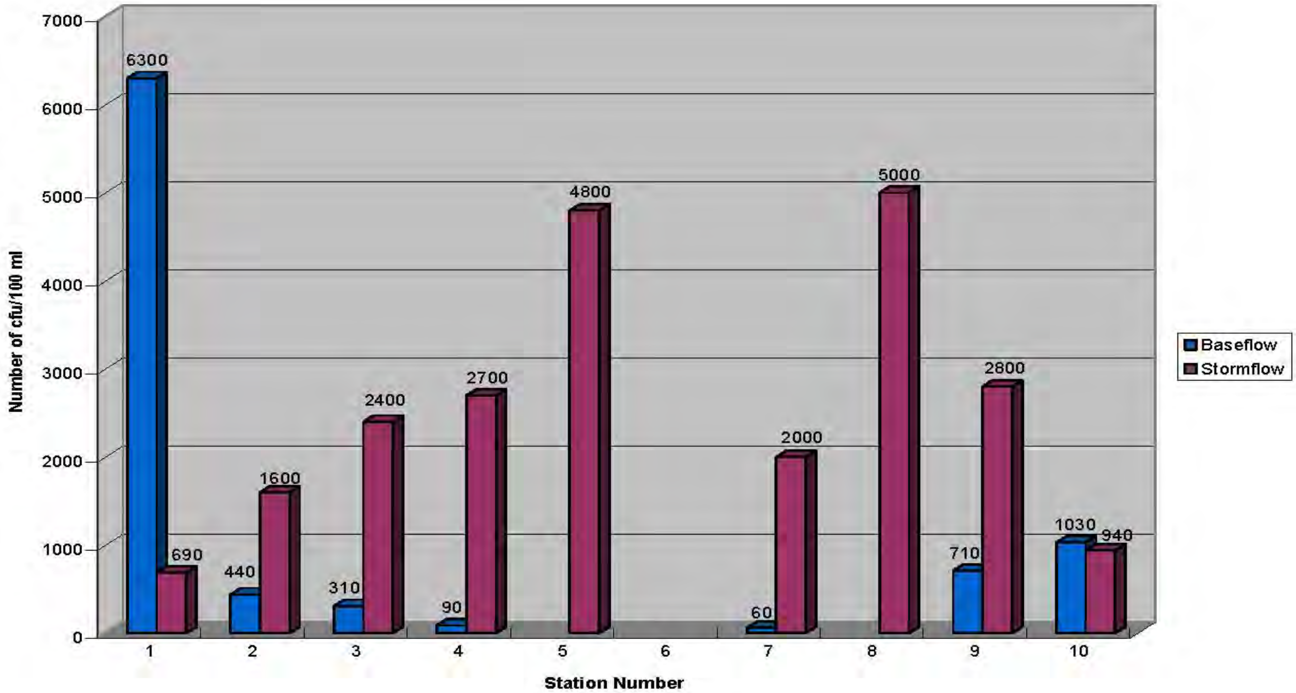


Figure 55: E. coli levels at baseflow (June 2004) and stormflow (January 2005) sampling events (figure from Lost River Watershed Final Water Quality Monitoring Study, 2006).

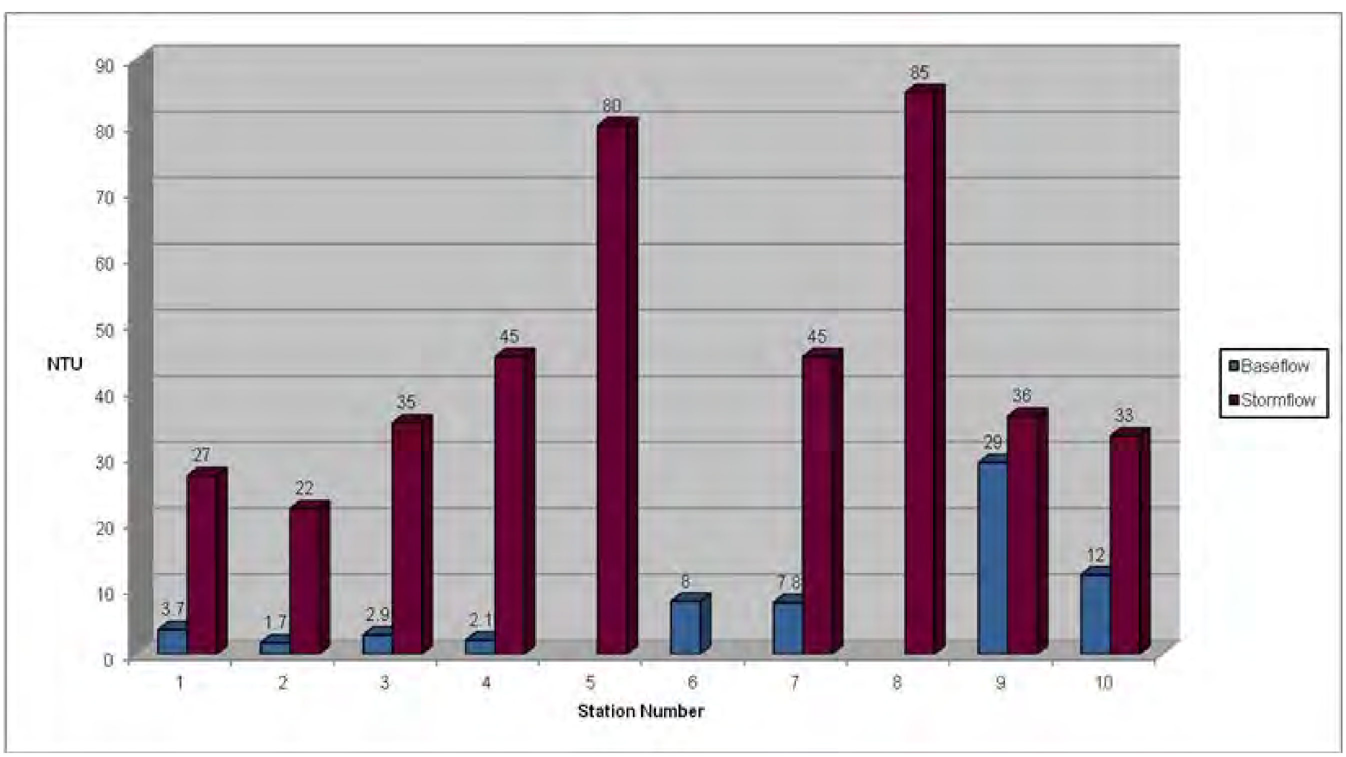


Figure 56: Turbidity levels at baseflow (June 2004) and stormflow (January 2005) sampling events (figure from Lost River Watershed Final Water Quality Monitoring Study, 2006).

Watershed Diagnostic Study: Lost River Watershed (2010, LARE study of lower Lost River in Martin, Orange, and Dubois Counties)

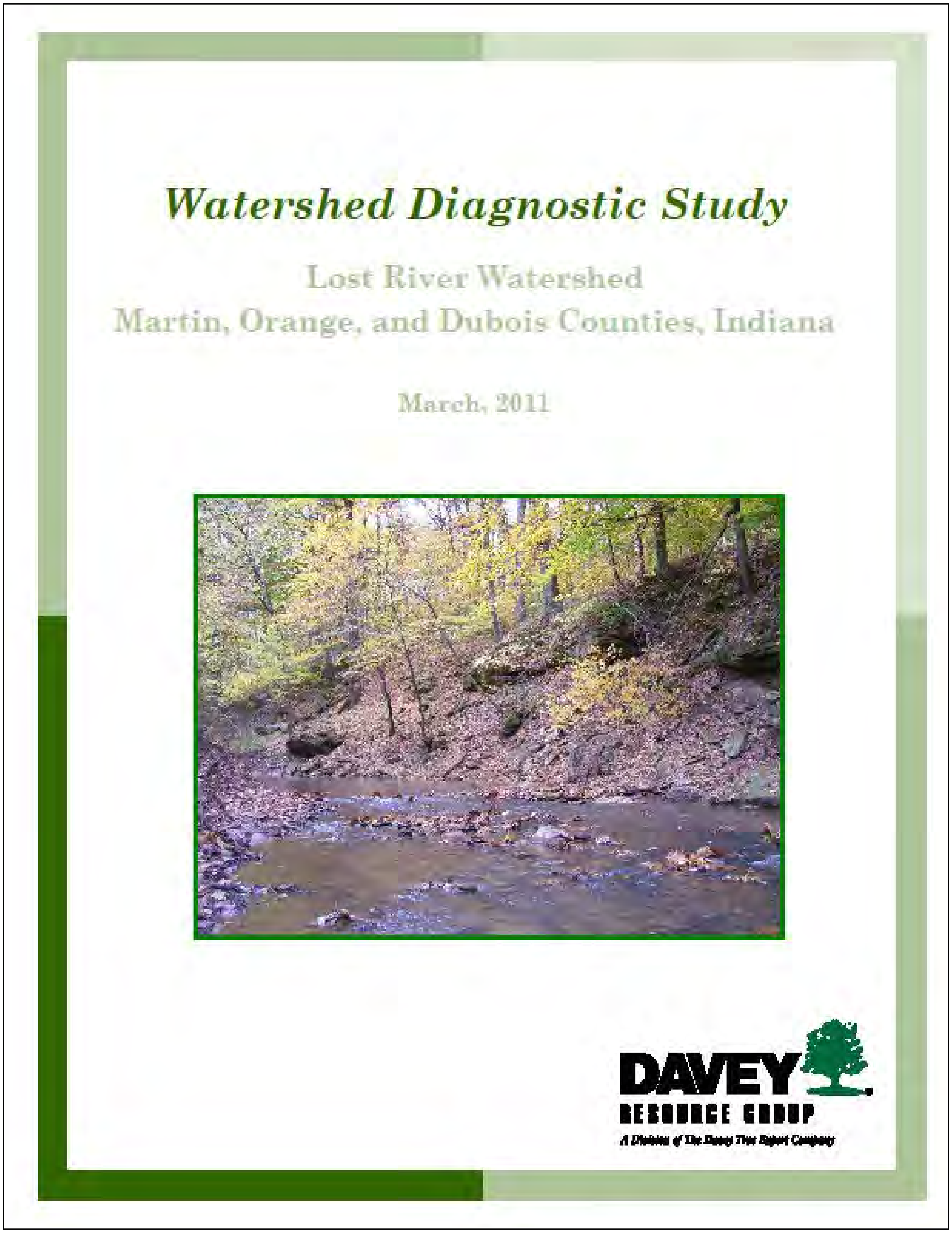


Figure 57: Report Cover (LARE 2011)

The Lost River Watershed Diagnostic Study (Figure 57) is a study of the water quality of the lower part of the Lost River and its tributaries and the factors that influence the water quality. This study was funded by an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program grant with a match provided by Martin County Soil and Water

Conservation District (SWCD). Martin County SWCD retained Davey Resource Group (Davey) to conduct the study. Work began in October, 2009 and concluded in August, 2010, with a final public meeting and publication of this report.

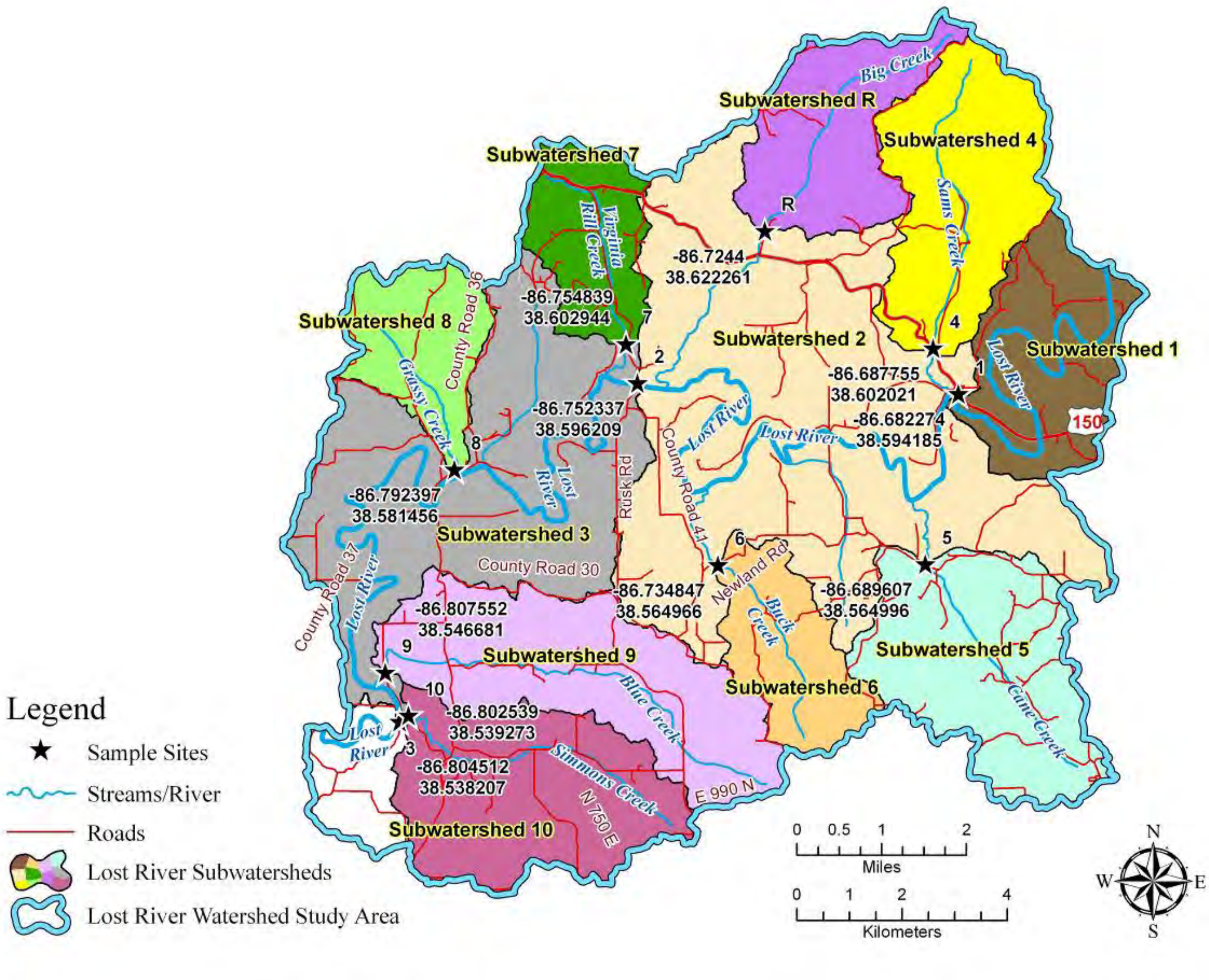


Figure 58: Sample Site Locations for the 2010 LARE Watershed Diagnostic Study conducted in Martin County

Figure 58 shows a total of 11 sample stations including 1 reference station (Station 101) established within the watershed by IDNR LARE staff, Martin County SWCD staff, and Davey staff. Data were collected at each sample site location relating to the physical and chemical properties of surface water in the Lost River watershed study area. Collection of water samples was limited to one baseflow event (10/27/2009 & 10/29/2009) and one stormflow event (4/26/2010). Benthic macroinvertebrates were sampled at all sample sites where water levels were less than 1 meter (3.28 feet) on October 26th-29th, 2009. The Qualitative Habitat Evaluation Index (QHEI) was used to evaluate the physical habitat of a waterway. A QHEI analysis was conducted at all sample sites on October 26th-29th, 2009

Data collected as part of this study documented high *E. coli* levels at multiple sites during base flow and storm flow conditions. Storm flow samples for Total Suspended Solids (TSS) and turbidity exceeded target and recommended values at all sites on Lost River, and turbidity was high at three tributaries during storm flow. Ammonia nitrogen levels consistently exceeded Indiana water quality standards at multiple sample sites.

Ammonia nitrogen was the only nutrient sampled for that consistently exceeds water quality standards. All sites were above standards at the time of the base flow sampling event, and Sites 5-10 and R exceeded standards at the time of the storm flow sampling event. Failing or inadequate septic systems are suspected to contribute to high ammonia nitrogen values in many subwatersheds in addition to livestock with direct access to streams.

E. coli concentrations exceeded water quality standards at multiple sites at the time of base flow and storm flow sampling. Free-ranging livestock have direct access to streams in multiple locations in the watershed study area. Failing septic systems are also suspected to be a significant contributor to E. coli concentrations in the watershed study area.

Storm flow samples for TSS and turbidity exceeded target and recommended maximums values at all sites on Lost River. Many of the pollutants contributing to these parameters entered Lost River upstream of the watershed study area. However, the watershed study area is also contributing a significant amount of TSS amounting to an estimated minimum of 2,936,620 kg per year (3,237 tons per year) based on base flow condition loads between Sites 1 and 3. Turbidity also exceeded recommended maximum values at tributary Sites 8-10 during storm flow, which is suspected to be due in large part to in-channel/streambank erosion. All base flow samples for both TSS and turbidity were below target and recommended maximum values.

In general, TSS loads are the highest for tributary Subwatersheds 4, 9 and 10 and Subwatersheds 2 and 3, which include the main stem of Lost River; thus, these subwatersheds should be emphasized in conservation efforts to reduce TSS and similarly turbidity. Davey recommends that conservation practices be implemented to reduce TSS loads from agricultural land throughout the watershed study area by approximately 20 percent. Davey also recommends that conservation practices are implemented and septic system maintenance education be promoted to bring E. coli concentrations below 235 CFU per 100 mL in all surface waters. Subwatersheds 6-8 should be emphasized for conservation efforts to reduce E. coli.

4.2.2 Flow Data

USGS Streamgage Network

USGS has six fixed streamgages throughout the watershed. Four of these gages were recently installed in 2010. They are Lost River near Prospect, IN (USGS 03373560), Lick Creek at Paoli, IN (USGS 03373610), French Lick Creek at French Lick (USGS 03373686), and French Lick Creek at West Baden Springs, IN (USGS 03373695). One gage, Orangeville Rise at Orangeville, IN (USGS 03373350) was installed in October of 2011. The only continuous long-term gage installed is Lost River near Leipsic, IN (USGS 03373530), and it has been in operation since October of 1992. These streamgages are operated by the USGS, in partnerships with Indiana Department of Transportation, Orange County, Town of French Lick, and Town of West Baden Springs. Streamgages continuously measure stage, or height of water at the gage in relation to some reference datum. The continuous record of stage is translated to river discharge by applying the stage-discharge relation (also called rating curve). Stage-discharge relations are still being developed for most of the stations. These stream gages are still in their infancy. Rating curves have been developed for the gage data up through November of 2011. Discharge measurements are confirmed for data up until this date, however only gage height can be used after this date while discharge data is still provisional. Figures 59 through 68 are graphs that show gage heights or discharge for these stations from October of 2010 through December of 2012. USGS gage locations can be seen in Figures 71, 88, 113, 149, and 170 in Section 5.

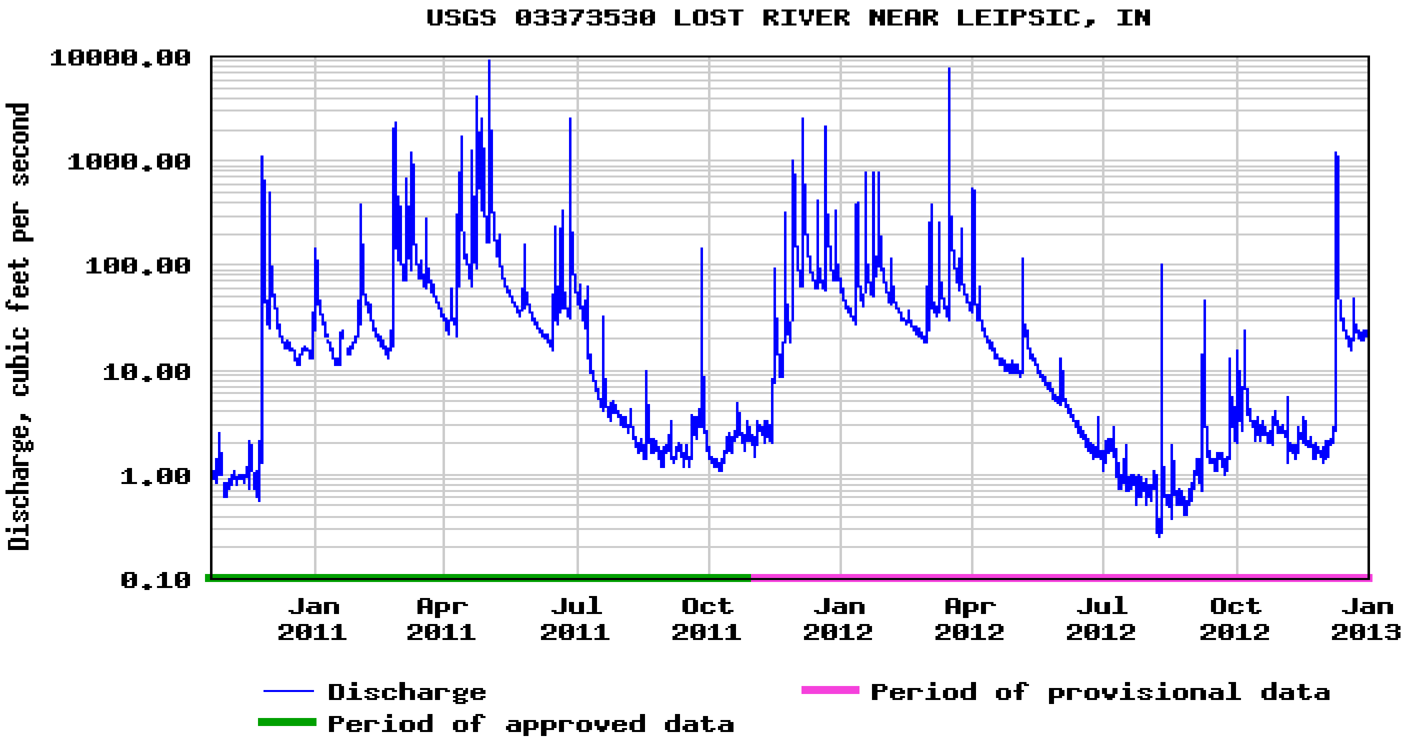


Figure 59: Discharge at Lost River near Leipsic, IN (Site B of current sampling)

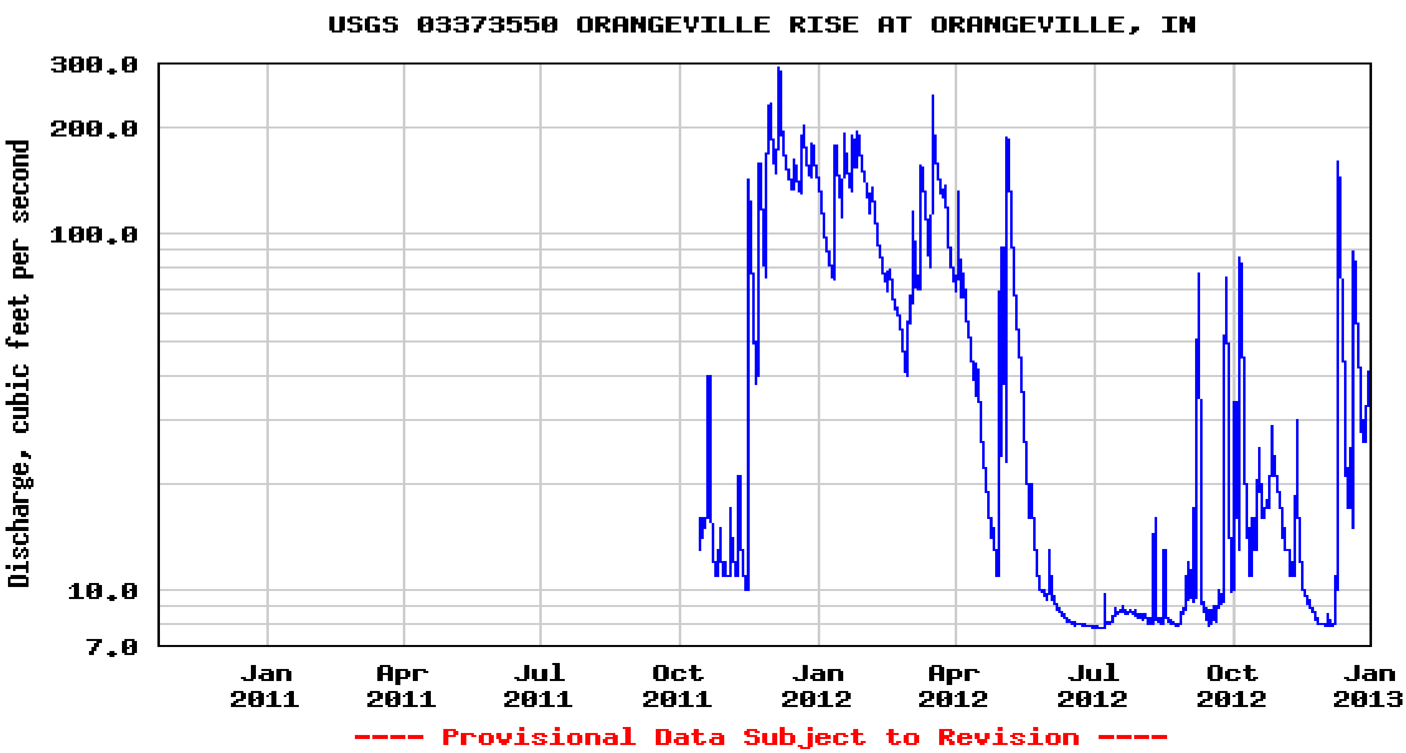


Figure 60: Discharge at Orangeville Rise at Orangeville, IN (Site 7 of current sampling)

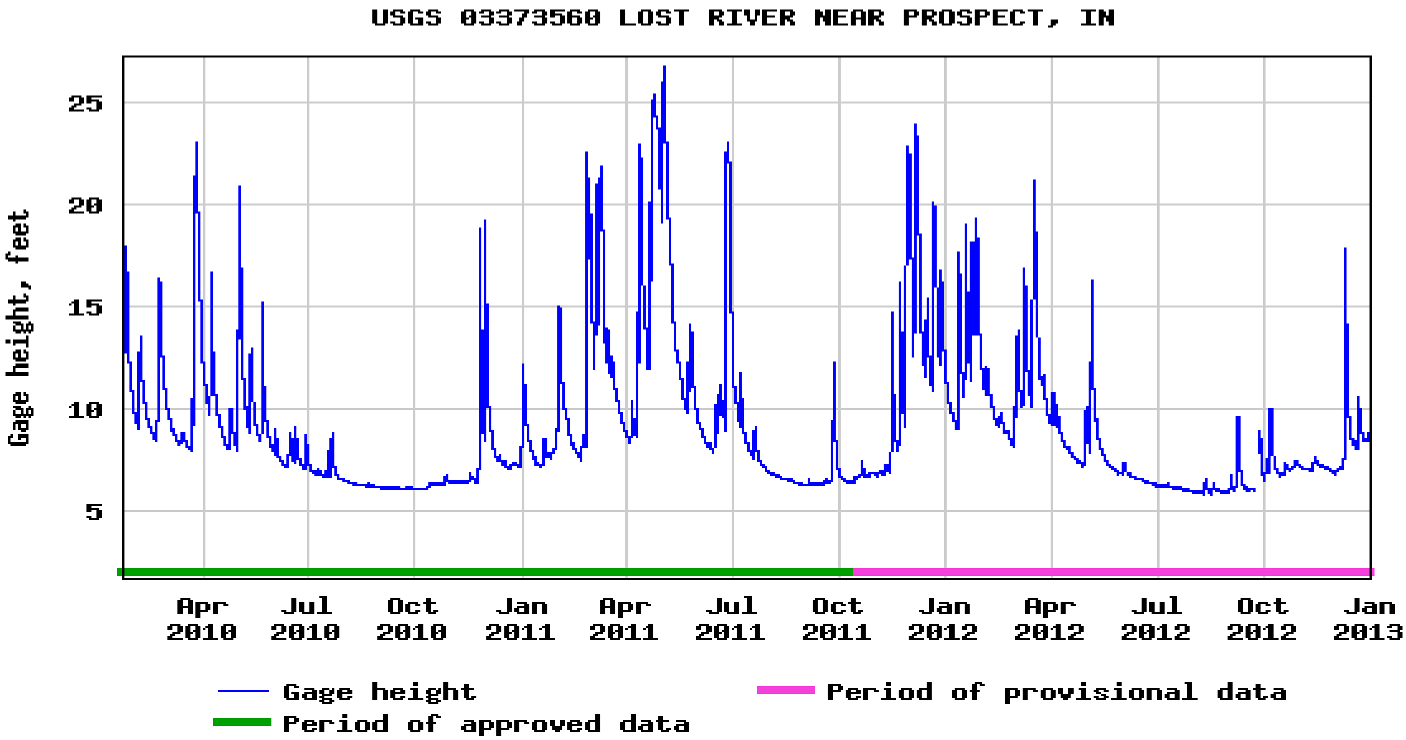


Figure 61: Gage height at Lost River near Prospect, IN (Site 9 of current sampling)

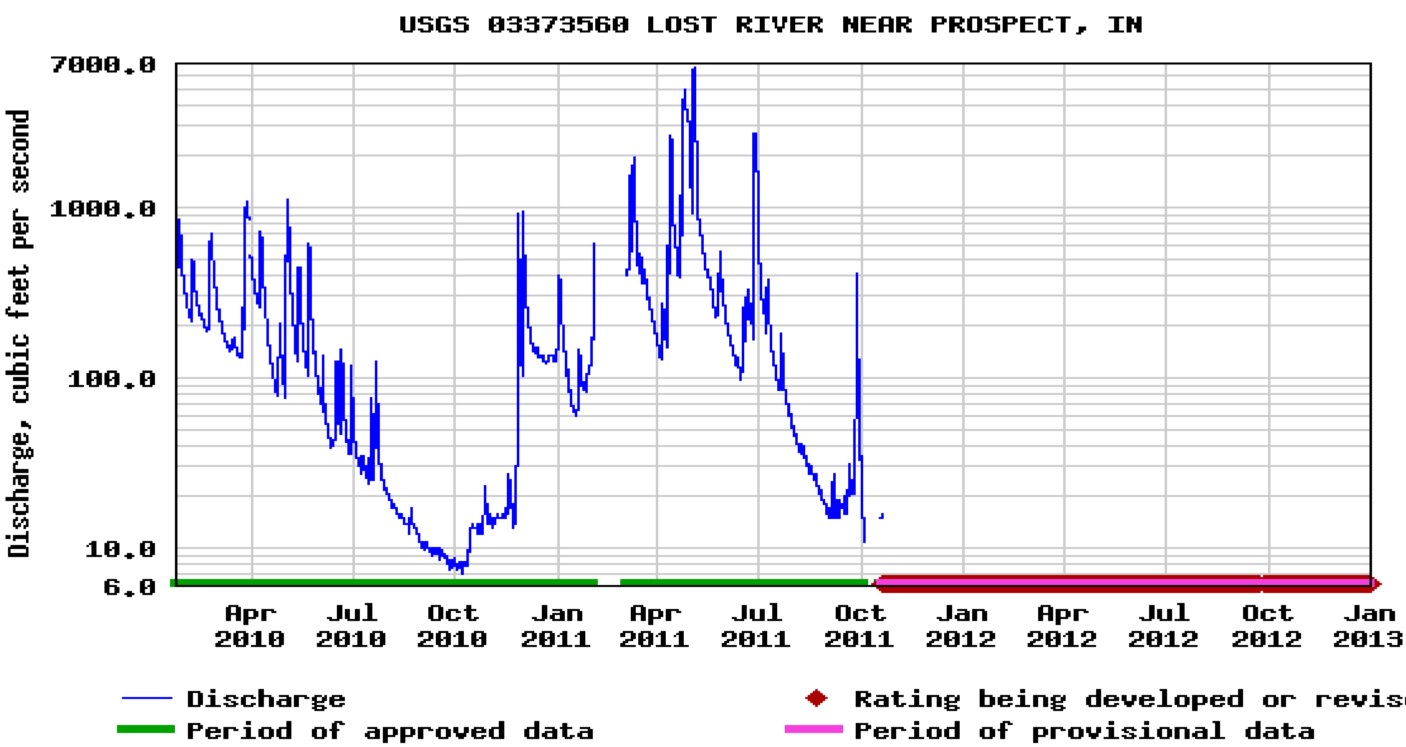


Figure 62: Discharge at Lost River near Prospect, IN (Site 9 of current sampling)

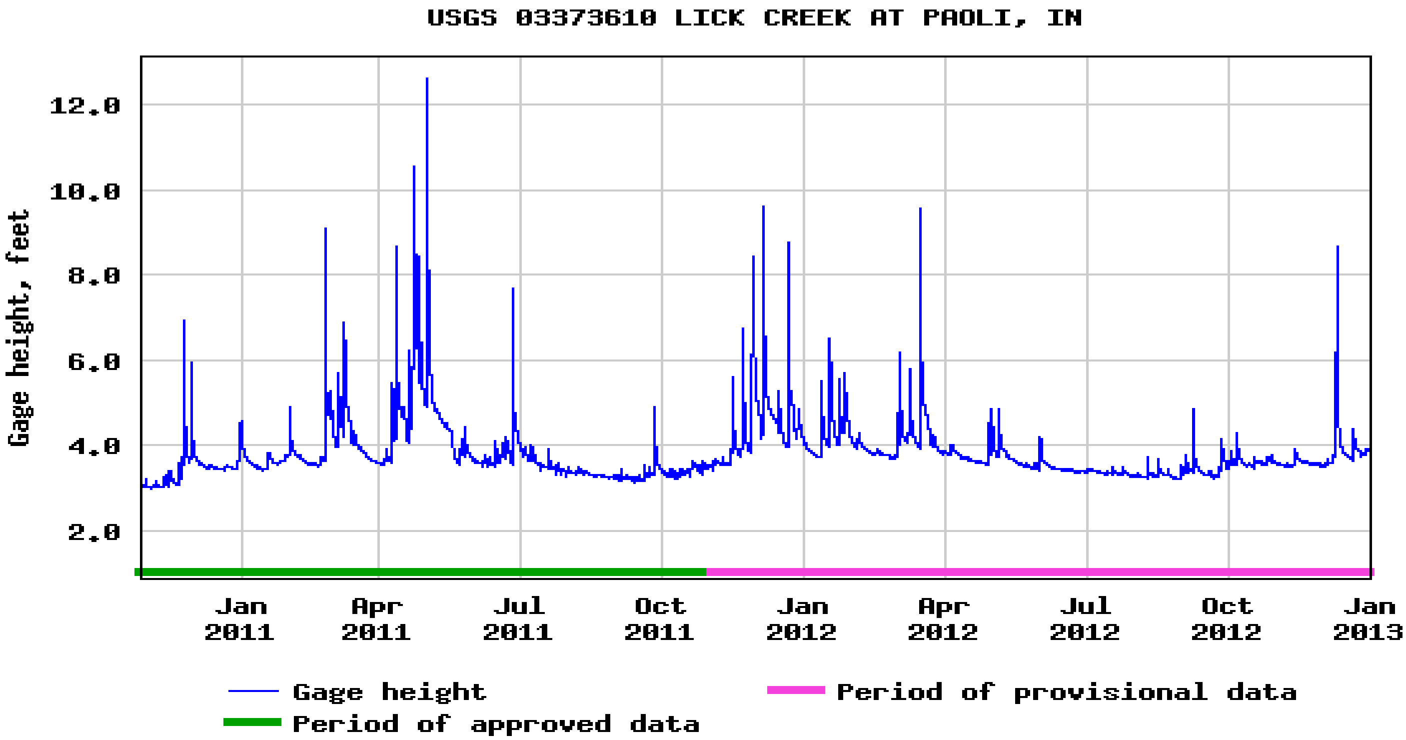


Figure 63: Gage height at Lick Creek at Paoli, IN (Site C of current sampling)

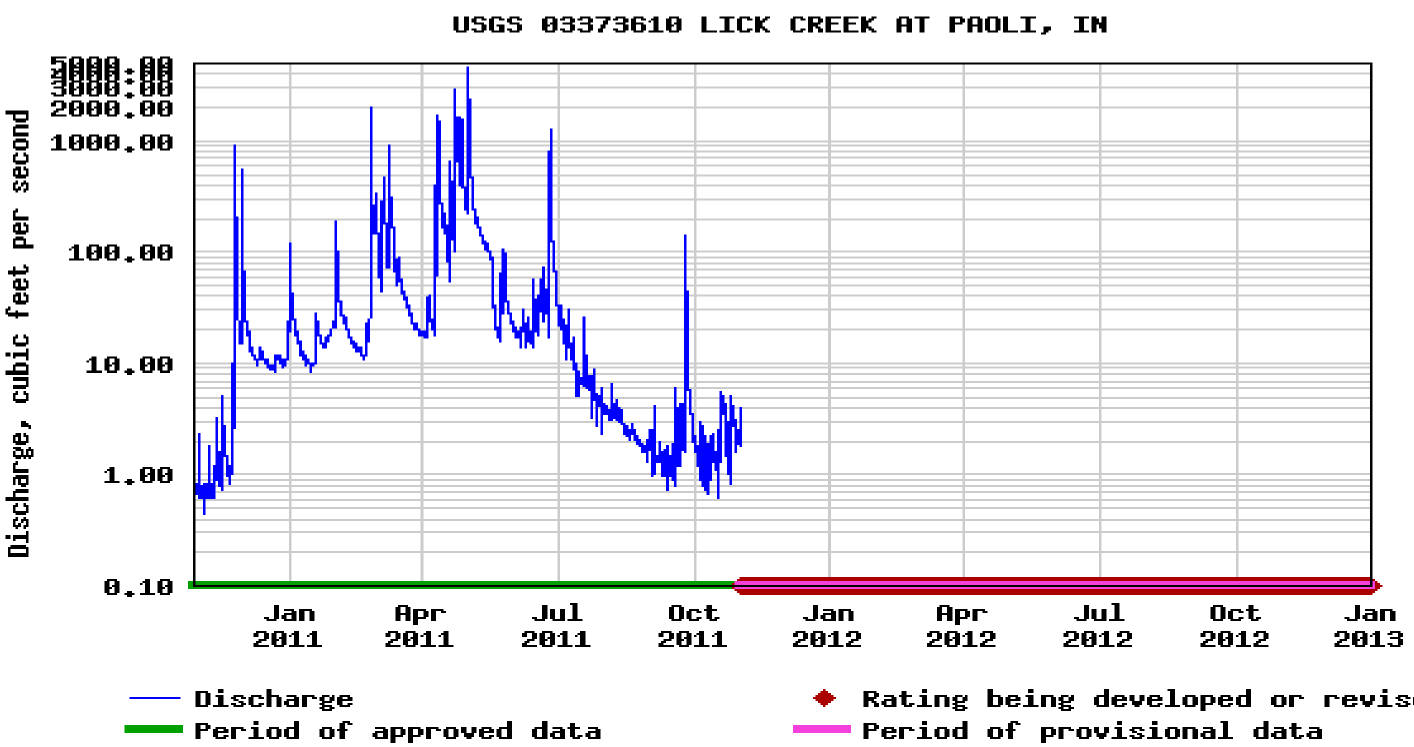


Figure 64: Discharge on Lick Creek at Paoli, IN (Site C of current sampling)

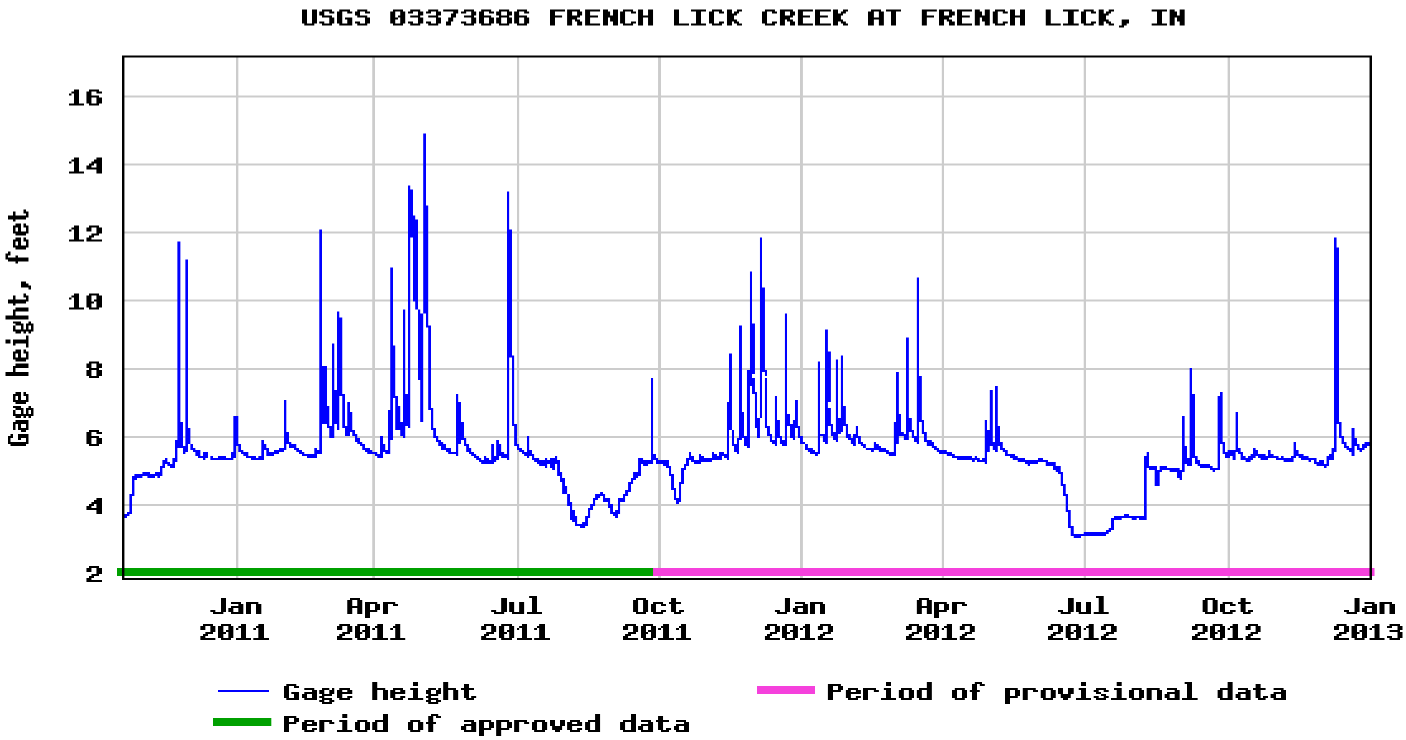


Figure 65: Gage height at French Lick Creek at French Lick, IN (upstream of Site 10 of current sampling)

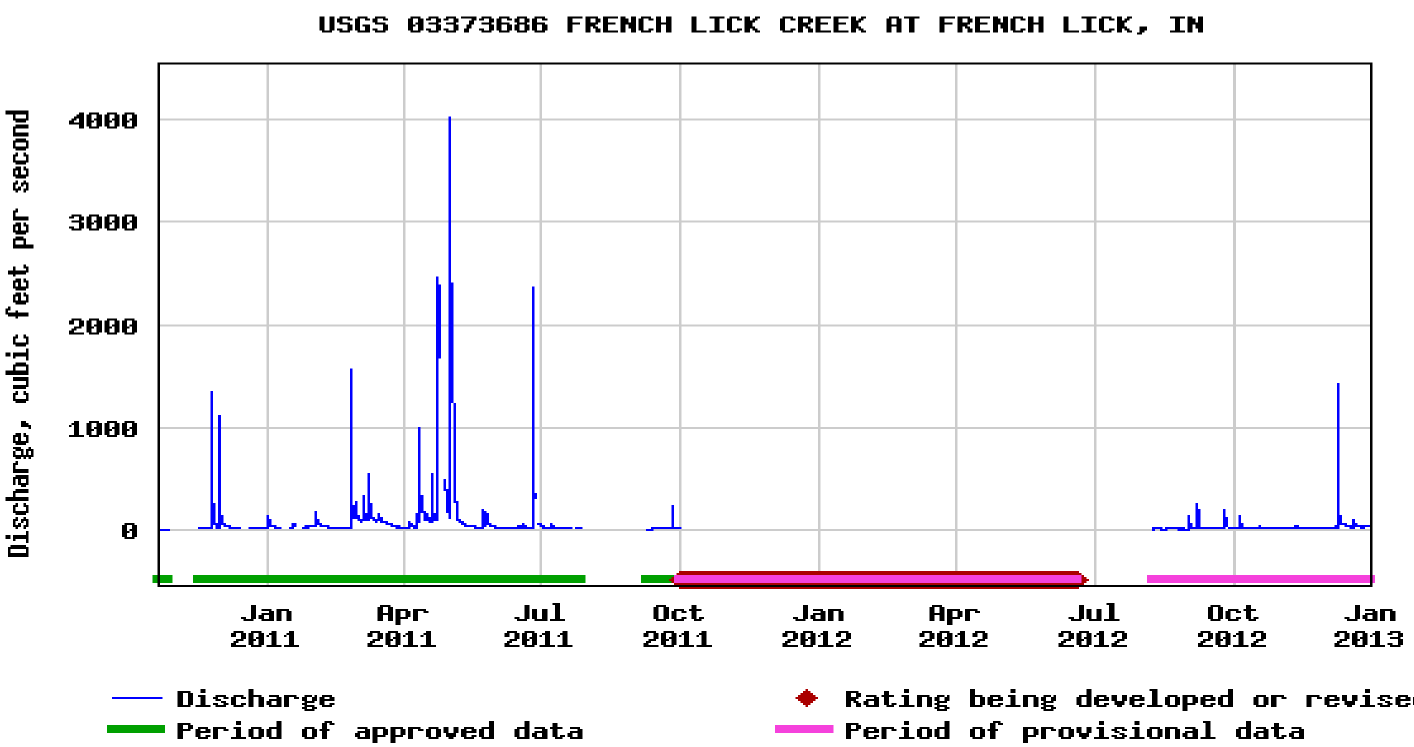


Figure 66: Discharge at French Lick Creek at French Lick, IN (upstream of Site 10 of current sampling)

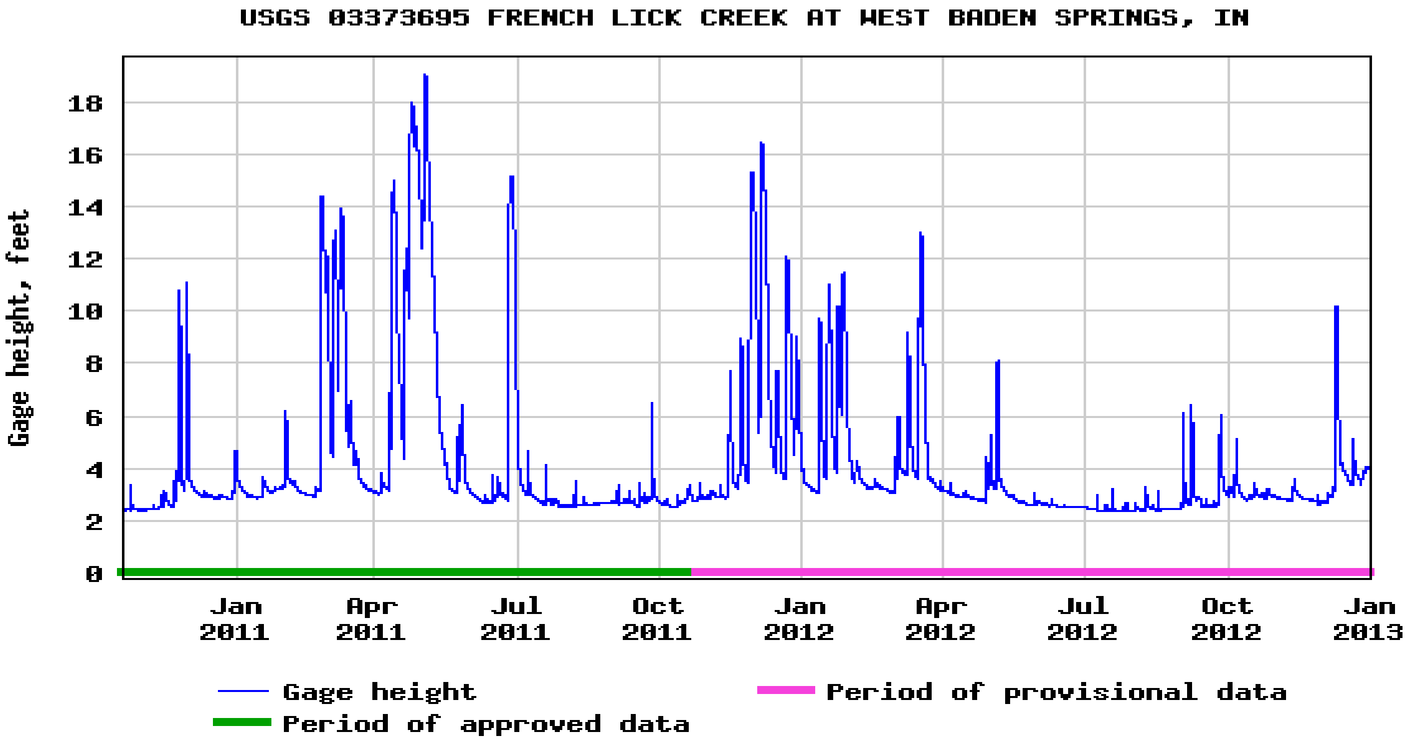


Figure 67: Gage height at French Lick Creek at West Baden Springs, IN (Site 10 of current sampling)

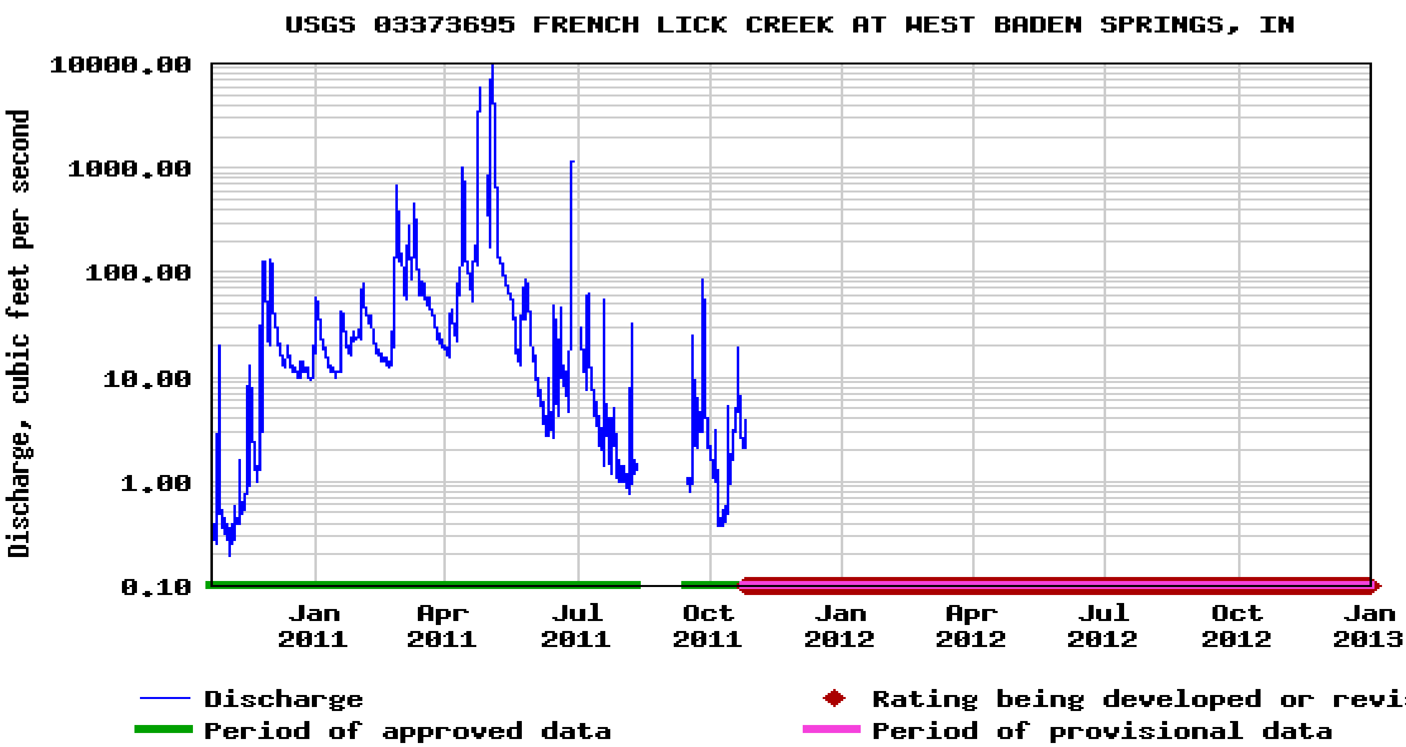


Figure 68: Discharge at French Lick Creek at West Baden Springs, IN (Site 10 of current sampling)

These gages have been very valuable for both data collection and data analysis for translating concentration data into loads in Section 8.2. Discharge from these stations is used when available. At stations where discharge has not been released stage was compared to existing stage-discharge relationships to approximate flow for sampling times to approximate loads. This data was also used to determine flow at surrounding subwatersheds using watershed ratio methods and/ or time of concentration analytic methods.

It is recommended that these gages be maintained in the area for flood alerts, data collection, and karst analysis. The foresight of the local towns and county governments will benefit the local community with future grants to address flooding and to further the investigations into karst systems for the country as a whole. These gages will be of significant help in the efforts of the Lost River Watershed Partnership in their future data collection efforts and development of long term trends.

4.2.3 Biological Data

The evaluation of macroinvertebrate and fish communities within the watershed describe the biological health at a level which provides insight into point and nonpoint source impacts which otherwise may or may not be able to be measured. Several groups have conducted biological assessments of Lost River watershed water bodies. IDEM along with DNR have done fish surveys in the watershed in different areas. V3, and Davey group conducted macroinvertebrate studies for their biological assessments as part of the LARE diagnostic studies in 2006 and 2011, respectively. IDEM also conducted macroinvertebrate sampling as part of their Integrated Water Monitoring and Assessment Report.

4.2.3.1 Benthic Macroinvertebrates

Indiana's 2012 Integrated Water Monitoring and Assessment Report (IDEM) (Macroinvertebrate)

IDEM has developed scoring criteria for a family level macroinvertebrate index of biotic integrity (mIBI) based on multiple sampling techniques. These two techniques include the single habitat (KICK) and multi-habit (MHAB) methods. KICK methods data are evaluated using 10 metrics designed to assess macroinvertebrate communities' structural, compositional, and functional integrity. The MHAB approach evaluates the macroinvertebrate community using 12 metrics of which there are 3 metrics in common with the KICK method.

The mIBI allows IDEM to determine waterways that are impaired for aquatic life use based on the macroinvertebrate community present. Any site sampled using the KICK method and receiving a score less than 2.2 is designated as impaired for aquatic life use by IDEM (IDEM, 2008a). Any site sampled using the MHAB method and receiving a score less than 36, is designated as impaired for aquatic life use.

Lost River Watershed: Final Water Quality Monitoring Study (2006, LARE study of Dry Branch Lost River)

The biological evaluation of macroinvertebrate communities performed by V3 followed the multi-habitat approach provided in the USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, Periphyton, Benthic Macroinvertebrates and Fish, Second Edition, publication number EPA 841-B-99-002.

All four of the evaluated stations possess a slightly impaired biological condition. Habitat incorporates all aspects of physical and chemical constituents along with the biotic interactions. Habitat includes all of the instream and riparian habitat that influences the structure and function of the aquatic community in a stream. All four of the sampling stations evaluated for habitat during the Lost River Watershed Final Water Quality Monitoring Study resulted in Good habitat ratings.

Watershed Diagnostic Study: Lost River Watershed (2010, LARE study of lower Lost River in Martin, Orange, and Dubois Counties)

A mIBI analysis of macroinvertebrate populations indicated that none of streams sampled for macroinvertebrates are impaired for aquatic life use. Qualitative Habitat Evaluation Index (QHEI) indicated that nearly all sites had good or excellent habitat.

Macroinvertebrate Hilsenhoff Biotic Index (HBI) scores suggest that five out of seven sites sampled (Stations 5-7 and 9-10 in Figure 58) have very substantial to fairly substantial organic pollution. Some organic pollution is likely at Station R, and organic pollution is unlikely at Station 4. In HBI, the degree of organic pollution is indirectly determined by the number of organisms tolerant of low DO levels. Stations 5 and 6 had the worst HBI scores and the consistently lowest levels of DO. Dissolved oxygen levels at both sites were well within water quality standards.

Scores from mIBI are indicative of environmental stress on macroinvertebrate communities. Watershed study area mIBI scores are generally typical of Indiana streams and ranged from moderately impaired to slightly impaired. No streams in the Lost River watershed study area were determined to be impaired for aquatic life use. QHEI scores indicate that all streams in the watershed study area have good to excellent quality habitat with the exception of Station 8 which is fair. Since QHEI indicates that all streams in which macroinvertebrate communities were sampled have good to excellent habitat it can be concluded that water chemistry is the most influential factor impairing the macroinvertebrate communities.

4.2.3.2 Fish

Indiana's 2012 Integrated Water Monitoring and Assessment Report (IDEM)

The IDEM Water Quality Assessment Branch conducted fish community sampling in the Lost River and its tributaries in 1997 and 2007. To evaluate fish community assemblages, IDEM uses an Index of Biotic Integrity (IBI) composed of 12 metrics. A waterway is non-supporting for aquatic life use when the fish community sampled receives an IBI score less than 35. Table 15 lists the sampling locations, sampling dates, site IBI scores, and the integrity class based on the IBI scores.

Table 15: IDEM sampling locations, sampling dates, site IBI scores, and the integrity class

IDEM Sample Site	Stream Name	Location in Relation to Current Study Sample Sites	Sample Date	IBI Score	Integrity Class
WEL150-0007	Lost River	upstream of Site B	08-06-02	46	Fair
WEL150-0008	South Fork Lost River	upstream of Site 1	09-09-97	32	Poor
WEL150-0010	Lost River	Site 3	06-18-07	48	Good
WEL160-0022	Unnamed tributary to French Lick Creek	2.5 miles southeast of Site 10	06-04-07	30	Poor
WEL160-0018	Sams Creek	upstream of Site H	09-09-97	36	Fair
WEL160-0025	Lost River	upstream of Site 13	07-02-07	20	Very poor
WEL160-0027	Lost River	upstream of Site 1	06-18-07	16	Very poor
WEL160-0028	unnamed tributary to Lost River	1 mile northeast of Site 8	06-04-07	28	Poor

The good integrity class is characterized by a decreased species richness (intolerant species in particular) with sensitive species present. The fair integrity class is characterized by an absence of intolerant and sensitive species and a skewed trophic structure. The poor integrity class is characterized by an absence or rare occurrence of top carnivores and many expected species with dominance of omnivores and tolerant species. The very poor integrity class is characterized by very few species and individual fish present, diseased fish may be frequent, and tolerant species are dominant (IDEM, 2007). In general, the fish community of the watershed study area appears to have suffered some degradation in both Lost River and its tributaries. However, IDEM determined for sites WEL 160-0025 and WEL 160-0027 that IBI was not an appropriate tool for the waterbody, and results at site WEL 160-0028 were influenced by lack of flow. In all three instances, IDEM gave precedence to the mIBI scores for determining impairment (Davey, 2011).

Springs Valley Fish Management Report (2009, Indiana DNR, Department of Fish and Wildlife)

Indiana Department of Natural Resources (DNR) conducted a general fish survey of Springs Valley Lake (also referred to as Tucker Lake) on May 4 and June 1 to 2, 2009 and a survey of submersed aquatic vegetation on July 13, 2009. The 2009 general survey revealed low numbers of largemouth bass and a decreased bluegill population. A total of 551 fish, representing ten species, was collected that weighed an estimated 182 lbs. Largemouth bass ranked first by number, followed by redear sunfish, and longear sunfish. Largemouth bass also ranked first by weight, followed by redear sunfish, and channel catfish. Submersed vegetation was found to a maximum depth of 11.0 ft. Six native species, American pondweed, brittle naiad, coontail, American elodea, small pondweed, and southern naiad were collected. Brittle naiad was the most frequently occurring, followed by American elodea, small pondweed, and coontail.

Fish Consumption Advisory (FCA)

Three state agencies collaborate annually to compile the Indiana Fish Consumption Advisory (FCA). The Indiana Department of Natural Resources, Indiana Department of Environmental Management, and Indiana State Department of Health have worked together since 1972 on this effort. Samples are collected through IDEM's rotating basin assessment for bottom feeding, mid-water column feeding, and top feeding fish. Fish tissue samples are analyzed for heavy metals, PCBs, and pesticides. The advisories for the waters within the Lost River watershed from the 2010 report (ISDH, 2011) are at level one advisories. Level one restrictions are for warmouth and yellow bullhead out of Tucker Lake. Advisory listings are as follows:

- Level 1 – Unrestricted consumption. One meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under 15.
- Level 2 – Limit consumption to one meal per week for adults. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under 15
- Level 3 – Limit consumption to one meal per month for adults. Women who are pregnant or breastfeeding, women who plan to have children, and children under 15 DO NOT EAT
- Level 4 – Limit consumption to one meal every 2 months for adults. Women who are pregnant or breastfeeding, women who plan to have children, and children under 15 DO NOT EAT
- Level 5 – Zero consumption. DO NOT EAT.

4.2.3.3 Aquatic Nuisance Species

DNR identified *Oscillatoria spp*. (blue-green algae) for the first time in Springs Valley Lake during their 2009 general survey. Oscillatoria and many other species of blue-green algae have the potential to produce toxins that are harmful to humans, fish, and other animals. Blue-green algae are common in nutrient rich environments. They recommended investigating methods to reduce nutrient loading in the lake's watershed. Mute Swans have been observed within the watershed and may be disturbing the aquatic plant species within wetland, ponds, lakes and streams.

Section 5 - Pollutant Source Assessment

The Lost River watershed is divided into smaller regions for the watershed pollutant source assessment section of the Watershed Management Plan. These regions are composed of one to three subwatersheds within the Lost River watershed (Table 16, Figure 69). They are grouped based on similar location, land use, soils, and management practices. The Upper Headwaters of Lost River include the subwatersheds of Carters Creek and South Fork Lost River. The Lost Sinking Area is comprised of the subwatersheds of Lost River Sink, Orleans Karst Area, and Mt. Horeb Drain. The Lick Creek subwatersheds include Headwater Lick Creek, Log Creek-Lick Creek, and Scott Hollow-Lick Creek. Stampers Creek and Sulphur Creek subwatersheds are looked at individually along with French Lick Creek subwatershed. The Lower Lost River region is made up of three subwatersheds Sams Creek- Lost River, Big Creek - Lost River, and Grassy Creek - Lost River.

Table 16: Watershed Areas of Focus- Subwatershed groupings

Section	HUC	Subwatershed	Sample Site Subwatersheds
Headwaters Lost River	51202081203	South Fork Lost River	1
	51202081204	Carters Creek-Lost River	A & B
Lost Sinking Area	51202081202	Orleans Karst Area	7
	51202081205	Lost River Sink	3
	51202081206	Mt. Horeb Drain-Lost River	7
Stampers Creek	51202081201	Stampers Creek	2
Lick Creek Area	51202081301	Headwaters Lick Creek	4
	51202081302	Log Creek-Lick Creek	C, D, & 5
	51202081303	Scott Hollow-Lick Creek	6 & 8
Sulphur Creek	51202081305	Sulphur Creek-Lost River	9, 11, & E
French Lick Creek	51202081304	French Lick Creek	10, F, & G
Lower Lost River	51202081306	Sams Creek-Lost River	12 & H
	51202081307	Big Creek-Lost River	13, I, & L
	51202081308	Grassy Creek-Lost River	14, J, K, & M

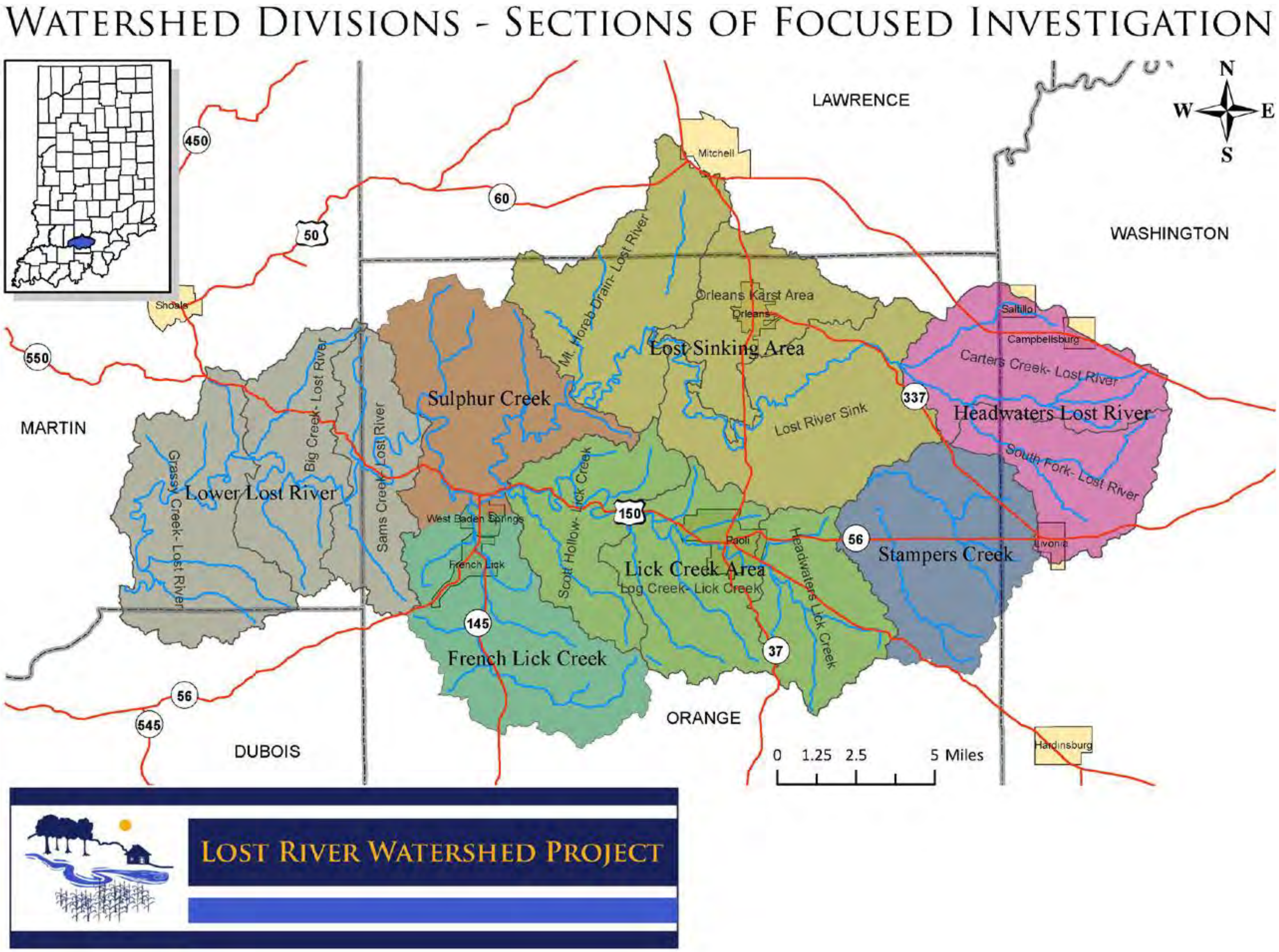


Figure 69: Subdivisions of Lost River Watershed- used for investigating similar areas

5.1 Headwaters Lost River Watersheds

The eastern most area of the Lost River watershed is also the headwaters of Lost River. Two subwatersheds, Carters Creek and South Fork Lost River, are the initial start to the trunk of Lost River (Figure 69). The southern subwatershed South Fork Lost River contains the highest elevation, 962.2 feet, within the watershed just west of the Town of Livonia. This area is considered the upper segment of the watershed. This segment is characterized by mostly normal surface-flowing streams crossing the eastern part of the Mitchell Plain. There are a few areas that can be seen in this area where sinkholes collect water during a rain event from an ephemeral channel. Sinkholes in this area will often stay filled with water slightly longer than other karst areas where water has receded. This may be due to the higher clay content of soils within this area, or may be a characteristic of the groundwater flow in this area.

Land Use

The total area of the watersheds is 28,265 acres with South Fork Lost River at 11,981 acres and Carters Creek covering 16,284 acres. The majority of landuse in these two subwatersheds is cultivated crops (18,754 acres) followed by pasture or hay lands (4,082 acres). Together they make up 22,836 acres or 80.8% of the watershed. Developed area makes up 1,730 acres and of that 1,667 is open space. Crop farming and livestock operations is the primary industry and income within this portion of the watershed. Forest comprises 3,594 acres and shrubs make up only 15 acres.

Streams flow through these landscapes readily and in many instances do not contain adequate amounts of stream buffers. Natural Resource Conservation Service recommends 100 foot riparian buffers on 3rd order streams or larger, and 35 foot riparian buffers on 1st & 2nd order streams along with ditches, intermittent streams, wetlands, ponds, and lakes. Within South Fork subwatershed, 539.6 acres are in need of riparian buffers representing 24.083 miles of channels of which 6.761 miles are perennial in nature (Figure 70). This is out of a total of 33.78 miles of channels within South Fork subwatershed and 11.738 miles of perennial channels that have a total of 725.46 acres of riparian corridor. In Carters Creek subwatershed, 628.6 acres or 26.962 miles of channels including 10.212 miles of perennial streams are in need of riparian buffers. This is out of the total 1027.7 acres or 47.643 miles of channels with 22.077 miles of perennial stream corridors.

Windshield Surveys

Windshield surveys conducted in this area uncovered several areas that may contribute to non-point source pollution in the South Fork subwatershed. In several areas, streambank erosion could be seen from windshield surveys. Streams and road ditches showed signs of extreme erosion for 3.2 miles of channels that could be seen from the road in this area. Numerous cattle and pigs were found to have direct access to sinkhole ponds and streams for water. Livestock had access to the streams in at least 5 locations within South Fork Lost River subwatershed as seen through windshield surveys. Banks along these areas were heavily trampled and showed signs of erosion problems. The windshield survey also showed many other areas with grassed waterways and riparian buffers. Most fields had evidence of no-till practices; however, other fields had conventional tillage practices, especially on Amish land.

Similar issues were witnessed in the Carter Creek subwatershed from windshield surveys. A total of 8.5 miles of stream banks were identified as eroding in 16 separate locations as seen from windshield and desktop surveys. Residential lands adjacent to stream channels see a significant amount of erosion due to the lack of buffers. At least 18 locations along streams were lands where livestock was being raised. Livestock had access to the streams in at least 10 locations within Carters Creek subwatershed contributing to the severity of stream bank erosion seen in this subwatershed.

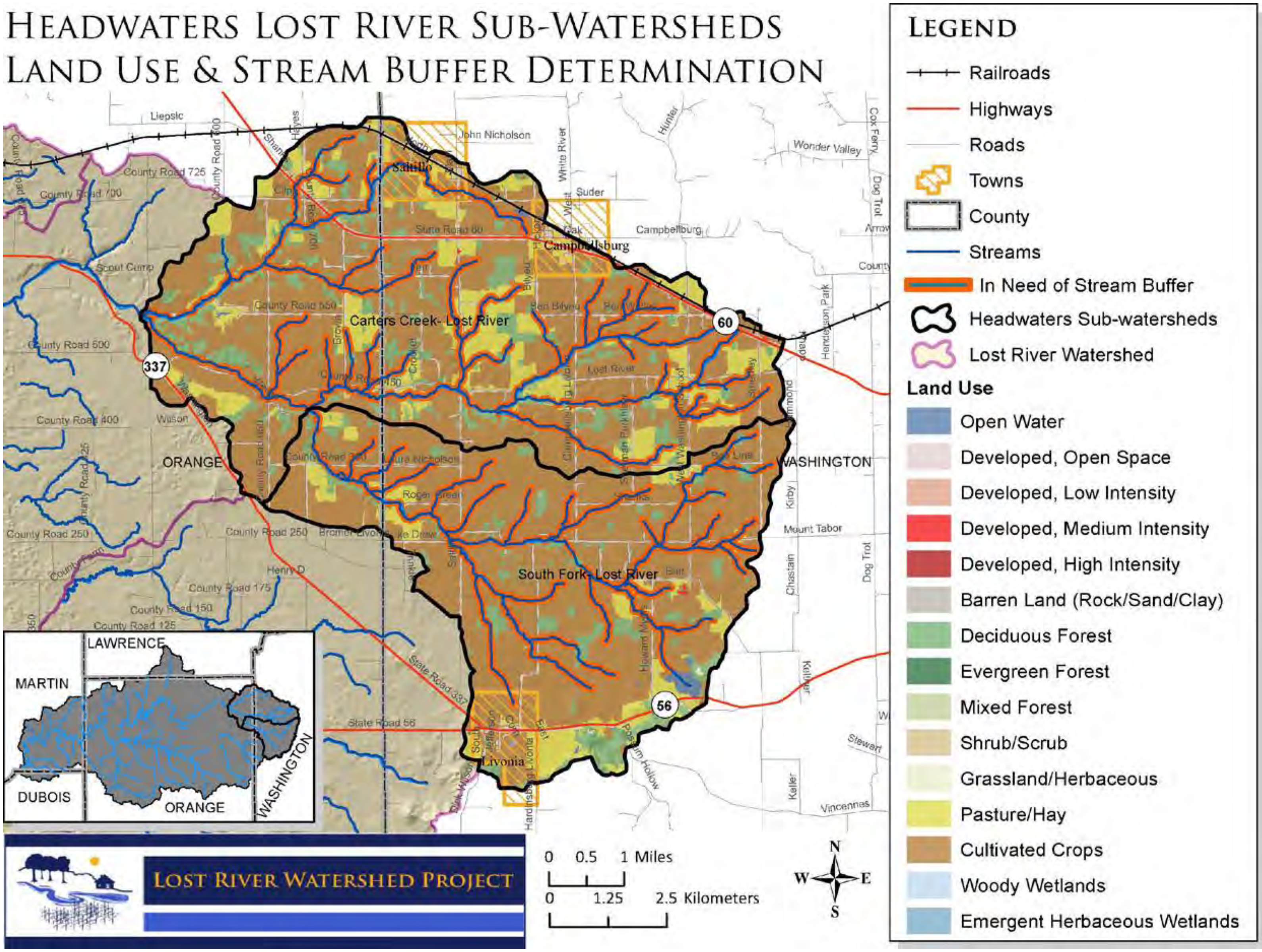


Figure 70: Headwaters of Lost River showing land use in 2006 and areas of drainage in need of additional stream buffering.

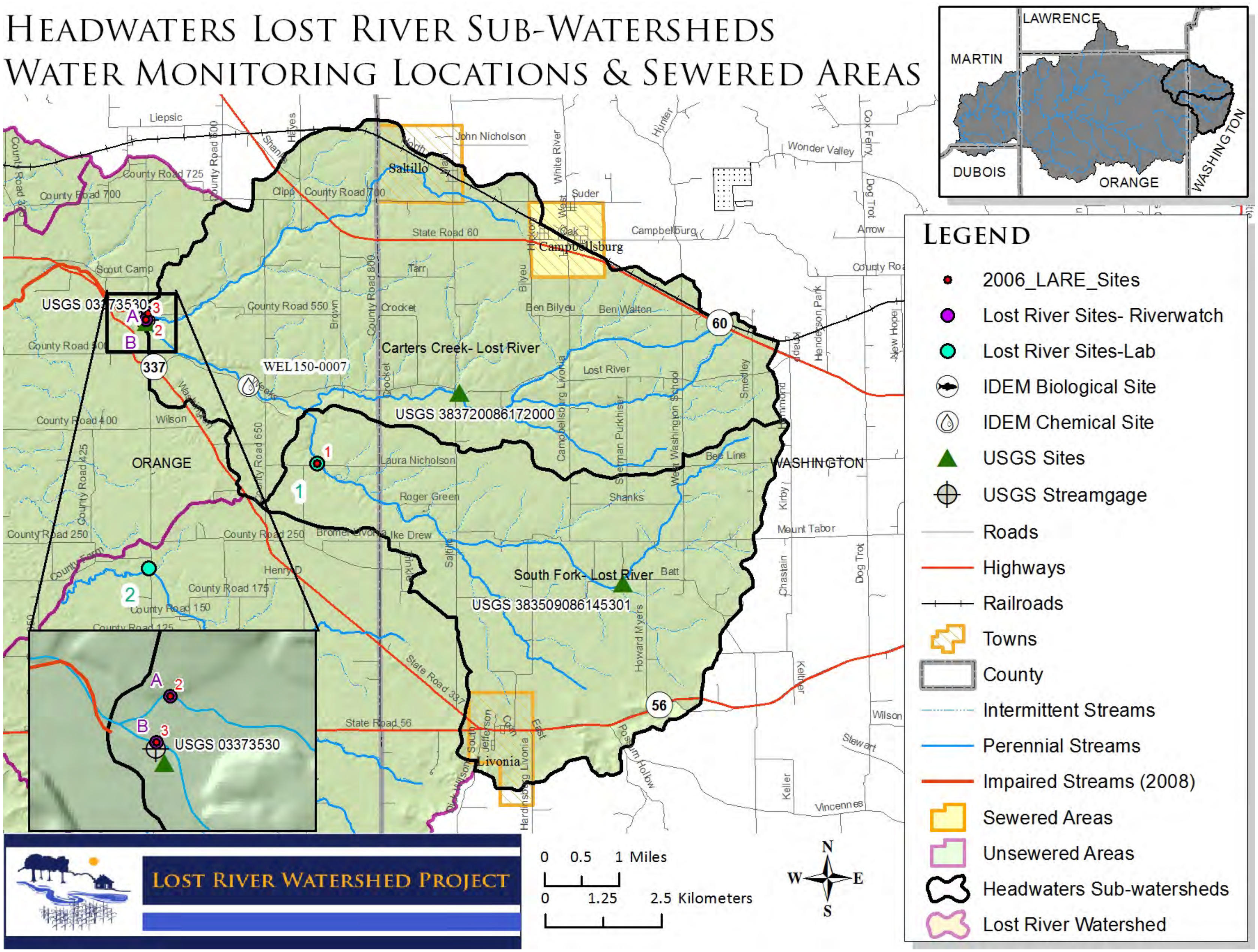


Figure 71: Headwaters of Lost River Monitoring locations (Historic and current); Map indicates sewered and unsewered area within the watershed.

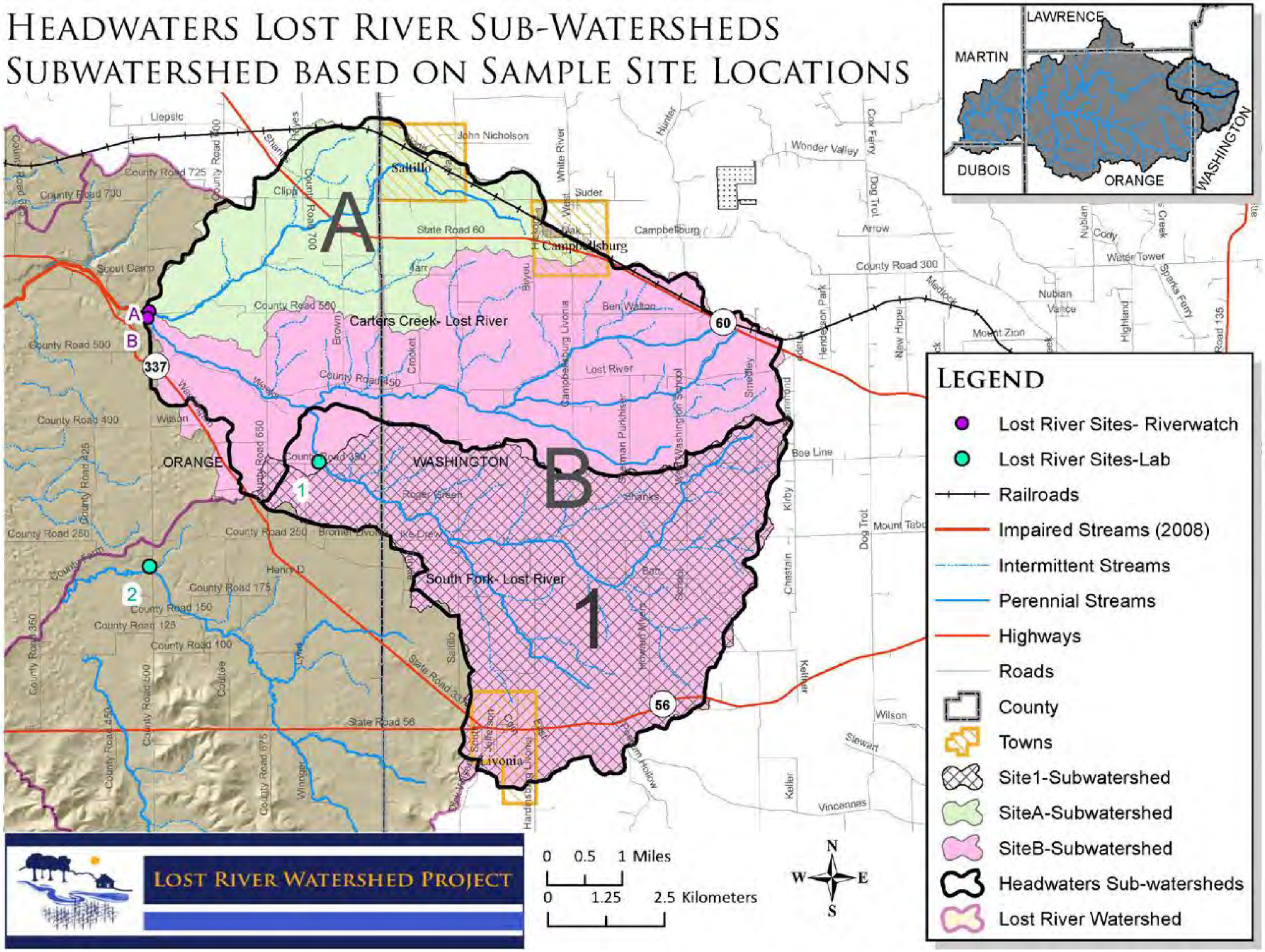


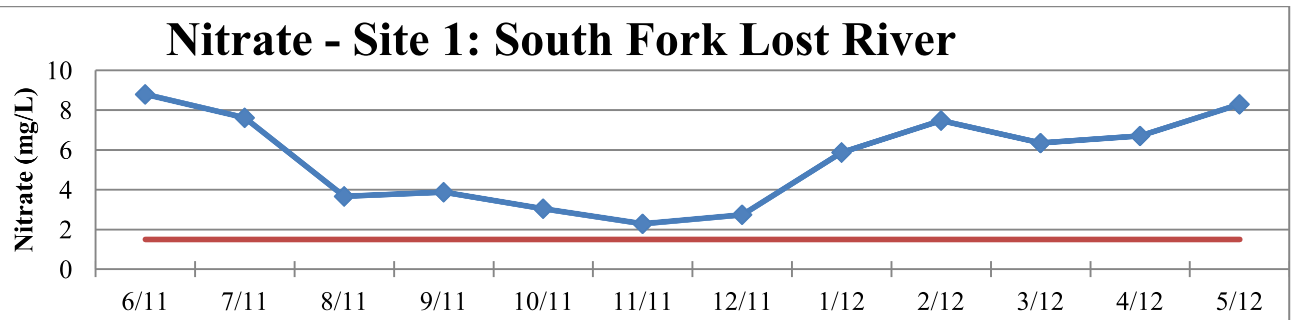
Figure 72: Sample Site subwatersheds for Headwaters Lost River Area- based on 2011-2012 sampling period

Four locations within these subwatersheds are currently, or have been monitored in the past by different organizations (Figure 71). The stations represent the outlet of South Fork Lost River (Site 1), the convergence of North Fork Lost River and South Fork Lost River (IDEM Site-WEL 150-0007), Lost River before converging with Carters Creek (Site B), and the outlet of Carters Creek (Site A). The watersheds draining to these sample locations are shown in Figure 72. The subwatersheds based on 2011-2012 sampling locations will be used throughout the Watershed Management Plan for analysis, goal setting, and determination of critical areas. You may notice for the Headwaters Lost River area, three subwatershed are listed representing sample Sites 1, A, and B. These sample sites and subwatersheds will be analyzed within this section and represent the water quality for the Headwaters Lost River area.

South Fork Lost River Monitoring Site 1

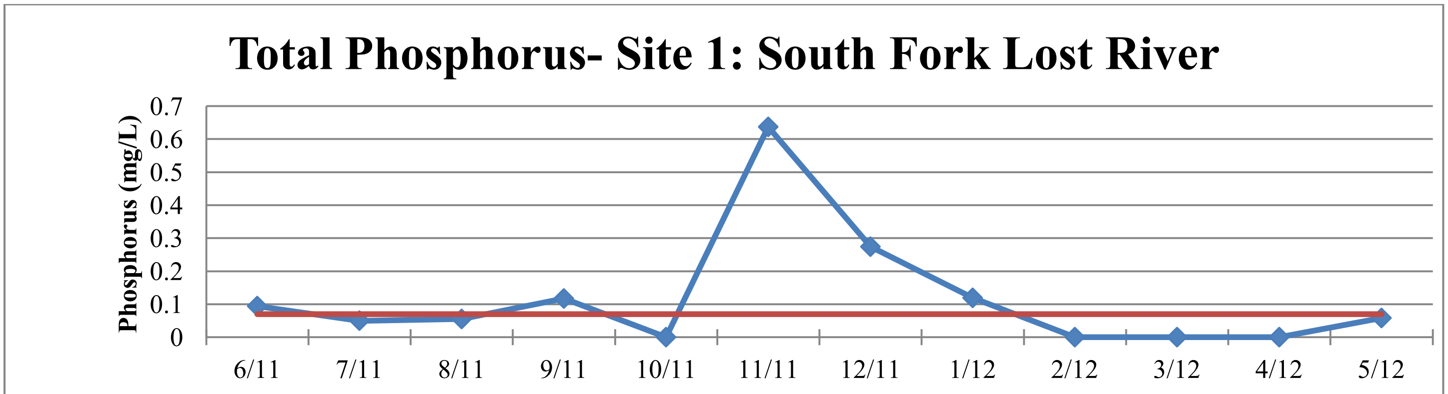
South Fork Lost River is monitored near its outlet into Carters Creek Subwatershed (Site 1) by both current monitoring efforts along with the 2006 LARE study (LARE Site 1) (Figure 71). At the outlet of South Fork Lost River, the stream has exceeded water quality targets in 2005 for nitrate, phosphorus, *E. coli* and turbidity during a storm sampling effort on January 5th & 6th. The base flow sampling in June of 2004 showed high levels above the standards for *E. coli* and nitrogen.

During the Lost River Watershed Team Sampling in 2011-2012, Nitrates were consistently above target levels of 1.5 mg/L throughout the testing period, Figure 73. Phosphorus levels at Site 1exceeded target levels of 0.07 mg/L five times during the 2011-2012 sampling period, Figure 74. Nitrates exceeded target levels in the same months Phosphorus exceeded targets indicating the chance for algal blooms. Blooms of algae have been seen at this location and further downstream. Turbidity and total suspended sediment (TSS) levels mimic the levels seen in Phosphorus, as seen in Figures 75 and 76. These levels spiked during rain events indicating the level of erosion that occurs with within the watershed. *E. coli* levels exceeded target values of 235 MPN/100ml during 7 months with one month the samples exceeded levels that the laboratory could test, see Figure 77. Several of the exceeded months were during winter months when bacteria are not as viable due to cold temperatures. A high level of *E.coli* during colder periods indicates a nearby source, or a strong septic influence. In this area, there are livestock directly adjacent to the sample location along with several locations directly upstream. Other parameters measured at that site showed little to no impairments for that parameter including specific conductance, salinity, and dissolved oxygen. Measurements of pH did go basic in March 2012 likely due to the addition of lime to the fields during this time of year. Temperature of the stream in March 2012 was above levels set by the state. However, the area had an unusually warm March. Typical March temperatures are 43.5°F for the area. In 2012, the average temperature for March was 57.2°F. This likely caused the abnormally warm water temperatures seen at multiple sample locations.



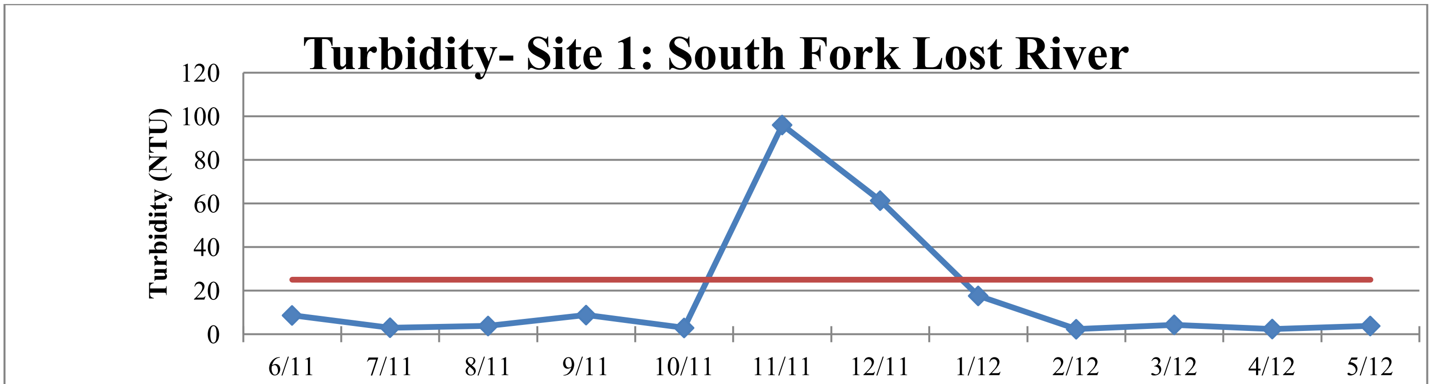
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	8.79	7.614	3.66	3.87	3.044	2.282	2.738	5.868	7.475	6.341	6.7	8.29
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 73: Nitrate Levels at Site 1 (2011-2012 testing period)



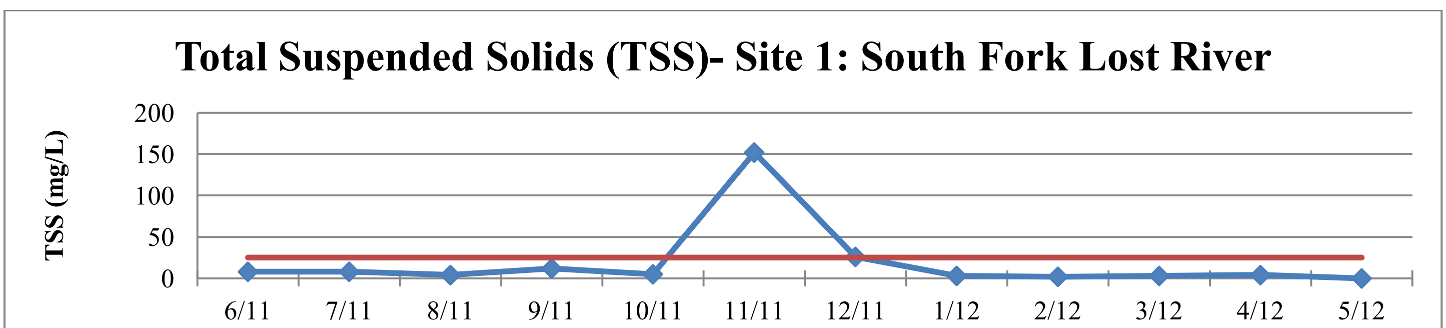
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Total Phos	0.094	0.05	0.055	0.117	0	0.637	0.274	0.119	0	0	0	0.058
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 74: Total Phosphorus Levels at Site 1 (2011-2012 testing period)



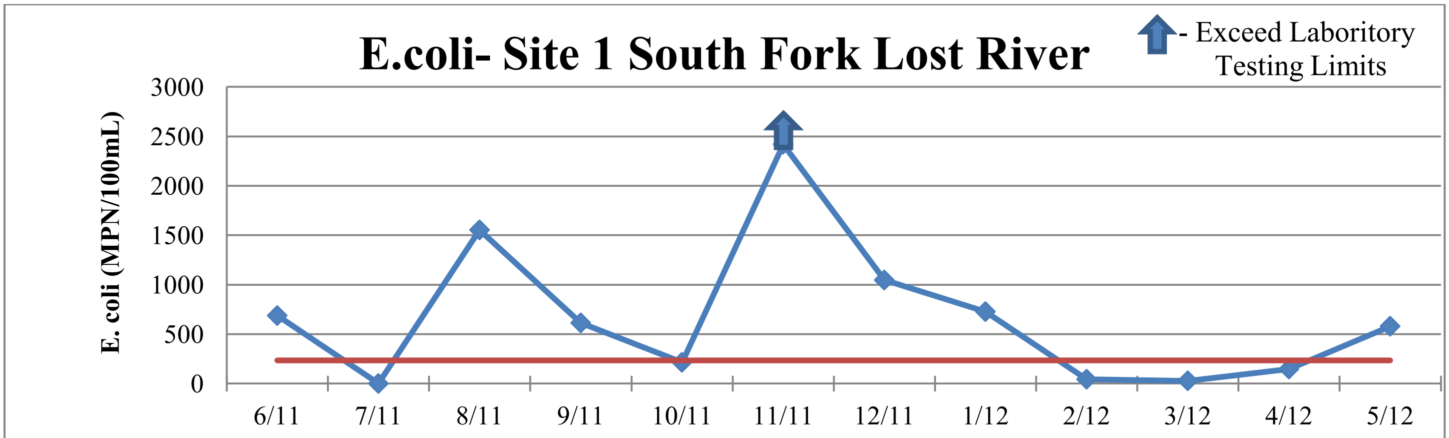
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	8.64	3	3.79	8.79	2.9	96	61.3	17.6	2.3	4.33	2.4	3.79
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 75: Turbidity Levels at Site 1 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	8	8	4	12	5	152	26	3	2	3	4	0
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 76: Total Suspended Solid Levels at Site 1 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	686.7	0	1553.1	613.1	214.2	2419.6	1046.2	727	43.5	27.5	146.7	579.4
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 77: E.coli Levels at Site 1 (2011-2012 testing period)

QHEI assessments indicated that Site 1 with a score of 55 has fair habitat values for aquatic life and did reach our target score of at least 51 for Lost River watershed. The macroinvertebrate community was not impaired per mIBI score of 38.

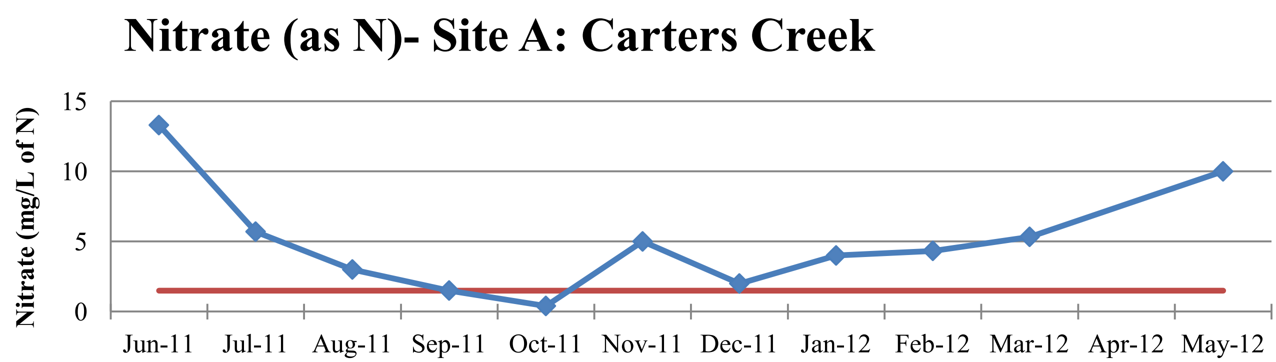
Biological data collected by V3 in 2004 for the 2006 LARE study state that the macroinvertebrates living in this area are a good mixture of tolerant and intolerant species, indicating a good presence of biological organisms at this location. Habitat data collected by V3 ranked this location as good with a QHEI score of 69.5.

Station WEL150-007 collected by IDEM and USGS Station 383726086202701 are at the same location where the North Fork of Lost River and the South Fork of Lost River converge. The data collected by IDEM in 2002 show no exceeding parameters. The USGS collection was for biomass, chlorophyll and other parameters not analyzed at this point.

Carters Creek Monitoring Site A

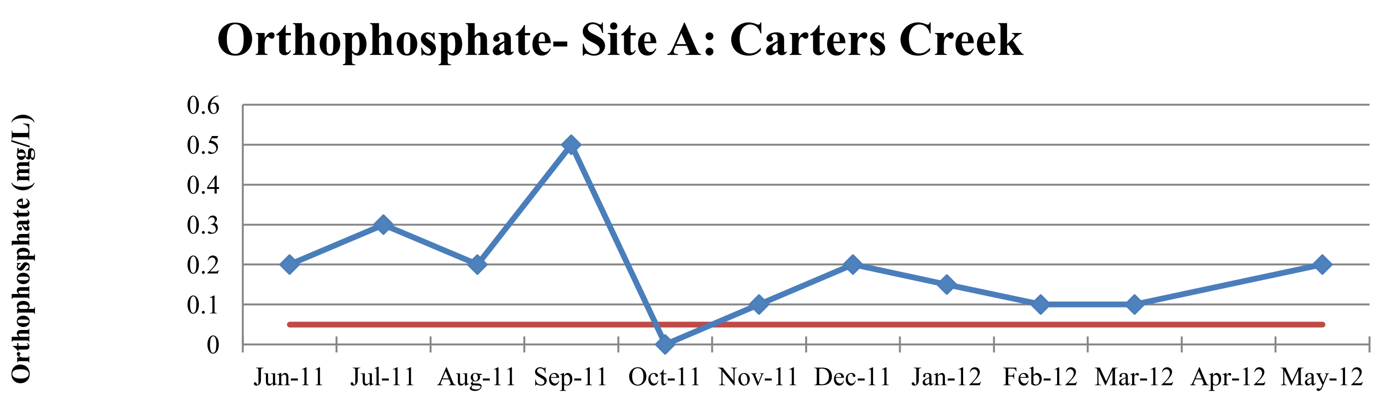
At the outlet of Carters Creek (Site A) both V3 and the Hoosier Riverwatch Lost River Team performed water monitoring (Figure 71). Site 3 of V3 2006 LARE study indicated the stream has exceeded water quality limits in 2005 for nitrate, phosphorus, and *E. coli* during a storm sampling effort on January 5^{th} & 6^{th}. The base flow sampling in June of 2004 showed high levels above the standards for *E. coli* and nitrogen.

During the Lost River Watershed Team Sampling in 2011-2012, Nitrates were above Lost River Watershed Steering Committee target levels of 1.5 mg/L in all but two months in Carters Creek at Site A, See Figure 78. Nitrate levels reach or exceeded state standards of 10 mg/L twice during the 2011-2012 sampling period. In June 2012, nitrate levels reached 13.3 mg/L and in May 2012 nitrate levels were at 10 mg/L. Orthophosphate levels at Site A exceed target levels of 0.05 mg/L ten times during the 2011-2012 sampling period (Figure 79). Nitrates exceeded target levels in the most of the same months Phosphorus exceeded targets indicating the chance for algal blooms. Blooms of algae have been seen at the site and further downstream from this location. Turbidity levels show a spike that is also seen in orthophosphate levels, as seen in Figures 80 and 79. These levels spiked during a rain event indicating erosion that occurs within the watershed during rain events. *E. coli* levels exceeded target values of 235 CFU/100ml during 3 months. One month the value exceeded 4,000, see Figure 81. Figure 81 also shows high levels of total coliforms in September 2011 and January 2012. In January values exceeded target levels indicating a nearby source, or a strong septic influence. In this area, there are livestock directly adjacent to the sample location along with several locations directly upstream. Other parameters measured at that site showed little to no impairments for that parameter included temperature, pH, and dissolved oxygen. Measurements of BOD5 did not show a significant use of oxygen by chemical or biological factors. Five out of the six times it was measured BOD5 values were below target values of a 2 mg/L or less change.



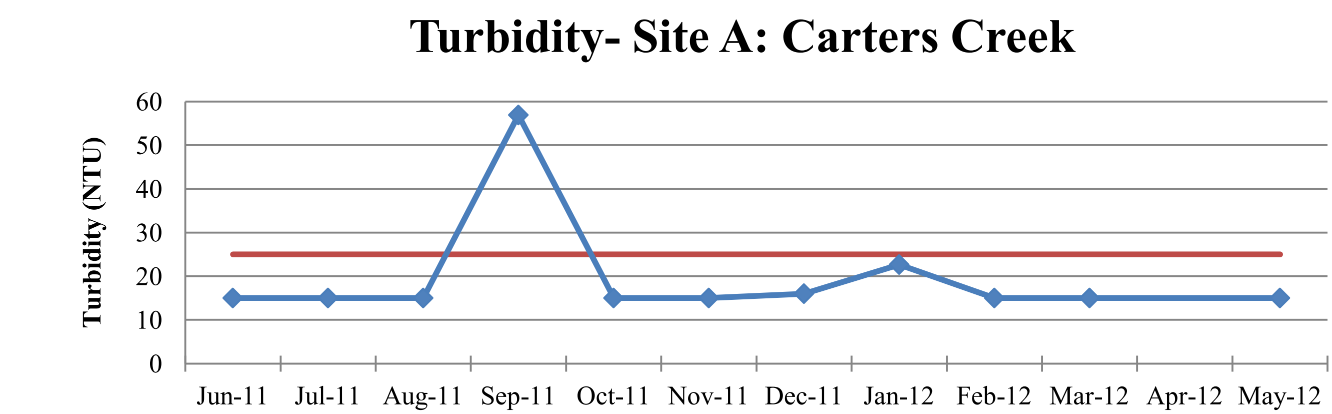
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	13.3	5.7	3	1.5	0.4	5	2	4	4.33	5.33	10

Figure 78: Nitrate Levels at Site A (2011-2012 testing period)



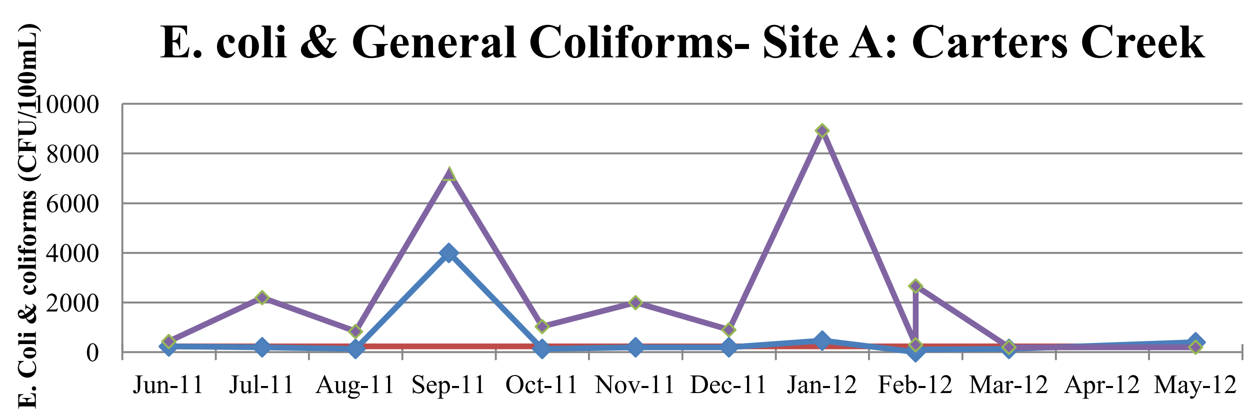
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.2	0.3	0.2	0.5	0	0.1	0.2	0.15	0.1	0.1	0.2

Figure 79: Orthophosphate Levels at Site A (2011-2012 testing period)



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	15	15	57	15	15	16	23	15	15	15

Figure 80: Turbidity Levels at Site A (2011-2012 testing period)



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Feb-12	Mar-12	May-12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235
E.coli	233.1	199.8	133.2	4000	133.2	199.8	200	466.2	0	133.2	400	99.9
General Coliforms	432.9	2197.8	832.5	7200	1032.3	1998	900	8924.4	299.7	199.8	200	2664

Figure 81: E.coli & Coliform Levels at Site A (2011-2012 testing period)

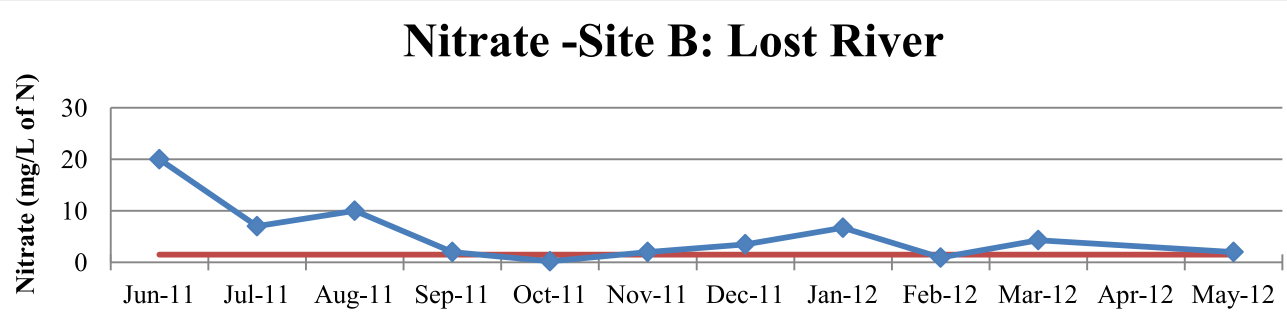
CQHEI assessments indicated that Site A with a score of 86 has good habitat values for aquatic life and did reach our target score of at least 51 for Lost River watershed. The macroinvertebrate community was not impaired according to the Pollution Tolerant Index score of 32 indicating an excellent aquatic life score.

At Carters Creek, biological data collected by V3 in 2004 for the 2006 LARE study state that the macroinvertebrates living in this area are a good mixture of tolerant and intolerant species, indicating a good presence of biological organisms at this location. Habitat data collected by V3 ranked this location as good with a QHEI score of 68.

Lost River Monitoring Site B

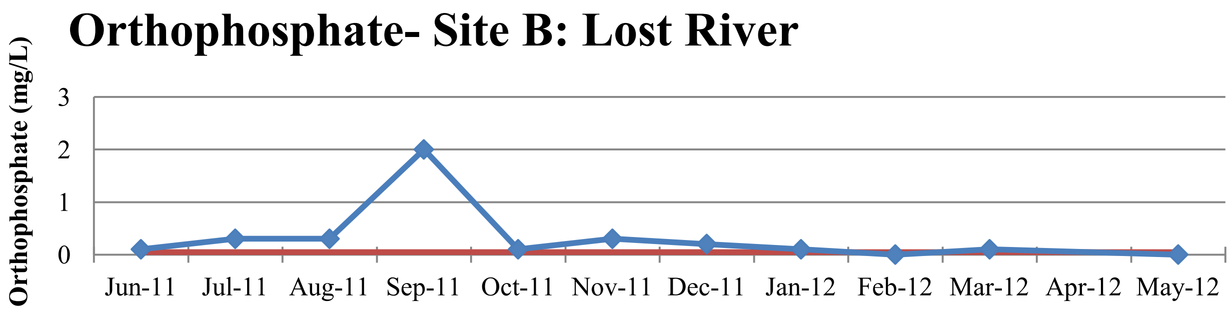
At Lost River just upstream of the confluence with Carters Creek (Site B), V3 and the Hoosier Riverwatch Lost River Team performed water monitoring (Figure 71). Site 2 of V3 2006 LARE study indicated the stream has exceeded water quality limits in 2005 for nitrate, phosphorus, and *E. coli* during a storm sampling effort on January 5th & 6th. The base flow sampling in June of 2004 showed high levels above the standards for *E. coli* and nitrogen.

During the Lost River Watershed Team Sampling in 2011-2012, Nitrates were above Lost River Watershed Steering Committee target levels of 1.5 mg/L in all but two months, See Figure 82. Nitrate levels reach or exceeded state standards of 10 mg/L twice during the 2011-2012 sampling period. In June 2012, nitrate levels reached 20 mg/L and in August 2012 nitrate levels were at 10 mg/L. Orthophosphate levels at Site B exceeded target levels of 0.05 mg/L nine times during the 2011-2012 sampling period (Figure 83). Nitrates exceeded target levels in the most of the same months phosphorus exceeded targets indicating the chance for algal blooms. Blooms of algae have been seen at the site and further downstream from this location. Turbidity levels show a spike in September that is also seen in orthophosphate levels, as seen in Figures 84 and 83. These levels spiked during a rain event indicating erosion that occurs within the watershed during rain events. *E. coli* levels exceeded target values of 235 CFU/100ml during 5 months with one month the value exceeded 35,000, see Figure 85. Figure 85 also shows high levels of total coliforms in September 2011 and January 2012. Several of the exceeded months were during winter months when bacteria are not as viable due to cold temperatures. A high level of *E.coli* during colder periods indicates a nearby source, or a strong septic influence. In this area, there are livestock directly adjacent to the sample location along with several locations directly upstream.



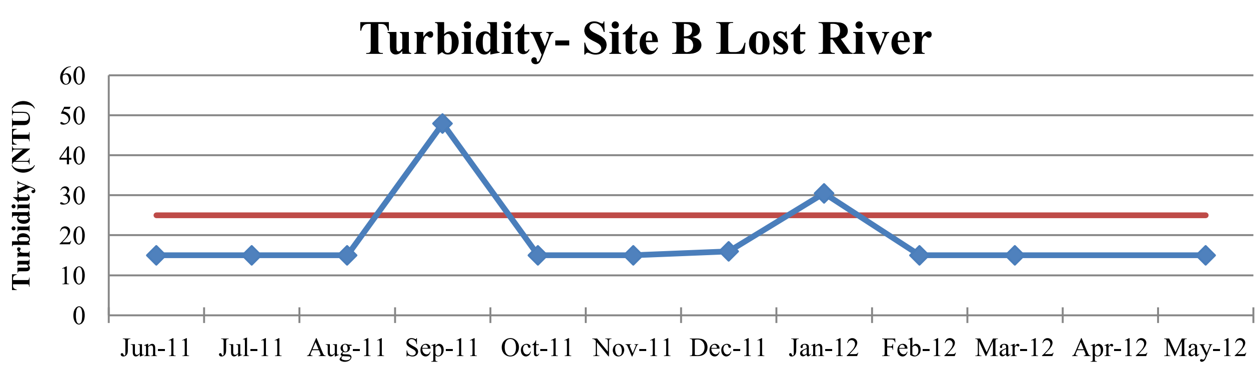
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	20	7	10	2	0.2	2	3.5	6.7	0.9	4.3	2

Figure 82: Nitrate Levels at Site B (2011-2012 testing period)



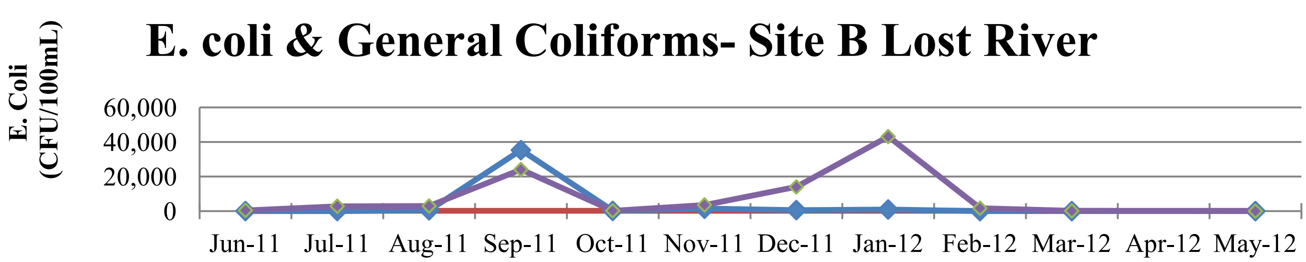
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.1	0.3	0.3	2	0.1	0.3	0.2	0.1	0	0.1	0

Figure 83: Orthophosphate Levels at Site B (2011-2012 testing period)



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	15	15	48	15	15	16	30	15	15	15

Figure 84: Turbidity Levels at Site B (2011-2012 testing period)



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	33.3	66.6	499.5	35300	133.2	1400	600	932.4	0	0	0
General Coliforms	466.2	2863.8	2997	24100	233.1	3600	14000	43156.8	1698.3	166.5	0

Figure 85: E.coli & Coliform Levels at Site B (2011-2012 testing period)

In early October, 2011 the Hoosier Riverwatch Lost River Team collected macroinvertebrates and habitat data at Site B. The CQHEI score, which evaluates habitat, was well above target score of 60 indicating that the site is conducive to the existence of warm water fauna. The macroinvertebrates living at Site B showed a healthy population of diverse species indicating a good presence of biological organisms at this location. The Pollution Tolerant Index score for Site B was 36 indicating an excellent aquatic life score.

Biological data collected by V3 in 2004 for the 2006 LARE study state that the macroinvertebrates living in this area are a good mixture of tolerant and intolerant species, indicating a good presence of biological organisms at this location. Habitat data collected by V3 ranked this location as good with a QHEI score of 62.5.

Water Quality Summary

IDEM does not list any of the waterbodies within these subwatersheds as impaired. However, Lost River is impaired for *E.coli* downstream of these subwatersheds. The source of that impairment may be from the landuse and practices within these subwatersheds. Water quality data indicate that *E.coli* is above allowable limits at all locations where it is monitored at least some of the time. Nitrates and phosphate seem to be high within areas of this watershed, as well.

Nitrates, phosphorus, and *E.coli* levels did exceed targets at least once at each site during the 2011-2012 sampling period. Aquatic life at this point has not been affected to the level of impairments. However, some practices should be changed to limit the amount of nutrients and pathogens that are able to reach the streams in this area.

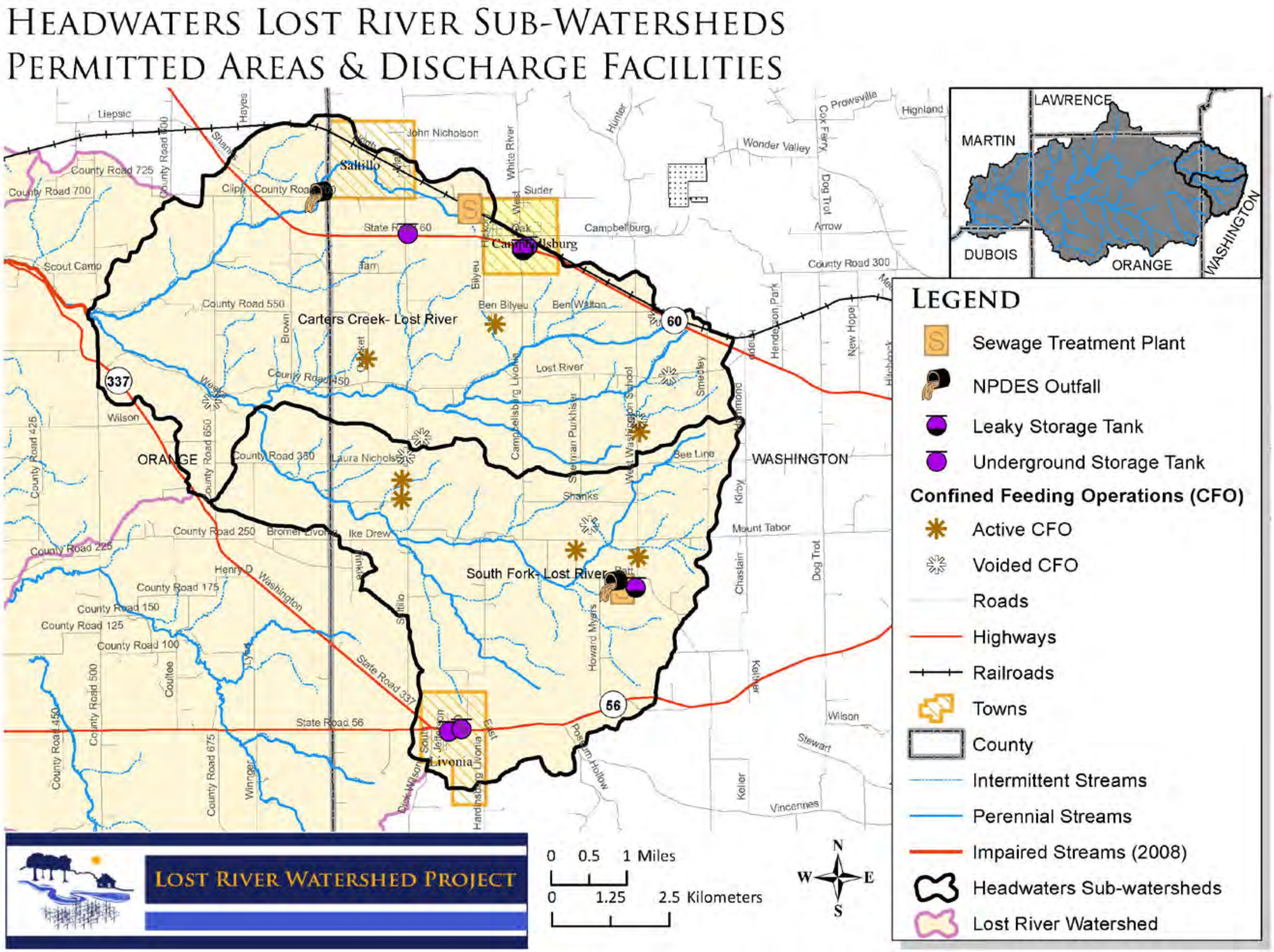


Figure 86: Headwaters of Lost River Subwatersheds showing potential point source pollution causes and NPDES discharge facilities; these entities are permitted under IDEM.

Permitted Facilities

The most predominant facilities within this portion of the watershed are confined feeding operations (CFO) (Figure 86). There are 14 cattle CFO permits for this area of these there are only 7 active permits as of 2012. The number of CFO's has been reducing in recent years due to old age and no legacy created with the farm to the children. However, an influx of poultry operations has revitalized the CFO populations lately. Some CFO's in this area rely on streams for water for their livestock. There are also many other large and smaller homestead farms in the area as well. There are at least five locations where cattle are allowed to enter the streams and streambanks freely. This is a concern of watershed stakeholders.

Point source inputs come from the two NPDES outfalls in the area. Both are sewage treatment facilities with discharge points to the streams in the area. One is from the Campbellsburg Wastewater Treatment Plant (WWTP), and the other is from the West Washington Jr-Sr High School WWTP. The Campbellsburg WWTP has been in non-compliance six quarters out of last 12 quarters beginning in July 2009. One quarter's violation was a reporting violation. The other five quarters were in violation for E.coli, pH, total suspended solids, carbonaceous BOD, and dilution factors. These violations can be contributing to pollution issues within Carters Creek and Lost River. The West Washington WWTP is a non-major facility and no data records have been submitted to EPA. It is unknown whether West Washington WWTP is operating within compliance. Overflow from these WWTP may be a source of contamination to the watershed and is a concern of stakeholders.

There are a total of three leaking underground storage tanks out of 7 underground storage tanks in the area that may be contributing fluids to the streams and aquifers in the area. Due to the strong connection between our streams and aquifers, this is a concern of the watershed stakeholders.

5.2 Lost Sink Area

The Lost Sinking Area is made up of the three watersheds that drain completely into the subsurface during normal flow periods. During rain periods, the subsurface drainage will fill and result in surface drainage in normally dry river beds, and the upwelling of sinkholes and other karst features. The three watersheds that make up this region of the watershed are the Mt Horeb Drain, the Orleans Karst Area, and Lost River Sink (Figure 69).

Land Use

The total area of the three sub-watersheds is 55,090 acres with Lost River Sink at 23,030 acres, Orleans Karst Area covering 12,207 acres, and Mt Horeb Drain having 19,853 acres. The majority of landuse in Mt. Horeb Drain subwatershed is forested (40.5%) followed by pastureland (30.6%) and crop ground (20.6%). Forested lands make up 12,706 acres within the three watersheds. The majority of the land in use in Lost River Sink and Orleans Karst Area subwatersheds is cultivated crops (54.7% and 50.8%, respectively). The total crop ground for the three subwatersheds totals 22,905 acres. Pasture and hay land in Mt Horeb Drain (30.6%), Lost River Sink (24.7%), and Orleans Karst Area (28.1%) covers a total of 15,209 acres. Livestock are also present within this area to a varying degree. Grasslands comprise of 358 acres and shrubs make up 175 acres. There is 22 acres of bare rock associated with remnant quarries. The other 3715 acres is developed with the town of Orleans and the outskirts of Mitchell. DNR, Hoosier National Forest, and Indiana Karst Conservancy manage some of the forested areas near the outlet of Mt Horeb Drain. These lands contain some of the wonders of the Lost River area specifically the Wesley Chapel Gulf and Orangeville Rise.

Stream flow through these landscapes is flashy. In many instances, these streams do not contain adequate amounts of stream buffers to absorb the impact of the flashy streams. Within Lost River Sink subwatershed, 504.3 acres representing 22.465 miles of channels are in need of riparian buffers. This includes 10.409 miles of perennial streams in need of buffers (Figure 87). This is out of a total of 741.73 acres of stream corridor acreage with a total of 34.763 miles of channels of which 18.082 are perennial in nature or part of the Dry Branch of Lost River. While in Orleans Karst Area subwatershed there are 119.77 acres representing 5.196 miles of stream channels in need of stream buffers. There are no perennial channels within Orleans Karst Area. There are a total of 6.468 miles of channels within this watershed and a total of 146.77 acres of stream corridors. The number of sinkholes in the area needing riparian buffers is always changing because of the constant formation of sinkholes in the area. The Orleans Karst Area subwatershed is the location where 1022 sinkholes were mapped within one square mile (Merlott, 1968). Watershed stakeholders are concerned over the lack of buffers surrounding some sinkholes, while others are concerned about losing useful land and increasing fuel costs by having to navigate around these features. The Mt Horeb Drain subwatershed is more forested than the other two. It needs a total of 526.3 acres of riparian buffers, which lies on 24.080 miles of channels of which 8.670 are perennial in nature. This is out of a total of 49.099 miles of channels with 18.239 miles as perennial streams and 1,044.4 acres of stream corridors. In general, stakeholders are concerned over the lack of riparian buffers along stream corridors.

Many stakeholders in this area use the streams for recreational purposes. Streams and rivers are used for fishing, fossil hunting, karst touring, swimming, and boating. The Small Mouth Bass Alliance adopted a section of Lost River for clean up and protection. Stakeholders are very interested in improving the quality of the water here to support that recreation.

Windshield Survey

Windshield surveys performed in this area indicated high levels of algae visible within Lost River. There are approximately 4 miles of stream banks in need of stabilization and increased riparian buffers in the Lost River corridor and side tributaries. Several small side tributaries to the Lost River are also showing signs of destabilization and increased erosion from these areas will disrupt the ecosystem function. Windshield surveys also show multiple homestead farms in the area with small numbers of livestock. At least 12 locations livestock were seen in sinkholes that show signs of ponding. A higher percentage of conventional tilled and disked fields can be observed in this area than in other watersheds. In addition a high amount of land is Amish owed in this area where conventional tilled fields is the standard practice. Livestock has been seen in one of the few drainage channels in these subwatersheds. Several areas in Mt. Horeb Drain showed noticeable hillside erosion in pasture fields. Numerous cattle and other livestock including camels were found to have direct access to sinkholes, ponds, and streams for water. Banks along these areas are heavily trampled, and they showed signs of erosion problems. These areas may contribute to non-point source pollution in the Lost Sink Area.

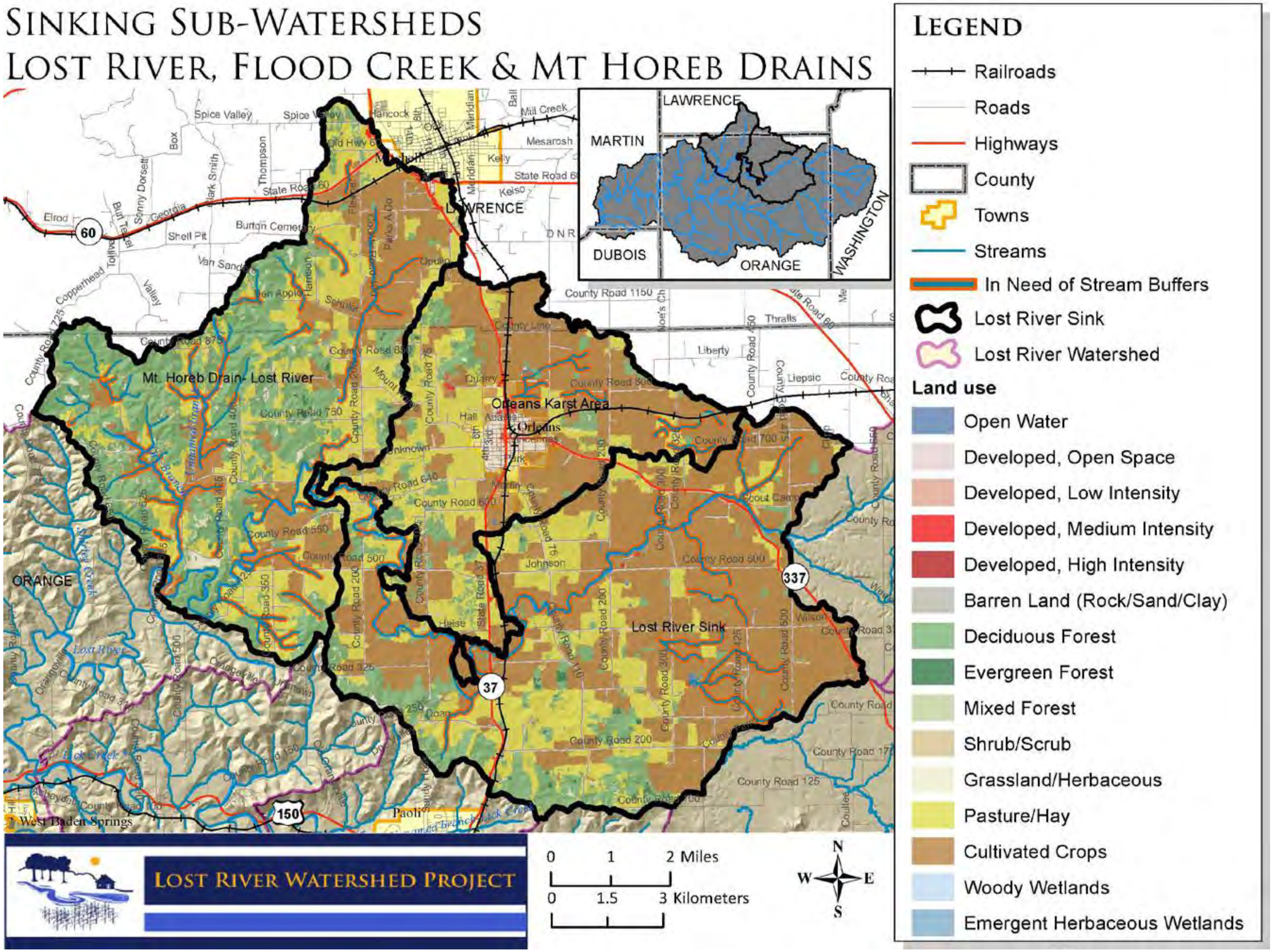


Figure 87: Lost River Sinking Sub-watersheds: Land use (2006) and areas in need of stream buffers

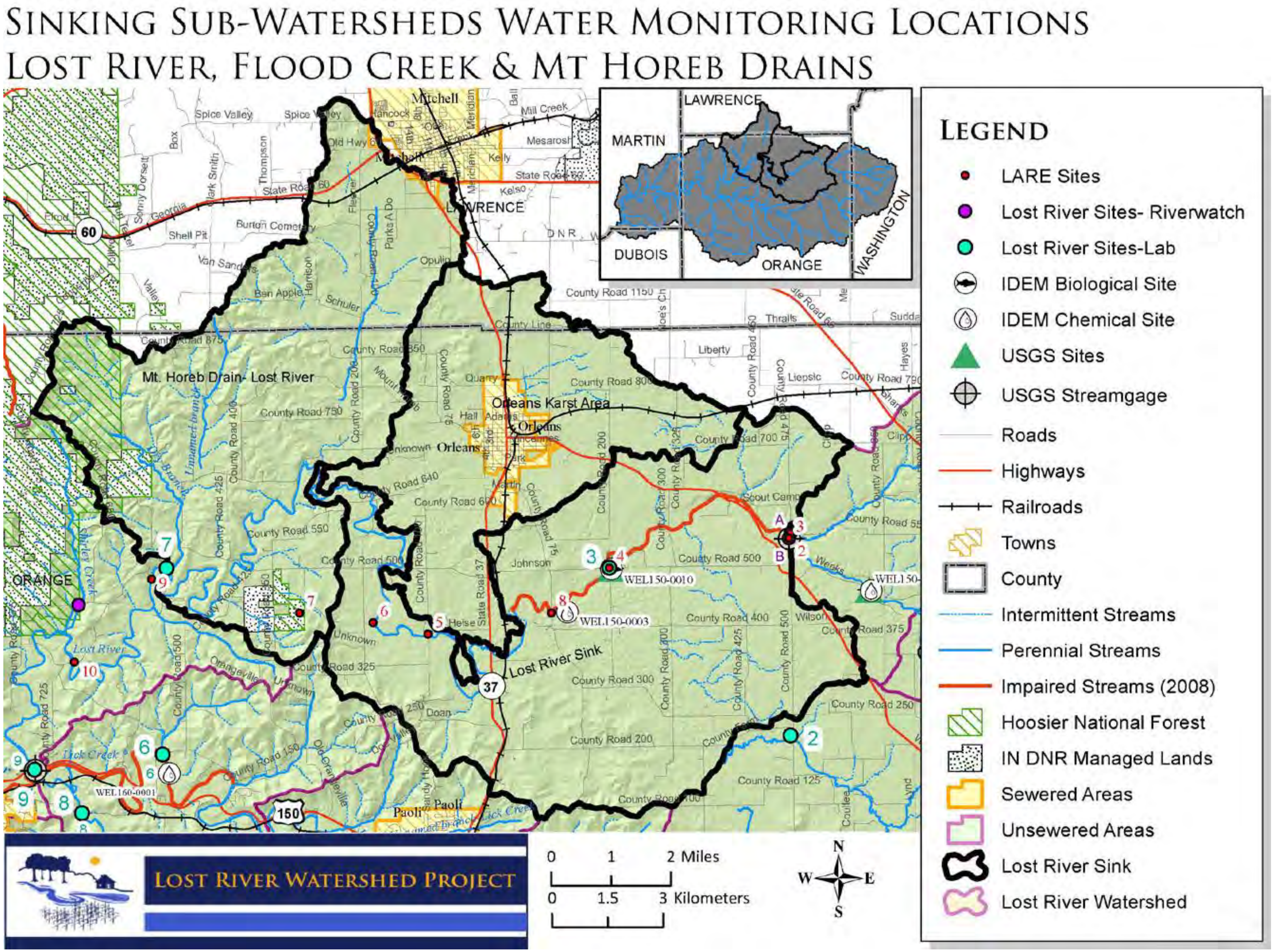


Figure 88: Lost River Sinking Sub-watersheds: Monitoring locations (Historic and current); Map indicates managed lands within the watershed.

There are six locations within these three subwatersheds where monitoring has occurred (Figure 88). The locations represent different degrees of flow within Lost River. The upstream monitoring location is Lost River without any major reductions of flow to subsurface drainage. The second location is Lost River after the principal Dry Weather Sink. The middle three locations are at different swallow holes and sinkholes along the subterranean path. The downstream site is at Orangeville Rise, which is near the outlet of the subwatersheds and the spring water from the Mt Horeb Drain and Orleans Karst Area subwatersheds.

Fishers Ford Bridge (Site 3) is a location of longer term data than some of the other sites within the watershed. It is Site 4 for the 2006 LARE study, site WEL150-0010 for IDEM biological monitoring, and site 383746086251301 USGS water quality station. This station along with the one at Orangeville Rise (Site 7) are the only two locations within this area where the 2011-2012 sampling efforts were made. The Lost River Sinking area is not easily monitored due to the lack of perennial streams within most of the area.

The five sites (4, 5, 6, 7, & 8) monitored by V3 in this area have similar results. The river exceeded water quality limits in 2005 for nitrate, phosphorus, *E. coli* and turbidity during a storm sampling effort on January 5th & 6th at all these sites except 6 which was not monitored for stormflow. The baseflow sampling at LARE site 4 in June of 2004 showed high levels above the standards for nitrogen. LARE site 7 showed high levels of nitrogen and *E.coli* during the base flow monitoring. However, LARE site 6 did not find any impairment. Water quality monitoring preformed by USGS in 2007 at site 383746086251301 indicates that the river was not over any target value for temperature, conductivity, dissolved oxygen, nitrogen, or pH at the time of sampling.

The Lost River is impaired for *E.coli* according to IDEM within the Lost River Sink subwatershed. *E.coli* has been elevated in several of the water samples collected within this subwatershed.

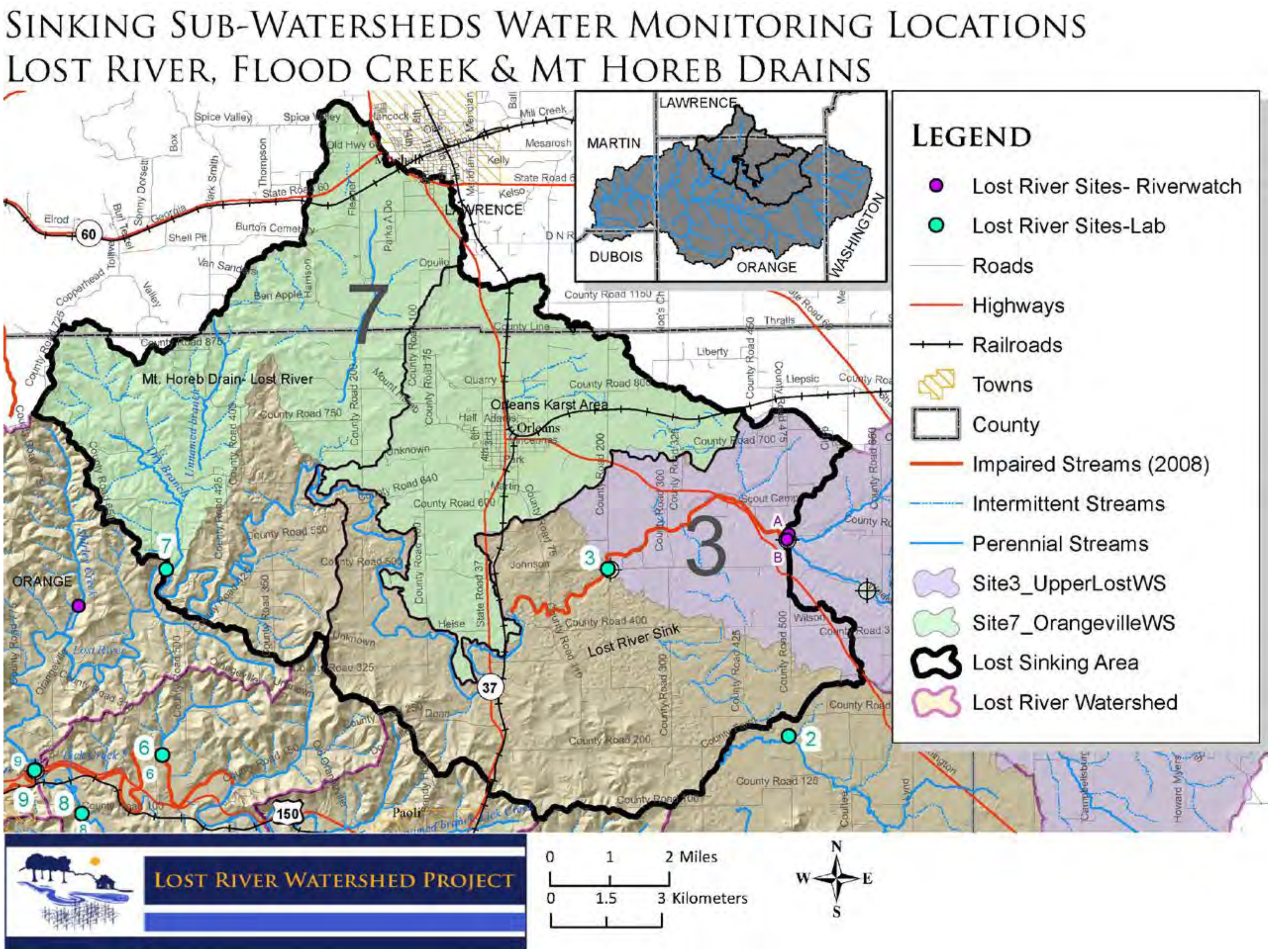


Figure 89: Sample Site subwatersheds for Headwaters Lost River Area- based on 2011-2012 sampling period

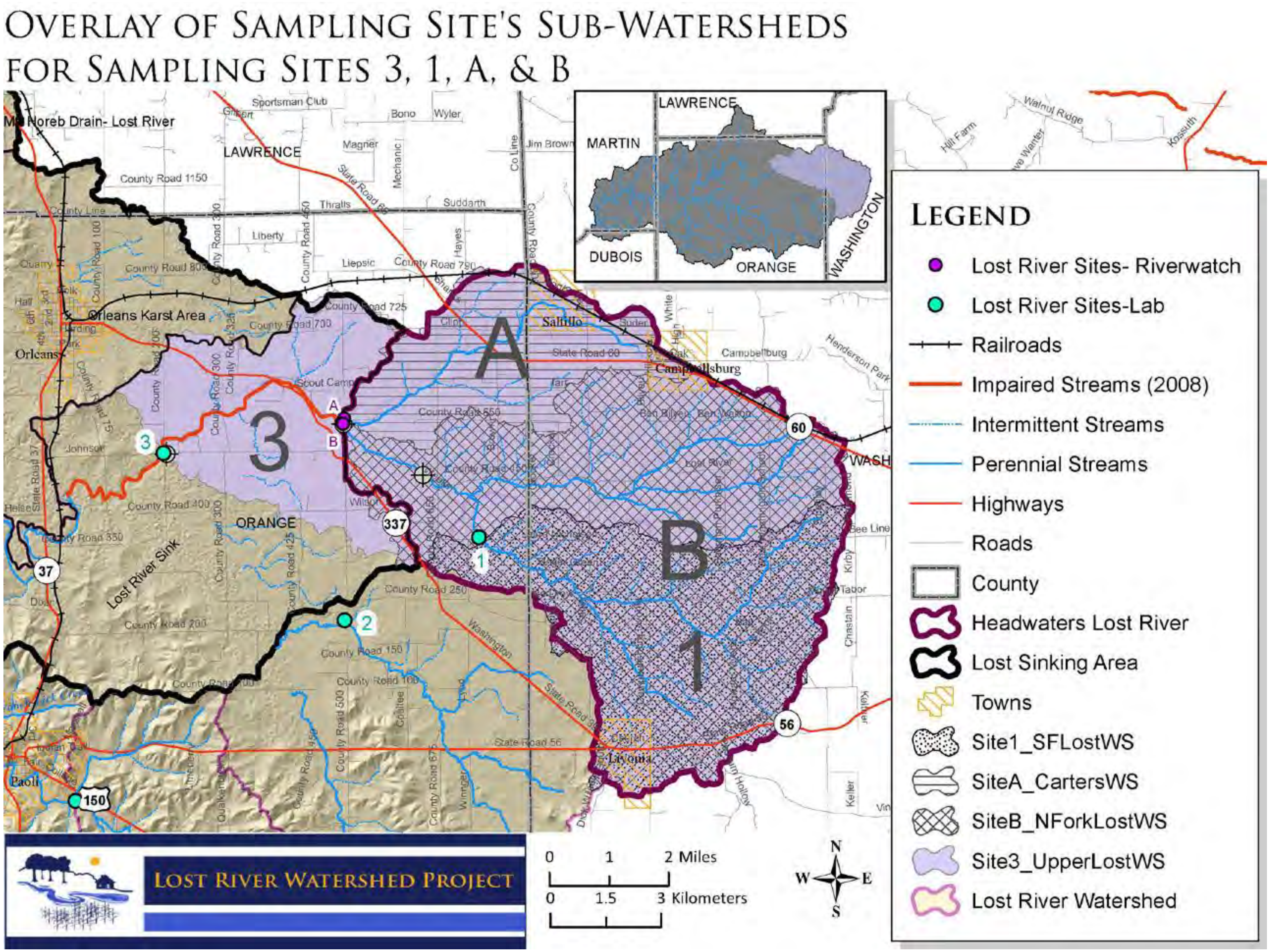
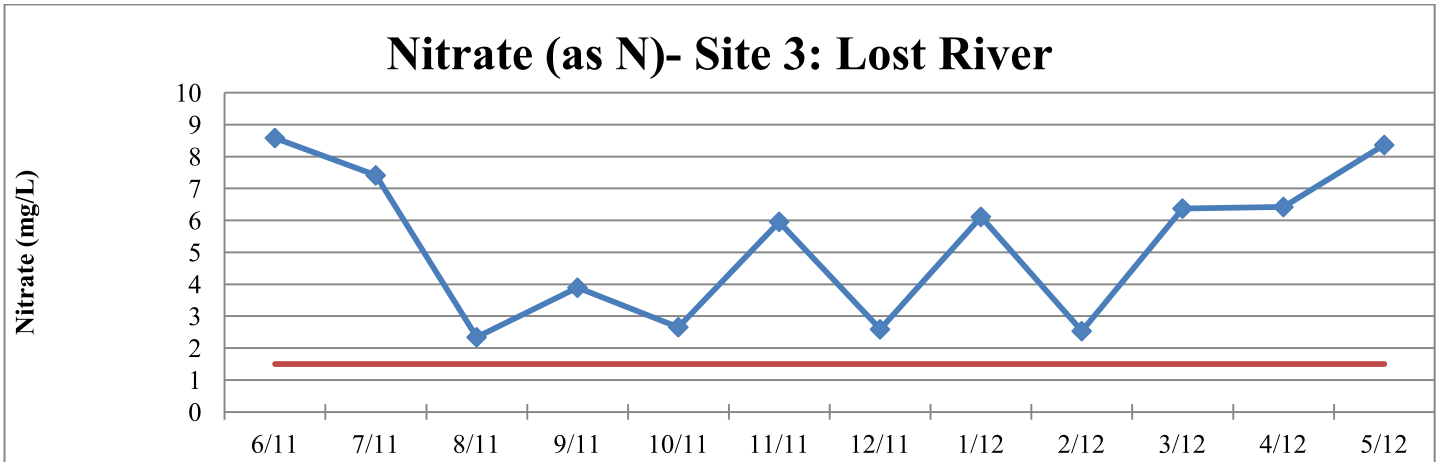


Figure 90: Proximity of Sample Site 3 subwatershed to other sampling subwatersheds within Headwaters Lost River

Lost River Monitoring Site 3

Due to the similarity in nature of the samples along this stretch of Lost River, the 2011-2012 Lost River Watershed Team Sampling decided to sample along Lost River at only one location prior to the sub-surface drainage (Figure 90). Site 3 drains a large portion of the watershed as seen in Figure 90. Site 3 has the most historic data collected within the watershed, so this location continues to be a good location to collect water quality samples from Lost River.

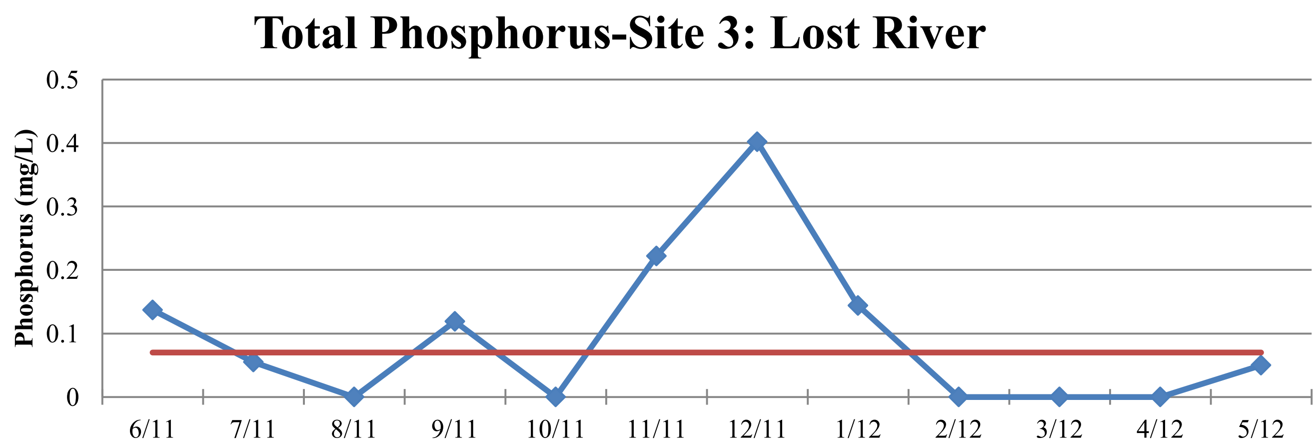
During the Lost River Watershed Team Sampling in 2011-2012, Nitrates were consistently above target levels of 1.5 mg/L throughout the testing period at Site 3, See Figure 91



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	8.58	7.41	2.34	3.892	2.656	5.955	2.588	6.11	2.532	6.371	6.42	8.362
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 91 : Nitrate Levels at Site 3 (2011-2012 testing period)

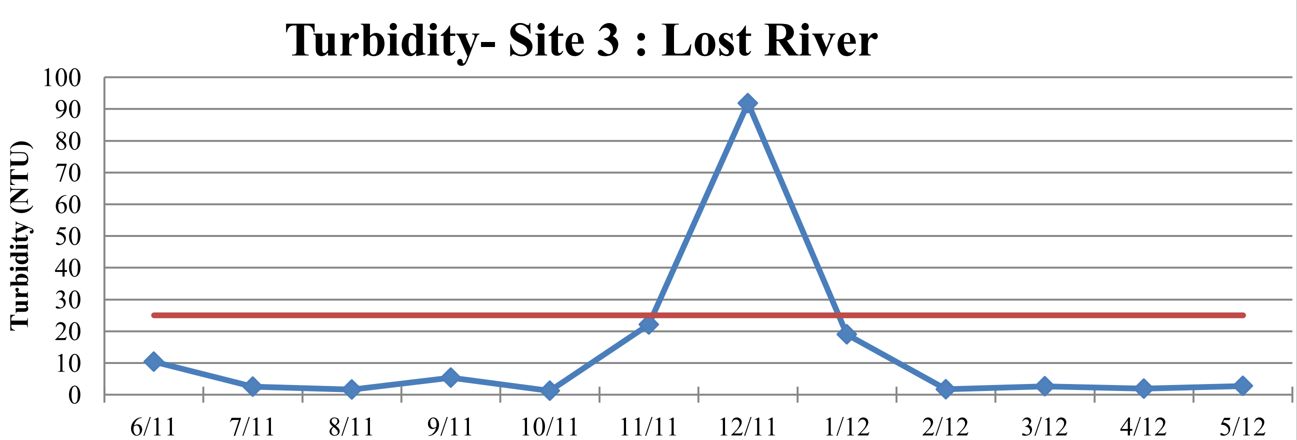
Phosphorus levels at Site 3 exceeded target levels of 0.07 mg/L five times during the 2011-2012 sampling period, see Figure 92. Nitrates exceeded target levels in the same months phosphorus exceeded targets indicating the chance for algal blooms. Blooms of algae have been seen at this location.



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Total Phos	0.137	0.055	0	0.119	0	0.222	0.402	0.144	0	0	0	0.05
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

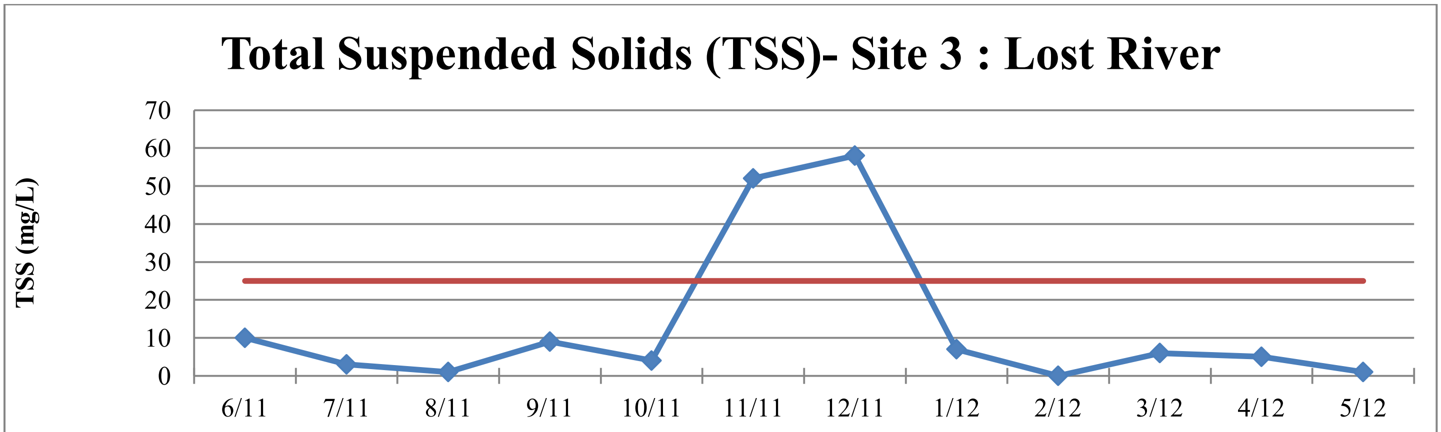
Figure 92 : Total Phosphorus Levels at Site 3 (2011-2012 testing period)

Turbidity and total suspended sediment (TSS) levels mimic the levels seen in phosphorus, as seen in Figures 93 and 94. These levels spiked during rain events indicating the level of erosion that occurs within the watershed.



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	10.4	2.52	1.63	5.37	1.25	22.1	91.8	19	1.7	2.65	1.9	2.77
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

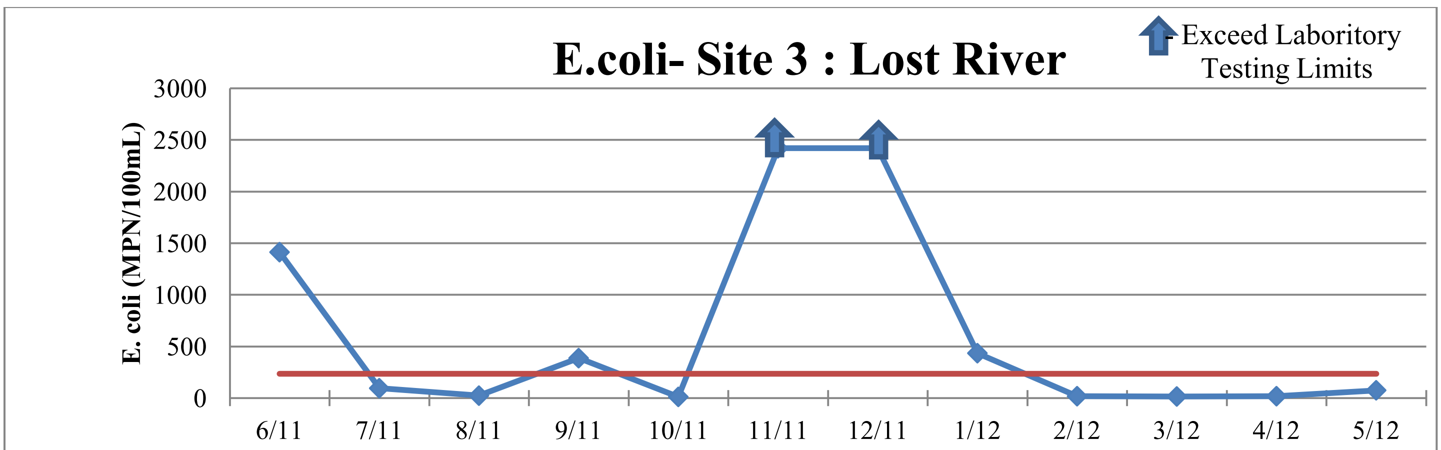
Figure 93: Turbidity Levels at Site 3 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	10	3	1	9	4	52	58	7	0	6	5	1
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 94: Total Suspended Solid Levels at Site 3 (2011-2012 testing period)

E. coli levels exceeded target values of 235 MPN/100ml during 5 months with two months the value exceeded levels that the laboratory could test, see Figure 95. Several of the exceeded months were during winter months when bacteria levels are not as viable due to cold temperatures. A high level of *E.coli* during colder periods indicates a nearby source, or a strong septic influence. In this area, there are livestock and CFOs directly adjacent to the sample location along with several locations directly upstream.



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	1413.6	95.9	24.1	387.3	12.1	2419.6	2419.6	435.2	18.7	16	18.7	75.9
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 95: E.coli Levels at Site 3 (2011-2012 testing period)

Other parameters measured at that site showed little to no problems including specific conductance, pH, salinity, and dissolved oxygen. Temperature of the stream in March 2012 was above levels set by the state. However, the area had an unusually warm March. This likely caused the abnormally warm water temperatures seen at multiple sample locations.

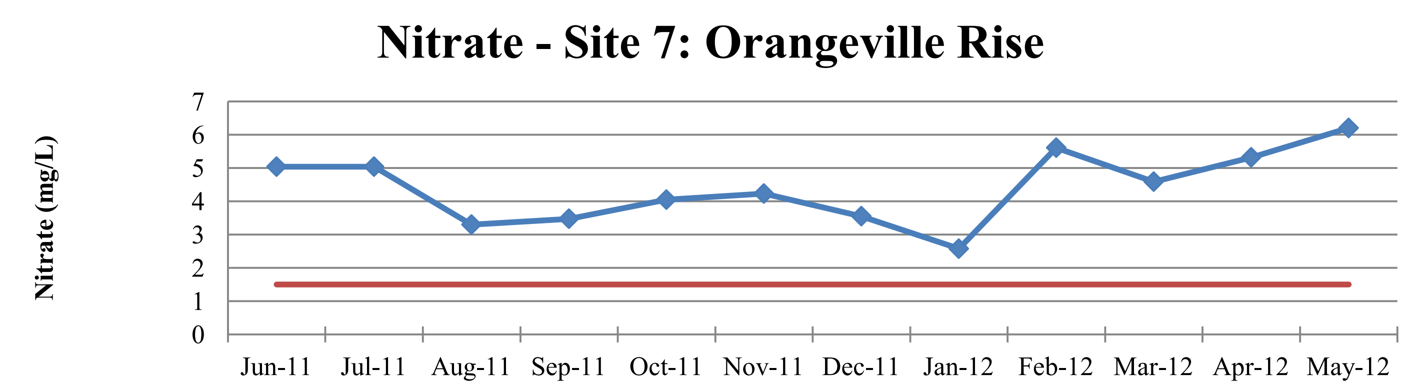
QHEI assessments indicated that Site 3 has good quality habitat. The QHEI for Site 3 had a score of 69. The macroinvertebrate community was impaired per the mIBI score of 30. Poor water quality is suspected to be the primary factor negatively affecting the macroinvertebrate community in this location due to the presence of good quality habitat. Water quality seems to be declining as seen in the reduction of biological condition

Biological data collected by V3 in 2004 for the 2006 LARE study at site 4 (current sampling Site 3) state that the macroinvertebrates living in this area are slightly impaired for biological condition. Habitat data collected by V3 ranked this location as good with a QHEI score of 60.5.

Biological monitoring performed by IDEM at site WEL 150-0010 in 2007 collected information on habitat, macroinvertebrates, and fish. A QHEI score of 67 was obtained which indicates a good quality habitat. The macroinvertebrate population was also at tolerant levels with a mIBI score of 38. They found 13 species of suckers, perch, sunfish, sculpins, carps, and minnows with a total count of 274. The most predominant fish was largescale stoneroller accounting for 33% of the fish count. A close second was the longear sunfish and striped shiner, which accounted for another 43% of the fish counted. Reports from local anglers suggest that in the past large populations of largemouth and smallmouth bass also existed in Lost River in this area. However, fish counts do not see large amounts of these populations. Many anglers of this area have seen declining bass populations. Stakeholders are concerned that these sport fish will continue to decline unless actions are taken to reverse this trend.

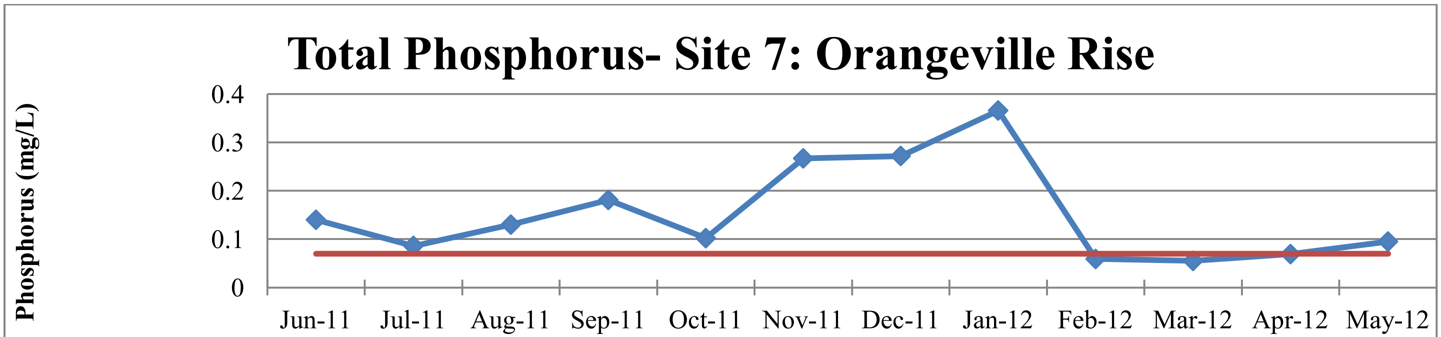
Orangeville Rise Monitoring Site 7

Orangeville Rise is the fourth largest spring in Indiana and it drains much of the northern karst area where surface streams do not connect to trunk streams on the surface. This spring is the reemergence of drainage that occurs in areas void of streams but numerous in sinkholes. Drainage from the north of the dry branch is assumed to go into Orangeville Rise based on dye test results (Figure 88). Dye tracing results have shown that this area is collecting water from various locations as seen in Figure 4. The Lost River Watershed Team Sampling found that Nitrates were consistently above target levels of 1.5 mg/L throughout the testing period at Site 7 (Figure 96) located at Orangeville Rise on Lost River. Phosphorus levels at Site 7 exceed target levels of 0.07 mg/L nine times during the 2011-2012 sampling period (Figure 97). Nitrates exceeded target levels in the same months that phosphorus exceeded targets at this site. However, algal blooms are not seen at this location because water has just emerged from the underground system. Algae need sunlight for photosynthesis to survive. Blooms have been seen downstream from this location. Turbidity and total suspended sediment (TSS) levels mimic the levels seen in phosphorus, as seen in Figures 98 and 99. These levels spiked during rain events indicating the level of erosion that occurs within the watershed. *E. coli* levels exceeded target values of 235 MPN/100ml during 8 months with two months the value exceeded levels that the laboratory could test (Figure 100). Several of the exceeded months were during winter months when bacteria is not as viable due to cold temperatures. A high level of *E.coli* during colder periods indicates a nearby source, or a strong septic influence. In this area, the Orleans wastewater treatment plant (WWTP) outflow and overflow is directed into the underground system that eventually emerges at Orangeville Rise. During the testing period, the only time Orleans WWTP exceeded their allowable limits for *E. coli* was in June of 2011. The WWTP discharged effluent with a concentration of 328.2 CFU/100 mL during that month.



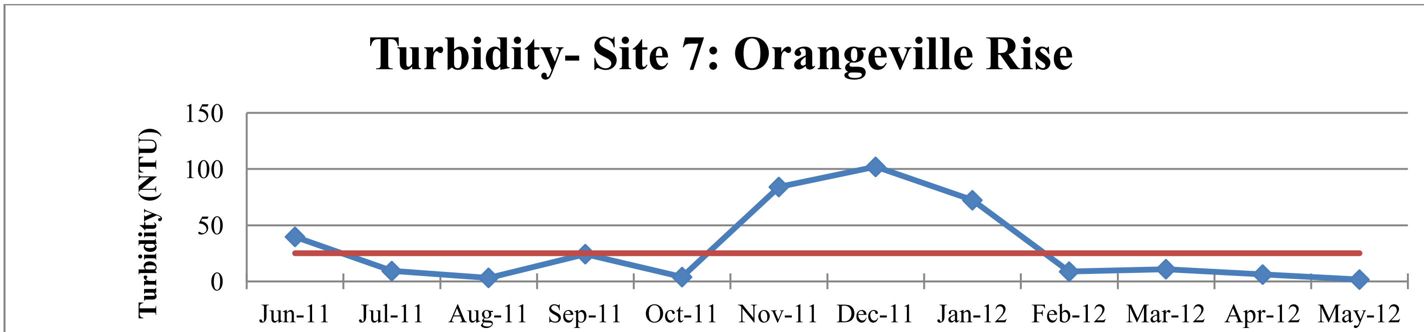
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	5.04	5.04	3.3	3.476	4.049	4.232	3.552	2.575	5.61	4.59	5.32	6.203
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 96: Nitrate Levels at Site 7 (2011-2012 testing period)



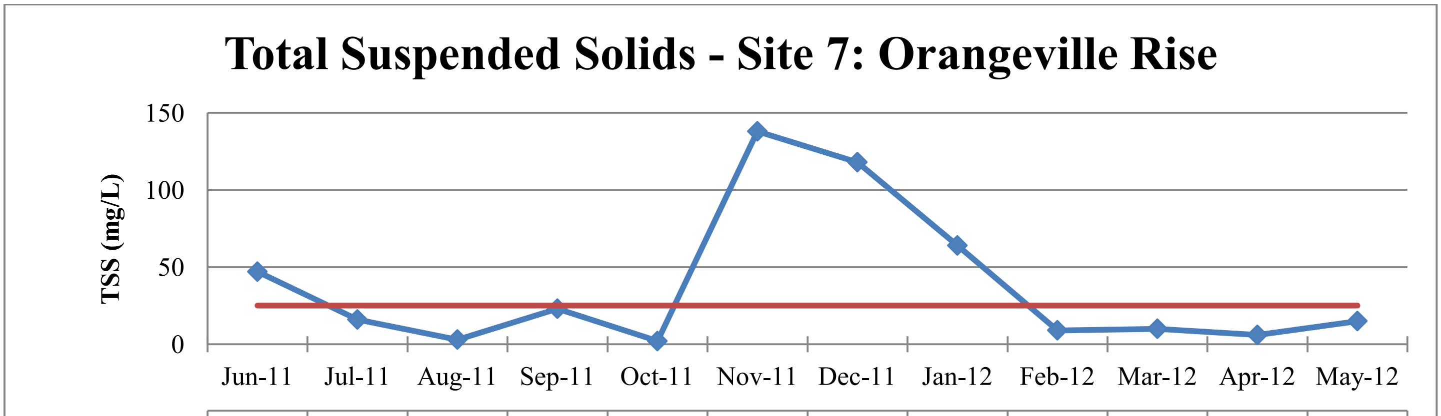
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.14	0.086	0.13	0.181	0.102	0.267	0.272	0.366	0.059	0.055	0.069	0.095
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 97: Total Phosphorus Levels at Site 7 (2011-2012 testing period)



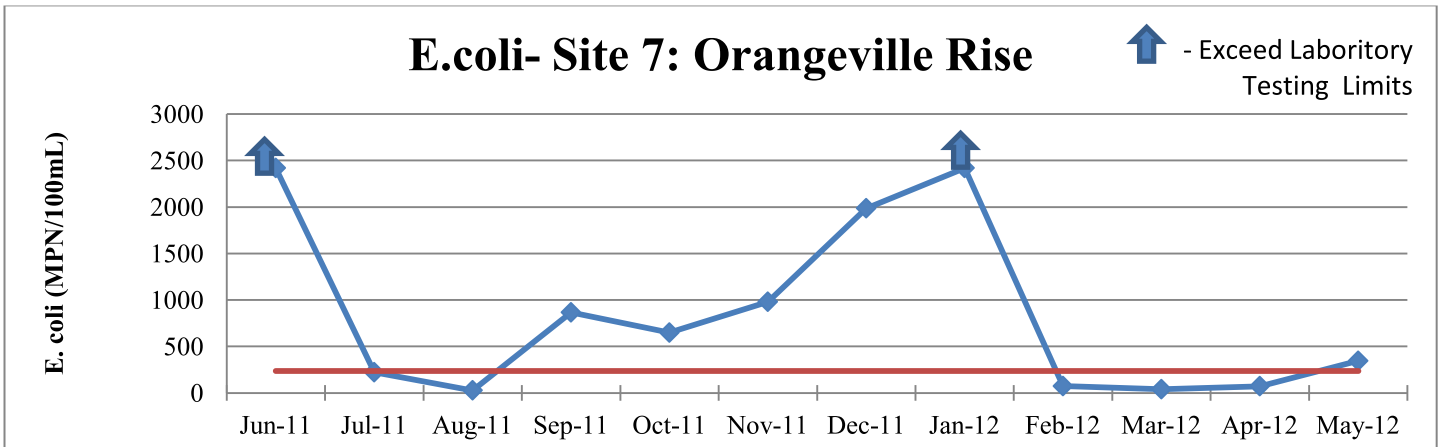
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	39.7	9.19	3.18	24.3	3.87	84.1	102	72.3	8.73	10.9	6.1	1.64
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 98: Turbidity Levels at Site 7 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	47	16	3	23	2	138	118	64	9	10	6	15
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 99: Total Suspended Solid Levels at Site 7 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	2419.6	222.4	27.9	866.4	648.8	980.4	1986.3	2419.6	73.3	39.9	72.7	344.8
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 100: E.coli levels at Site 7 (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site 7. At Orangeville Rise, the habitat was determined to be excellent with a QHEI score of 72. However, the macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 34. These low scores may be due to the reemergence of water from the subterranean at this site, or it may be attributed to the poor water quality seen at this site. Poor water quality may be affecting macroinvertebrate populations and may also be affecting life within the subterranean cave system. Biological samples have not been collected at this site before by either IDEM or through either of the LARE diagnostic studies.

Water Quality Summary

Nitrate was consistently high at sample points throughout the subwatershed. Nitrate exceeded standards and targets in 100% of the subwatershed samples. Phosphorus was also above target levels at these sites. The combination of high nitrogen and phosphorus levels will affect algae levels within the streams and may lead to low dissolved oxygen levels especially during early morning hours. Samples did not show declined levels of dissolved oxygen at these sites, but that may be due to the collection times and the recent emergence from the underground system at Site 7. Algae blooms have been seen at or near both of these locations. Turbidity and total suspended sediments did spike during wet weather events and may be attributed to erosion in the area. *E. coli* levels indicate an impairment at Site 3, which confirms IDEM's assessment and addition to this section of the 303(d) list. However, *E.coli* levels also indicate an impairment at Site 7 and may cause it to be added to this list in the near future.

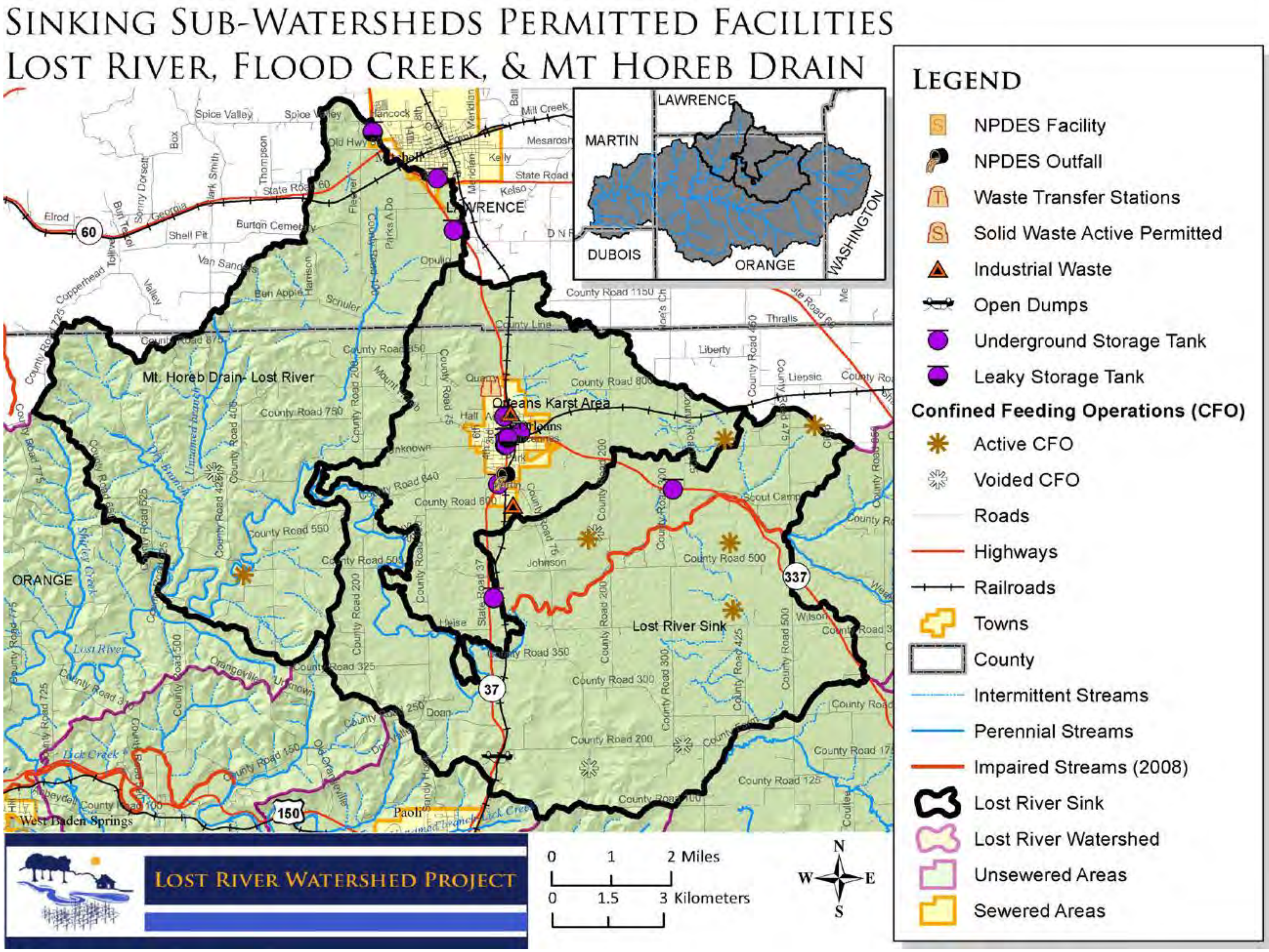


Figure 101: Lost River Sinking Subwatersheds- Locations within the subwatersheds showing potential point source pollution causes and NPDES discharge facilities; these entities are permitted under IDEM. Location of sewered and unsewered areas are also indicated on the map.

Permitted Facilities

Confined Feeding Operations make up some of the lands permitted in this area (Figure 101). There are nine CFO permits for this area and one CAFO permit. Six of the CFOs are active while three are voided. Two of these permits are for new turkey houses that will be producing large amount of turkey litter in this area. The other CFO's are for chicken, cattle, and/or sows.

Some underground storage tanks are scattered throughout the area with the majority of them centered in the town of Orleans. A total of 13 underground storage tanks are within these three subwatersheds. Of those, three underground storage tanks are leaky. Fluids from leaky tanks in this area have direct connection to subsurface conduits and are likely a source of contamination to our water system.

There is one Transfer waste station in the town limits of Orleans, which also holds a Solid Waste Active permit (Figure 102). Two businesses produce industrial waste within the town of Orleans. One has been closed and no longer has industrial waste on its premise. One open dump is located in the area and it is a used car parts lot. There is one NPDES Facility with one NPDES outlet from the wastewater treatment plant in Orleans. Discharges from this plant are to a sinkhole that drains to the underground river system. This plant has had some discharge violations due to an old collection system that allows for leaking and infiltration into the sewer lines. This causes a surge of water to the treatment plant during rain events and leads to overflows of the system. This plant has been in violation seven of the last 12 quarters. The violations are for biochemical oxygen demand, high levels of ammonia nitrogen and high levels of E.coli being discharged as effluent.

Town of Orleans Permitted Facilities
Flood Creek and Orleans Karst Area Drainage

Figure 102: Town of Orleans Permitted facilities and Sewer Boundaries

5.3 Stampers Creek Subwatershed

Stampers Creek subwatershed is separated in this discussion due to unique hydrology. Stampers Creek and Wolf Creek are the two streams that make up this watershed. Neither stream flows into another surface stream, instead they both flow northwest terminating by draining into a sinkhole. Stampers Creek flows from the southwest side of Livonia to nearly the center of the eastern part of Lost River parallel to State Rd 337. Through dye-tracing it has been determined that Stampers Creek then rises with Lost River at the True Rise of Lost River. Wolf Creek flows parallel to Stampers Creek from the Rego area to just north of State Rd 56 east of Paoli. Wolf Creek also terminates by draining into a sinkhole. Unlike Stampers Creek, Wolf Creek reemerges in Lick Creek prior to Paoli (Figure 4).

Stampers Creek and the area draining to it runs over the Mitchell Plain. Stampers Creek is intermittent in nature, meaning it flows only part of the year. Wolf Creek, on the other hand, flows through mostly the Crawford Upland and only ends its surface journey on the Mitchell Plain. This creek only has water flowing through it during part of the year in the upper portions of the stream starting out as intermittent. However part way down its path it sinks into the subsurface and the remaining channel only has water during rain events, so it is ephemeral in nature. There are approximately 40 miles of stream channels within Stampers Creek subwatershed.

Land Use

The area of Stampers Creek subwatersheds is 20,405.9 acres. Roughly 11,143 acres drain into Stampers Creek and roughly 9263 acres drain into Wolf Creek. The majority of landuse in these two subwatersheds is cultivated crops (9,709 acres) followed by pasture or hay lands (2,896 acres). Together they make up 12,605 acres or 61.7% of the watershed. Developed area makes up 1,129 acres, and of that 1,116 acres is open space. Farming is the primary industry and income within this portion of the watershed. Livestock are also present within this area. Natural areas make up 6,613 acres. Forest comprises 6,230 acres. Grasslands encompass 309 acres and shrubs make up 74 acres.

Streams that flow through these landscapes are exposed to agricultural land use and in most instances do not contain adequate amounts of stream buffers. Within Stampers Creek subwatershed, a total of 23.458 miles of channels are in need of buffers of that 14.62 miles are perennial (Figure 103). This is out of the total of 33.78 miles of stream channels and 21.56 miles of perennial streams. This represents 516.6 acres that are in need of riparian buffers on the streams out of the total 720.5 acres of stream corridors. The number of sinkholes in the area needing riparian buffers is always changing because of the constant formation of sinkholes in the area. Some watershed stakeholders are concerned over the buffers surrounding sinkholes, while others are concerned about losing useful land and increasing fuel costs by having to navigate around this land.

Windshield Survey

Windshield surveys performed in this area indicated high levels of sediment erosion occurring along both Stampers Creek and Wolf Creek. There are approximately 6.94 miles of stream banks in need of stabilization and increased riparian buffers in the stream corridors and side tributaries. Fourteen locations along these stream channels were identified with stream bank erosion. Several small side tributaries to both creeks are also showing signs of destabilization and increased erosion from these areas will disrupt the ecosystem function. Windshield surveys also show multiple homestead farms in the area with small numbers of livestock. Over 27 farms with livestock were identified along the stream channels. At least 7 locations livestock were seen with access to stream channels and likely this is occurring in other areas within this watershed, as well. A higher percentage of conventional tilled and disked fields can be observed in this area than in other watersheds. In addition, a high amount of land is Amish owned in this area where conventional tilled fields are a standard practice. These areas may contribute to non-point source pollution in the Stampers Creek.

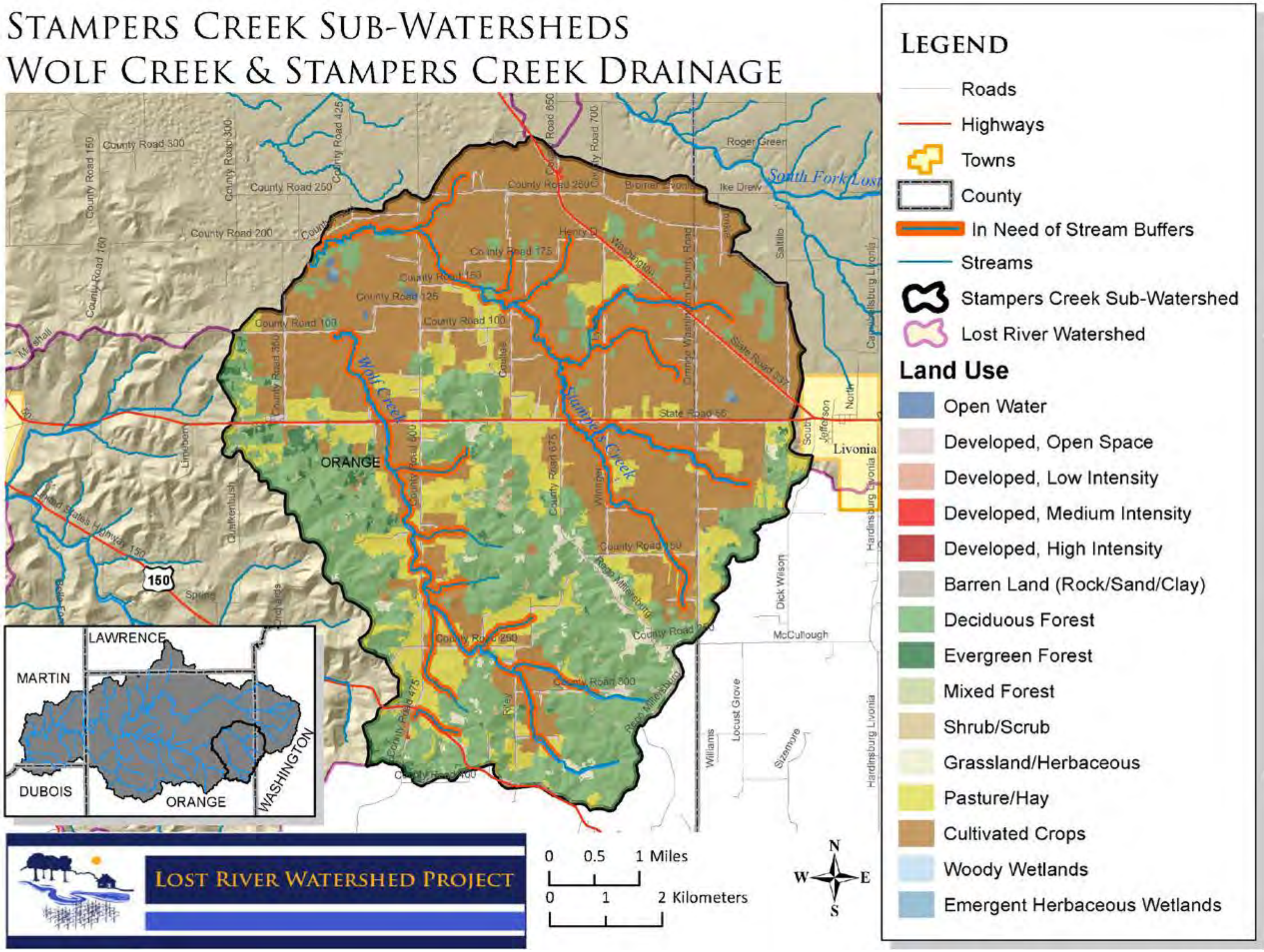


Figure 103: Stamper Creek Subwatershed Land Use and Stream Buffers (Land use in 2006 and areas of drainage in need of stream buffers)

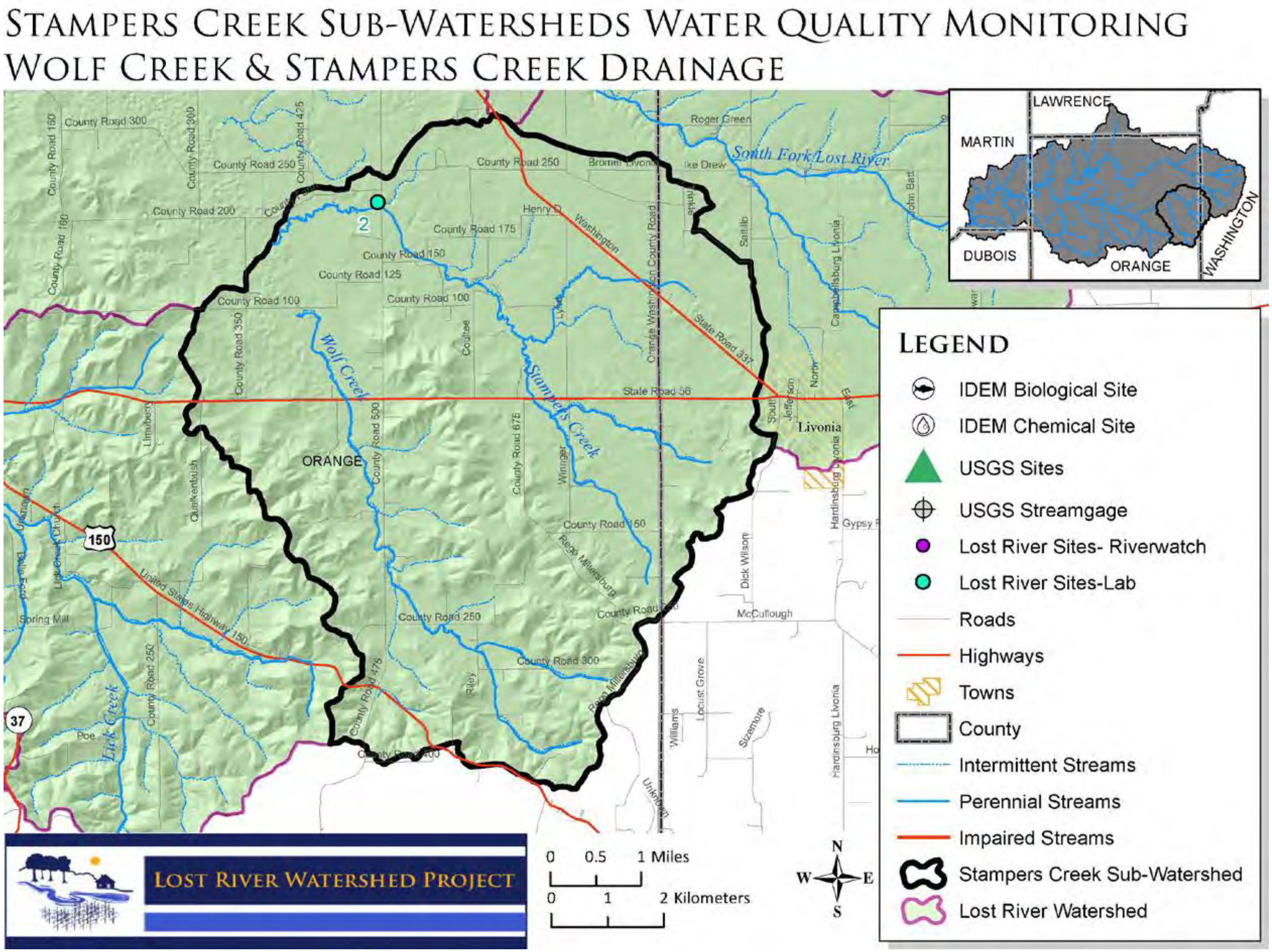


Figure 104 : Stampers Creek Subwatersheds **-** Monitoring locations (Historic and Current)

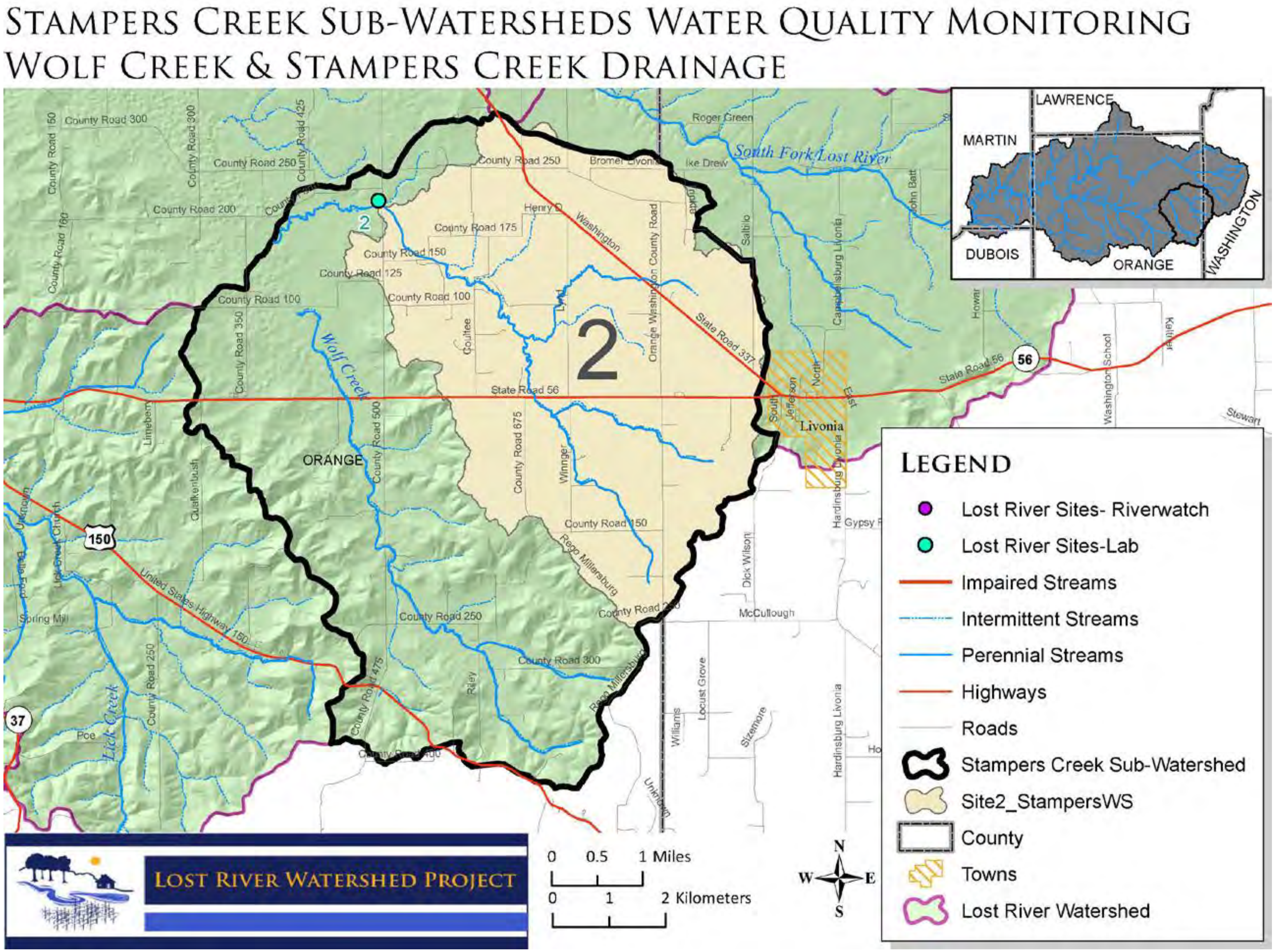
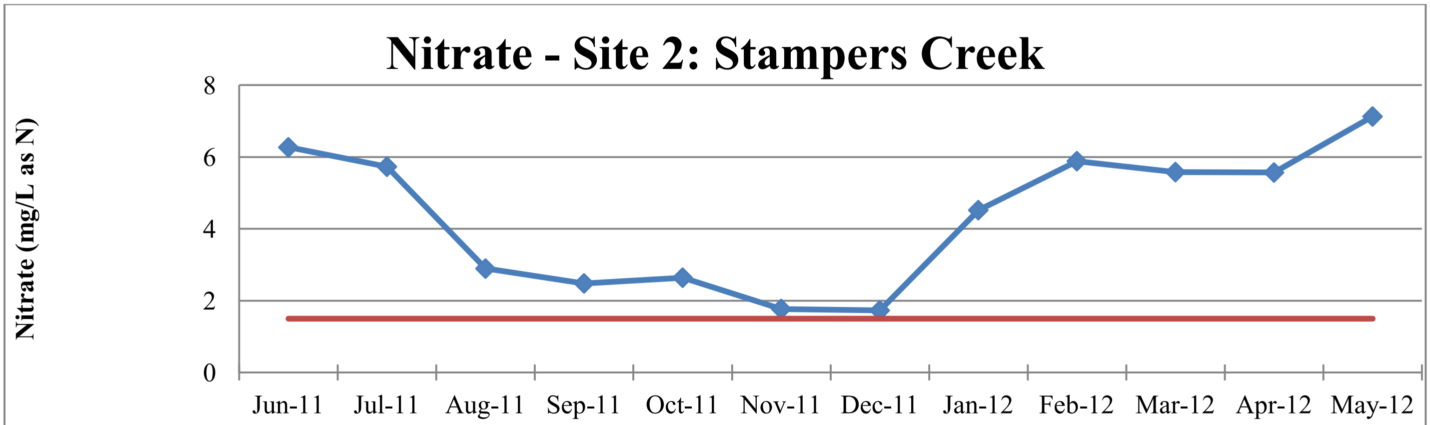


Figure 105 : Sample Site subwatersheds for Stampers Creek Area- based on 2011-2012 sampling period

Water quality monitoring has not been previously conducted on Stampers Creek (Figure 104) within the last 30 years. USGS did monitor the site for water quality characteristics back in 1974-1975 twice but this data will not be considered here.

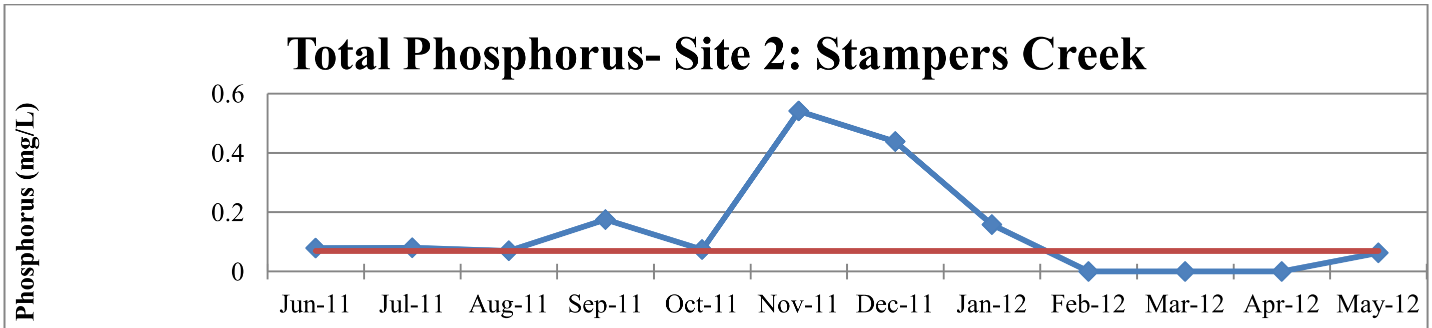
Stampers Creek Monitoring Site 2

The subwatershed created from Site 2 (Figure 104) can be seen in Figure 105. Water quality parameters gathered here represent any point or nonpoint sources in this area. The Lost River Watershed Team Sampling found that Nitrates were consistently above target levels of 1.5 mg/L throughout the testing period at Site 2 (Figure 106). Phosphorus levels at Site 2 exceeded target levels of 0.07 mg/L eight times during the 2011-2012 sampling period (Figure 107). Nitrates exceeded target levels but are lower than in other samples in the same months that phosphorus exceeded targets. Algal blooms have been seen upstream of this location. Turbidity and total suspended sediment (TSS) levels spiked during rain events, as seen in Figures 108 and 109. This may indicate the level of erosion that occurs within the watershed during rain events. *E. coli* levels exceeded target values of 235 MPN/100ml during 8 months with two months the value exceeded levels that the laboratory could test (Figure 110). Several of the exceeded months were during winter months when bacteria is not as viable due to cold temperatures. A high level of *E.coli* during colder periods indicates a nearby source, or a strong septic influence.



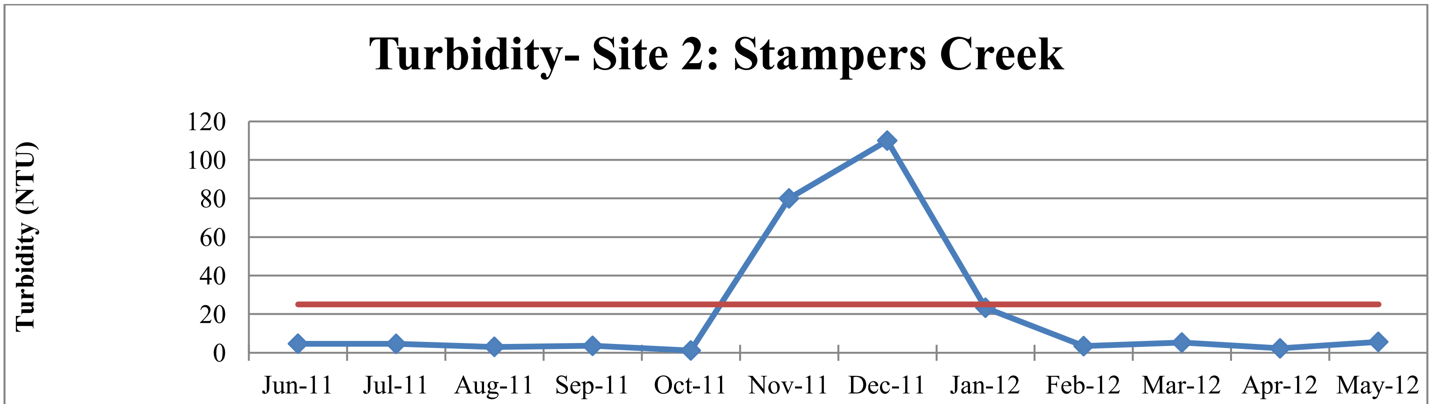
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	6.27	5.73	2.892	2.48	2.639	1.768	1.726	4.52	5.884	5.58	5.568	7.128
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 106: Nitrate Levels at Site 2 (2011-2012 testing period)



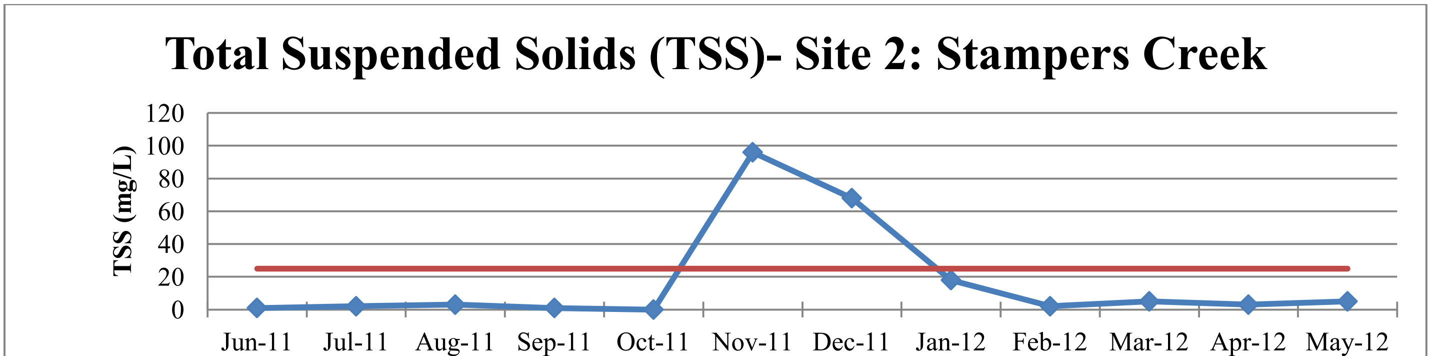
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.079	0.08	0.07	0.175	0.074	0.541	0.438	0.158	0	0	0	0.063
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 107: Total Phosphorus Levels at Site 2 (2011-2012 testing period)



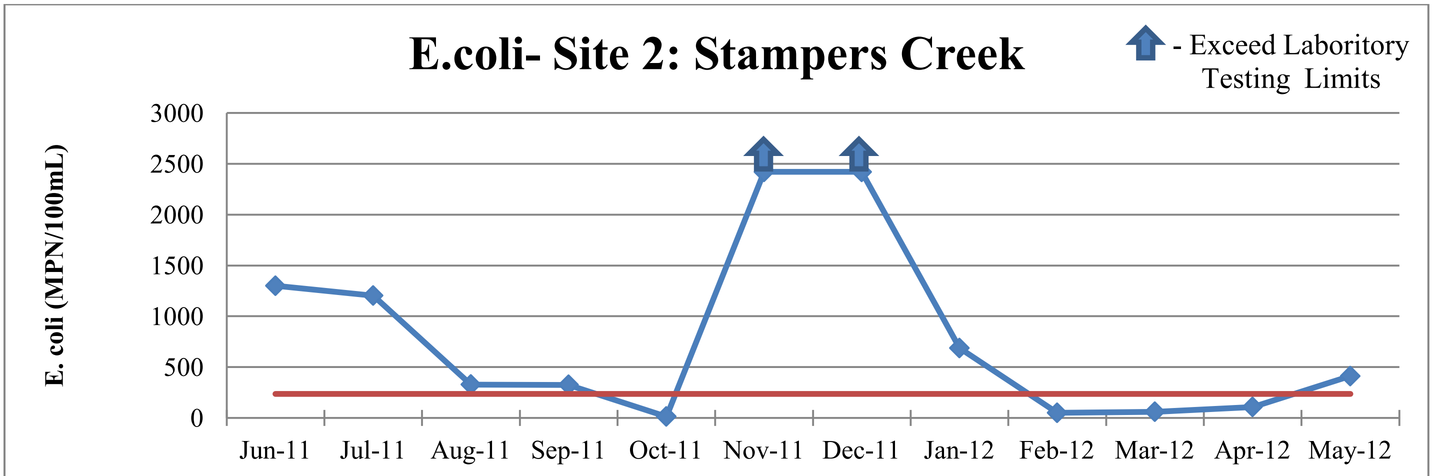
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	4.65	4.57	3.03	3.54	1.13	80	110	23.3	3.39	5.25	2.22	5.6
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 108: Turbidity Levels at Site 2 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	1	2	3	1	0	96	68	18	2	5	3	5
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 109: Total Suspended Solid (TSS) Levels at Site 2 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	1299.7	1203.3	328.2	325.5	13.5	2419.6	2419.6	686.7	49.6	60.2	107.6	410.6
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 110: E.coli levels at Site 2 (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts. At Site 2, the habitat was determined to be good with a QHEI score of 60. However, the macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 36. Poor water quality may be affecting macroinvertebrate populations, and it may also be affecting life within the subterranean cave system. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

Permitted Facilities and Managed Lands

Two active Confined Feeding Operations (CFOs) are located within Stampers Creek subwatershed along with two voided CFOs (Figure 111). The active operations may be partially contributing to high E. coli levels found within Stampers Creek. There is one underground storage tank in this area which is not leaking. Approximately 62 acres of land is managed by DNR through classified forest programs within the southern portion of the watershed. There is approximately 407 acres of land that is managed by Hoosier National Forest within this watershed. All residences in this area are on septic systems or open tank systems, also called outhouse, in the case of the Amish.

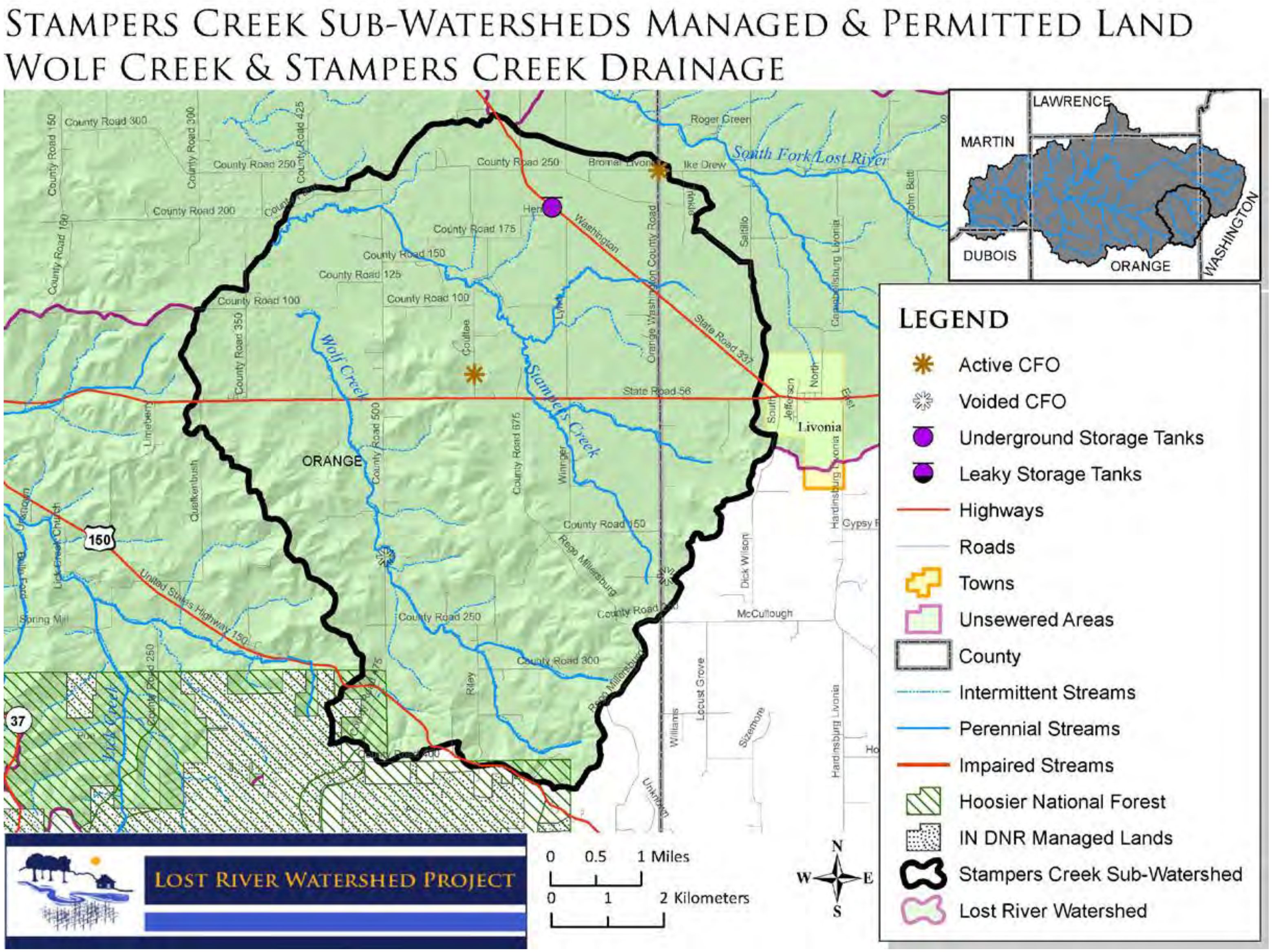


Figure 111: Stampers Creek Subwatershed- Locations within the subwatersheds showing potential point sources, sewered areas, and managed lands.

5.4 Lick Creek Area

Lick Creek Area is made up of the three subwatersheds that contain all the drainage to Lick Creek. They are The Headwaters Lick Creek subwatershed, Log Creek-Lick Creek subwatershed, and Scott Hollow-Lick Creek subwatershed (Figure 69). Twenty-seven known springs rise within these three subwatersheds. Wolf Creek drainage rises at one of these springs in the headwaters of Lick Creek. Water quality in this area may be heavily influenced by these springs. There are 10 perennial tributaries that drain into Lick Creek. Most of these are unnamed, but the larger named ones are Willow Creek, Log Creek, and Upper Sulphur Creek. The Orange County seat, Paoli, is within this watershed. Lick Creek flows through the town and can be seen from the many vehicle bridges, walking bridges, and parks along its course.

Land Use

The total area of the three subwatersheds is 41,871 acres with Headwaters Lick Creek at 12,087 acres, Log Creek-Lick Creek covering 15,914 acres, and Scott Hollow-Lick Creek having 13,870 acres. The majority of landuse in these subwatersheds is forested. Forested lands make up 26,210 acres, or 62.6% within the 3 subwatersheds. The majority of cultivated crops (3,495 acres) and pasture or hay lands (7,478 acres) are along stream channels or in other flatter land in the area. Livestock are also present within this area in the form of smaller homestead farms and open pasture livestock. Grasslands comprise 1,271 acres and shrubs make up 276 acres. The other 2,737 acres is developed with the county seat of Paoli. Open space makes up 2,315 acres of the developed area. There are a total of 150.9 miles of drainage channels within the Lick Creek Area watershed. Of this, 61.94 miles is perennial in nature, meaning there is flow within these channels year round. Headwaters Lick Creek subwatershed has 39.35 miles of channels and 14.95 miles of perennial channels. Log Creek-Lick Creek subwatershed has 55.15 miles of channels and 25.11 miles of perennial channels. Scott Hollow-Lick Creek subwatershed has 56.40 miles of channels, and 21.88 miles are perennial.

Within Headwaters Lick Creek subwatershed, 12.89 miles of channels are in need of riparian buffers on the streams, of this 5.99 miles are perennial (Figure 112). This makes up 290.5 acres out of the total 838 acres of stream corridors. While in Log Creek-Lick Creek subwatershed, 26.34 miles of stream channels are in need of riparian buffers with 12.71 miles as perennial channels. This occurs in 557.9 acres out of the total 1,162 acres of stream corridors. The Scott Hollow-Lick Creek subwatershed is in need of 19.67 miles of channel buffers with 10.17 miles of perennial channels in need of buffers. This accounts for 398.6 acres in need of riparian buffer out of a total of 1,180.2 acres of stream corridors. In general, stakeholders are concerned over the lack of riparian buffers along stream corridors. Riparian buffers are in place within these watersheds, but in many instances, they are not wide enough to perform proper filtration of surrounding land uses.

Hoosier National Forest and DNR have areas of managed lands seen in Figure 145. Included in these lands is Pioneer Mother’s Memorial Forest. The Pioneer Mother's Memorial Forest Research Natural Area is an 88-acre grove of virgin Central Hardwood forest, which includes cathedral stands of mature black walnut (Juglans nigra), yellow-poplar (Liriodendron tulipifera), white oak (Quercus alba), and white ash (Fraxinus americana). Some of these trees exceed 50 inches in diameter at breast height and 60 feet to the first limb. This is one of the few remaining virgin tracts of Central Hardwoods in the region.

Windshield Survey

Windshield surveys performed in this area indicated high levels of sediment erosion occurring along Lick Creek. There are 35 sections along Lick Creek and its tributaries where streambank erosion can be witnessed. There is approximately 14.36 miles of stream banks in need of stabilization (Figure 39). The area could benefit from increased riparian buffers in the stream corridors and side tributaries. Several small side tributaries to both creeks are also showing signs of destabilization and increased erosion from these areas will disrupt the ecosystem function. Windshield surveys also show multiple homestead farms in the area with small numbers of livestock. There are at least 19 homestead farms within Headwaters Lick Creek subwatershed, 8 homestead farms within Log Creek- Lick Creek subwatershed, and 11 homestead farms located within Scott Hollow- Lick Creek subwatershed. Over 20 farms had livestock on pastures where they had access to the stream channels. In addition, a high amount of land had trashed stream channels or properties. At least seven locations were identified where properties had an accumulation of metals and other refuse that may be contributing to nonpoint source pollution. There are also several locations with trash along roadside ditches and within streams. One drainage channel within Scotts Hollow – Lick Creek subwatershed looked to be a dumping ground for deer carcasses. Over 12 deer carcasses were identified at this location.

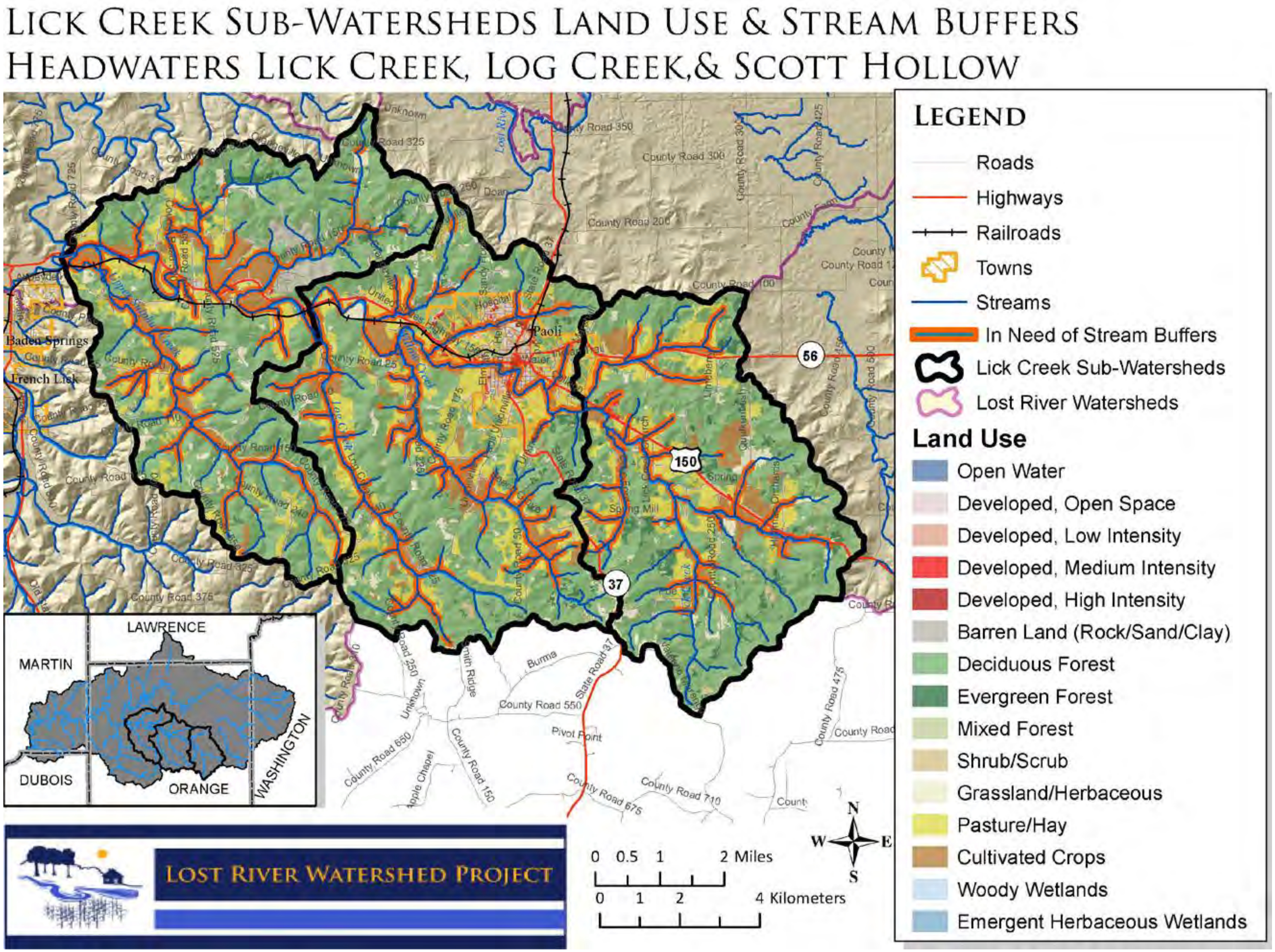


Figure 112: Lick Creek Area- Land use (2006) and areas in need of stream buffers

Lick Creek Sub-Watersheds Water Monitoring Stations
Headwaters Lick Creek, Log Creek,& Scott Hollow

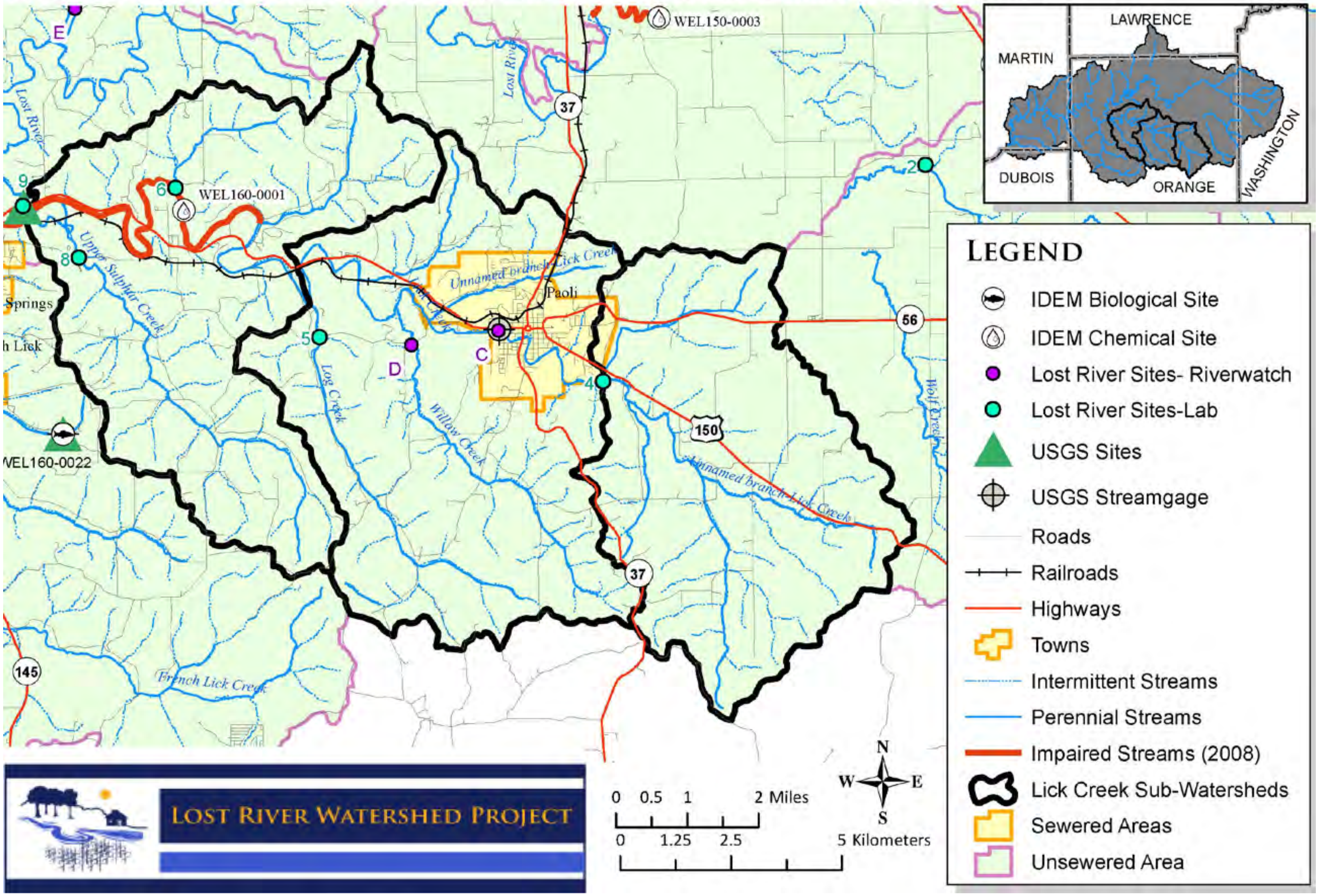


Figure 113: Lick Creek Area- Location of water monitoring stations (current and historical). Map also indicates sewered and unsewered areas.

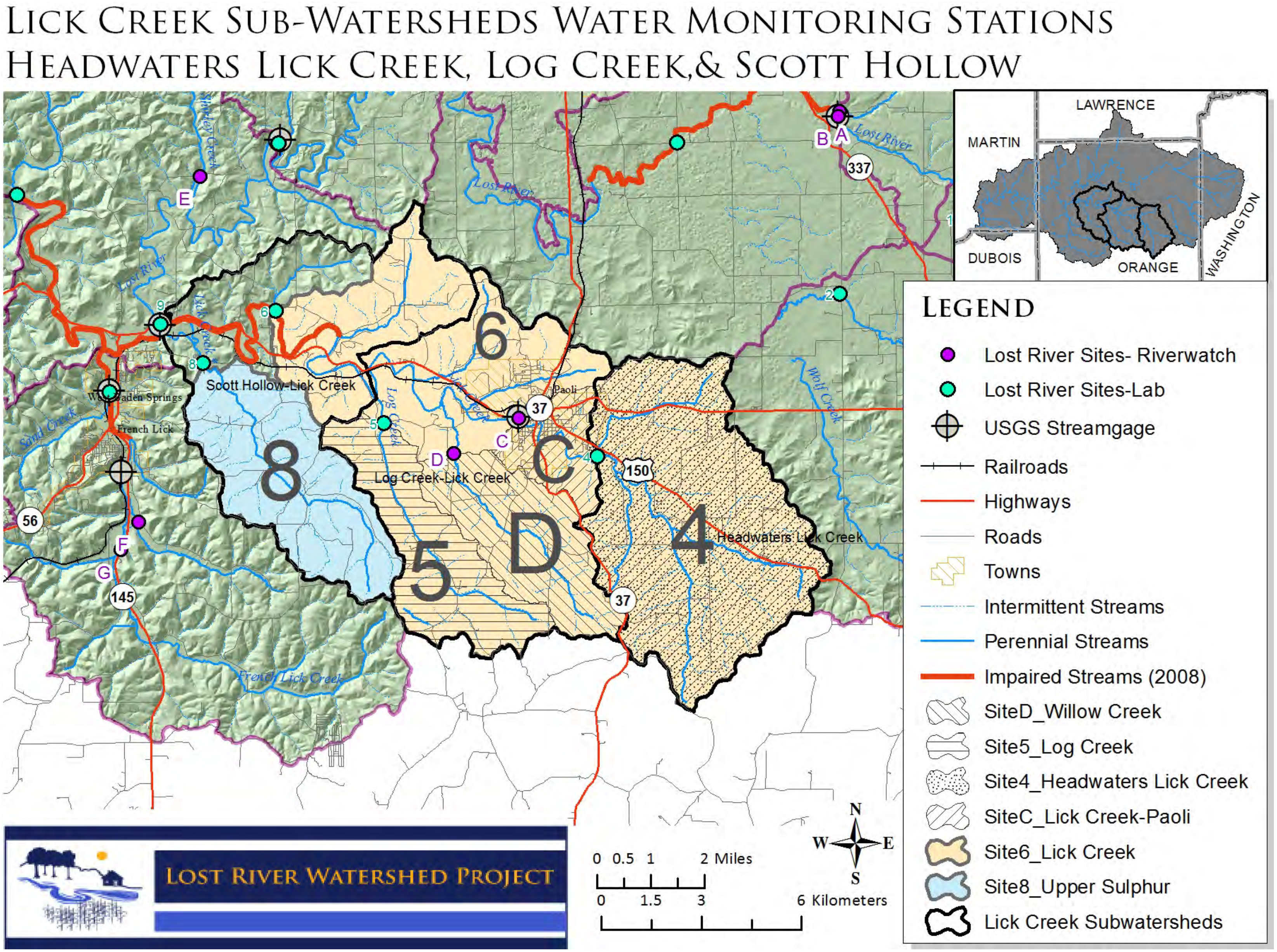
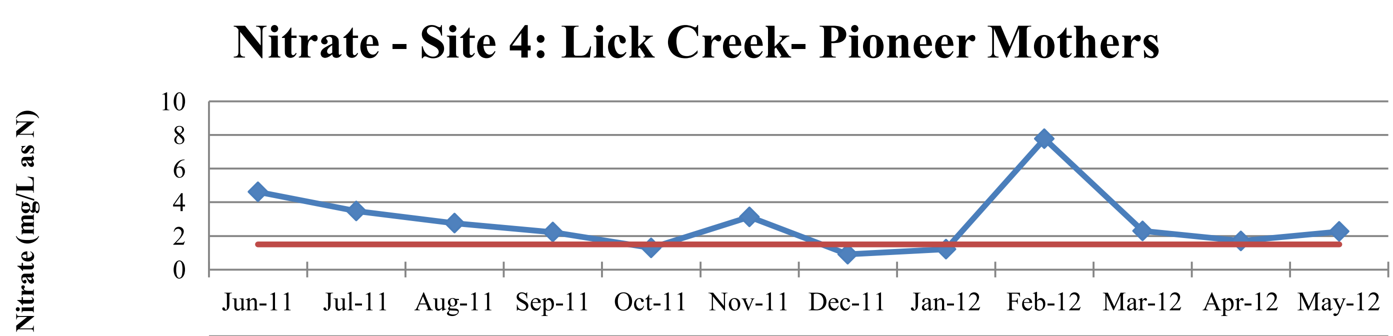


Figure 114: Sample Site subwatersheds for Stampers Creek Area- based on 2011-2012 sampling period

Seven locations were monitored within the three subwatersheds of Lick Creek (Figure 113). Of these stations, four are on Lick Creek at various points along its path to Lost River. One of the four is an IDEM monitoring site (WEL160-0001, see Figure 113) that was measured in 1997 and 2002. The other three sites were monitored in the current 2011-2012 monitoring study. Site 4 is located on Lick Creek at the outlet of Headwaters Lick Creek subwatershed. Site C on Lick Creek is collocated at the USGS streamgage station (USGS 03373610) within Paoli at Marea Radcliff Park. Site 6 is on Lick Creek near the IDEM sampling location and also just upstream of the outlet of Lick Creek into Lost River. Three other locations were monitored during the current 2011-2012 sampling. Site D is located on Willow Creek along an old county road that crosses the stream. Site 5 is located on Log Creek off a bridge on County Rd 25 South. Site 8 is located on Upper Sulphur Creek off Abbeydell Rd (Co Rd 100 S).

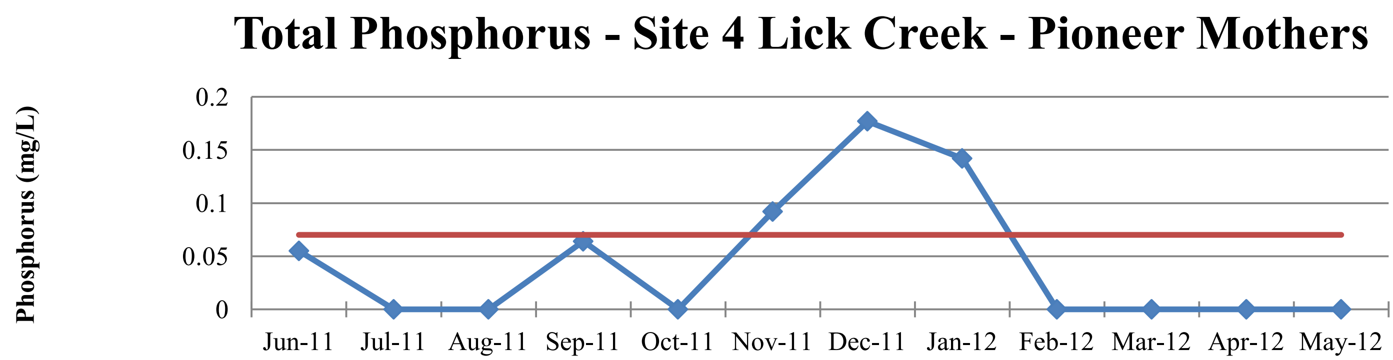
Lick Creek (Pioneer Mothers) Monitoring Site 4

The headwaters of Lick Creek are monitored at one location, Site 4, at the outlet of the Headwaters Lick Creek subwatershed. This site is located in Pioneer Mothers Memorial Forest and drains land out to the east and south of Paoli (Figure 114). Site 4 has shown elevated levels of nitrates in 10 out of the 12 months monitored (Figure 115). Nitrates spiked in February 2012 with a measurement of 7.77mg/L, 5 times the target level of 1.5 mg/L. Total Phosphorus was above target levels of 0.07 mg/L in three months - November 2011, December 2011 and January 2012(Figure 116). The highest measured total phosphorus reading was in December with 0.177 mg/L which is 2.5 times the target level. Turbidity and total suspended solids (TSS) saw similar results with levels exceeding target levels in November 2011 through January 2012. Turbidity spiked in December 2011 with 107 NTU reaching over 4 times the target levels of 25 NTU (Figure 117). TSS levels also spiked in December 2011 with 122 mg/L almost 5 times the target level of 25 mg/L (Figure 118). *E.coli* was also elevated above testing limits (2,419.6 MPN/100mL) twice in the 12 months of sampling. *E. coli* was above target levels (235 MPN/100mL) half of the time , or 6 out of 12 samples (Figure 119). Dissolved oxygen, specific conductivity, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.



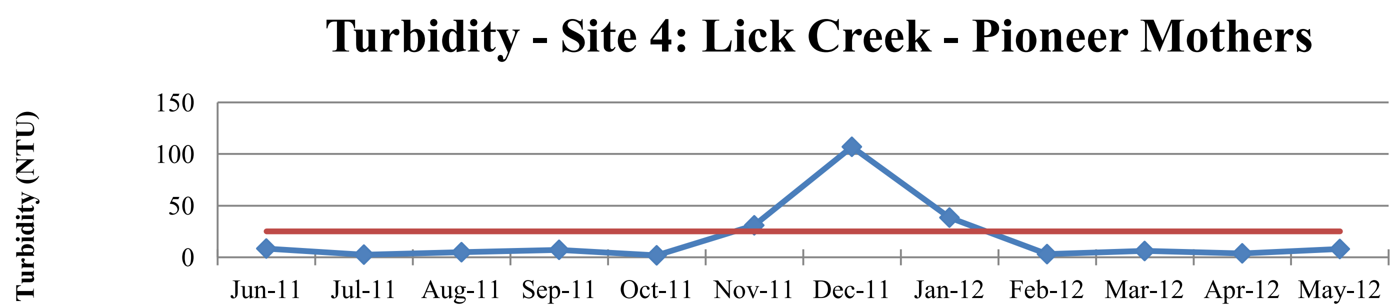
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	4.62	3.48	2.76	2.23	1.284	3.128	0.908	1.21	7.777	2.294	1.698	2.266
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 115: Nitrate Levels at Site 4 (2011-2012 testing period)



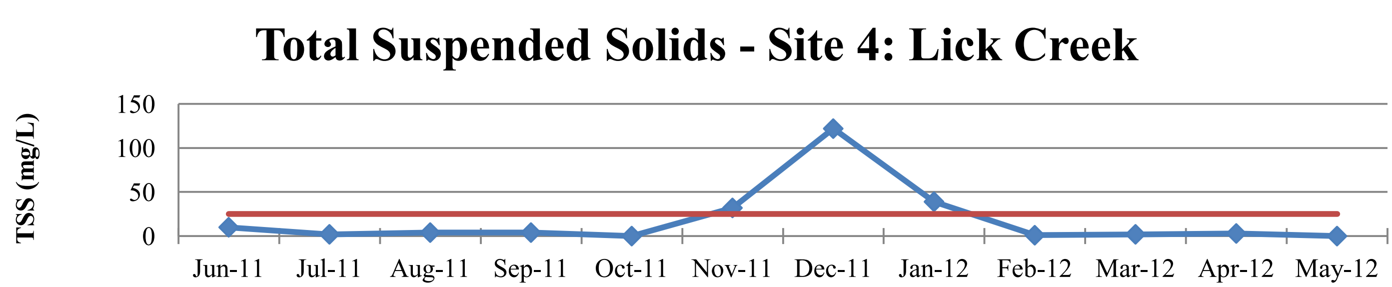
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.055	0	0	0.064	0	0.092	0.177	0.142	0	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 116: Total Phosphorus Levels at Site 4 (2011-2012 testing period)



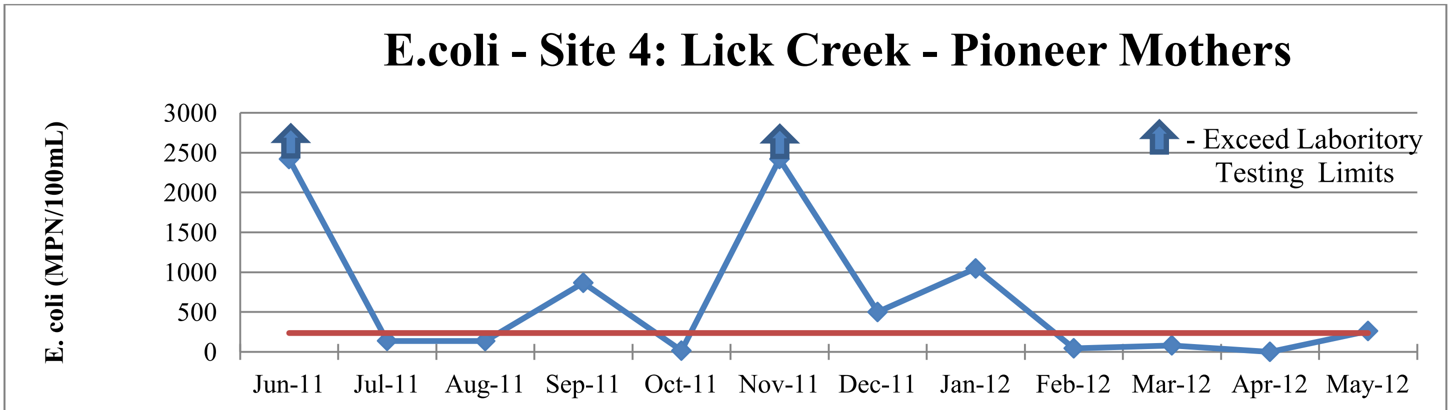
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	8.4	2.51	4.86	7.17	1.82	30.9	107	38.4	3	6.02	3.75	7.96
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 117: Turbidity Levels at Site 4 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	10	2	4	4	0	32	122	39	1	2	3	0
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 118: Total Suspended Solids (TSS) Levels at Site 4 (2011-2012 testing period)



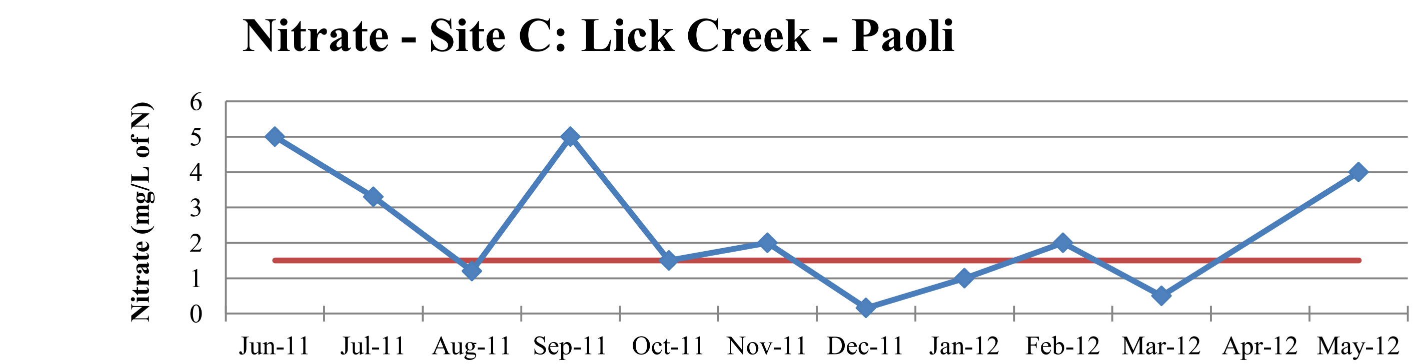
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	2419.6	137.6	135.4	866.4	14.5	2419.6	499.6	1046.2	44.1	81.3	0	261.3
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 119: E. coli Levels at Site 4 (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site 4. The habitat in Lick Creek within Pioneer Mothers was determined to be excellent with a QHEI score of 71. The macroinvertebrate scores indicate that this section of Lick Creek is not impaired for aquatic life. The mIBI score at this site was 36 points which is at the target score. Biological samples have not been collected at this site before by IDEM or through either of the LARE diagnostic studies.

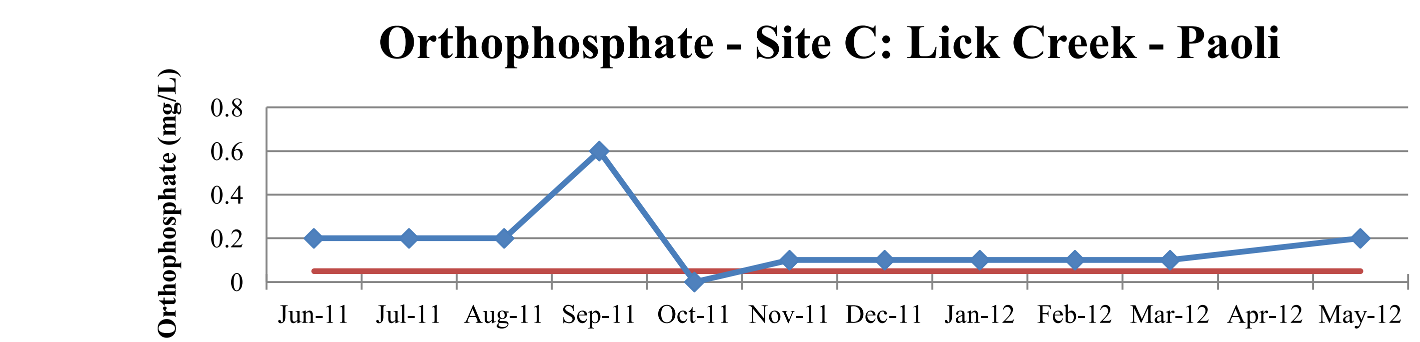
Lick Creek (Paoli) Monitoring Site C

Lick Creek is also monitored within the town of Paoli at Site C. Site C drains the area from Site 4 plus some of the town of Paoli (Figure 114). Site C was monitored by the Hoosier Riverwatch Lost River Team during the 2011-2012 sampling event. This site is located in Marea Radcliff Park and is collocated with USGS Streamgage (USGS 03373610). Site C has shown elevated levels of nitrates in 6 out of the 12 months monitored (Figure 120). Nitrates spiked in June and September 2011 with a measurement of 5 mg/L, 3.3 times the target level of 1.5 mg/L. Orthophosphate was above target levels of 0.05 mg/L in every sample except the one collected in October 2011(Figure 121). The highest measured orthophosphate reading was in September 2011 with 0.6 mg/L, which is 12 times the target level. Biochemical Oxygen Demand (5-day) had levels below target values except in September 2011 where levels spiked at 2.7 mg/L change (Figure 122). Turbidity spiked in September 2011 and January 2012 with 39 NTU above target levels of 25 NTU (Figure 123). *E.coli* was also elevated above target levels (235CFU/100mL) seven times in the 12 months of sampling. *E. coli* spiked in September 2011 with levels at 23,900 CFU/100mL (Figure 124). Figure 124 also shows high levels of total coliforms in September and December 2011 along with January 2012. Dissolved oxygen, temperature, and pH from all samples fell within normal levels during the sampling season at this location.



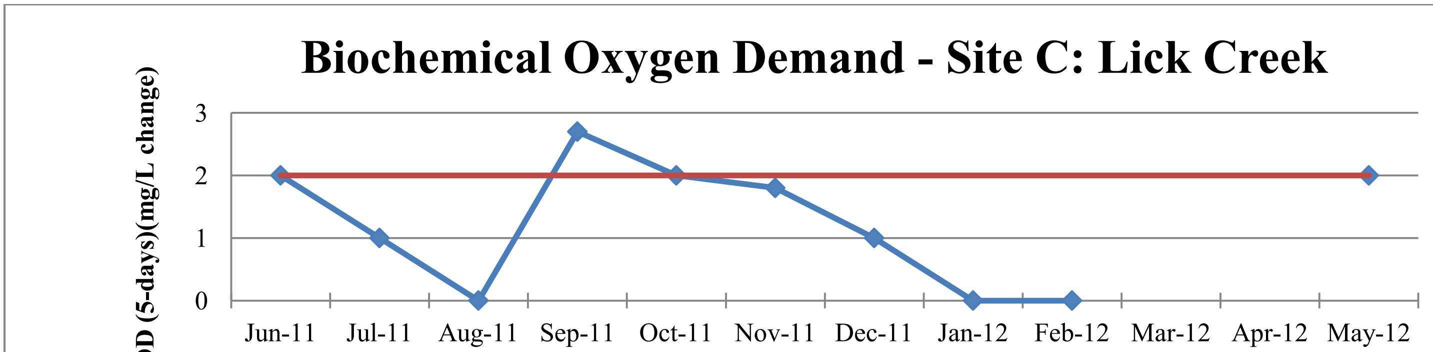
	6/15/11	7/29/11	8/28/11	9/26/11	10/29/11	11/18/11	12/28/11	1/27/12	2/26/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	5	3.3	1.2	5	1.5	2	0.16	1	2	0.5	4

Figure 120: Nitrate Levels at Site C (2011-2012 testing period)



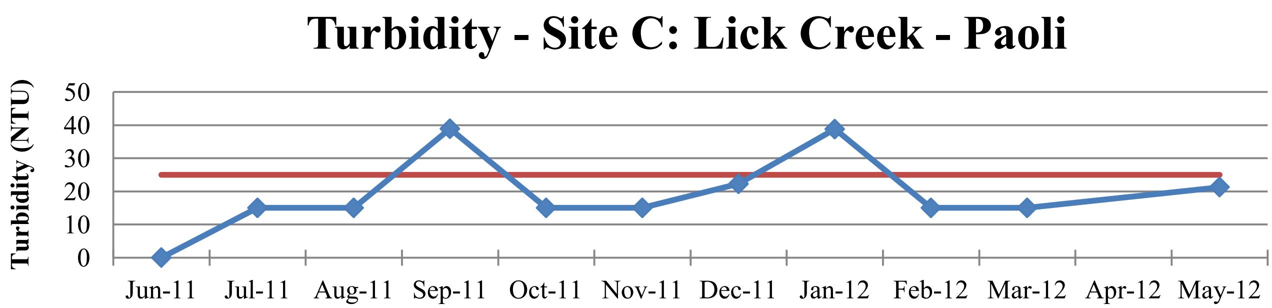
	6/15/11	7/29/11	8/28/11	9/26/11	10/29/11	11/18/11	12/28/11	1/27/12	2/26/12	3/30/12	5/2/12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.2	0.2	0.2	0.6	0	0.1	0.1	0.1	0.1	0.1	0.2

Figure 121: Orthophosphate Levels at Site C (2011-2012 testing period)



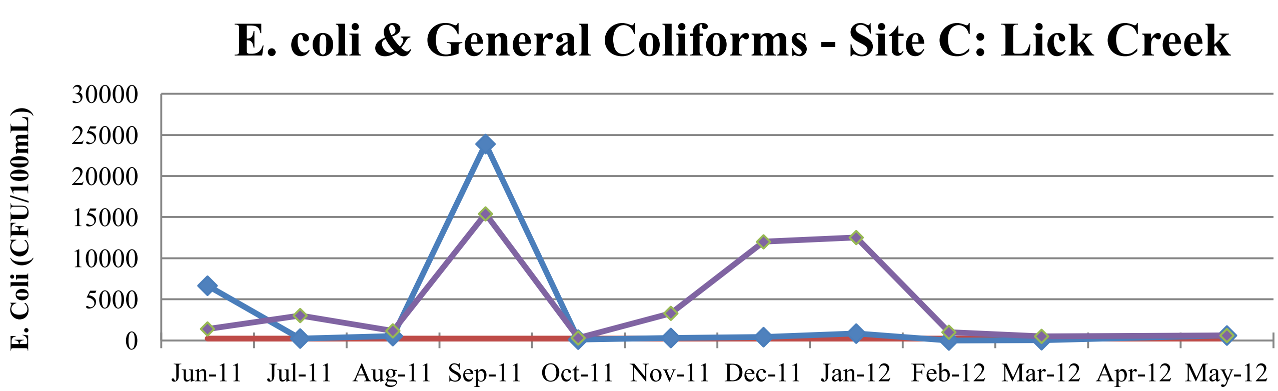
	6/15/11	7/29/11	8/28/11	9/26/11	10/29/11	11/18/11	12/28/11	1/27/12	2/26/12	3/30/12	5/2/12
BOD5	2	1	0	2.7	2	1.8	1	0	0		2
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 122: Biochemical Oxygen Demand (5-day) (BOD5) Levels at Site C (2011-2012 testing period) (no data in March)



	6/15/11	7/29/11	8/28/11	9/26/11	10/29/11	11/18/11	12/28/11	1/27/12	2/26/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	0	15	15	39	15	15	22	39	15	15	21

Figure 123: Turbidity Levels at Site C (2011-2012 testing period)



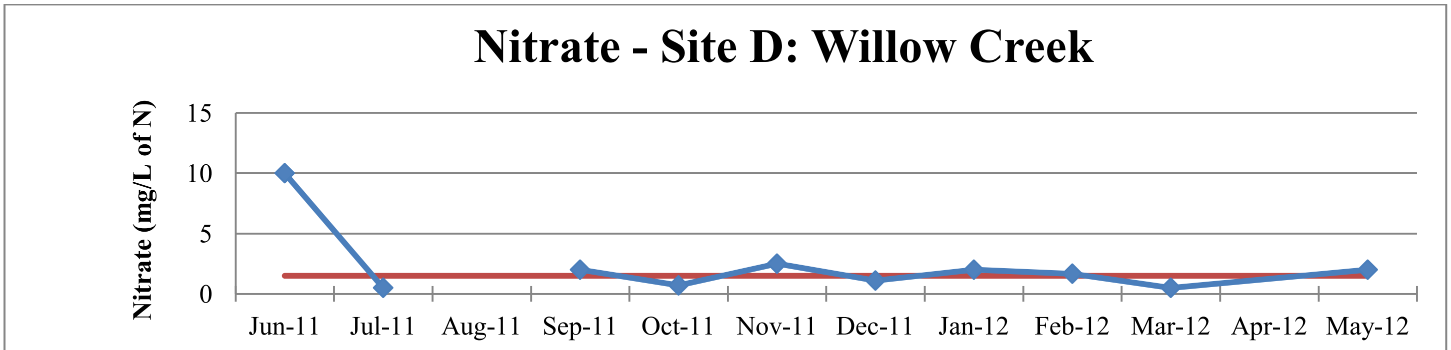
	6/15/11	7/29/11	8/28/11	9/26/11	10/29/11	11/18/11	12/28/11	1/27/12	2/26/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	6660	233.1	532.8	23900	100	300	400	832.5	0	33.3	600
General Coliforms	1398.6	3030.3	1165.5	15400	300	3300	12000	12520.8	999	499.5	600

Figure 124: E. coli and General Coliform Levels at Site C (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site C. The habitat at Lick Creek in Marea Radcliff Park was determined to be good with a citizens QHEI score of 64. The macroinvertebrate scores indicate that this section of Lick Creek is not impaired for aquatic life. The Pollution Tolerance Index score at this site was 27 points which indicates an excellent diversity and population of macroinvertebrates at this location. This high score is likely due to the good habitat, and fair water quality. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

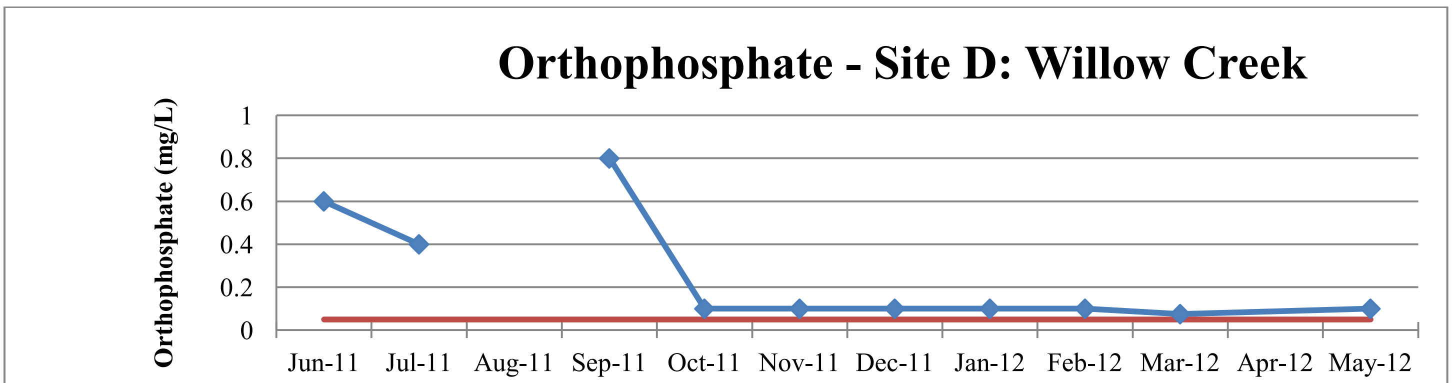
Willow Creek Monitoring Site D

The Hoosier Riverwatch Lost River Team on a monthly basis monitored Willow Creek (Site D) for the 2011-2012 sampling event. Site D contains most of the area that drains to Willow Creek (Figure 114). No data was collected in August of 2011 because flow was absent during this month. Nitrate levels fluctuated throughout the 2011-2012 sampling season and exceeded target levels 5 times during the sampling period. Nitrate spiked in June 2011 with 10 mg/L (Figure 125). Orthophosphate levels consistently were above target levels of 0.05 mg/L. The highest level seen was 0.8 mg/L in September of 2011, which is 16 times the target levels (Figure 126). Turbidity levels only spiked above target levels of 25 NTU once in September with a value of 37 NTU (Figure 127). *E.coli* levels spiked at 8,900 CFU/100mL in September 2011 (Figure 128). *E.coli* levels were above target levels 4 times during the sampling event. Figure 128 also shows high levels of total coliforms in September 2011 and January 2012. Dissolved oxygen, biochemical oxygen demand, temperature, and pH all fell within allowable levels for every sample collected at this site.



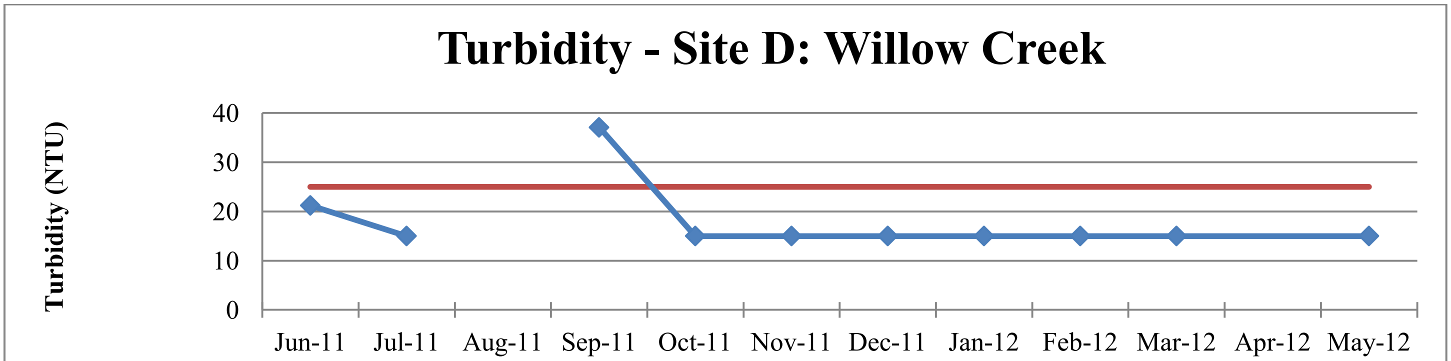
	06/15/11	07/29/11	08/28/11	09/26/11	10/28/11	11/17/11	12/28/11	01/28/12	02/26/12	03/30/12	05/02/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	10	0.5		2	0.7	2.5	1.1	2	1.67	0.5	2

Figure 125: Nitrate Levels at Site D (2011-2012 testing period)



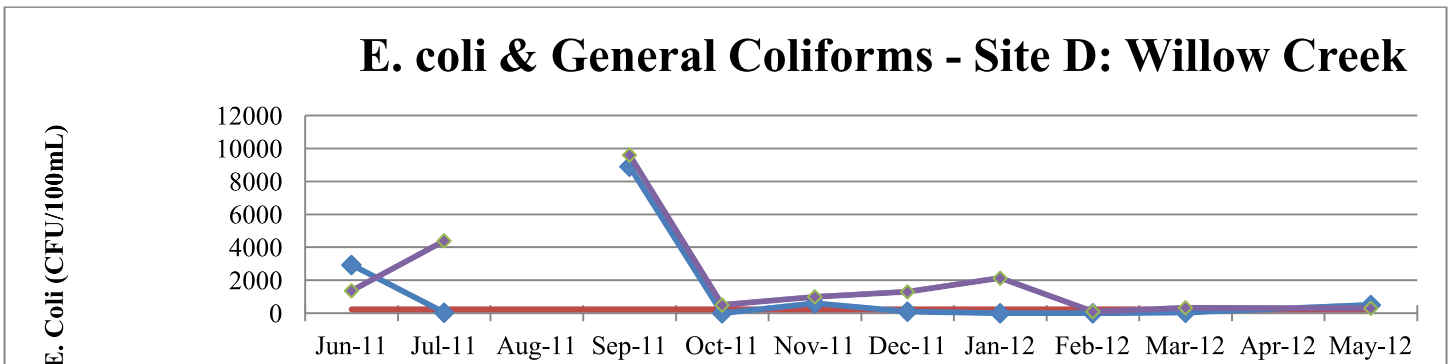
	06/15/11	07/29/11	08/28/11	09/26/11	10/28/11	11/17/11	12/28/11	01/28/12	02/26/12	03/30/12	05/02/12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.6	0.4		0.8	0.1	0.1	0.1	0.1	0.1	0.075	0.1

Figure 126: Orthophosphate Levels at Site D (2011-2012 testing period)



	06/15/11	07/29/11	08/28/11	09/26/11	10/28/11	11/17/11	12/28/11	01/28/12	02/26/12	03/30/12	05/02/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	21.2	15		37	15	15	15	15	15	15	15

Figure 127: Turbidity Levels at Site D (2011-2012 testing period)



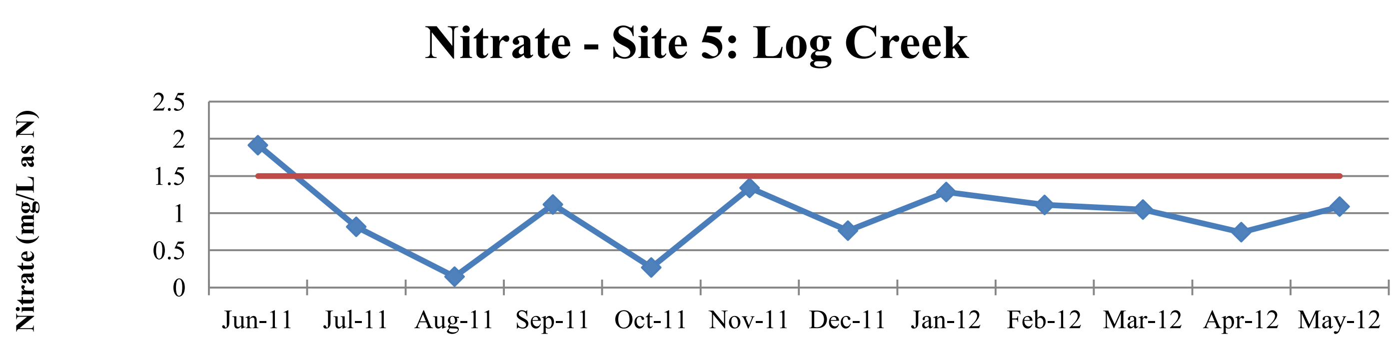
	06/15/11	07/29/11	08/28/11	09/26/11	10/28/11	11/17/11	12/28/11	01/28/12	02/26/12	03/30/12	05/02/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	2930.4	33.3		8900	0	600	100	0	0	33.3	500
General Coliforms	1365.3	4395.6		9600	500	1000	1300	2131.2	99.9	333	300

Figure 128: E. coli and General Coliform Levels at Site D (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site D. The habitat within Willow Creek in Marea Radcliff Park was determined to be excellent with a citizens QHEI score of 84. The macroinvertebrate scores indicate that this section of Willow Creek is not impaired for aquatic life. The Pollution Tolerance Index score at this site was 17 points, which indicates an good diversity and population of macroinvertebrates at this location. This high score is likely due to the excellent habitat, and fair water quality. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

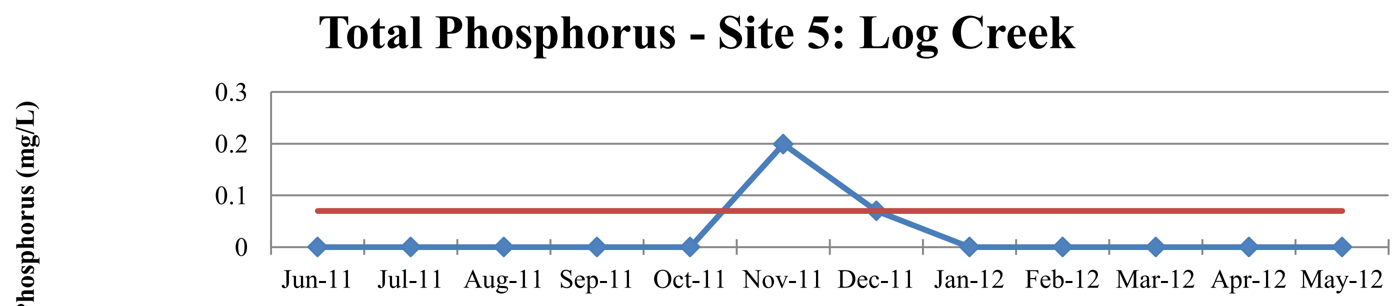
Log Creek Monitoring Site 5

Log Creek is monitored at Site 5 upstream of the outlet to Lick Creek. This site monitors the water within Log Creek (Figure 114). It should be noted that Betsey Spring is immediately upstream from the testing site and so water quality may be influenced by the spring water. Nitrate levels in Log Creek have been below target levels in all but one sample collected at this site (Figure 129). In June 2011, nitrate levels did exceed target levels with a spike of 1.914 mg/L. Total Phosphorus was above target levels of 0.07 mg/L in November 2011 (Figure 130). This total phosphorus reading was 0.199 mg/L, which is 2.8 times the target level. Turbidity levels exceeded target levels twice during the sampling period in November (42.5 NTU) and December (33.8 NTU) (Figure 131). The highest amount of turbidity seen at this site was at the same time that total suspended solids (TSS) spiked above target levels in December 2011. TSS levels in December 2011 reached 64 mg/L, which is 2.5 times the target level of 25 mg/L (Figure 132). *E.coli* was also elevated above testing limits (2,419.6 MPN/100mL) once in the 12 months of sampling. *E. coli* was above target levels (235 MPN/100mL) four times out of 12 samples (Figure 133). Specific conductivity dropped below target levels (150 µs/cm) once in December with a value of 118.5 µs/cm (Figure 134). Dissolved oxygen, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.



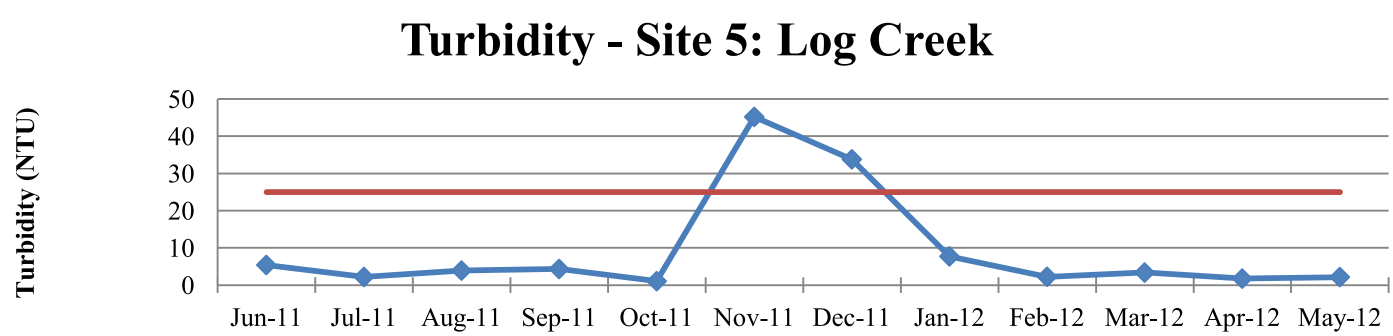
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	1.914	0.816	0.145	1.116	0.268	1.339	0.764	1.284	1.11	1.048	0.744	1.088
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 129: Nitrate Levels at Site 5 (2011-2012 testing period)



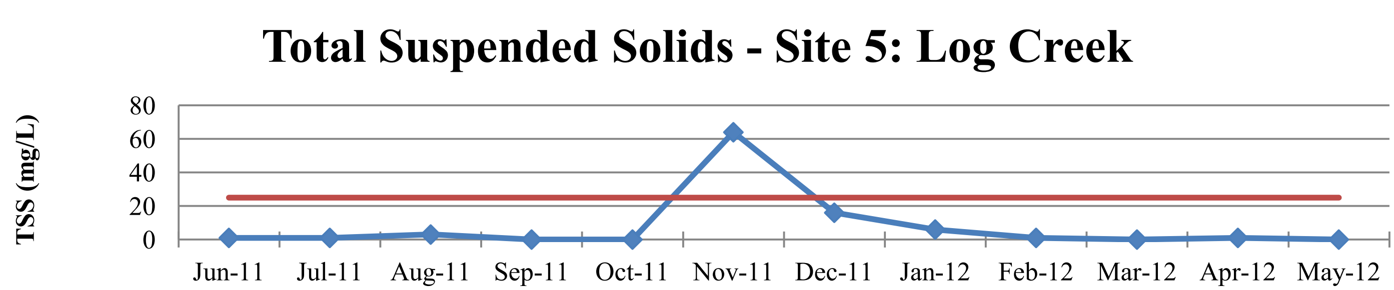
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0	0	0	0	0	0.199	0.07	0	0	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 130: Total Phosphorus Levels at Site 5 (2011-2012 testing period)



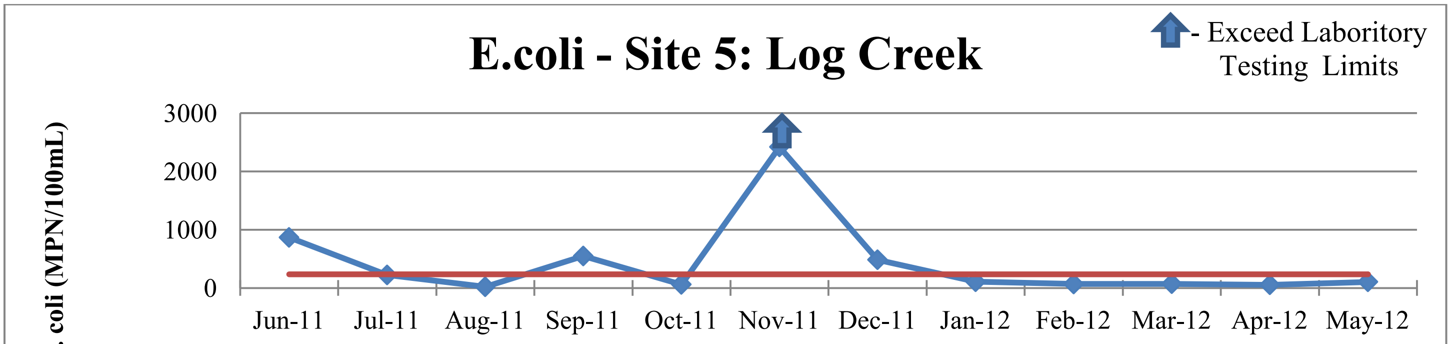
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	5.4	2.18	3.9	4.33	1.05	45.2	33.8	7.71	2.23	3.37	1.74	2.15
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 131: Turbidity Levels at Site 5 (2011-2012 testing period)



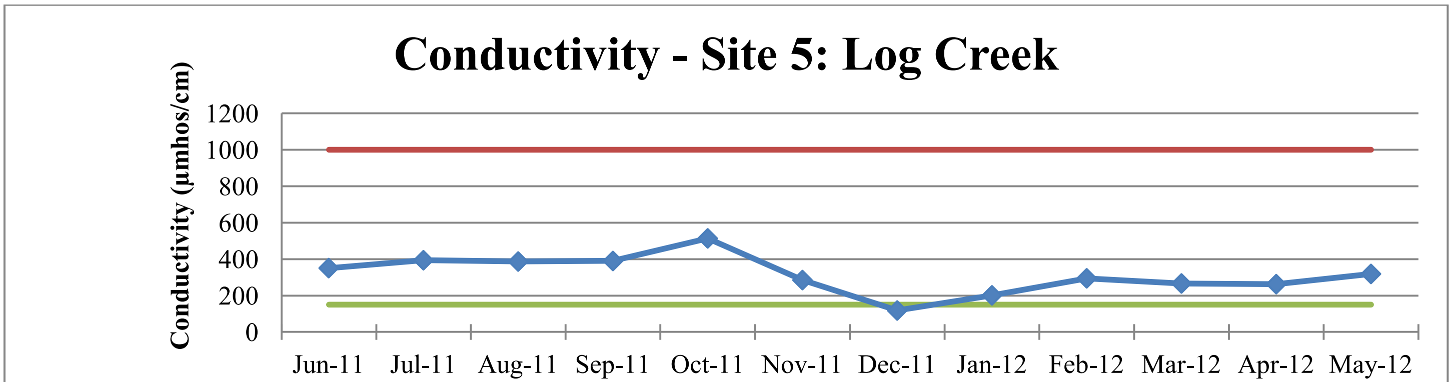
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	1	1	3	0	0	64	16	6	1	0	1	0
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 132: Total Suspended Solid (TSS) Levels at Site 5 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	866.4	222.4	19.5	547.5	59.8	2419.6	483.3	105.4	67	72.3	53.8	104.6
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 133: E. coli Levels at Site 5 (2011-2012 testing period)



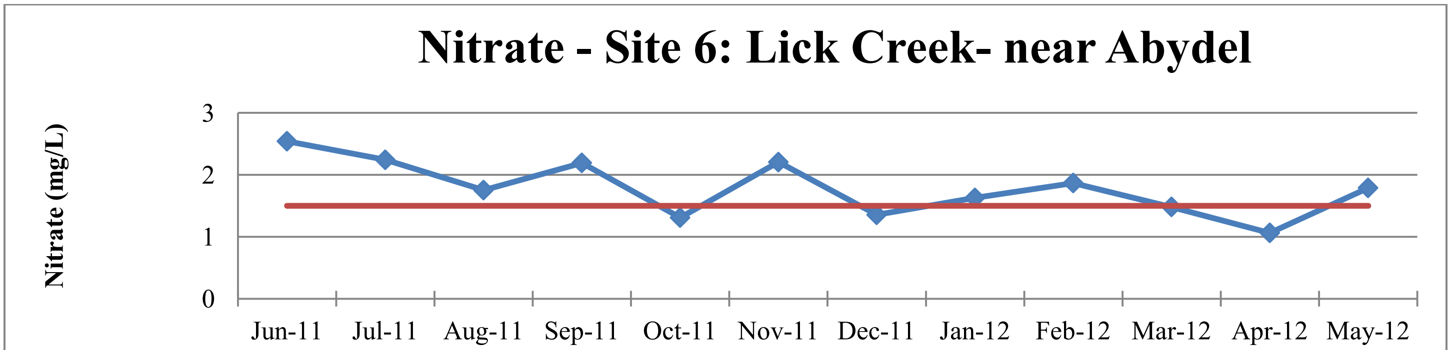
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Conductivity Min	150	150	150	150	150	150	150	150	150	150	150	150
Conductivity	351	394	387	390	514	285.3	118.2	201.4	294.8	266.7	262.9	319
Conductivity Max	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Figure 134: Specific Conductivity Levels at Site 5 (2011-2012 testing period)

Biological samples have only been collected at Site 5 through current sampling efforts. The habitat in Log Creek was determined to be fair with a QHEI score of 50. The macroinvertebrate scores indicate that this section of Log Creek is impaired for aquatic life. The mIBI score at this site was 32 points, which is below the target score of 36 points. This low score is likely due to the lack of quality habitat. Biological samples have not been collected at this site before by IDEM or through either of the LARE diagnostic studies.

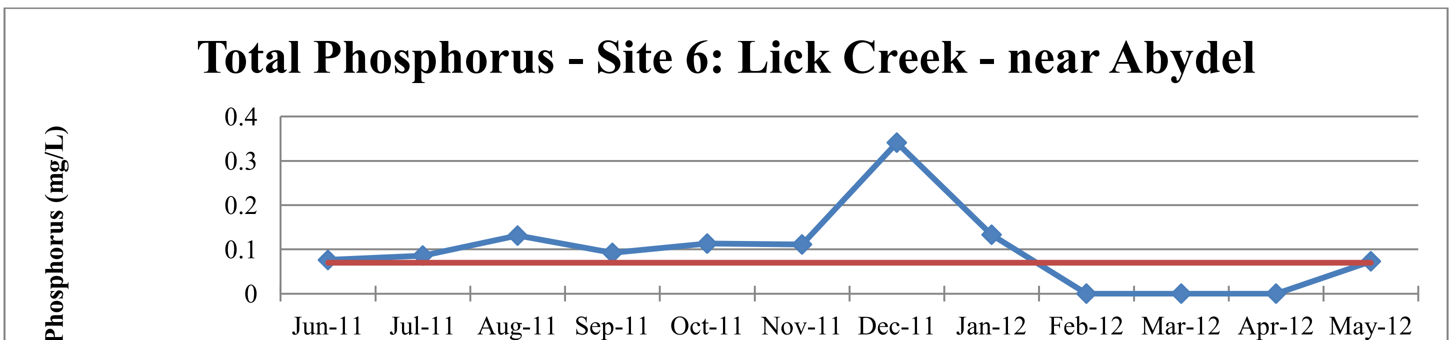
Lick Creek (near Outlet) Monitoring Site 6

The Lab monitored Lick Creek in 2011 just prior to the confluence with Upper Sulphur Creek and Lost River as Site 6. This site represents most of the drainage to Lick Creek (Figure 114). The river showed elevated levels of nitrates in all but four months of sampling (>1.5 mg/L). Nitrates were highest in June of 2011 with 2.541 mg/L (Figure 135). Total Phosphorus was above target levels in all but three months of sampling from February through April 2012. Total Phosphorus spiked in December 2011 with a value of 0.341 mg/L, which is 4.8 times the target value of 0.07 mg/L (Figure 136). Turbidity levels within Lick Creek were higher than target levels in November, December, and January (Figure 137). The highest level was seen in December with 177 NTU. This is over 7 times larger than the target levels of 25 NTU. Similarly, Total suspended solids also had levels above target levels in November, December, and January (Figure 138). The highest TSS level was seen in December with 310 mg/L, which is 12.4 times larger than the target value of 25 mg/L. *E. coli* exceeded target levels (235 MPN/100mL) in every month from June through January then dropped below target levels for the remainder of the sampling period (Figure 139). In November 2011, E. coli levels exceeded lab detection limits of 2419.6 MPN/100mL. Dissolved oxygen, specific conductivity, pH, and salinity were all within acceptable ranges during the 2011-2012 sampling period at this site.



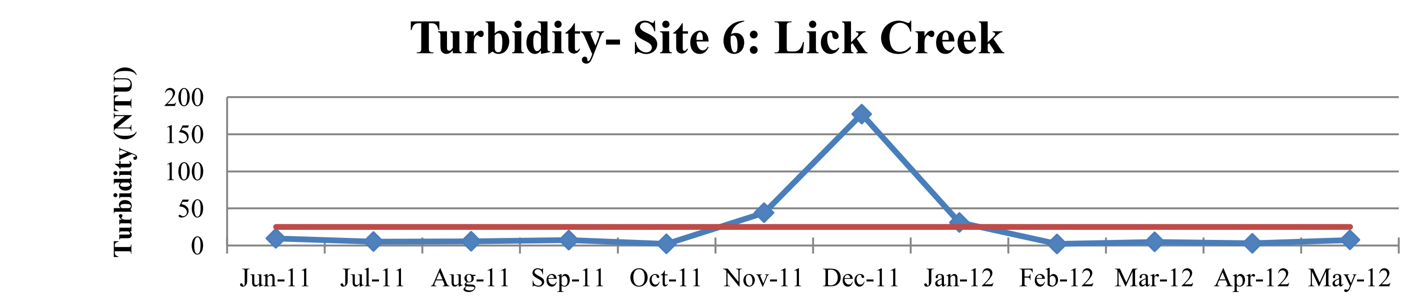
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	2.541	2.241	1.752	2.192	1.308	2.204	1.353	1.626	1.867	1.481	1.062	1.788
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 135: Nitrate Levels at Site 6 (2011-2012 testing period)



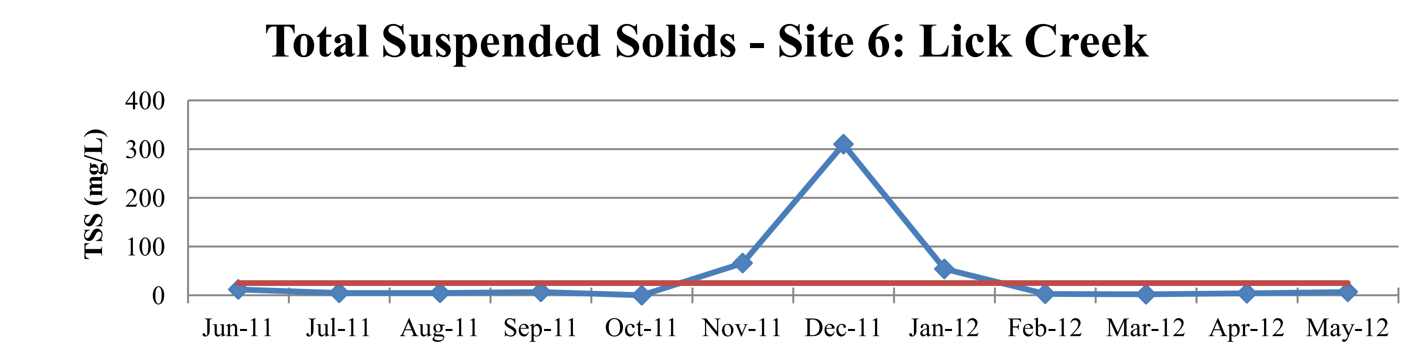
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.076	0.086	0.131	0.092	0.113	0.111	0.341	0.133	0	0	0	0.073
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 136: Total Phosphorus Levels at Site 6 (2011-2012 testing period)



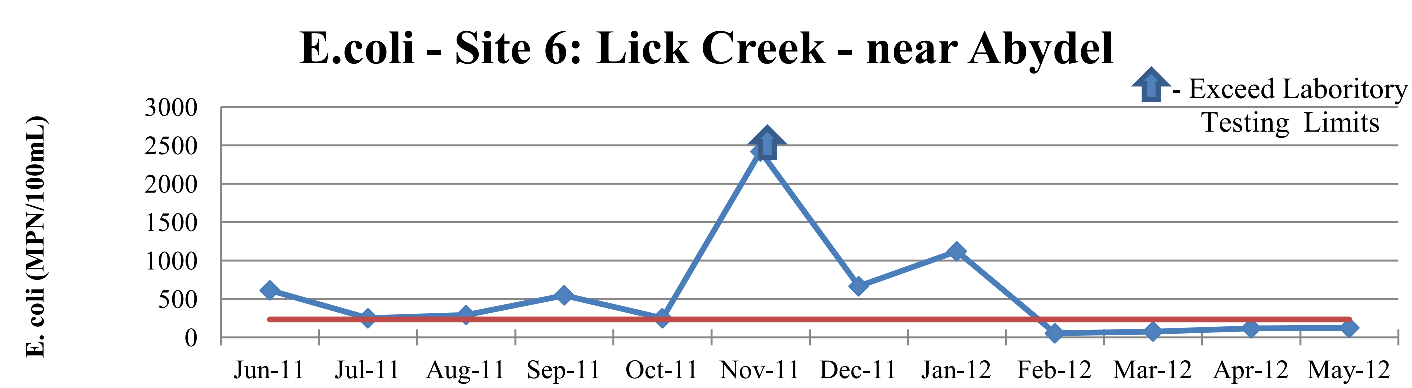
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	9.49	5.22	5.57	7.13	2.09	44.1	177	30.9	1.93	4.84	2.81	7.49
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 137: Turbidity Levels at Site 6 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	12	5	5	7	0	66	310	54	3	2	4	7
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 138: Total Suspended Solids (TSS) Levels at Site 6 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	613.1	248.9	290.9	547.5	248.9	2419.6	665.3	1119.9	52.9	77.1	118.7	123.6
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

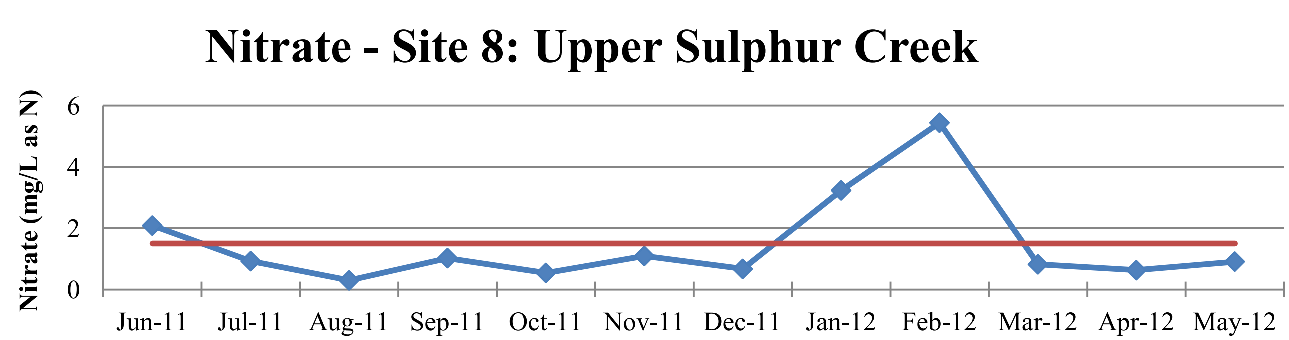
Figure 139: E. coli Levels at Site 6 (2011-2012 testing period)

Biological samples have only been collected at Site 6 through current sampling efforts. The habitat in Lick Creek at this location was determined to be fair with a QHEI score of 52. The macroinvertebrate scores indicate that this section of Lick Creek is impaired for aquatic life. The mIBI score at this site was 32 points, which is below the target score of 36 points. This low score is likely due to the lack of quality habitat. Biological samples have not been collected at this site before by IDEM or through either of the LARE diagnostic studies.

IDEM station WEL160-0001 monitored Lick Creek in the summer of 2002 and in 1997. Nitrates were above target levels in 1997 with 3 out of the 6 samples above our target levels of 1.5 mg/L. Total Phosphorus levels were elevated above our target levels in 4 of the 6 samples collected in 1997. Samples of nitrate, phosphorus, or Total Suspended Solid were not collected in 2002. Total Suspended Solids were above target levels twice in 1997. One time levels reached 650 mg/L, or 26 times our target value of 25mg/L. Turbidity measurements were taken in 1997 and 2002. Turbidity only exceeded our target levels of 25 NTU twice in the 11 samples collected in those 2 years. However, the large spike in TSS also had a large spike in turbidity (640 NTU). Levels of *E. coli* were elevated above the target value in two of the three samples (461.1 & 410.6 MPN/100mL) in 2002 and once (1444 CFU/100mL) in 1997. Lick Creek is considered impaired and on the 303(d) list due to the elevated levels of *E.coli* found during this sampling period (Figure 113). Levels at other stations were much higher indicating that other streams sections will likely find their way onto the impaired list in the future.

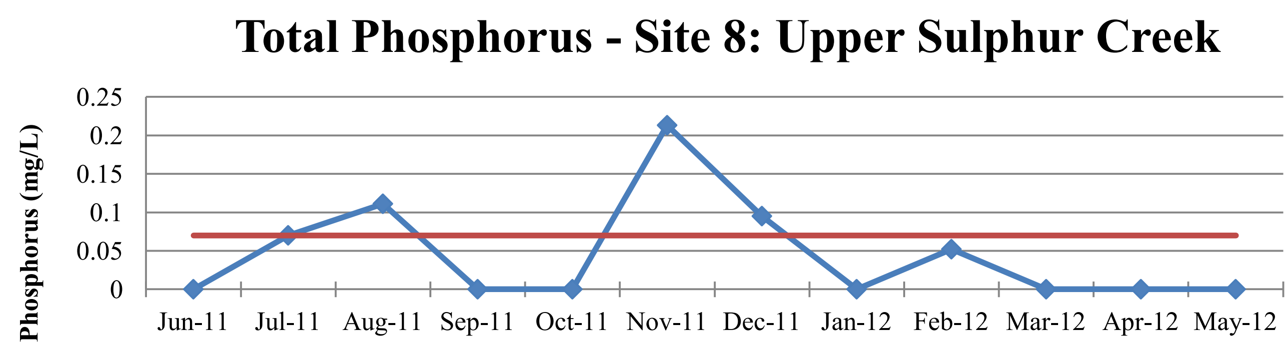
Upper Sulphur Creek Monitoring Site 8

The Lab monitored Upper Sulphur Creek (Site 8) monthly in the 2011-2012 sampling study. This site is influenced by drainage of land contributing to Upper Sulphur Creek (Figure 114). Nitrate concentration exceeded target levels three times during the 12 month sampling period (Figure 140). Nitrates spiked in February 2012 with a value of 5.44 mg/L, which is 3.6 times the desired amount of 1.5 mg/L. Total phosphorus levels were elevated above target levels of 0.07 mg/L three times during the 2011-2012 sampling year in August, November, and December (Figure 141). Total Phosphorus, turbidity, and total suspended solids (TSS) had similar shapes to their graphs (Figures 141, 142, & 143). There were three months August, November, and December when TSS and turbidity, along with the total phosphorus exceeded target levels. Turbidity spiked in November with 47.4 NTU, which is almost double the target levels of 25 NTU. Likewise, TSS spiked in November with 96 mg/L, which is almost 4 times the target value of 25 mg/L. *E.coli* exceeded target values (235 MPN/100mL) four times with a spike in November that exceeded the Lab detection limits (Figure 144). Dissolved oxygen, specific conductivity, pH, and salinity were all within acceptable ranges during the 2011-2012 sampling period at this site.



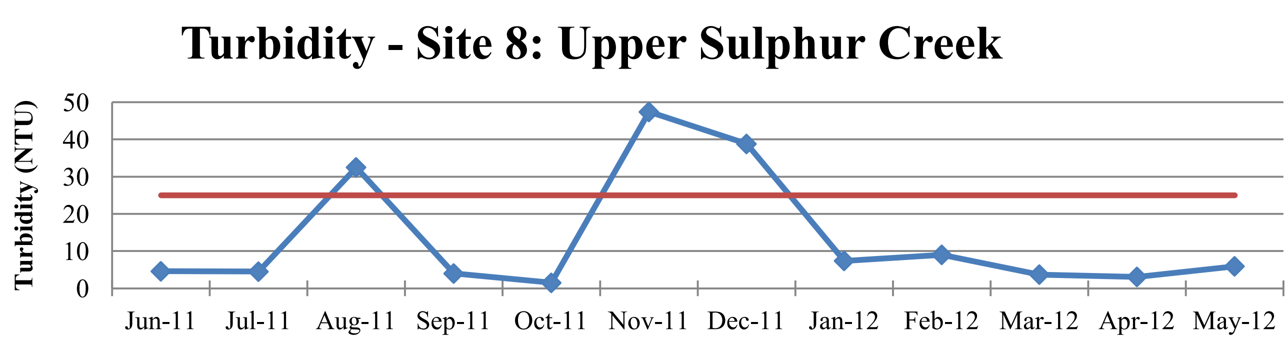
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	2.082	0.924	0.294	1.023	0.539	1.093	0.669	3.232	5.44	0.82	0.628	0.908
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 140: Nitrate Levels at Site 8 (2011-2012 testing period)



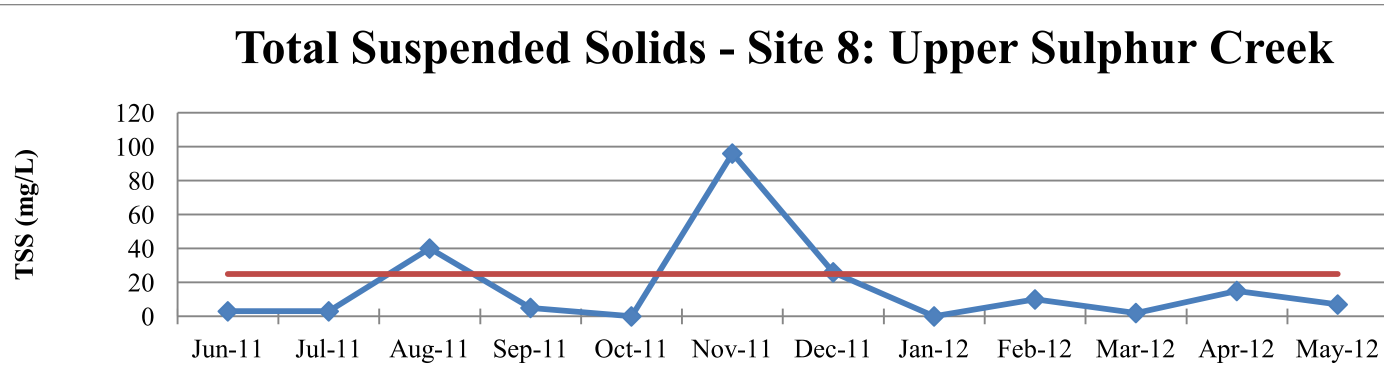
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0	0.07	0.111	0	0	0.213	0.095	0	0.052	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 141: Total Phosphorus Levels at Site 8 (2011-2012 testing period)



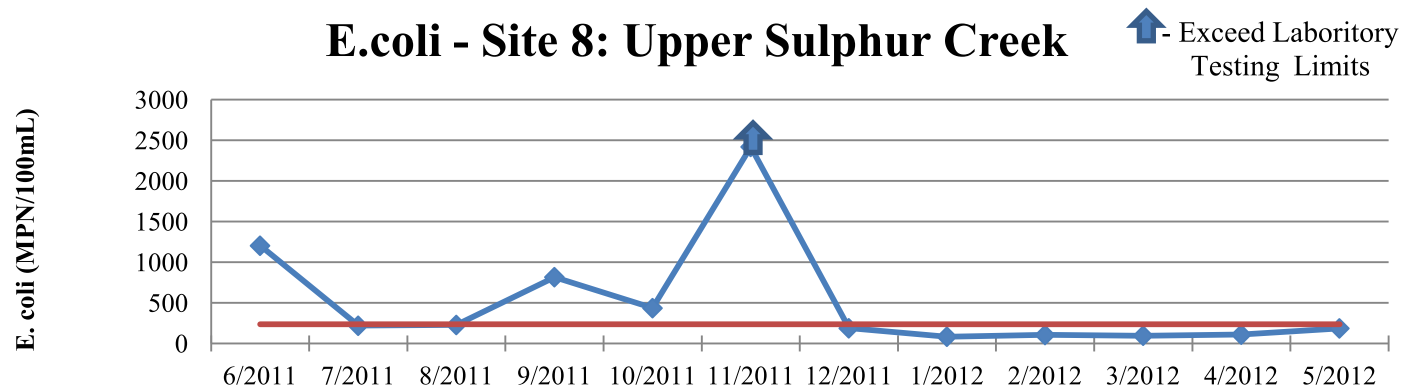
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	4.57	4.48	32.5	3.98	1.47	47.4	38.8	7.37	9	3.69	3.07	5.91
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 142: Turbidity Levels at Site 8 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	3	3	40	5	0	96	26	0	10	2	15	7
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 143: Total Suspended Solids (TSS) Levels at Site 8 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	1203.3	218.7	228.2	816.4	435.2	2419.6	187.3	83.6	104.3	96	108.6	186
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 144: E. coli Levels at Site 8 (2011-2012 testing period)

Biological samples have only been collected at Site 8 through current sampling efforts. The habitat in Lick Creek at this location was determined to be poor with a QHEI score of 29. This site had the worst habitat within the watershed. The macroinvertebrate scores indicate that this section of Lick Creek is also impaired for aquatic life. The mIBI score at this site was 30 points, which is below the target score of 36 points. This low score is likely due to the poor habitat quality, which may be a symptom of over siltation and channel modification that have occurred at this site. Biological samples have not been collected at this site before by IDEM or through either of the LARE diagnostic studies.

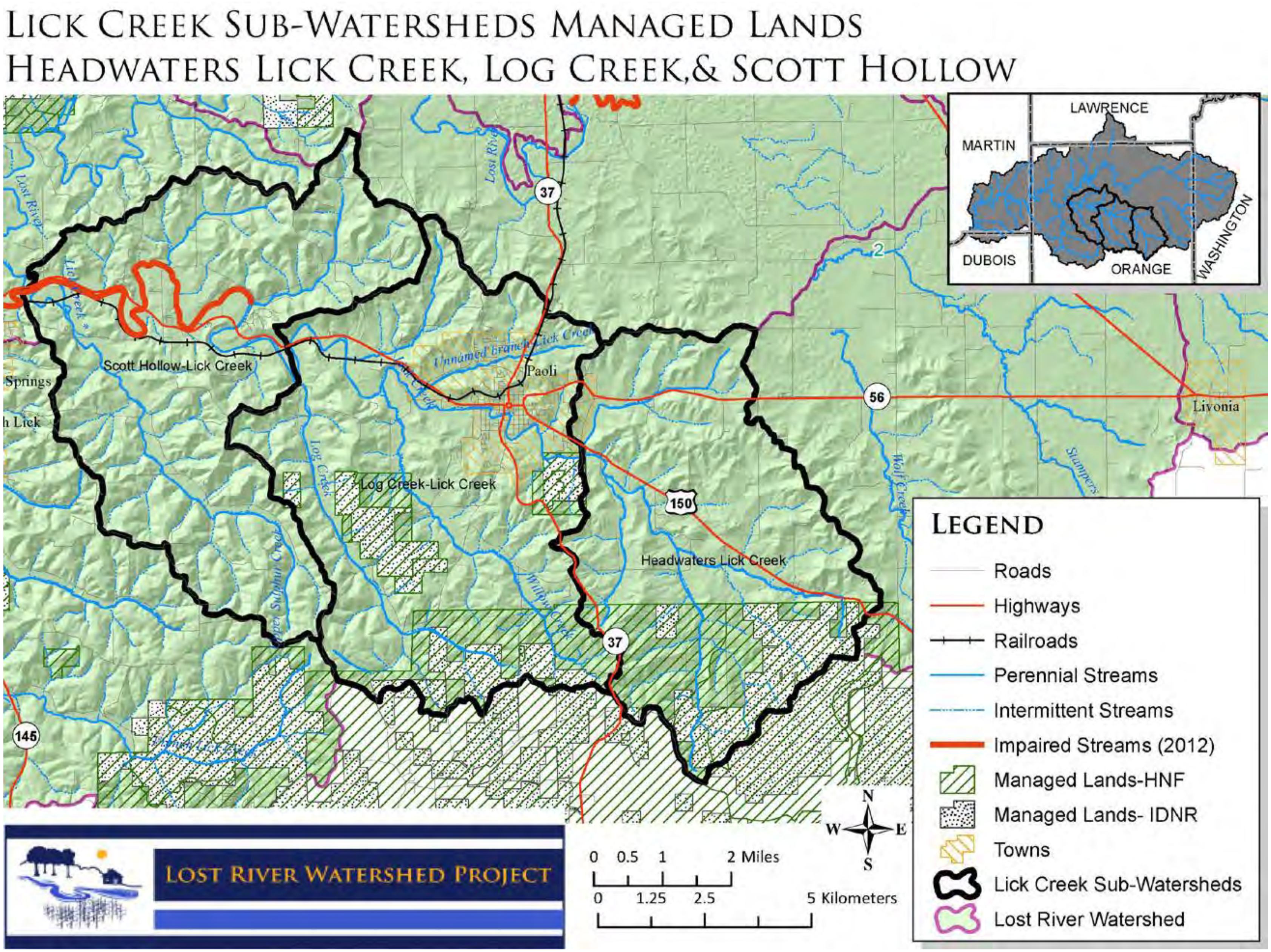


Figure 145: Lick Creek Area- Locations of managed areas and impaired streams.

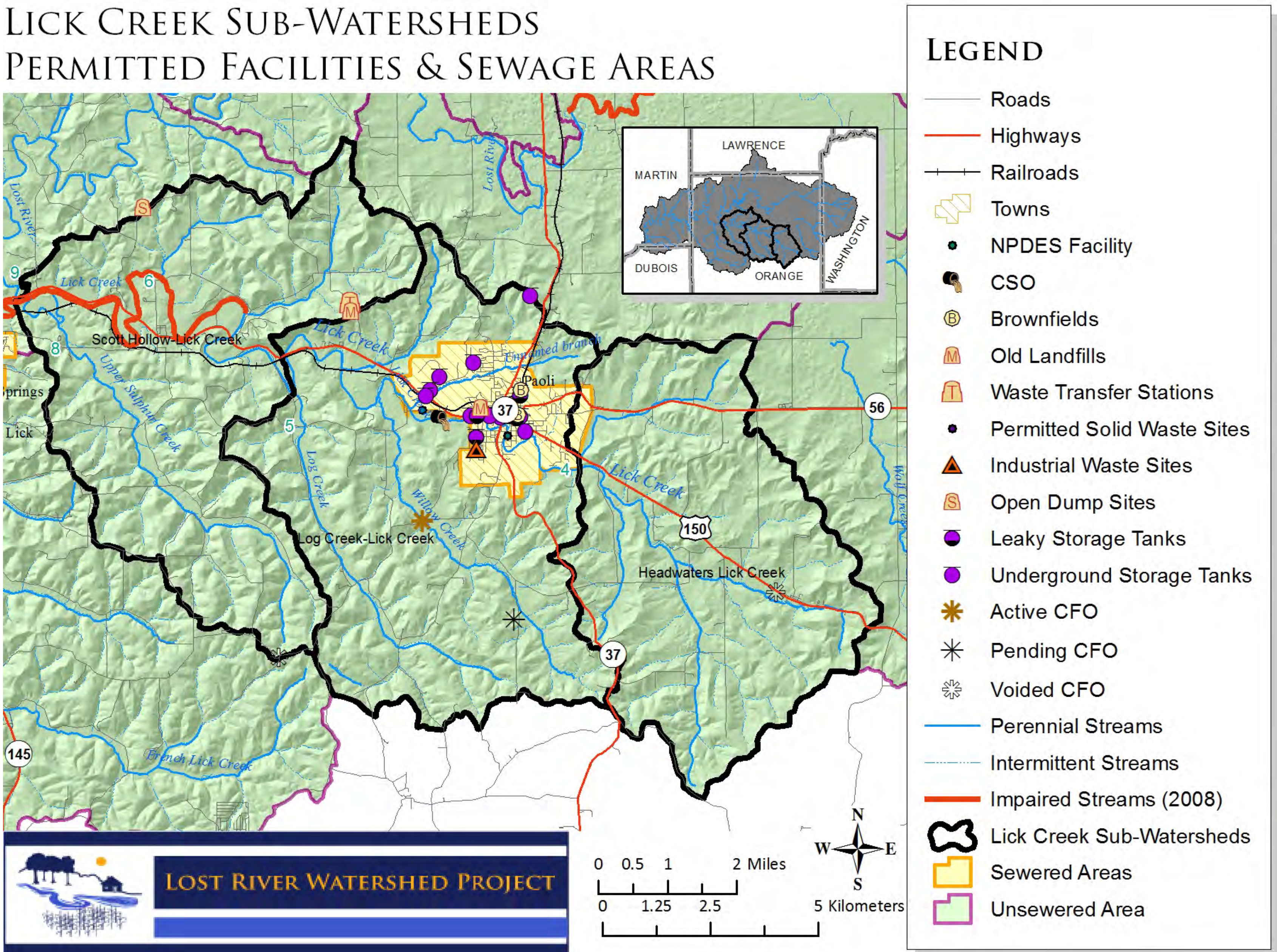


Figure 146: Lick Creek Area- Location of Permitted facilities and extent of sewer system and unsewered areas

Permitted Facilities

The Lick Creek Region contains most of the permitted facilities in the watershed. The majority of these facilities are within the Paoli Town boundaries. The exceptions are an old landfill that is now the site of a waste transfer station, and an old dump site. Both are within the Scott Hollow-Lick Creek subwatershed (Figure 146). One underground storage tank is located outside the Paoli town boundaries at the Paoli Airport. Four Confined Feed Operations (CFOs) are within the region. However, two have been voided since 2000, one has been pending for many years, leaving only one active CFO facility in the area. The remaining facilities lie within the town boundaries of Paoli (Figure 147). The permitted CFO facility is not operating and is likely also voided, however current records do not reflect this.

Within the town boundaries of Paoli lie three Brownfield sites, one industrial waste site, and an old landfill. There are 18 underground storage tanks of those eight are leaky underground storage tanks. There are two NPDES facilities within the Paoli town boundary, the Paoli Water Treatment Plant and the Paoli Municipal Wastewater Treatment Plant (WWTP). However, the Paoli Municipal Water Works is no longer in operation since water from Lake Patoka now serves the municipal drinking water needs of the area. The Paoli WWTP is now the only active NPDES permitted facility in the area. Over the last 12 quarters, the facility has been out of compliance only one quarter for bookkeeping issues. However, it should be noted that two combined sewer system overflows outfall into an agricultural field on the edge of town during rain events over 1 inch. That field is still cultivated, but has been for sale for several years. These outfalls flow through the field and flow into Lick Creek. Recently a riser was installed at this location and subsequent rains have not caused overflows at this location, but overflows are still occurring at the plant itself. There are accounts of residences that still have abandoned septic systems on the property that have not been cleaned or removed since being put on the town sewer system. Some people believe some of these remnant septic systems are still used within town limits and homeowners may not be aware of which system they are connected.

Town of Paoli Point Source Pollution & Sewage
Log Creek/Lick Creek Sub-Watershed

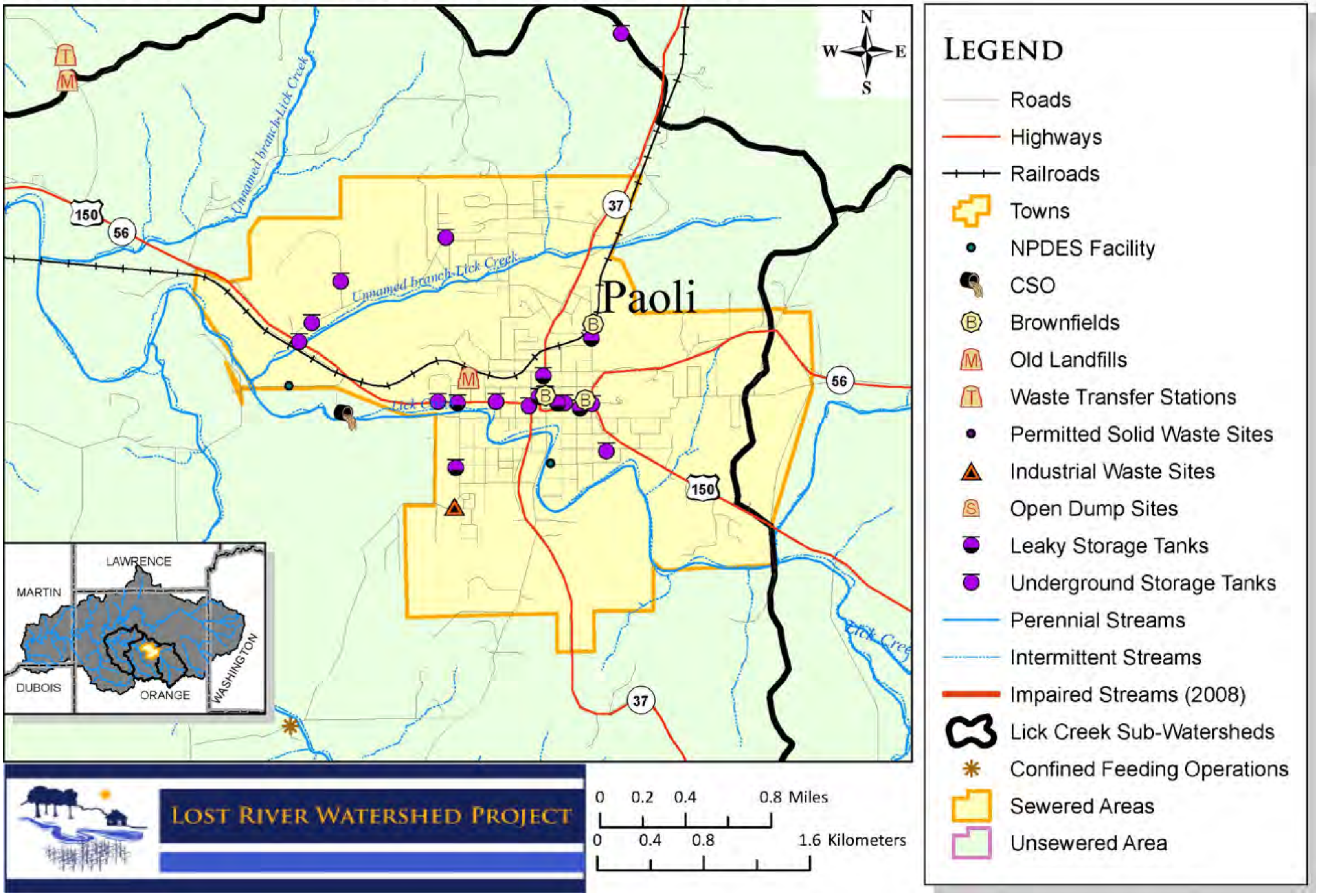


Figure 147: Town of Paoli- Location of Permitted facilities and sewer boundaries

5.5 Sulphur Creek Subwatershed

Sulphur Creek subwatershed is in the northern section of the watershed (Figure 69). Lost River flows through this subwatershed after rising at Orangeville Rise, but before the True Rise of Lost River. Lost River picks up Lick Creek and French Lick Creek within this subwatershed. The three main tributaries of the watershed converge near the community of Prospect. Sulphur Creek and Shirley Creek drain the remaining portions of this subwatershed (Figure 149).

Sulphur Creek flows through heavily forested and steep terrain. Shirley Creek also drains a highly forested portion of the watershed. These creeks cut through the Crawford Upland. Dye tracing has shown that the spring that emerges in Sulphur Creek received surface water from drainage from outside the watershed boundary (Figure 4). Water draining from near Hwy 60 north of the watershed boundary in Lawrence County contributes some of the water to this basin. The steering committee is interested in adding this area to our efforts to address nonpoint source contributions to the waters of Lost River. There are approximately 83.6 miles of stream channels within Sulphur Creek subwatershed. Over half of these are ephemeral or intermittent in nature. There are approximately 32 miles of perennial streams within this subwatershed.

Land Use

The total area of Sulphur Creek subwatershed is 20,871 acres. The majority of landuse in this subwatershed is forested (Figure 148). Forested lands make up 15,363 acres or 73.6% of the subwatershed. Pasture and hay lands makes up 2,117 acres or 10% of the watershed. Crop production occurs on 1,183 acres primarily along stream valleys. The developed area is rural in nature and takes up 827 acres. Developed areas are primarily along county roads and highways that pass through this subwatershed. Open space accounts for 811.6 acres of the developed areas. Pete Dye golf course is partially located within this subwatershed. Shrub land makes up 485 acres and grassland makes up 890 acres. Large sections of this watershed are managed by Hoosier National Forest and DNR (Figure 149).

Most of the pasture and crop lands are within the river valley where the soils are most fertile and the slope is gentle enough for equipment to harvest hay and row crops. Because of this, the areas along the streams and river are in the most need of riparian buffers. Within Sulphur Creek subwatershed, 13.5 miles of stream corridor are in need of riparian buffers representing 319 acres, of this 7.6 miles is perennial in nature. There is a total of 1,779 acres of stream or river corridor.

Windshield Survey

Sulphur Creek subwatershed is one of the harder subwatersheds to conduct windshield surveys due to the topography of the area and lack of roads within the area. There are no places located where livestock had access to stream channels. Livestock and hobby farms are not prevalent in this subwatershed and most agricultural land surrounds the river bottoms of Lost River. Conventional tilled fields are witnessed in this subwatershed at seven fields, likely due to the river bottom nature of the cropped ground. These river bottoms are more susceptible to runoff and contributions of soil, sediment, and nutrients due to their proximity within floodplains. The community of Prospect is within this subwatershed and may have a septic influence due to their location outside of West Baden Spring's town limits. Trash along streams and wetlands were seen at several of the populated areas within this subwatershed.

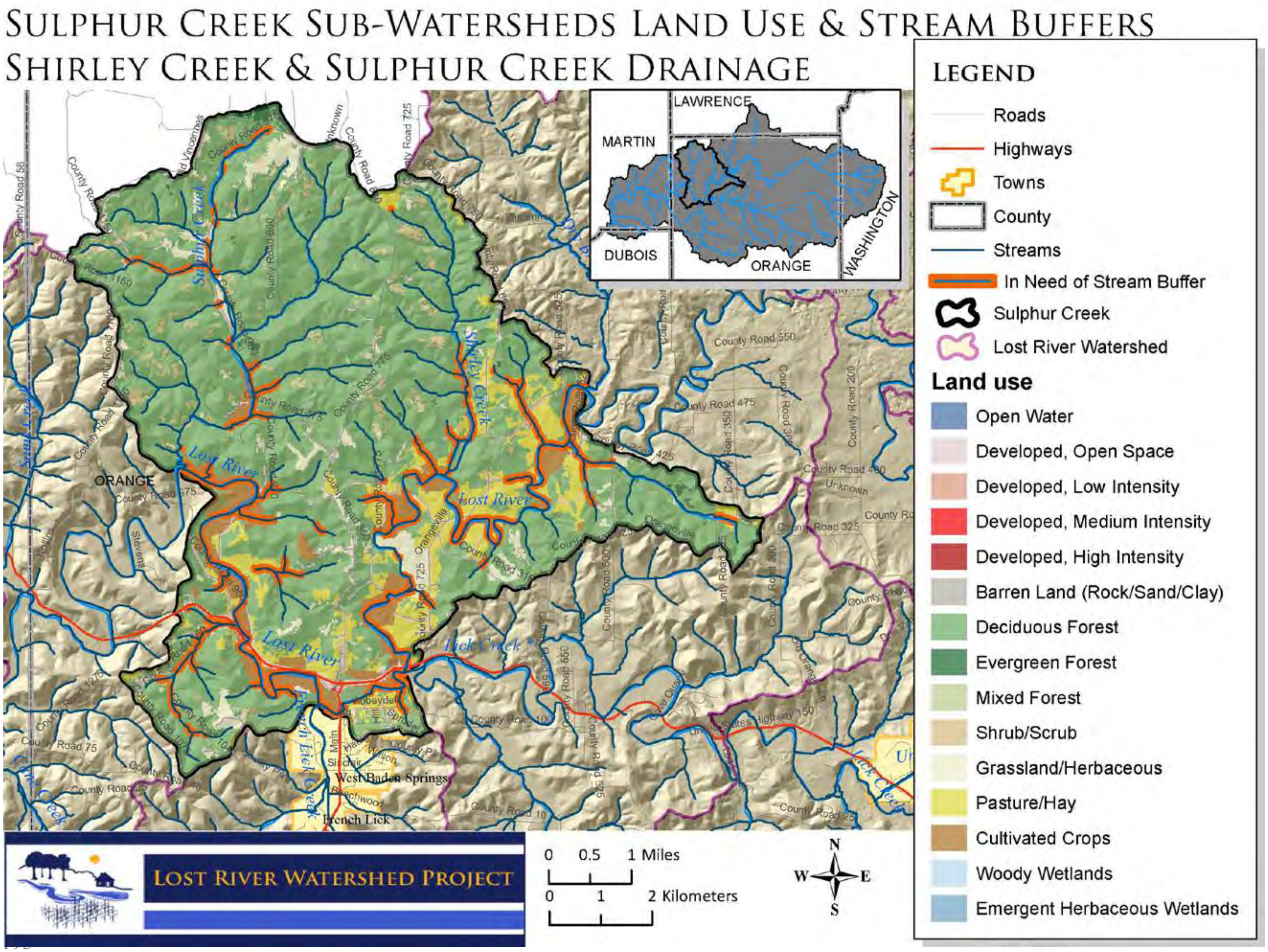


Figure 148: Sulphur Creek Land Use (2006) and areas in need of stream buffers

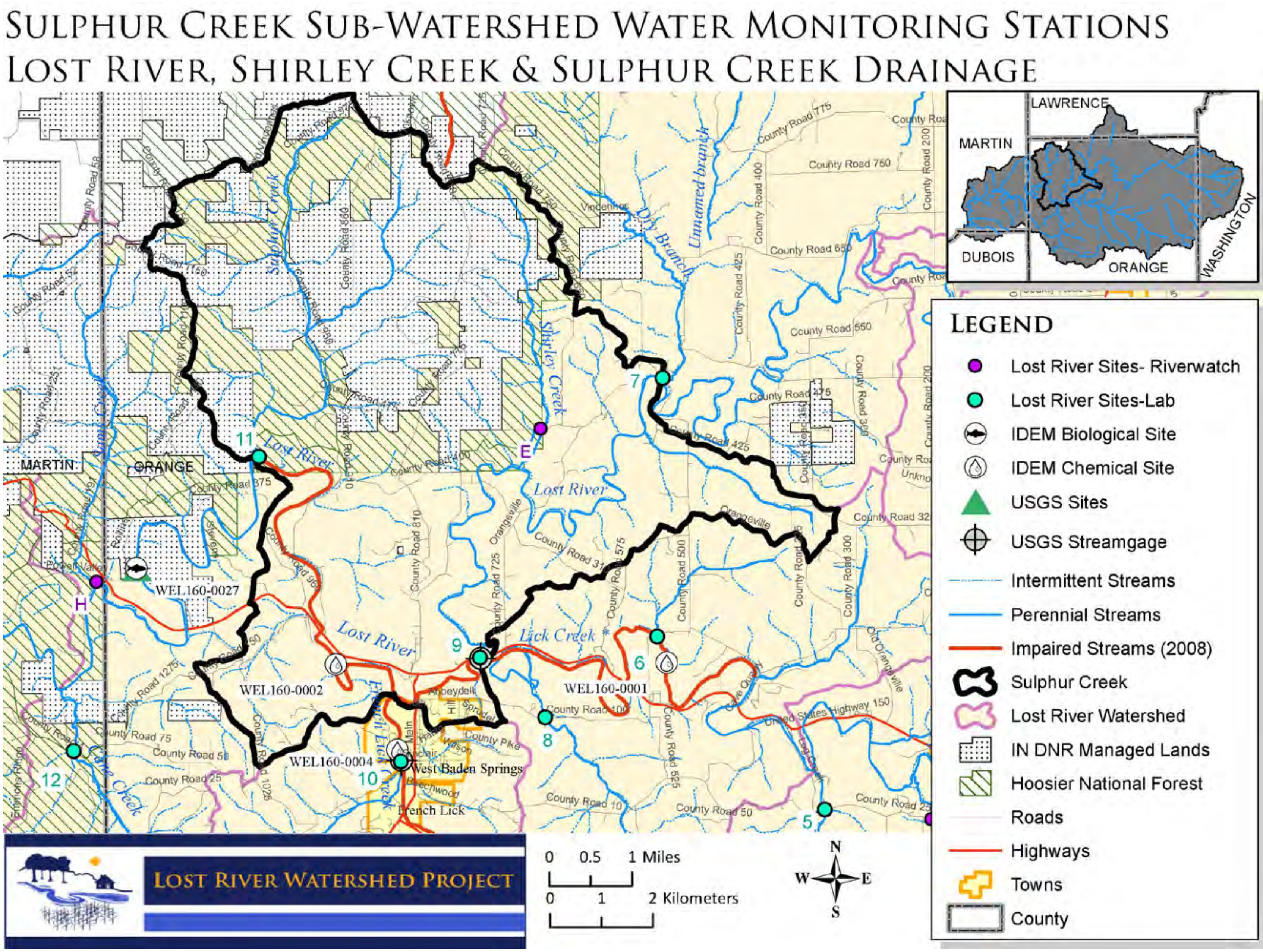


Figure 149: Sulphur Creek- Water monitoring locations (Current and Historical) and location of managed lands

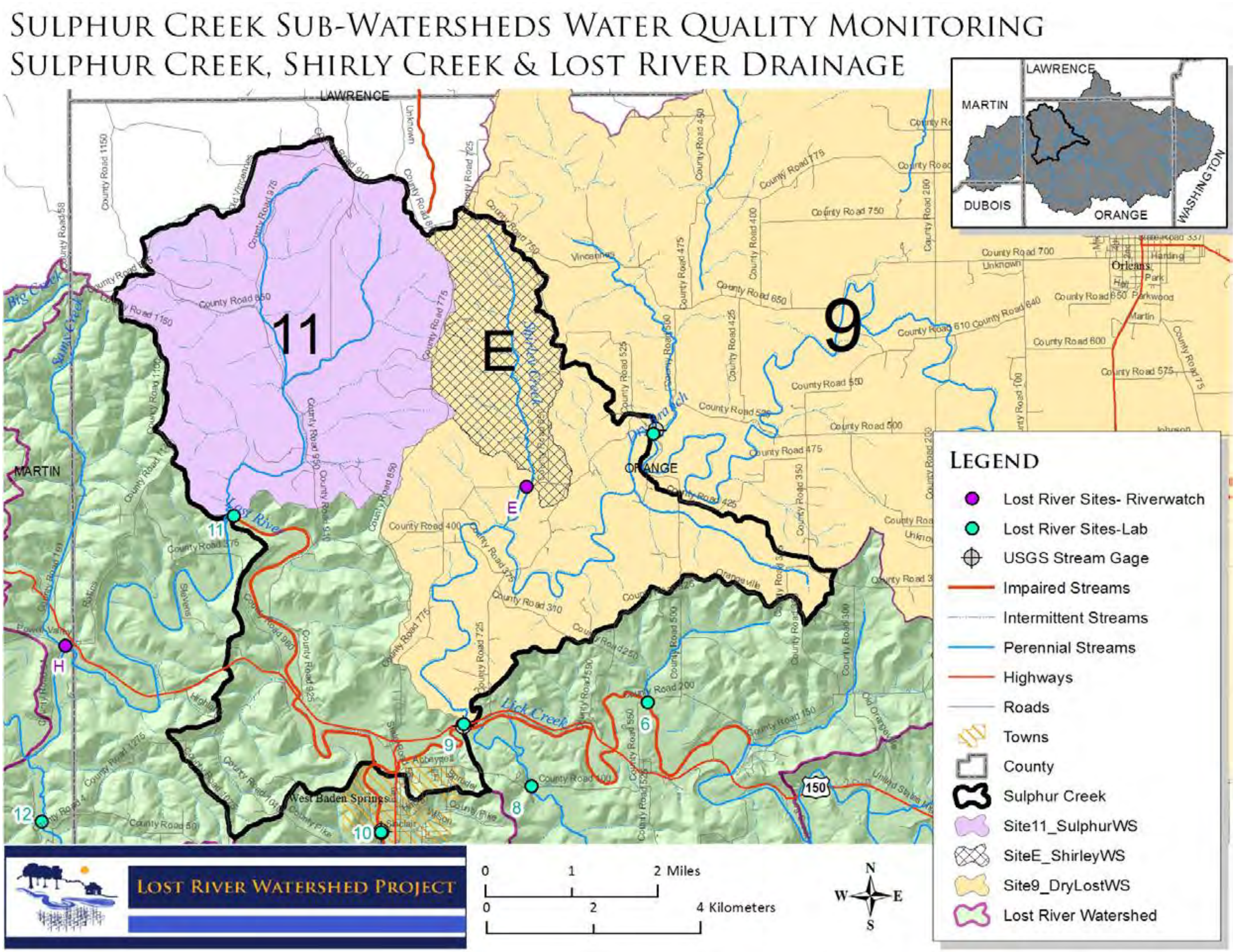
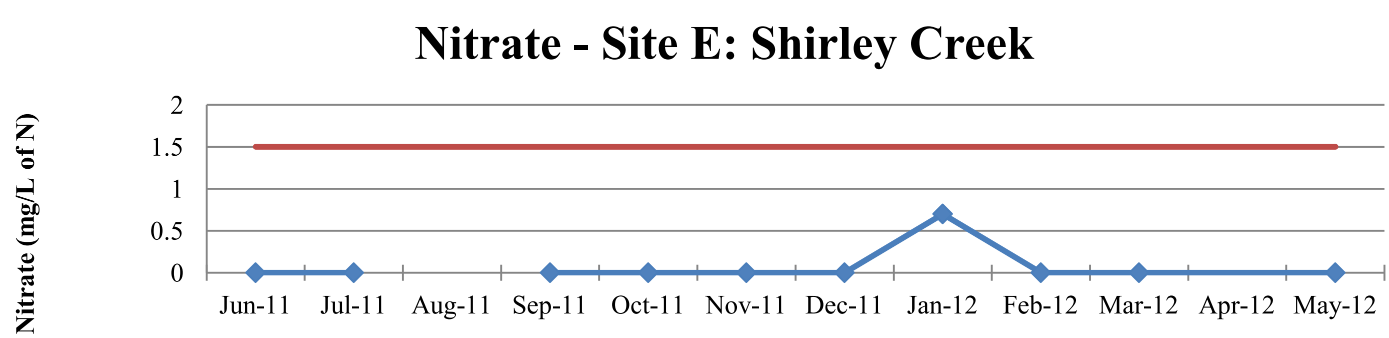


Figure 150: Sample Site subwatersheds for Sulphur Creek Area- based on 2011-2012 sampling period

A total of four locations were monitored for water quality within the Sulphur Creek subwatershed (Figure 149). Current water quality sampling efforts collected water quality data at three locations within the Sulphur Creek subwatershed. They represent the values at Lost River prior to its confluence with Lick Creek (Site 9), Shirley Creek (Site E), and Sulphur Creek (Site 11) (Figure150). Sulphur Creek monitoring station is just prior to its drainage into Lost River. Shirley Creek is also monitored upstream of the wetland that is near the outlet into Lost River. A USGS Streamgage (USGS 03373560) collects stage data and discharge data at the same location as Site 9 (Figure 149).

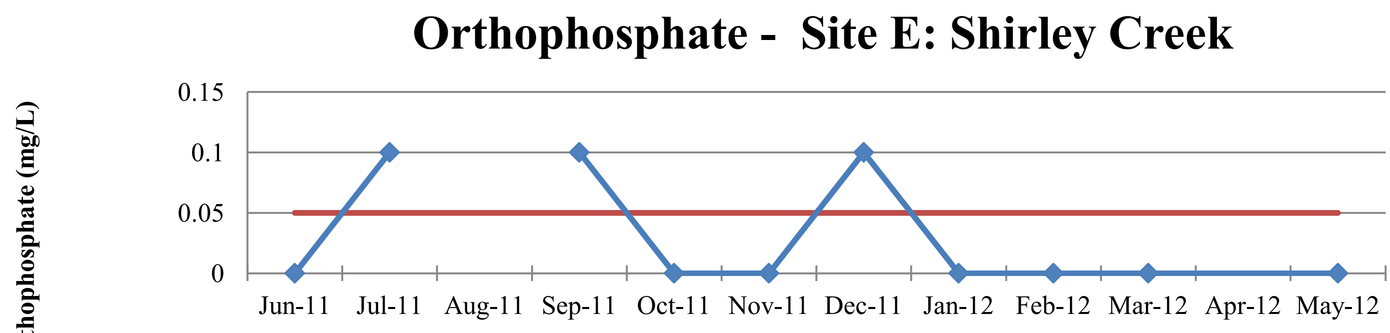
Shirley Creek Monitoring Site E

The Hoosier Riverwatch Lost River Team monitored Shirley Creek (Site E) on a monthly basis during the 2011-2012 sampling period. This sample location represents flow from land that drains to Shirley Creek (Figure 150). In August 2011 there was no flowing water at the site so water samples could not be collected for this month. Nitrate levels were consistently below target levels (Figure 151). The site showed three months where orthophosphate was slightly above target values (0.1 mg/L in July, September, and December 2011) (Figure 152). Dissolved oxygen levels did not go under target levels at this site. However, biochemical oxygen demand did see a spike in September 2011 (Figure 153). Turbidity spiked at the same time with a level double the water quality target (Figure 154). *E. coli* counts were very high in September 2011 with a count of 5200 CFU/100mL which is 22 times the target level (Figure 155). *E.coli* counts in July 2011 reached 266 CFU/100 mL, which is just slightly above target levels of 235 CFU/100mL. Figure 155 also shows high levels of total coliforms in September and November of 2011 along with January 2012. All months monitored had water temperatures and pH values that fell within normal levels and stayed within target values for the sampling period.



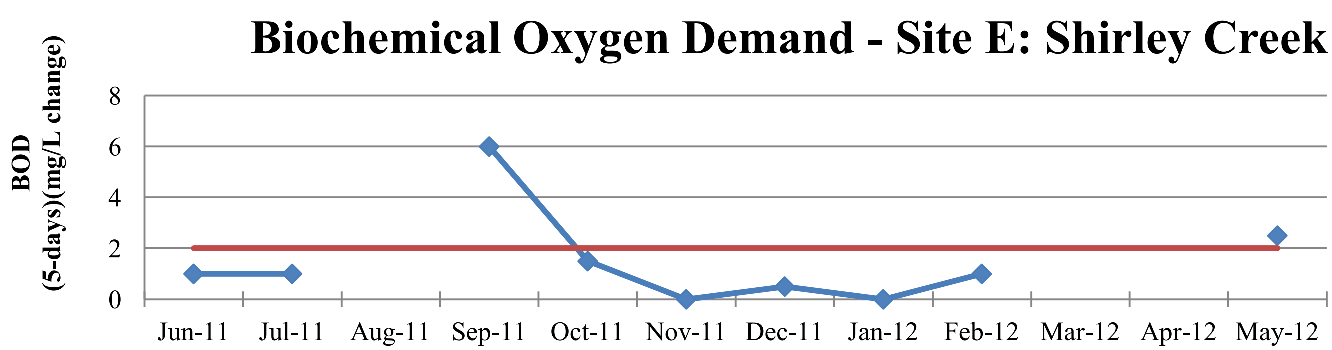
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0		0	0	0	0	0.7	0	0	0

Figure 151: Nitrate Levels at Site E (2011-2012 testing period)



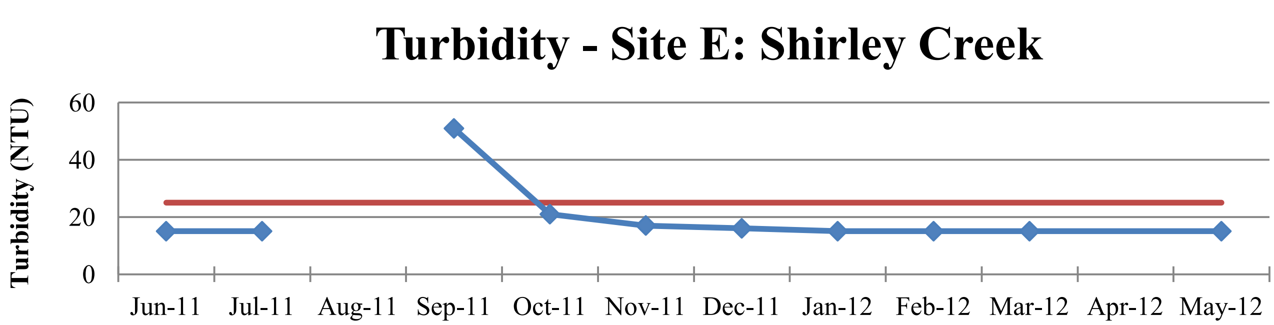
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0	0.1		0.1	0	0	0.1	0	0	0	0

Figure 152: Orthophosphate Levels at Site E (2011-2012 testing period)



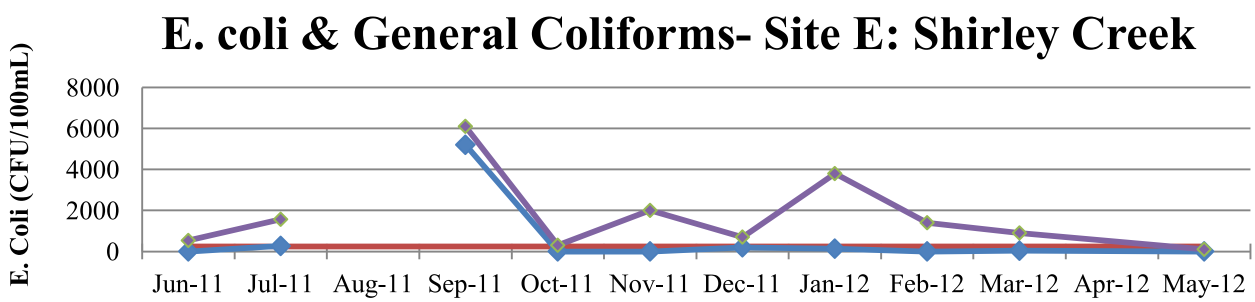
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
BOD5	1	1		6	1.5	0	0.5	0	1		2.5
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 153: Biochemical Oxygen Demand Levels at Site E (2011-2012 testing period)



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	15		51	21	17	16	15	15	15	15

Figure 154: Turbidity Levels at Site E (2011-2012 testing period)



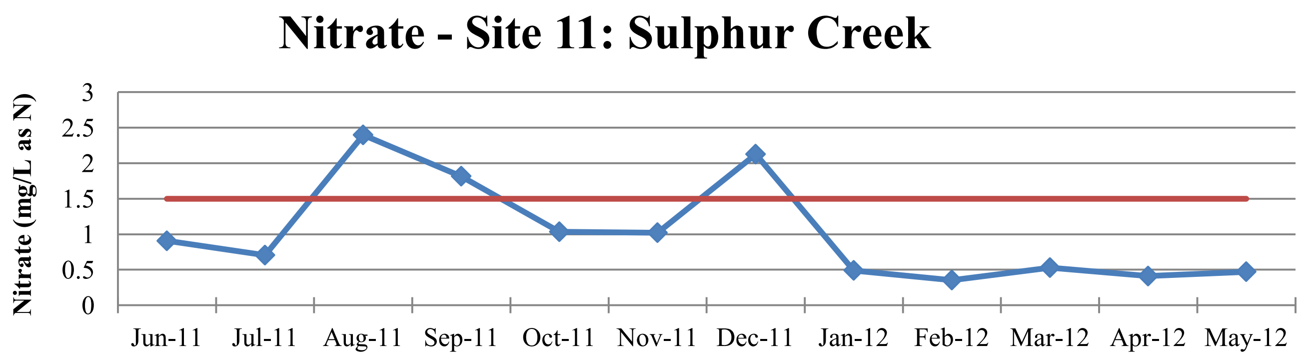
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	0	266.4		5200	0	0	200	133.2	0	33.3	0
General Coliforms	532.8	1565.1		6100	300	2000	700	3796.2	1398.6	899.1	100

Figure 155: E. coli and General Coliform Counts at Site E (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site E. The habitat at Shirley Creek was determined to be poor with a citizens QHEI score of 42. This is due to the fact that the stream is highly silted at this site and normal stream flow is influenced by the culvert. This area previously has been grazed and cattle were allowed in the stream. The site may be improving since previous landuse, but currently it is still in poor condition. The macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The Pollution Tolerance Index score at this site was 11 points. This low score is likely due to the lack of habitat, as opposed to poor water quality. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

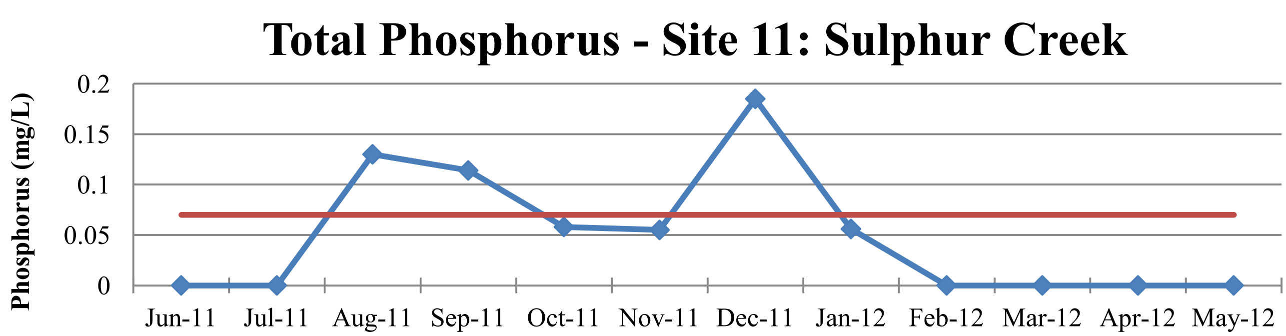
Sulphur Creek Monitoring Site 11

Sulphur Creek drains a large area to the north of Site 11 (Figure 150). This site drains a significant amount of area that is managed by Hoosier National Forest or DNR and landowners (Figure 149). Sulphur Creek (Site 11) showed nitrate levels elevated above target levels in August, September, and December of 2011 (Figure 156). Total phosphorus levels were also elevated above target levels during these same months (Figure 157). Turbidity and Total Suspended Solids exceeded target levels in December of 2011, but remained low the rest of the sampling period (Figure 158 & 159). *E.coli* was slightly above acceptable standards in five months, but in December E.coli counts were elevated so high that they exceeded laboratory testing limits (Figure 160). Dissolved oxygen, specific conductivity, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.



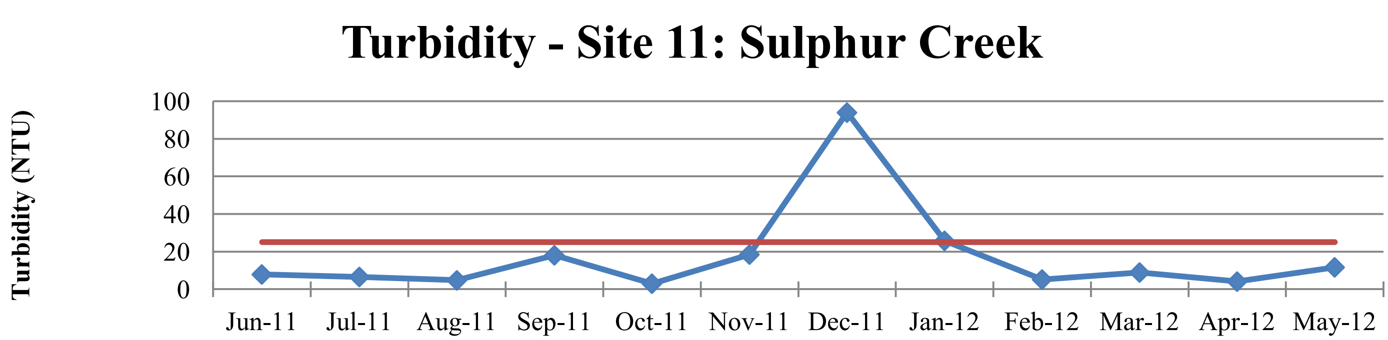
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	0.906	0.705	2.397	1.816	1.034	1.021	2.126	0.49	0.354	0.529	0.41	0.472
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 156: Nitrate Levels at Site 11 (2011-2012 testing period)



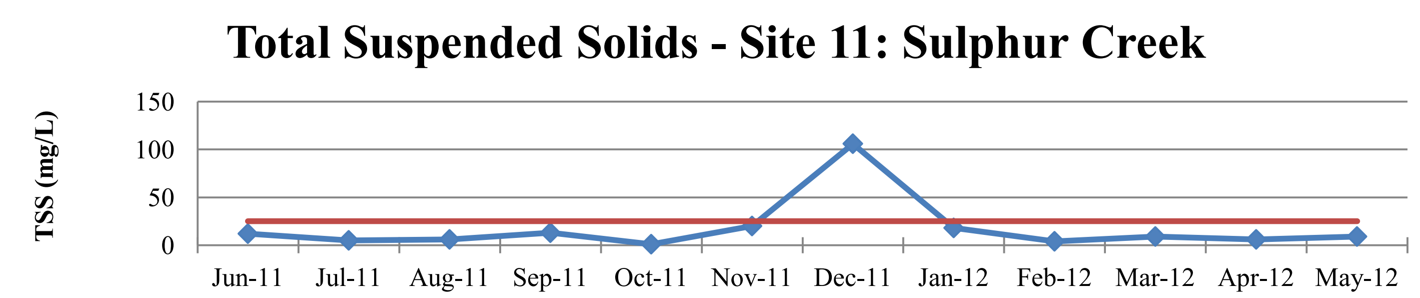
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0	0	0.13	0.114	0.058	0.055	0.185	0.056	0	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 157: Total Phosphorus Levels at Site 11 (2011-2012 testing period)



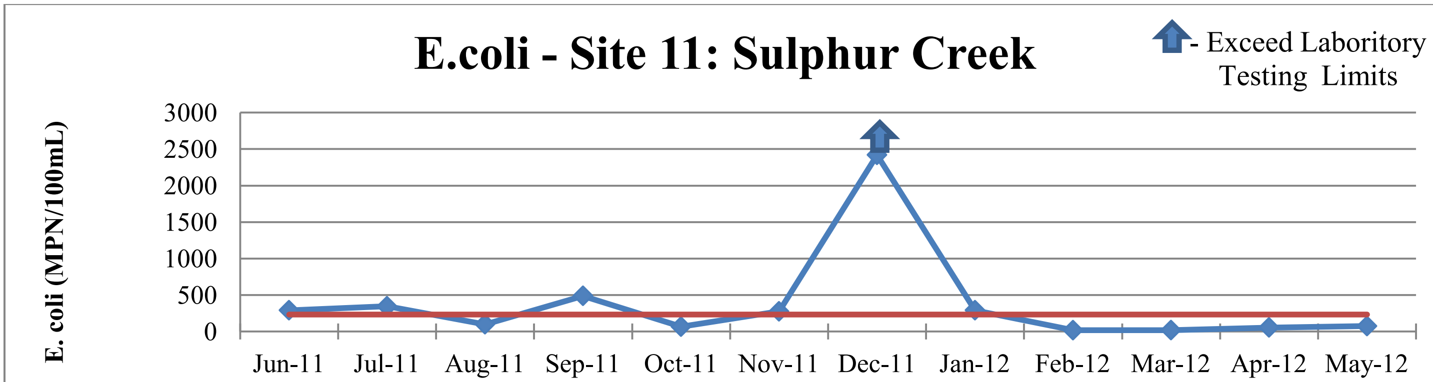
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	7.92	6.59	4.77	18.1	3.02	18.5	94	25.8	5.24	8.95	4.13	11.7
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 158: Turbidity Levels at Site 11 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	12	5	6	13	1	20	106	18	4	9	6	9
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 159: Total Suspended Solids (TSS) Levels at Site 11 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	290.9	344.8	99	488.4	65.7	275.5	2419.6	290.9	17.5	18.5	55.4	73.8
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 160: E. coli Levels at Site 11 (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site 11. The habitat in Sulphur Creek was determined to be poor with a QHEI score of 40. This is because the stream is highly channelized and silted at this site. The macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 34 points which is lower than the target score of 36. This low score is likely due to the lack of habitat. Biological samples have not been collected at this site before by IDEM or through either of the LARE diagnostic studies.

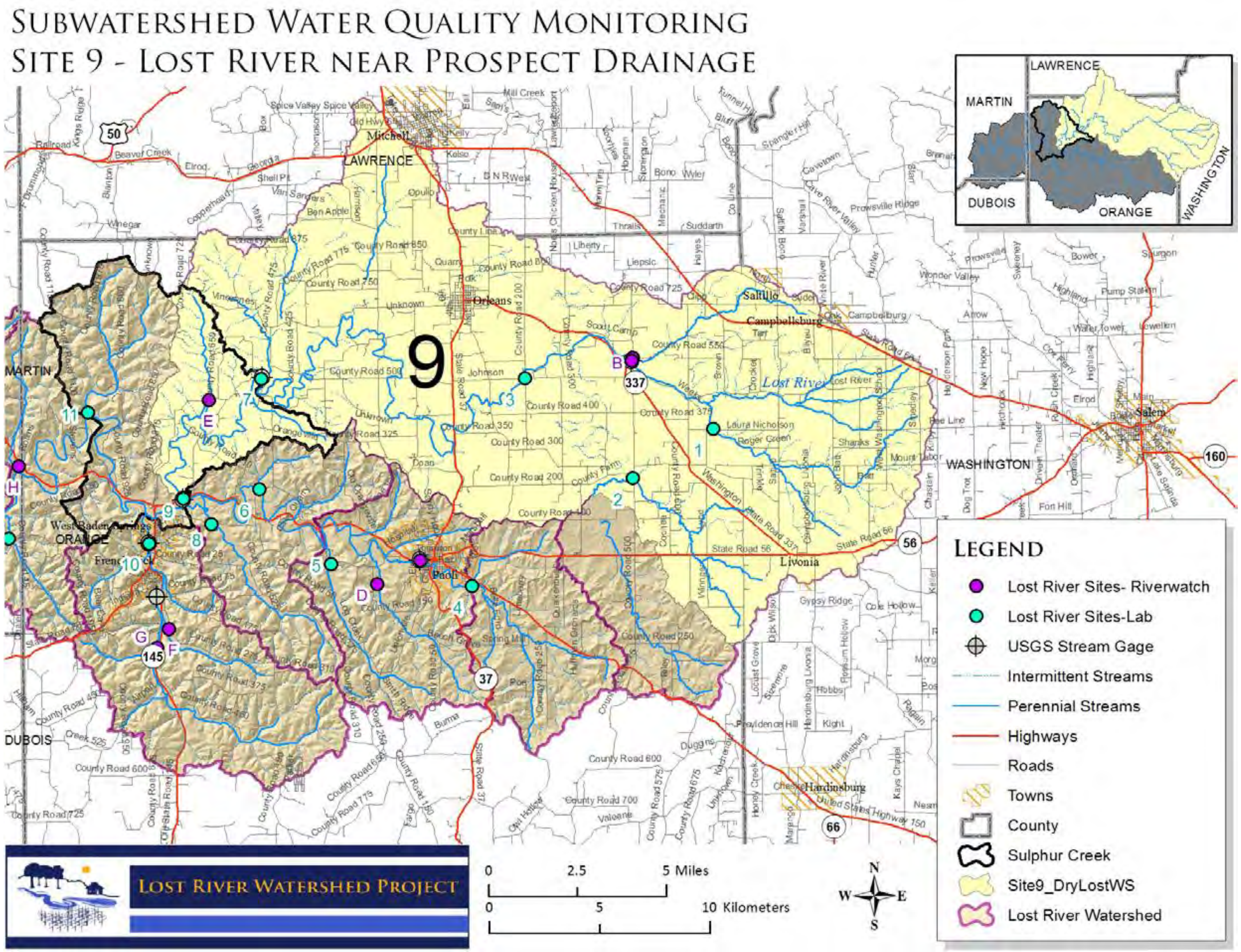
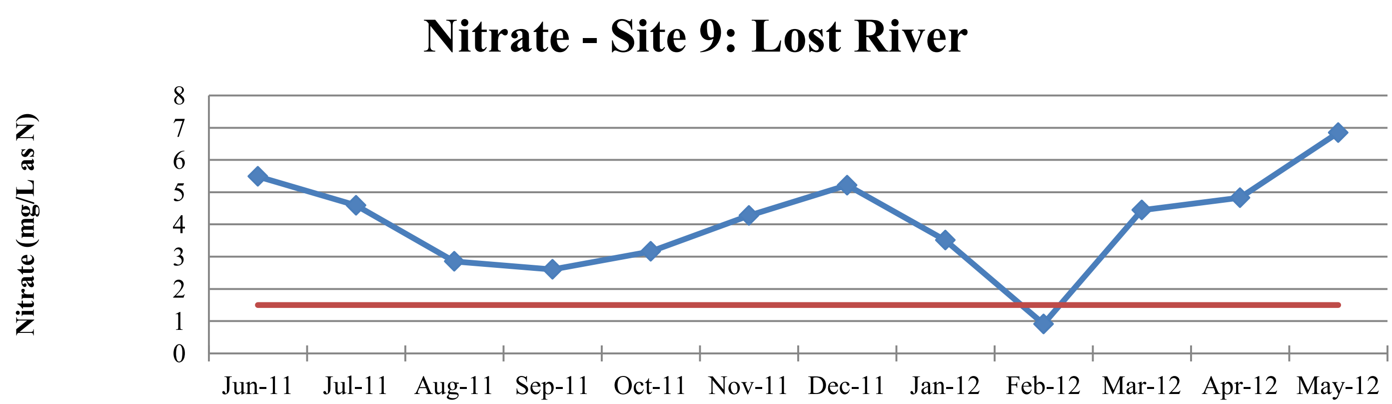


Figure 161: Proximity of Sample Site 9 subwatershed to Sulphur Creek Subwatershed and other sampling locations

Lost River near Prospect Monitoring Site 9

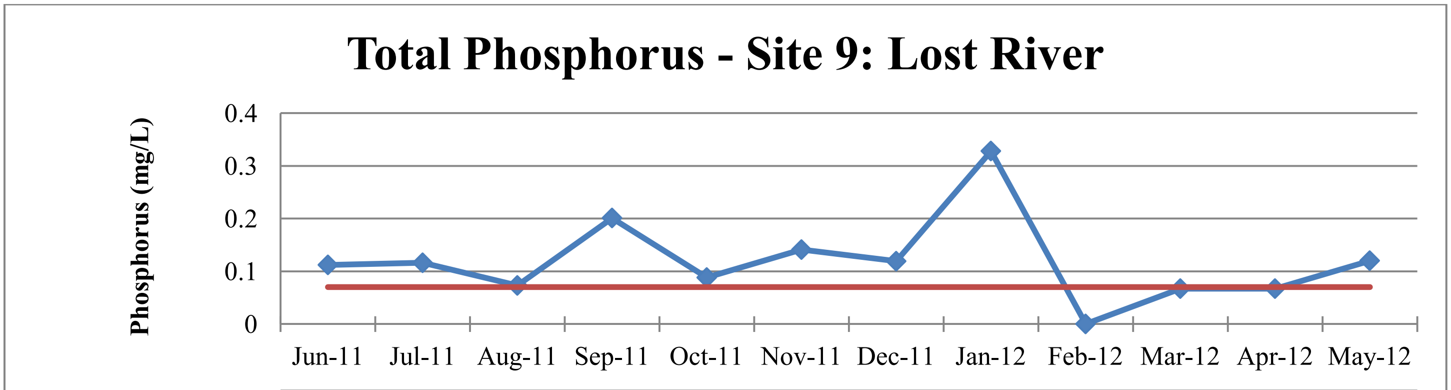
Lost River near Prospect (Site 9) drains all of the Dry Branch Lost River and part of Sulphur Creek subwatershed shown in Figure 161. This site is located just upstream from Lost River's confluence with Lick Creek. A USGS streamgage (USGS 03373560) is located at this sampling location. This gage is used for hydrologic investigations along with gathering data on flow characteristics (Figure 61 & 62). This site showed high levels of nitrates, turbidity, total suspended solids, phosphorus, and *E. coli* in samples collected over the summer months of 2011.

Site 9 showed nitrate levels elevated above target levels in every month except February 2012 (Figure 162). Nitrate levels spiked in May of 2012 with 6.846 mg/L. Total phosphorus levels were also elevated above target levels during most of the same months (Figure 163). Total Phosphorus spiked in January 2012 with 0.328 mg/L, which is over 4 times the target level of 0.07 mg/L. Turbidity and Total Suspended Solids exceeded target levels in January of 2012, but remained low the rest of the sampling period (Figure 164 & 165). *E.coli* was above target levels and Indiana Water Quality Standards of 235 CFU/100 mL 50% of the time. The majority of the samples levels were just somewhat above acceptable standards in five of the months with values ranging from 410.6 -980.4CFU/100mL. However, in January *E.coli* counts were elevated so high that they exceeded laboratory testing limits (Figure 166). Dissolved oxygen, specific conductivity, pH, temperature, and salinity were all within acceptable ranges during the 2011-2012 sampling period.



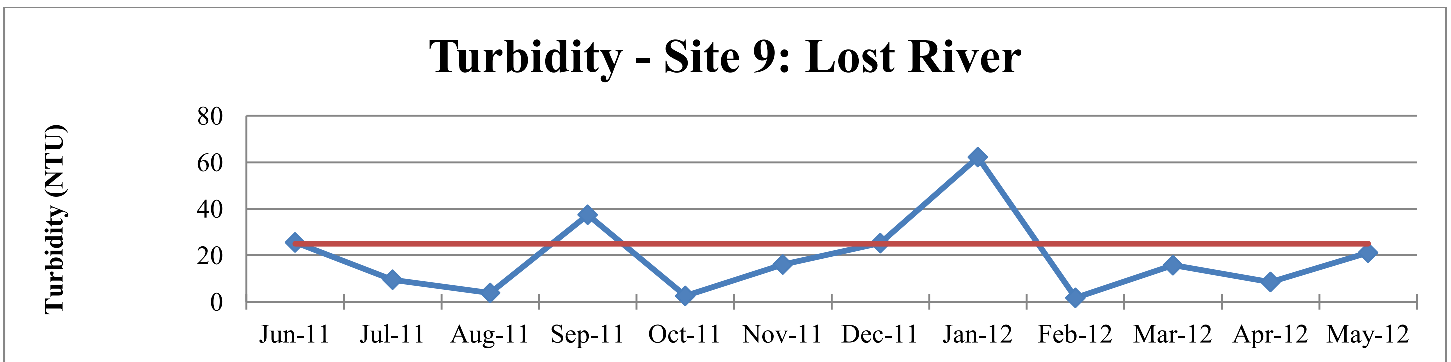
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	5.49	4.59	2.853	2.604	3.163	4.275	5.214	3.512	0.908	4.446	4.826	6.846
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 162: Nitrate Levels at Site 9 (2011-2012 testing period)



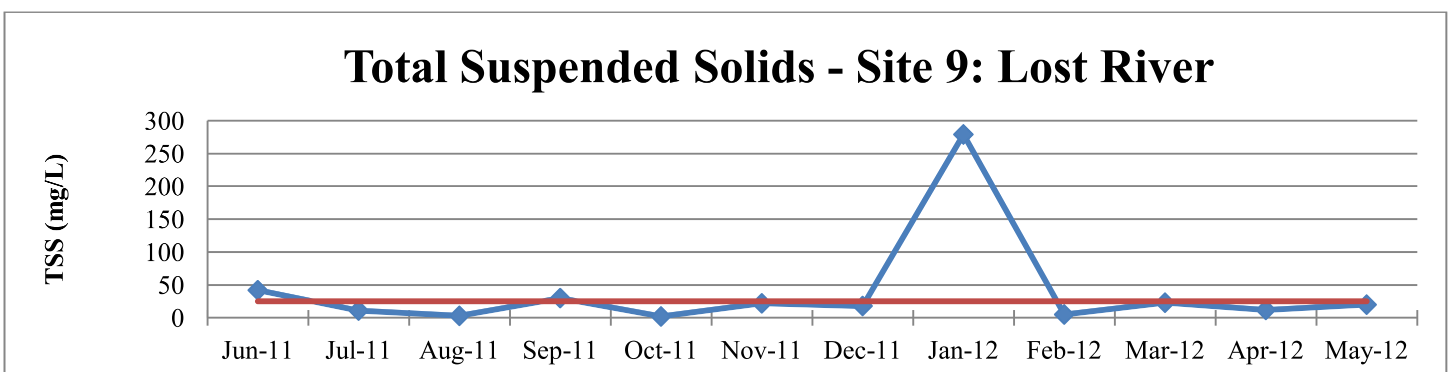
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.112	0.116	0.073	0.201	0.088	0.141	0.119	0.328	0	0.067	0.067	0.12
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 163: Total Phosphorus Levels at Site 9 (2011-2012 testing period)



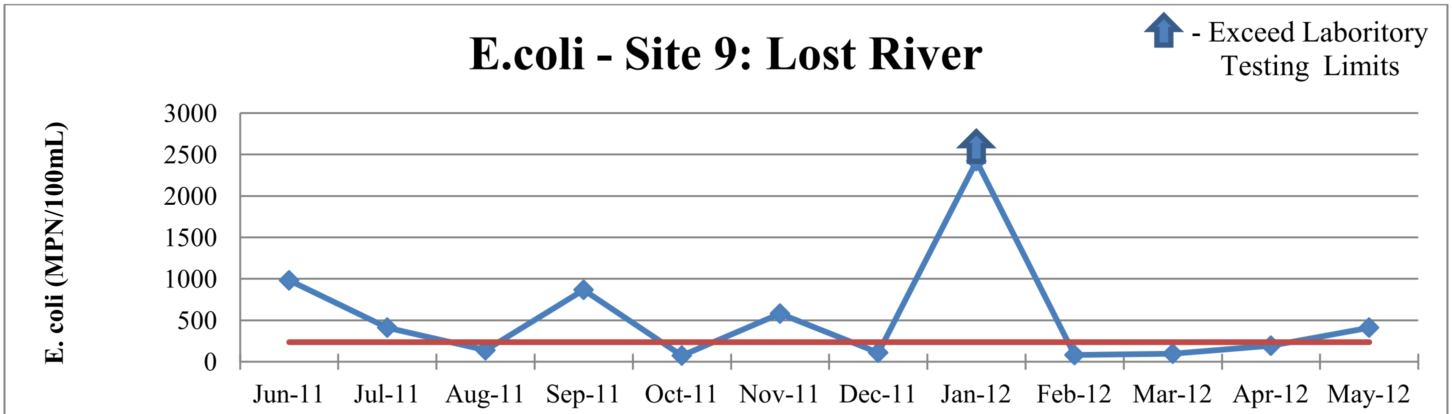
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	25.5	9.48	3.79	37.4	2.51	16	25.2	62.2	1.67	15.7	8.5	21.1
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 164: Turbidity Levels at Site 9 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	42	11	3	30	2	22	18	279	5	23	12	20
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 165: Total Suspended Solid Levels at Site 9 (2011-2012 testing period)



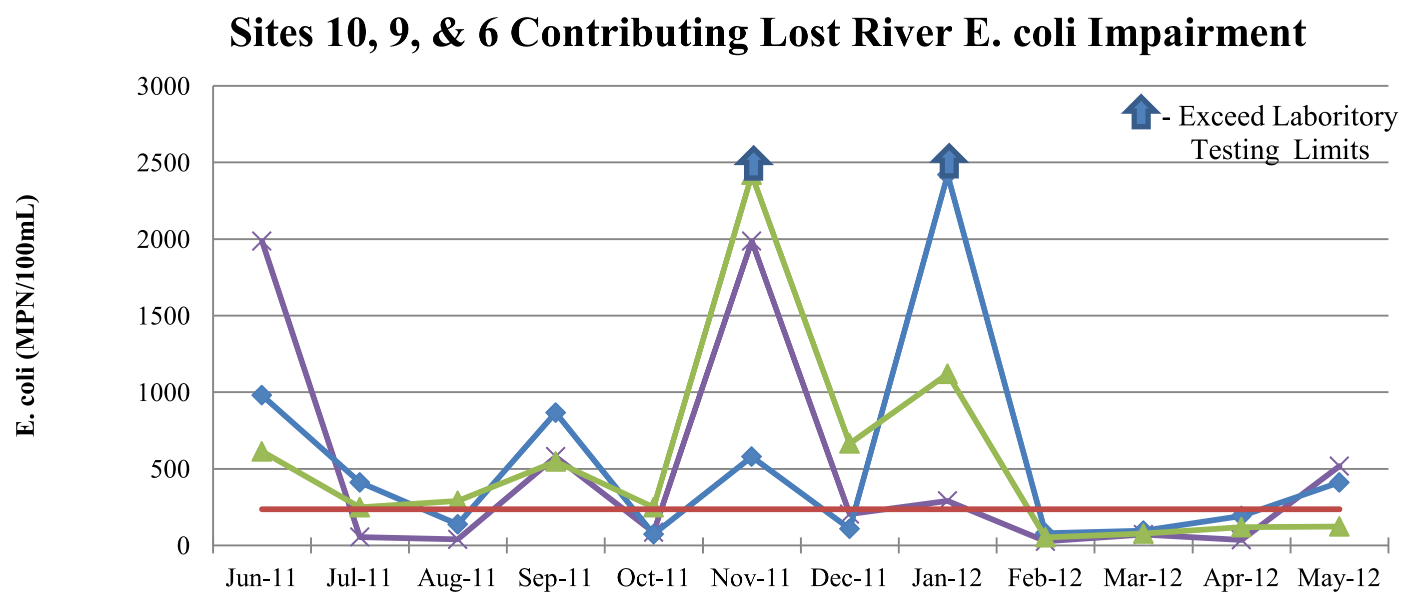
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	980.4	410.6	137.4	866.4	72.7	579.4	108.2	2419.6	79.4	95.9	191.8	410.6
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 166: E. coli Levels at Site 9 (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site 9. The habitat in this section of Lost River was determined to be good with a QHEI score of 62. The macroinvertebrate scores, however, indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 30 points which is lower than the target score of 36. This low score is likely due poor water quality in the river. High amounts of pesticides may influence these scores, and the associated high level of agricultural landuse upstream may be contributing to the poor aquatic life scores.

IDEM monitored Lost River downstream of the confluence of French Lick Creek and Lick Creek with Lost River at site WEL160-0002. Monitoring at this location was conducted in 1997 and 2002. Five out of the eight samples collected over this period, Lost River was above target levels for E. coli. Nitrates were above target levels in every sample collected at this site. During that same period total phosphorus exceeded target levels 5 out of the 6 samples collected. Dissolved oxygen, pH, and specific conductivity fell within allowable target levels for every sample. Temperature was also within allowable limits during sampling at this site. TSS and turbidity exceeded target levels at this site, as well. TSS exceeded target levels in 50% of the samples, and turbidity exceeded targets in 18% of the samples.

Lost River is on the 303 (d) list for *E.coli* within a stretch from Site 9 through the outlet of Lost River in Sulphur Creek Subwatershed. This section of Lost River was not analyzed under current sampling. However, *E. coli* levels at Site 9, Site 6 of Lick Creek, along with Site 10 of French Lick Creek show that E. coli levels do spike very high at times (Figure 167). Comparing values from these three tributaries show that *E. coli* levels exceed targets at least one station every sampling month except in February, March , and April 2012. Site 6 Lick Creek was discussed in Section 5.4 and Site 10 will be discussed further in sections 5.6.



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E. coli Site 10	1986.3	54.5	38.9	579.4	85.7	1986.3	203.7	290.9	26.2	70.6	36.4	517.2
E. coli Site 9	980.4	410.6	137.4	866.4	72.7	579.4	108.2	2419.6	79.4	95.9	191.8	410.6
E. coli Site 6	613.1	248.9	290.9	547.5	248.9	2419.6	665.3	1119.9	52.9	77.1	118.7	123.6
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 167: E.coli counts for site contributing to impairments on Lost River (Site 10 French Lick Creek, Site 9 Lost River near Prospect, and Site 6 Lick Creek near outlet)

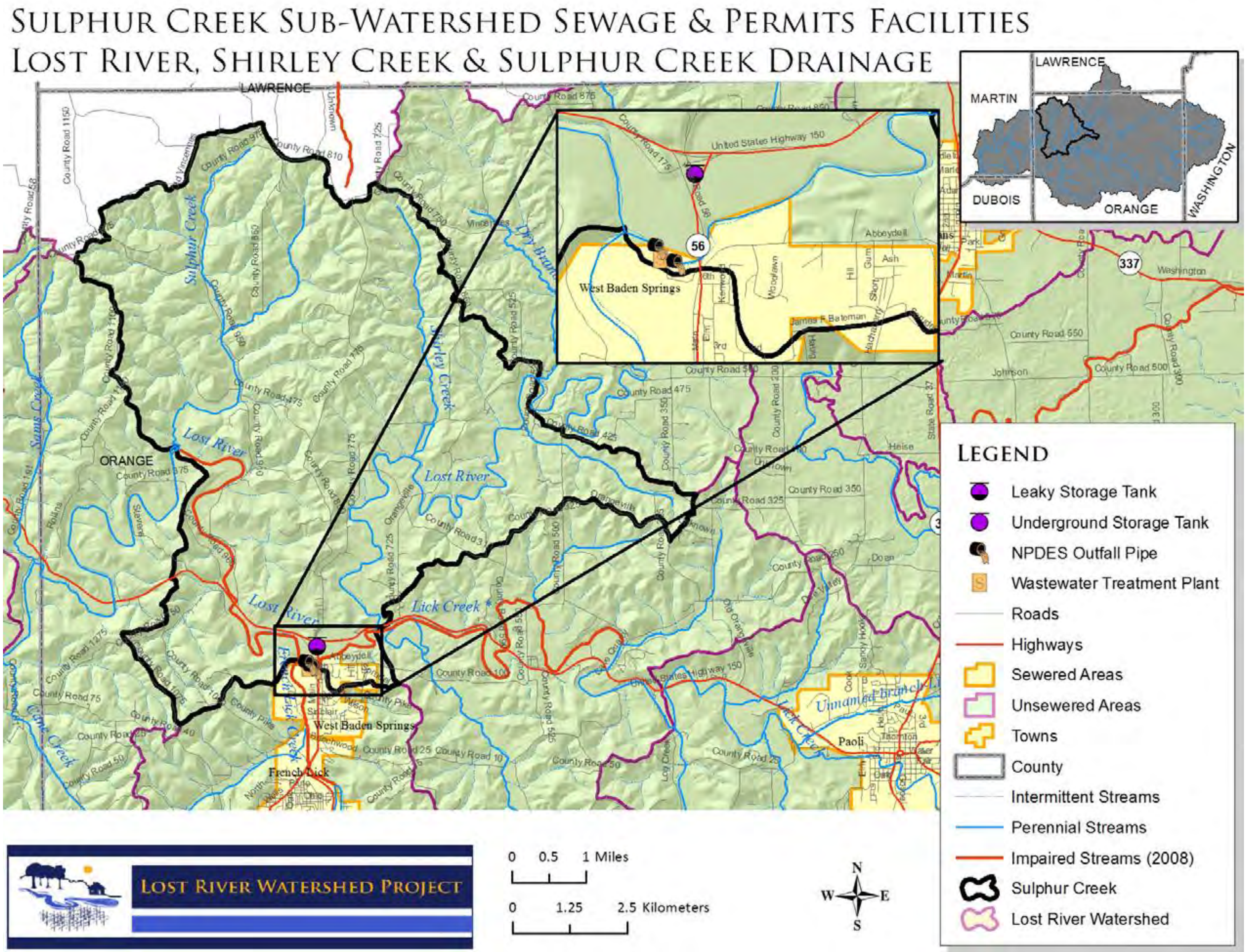


Figure 168- Sulphur Creek Subwatershed: Location of permitted facilities and areas that are currently sewered and unsewered.

Permitted Facilities

Permitted entities are limited to the Prospect and West Baden area within the Sulphur Creek subwatershed (Figure 168). There is only one underground storage tank in the subwatershed and it is leaky. The French Lick Municipal Sewer Treatment Plant and Springs Valley Regional Water District are the only NPDES facilities within the subwatershed. Since the initiation of this project, the Springs Valley Regional Water District facility has been closed and water is now pumped in from Patoka Lake. However, the French Lick Sewer Treatment Plant is still in operation. Since July of 2008, the facility has been out of compliance 3 times for discharging effluent with high amounts of total suspended solids. The majority of this watershed is unsewered, with the small exception of the areas of West Baden and community of Abydel that cross into the Sulphur Creek subwatershed boundary. People in the rest of the subwatershed are on septic systems and may be a source to the *E.coli* pollution in the area. There are no CFOs located within this watershed.

5.6 French Lick Creek Subwatershed

French Lick Creek subwatershed is in the southern section of the watershed (Figure 69). French Lick Creek is the main channel within the subwatershed with several side unnamed tributaries and Sand Creek contributing to its flow (Figure 171). French Lick subwatershed drains to the north starting upstream of Tucker Lake. There are numerous hills and valleys across this portion of the watershed. The occasional sinkhole can still be found in this area but are much more infrequent and rarer.

Land Use

The total area of French Lick Creek subwatershed is 21,928 acres. The majority of landuse in this subwatershed is forested (Figure 169). Forested lands make up 15,654 acres or 71.4% of the subwatershed. Pasture and hay lands makes up 2,692 acres or 12.2% of the watershed. Crop production occurs on 642.2 acres primarily along stream valleys or on hilltop plateaus. The developed areas are primarily in the Towns of French Lick and West Baden and in rural areas. The developed areas make up 1,570 acres of the watershed. Open space accounts for 1258.3 acres of the developed areas. Shrub land makes up 256 acres and grassland makes up 971 acres. Large sections of this watershed are managed by Hoosier National Forest and DNR (Figure 170). There are 76.99 miles of stream channels within the French Lick Creek subwatershed with 26.79 miles of perennial streams.

Most of the pasture land is on ridge tops while most crop lands are within the river valley where the soils are most fertile and the slope is gentle enough for equipment harvest and tend to row crops. Because of the location of the row crops, the areas along the streams and river in these areas are in need of riparian buffers. Within French Lick Creek subwatershed, 13.34 miles of stream corridor are in need of riparian buffers, of this 6.7 miles is perennial in nature (Figure 169).

Most of the development in the watershed occurs in the French Lick Creek subwatershed. The local economy of French Lick and West Baden is boosted by the French Lick Casino and Resort. Golf courses are in development along with a reservoir for irrigation. Water from Sand Creek is being captured for this purpose. French Lick Creek flows through the middle of French Lick and West Baden. Flooding does occur regularly within this area. This does not deter the expansion and development in the area.

Hoosier National Forest and DNR manage much of the southern portion of the watershed as well as areas surrounding Tucker Lake, or Spring Valley Lake (depending on who you talk to). Tucker Lake is a frequently visited recreation spot for many stakeholders of the watershed. People enjoy fishing and swimming within the lake. The majority of the land surrounding the lake is forested, but a large community development is located just to the southeast of the lake on the watershed boundary.

Windshield Survey

French Lick Creek subwatershed has some rolling hills and springs in its topography. There are five locations within the subwatershed where livestock had access to stream channels were observed. Livestock and hobby farms are not prevalent in this subwatershed, but there are a few. Timber harvesting is occurring in this area and several locations showed severe signs of erosion from the recently logged forests. Conventional tilled fields are witnessed in this subwatershed in 3 fields, likely due to the river bottom nature of the cropped ground. These river bottoms are more susceptible to runoff and contributions of soil, sediment, and nutrients due to their proximity within floodplains. The community of Wildwood Lake is within this subwatershed and may have a significant septic influence due to their location. Many reports of failed septic systems have come from this area. Trash along streams and wetlands was seen at several of the populated areas within this subwatershed.

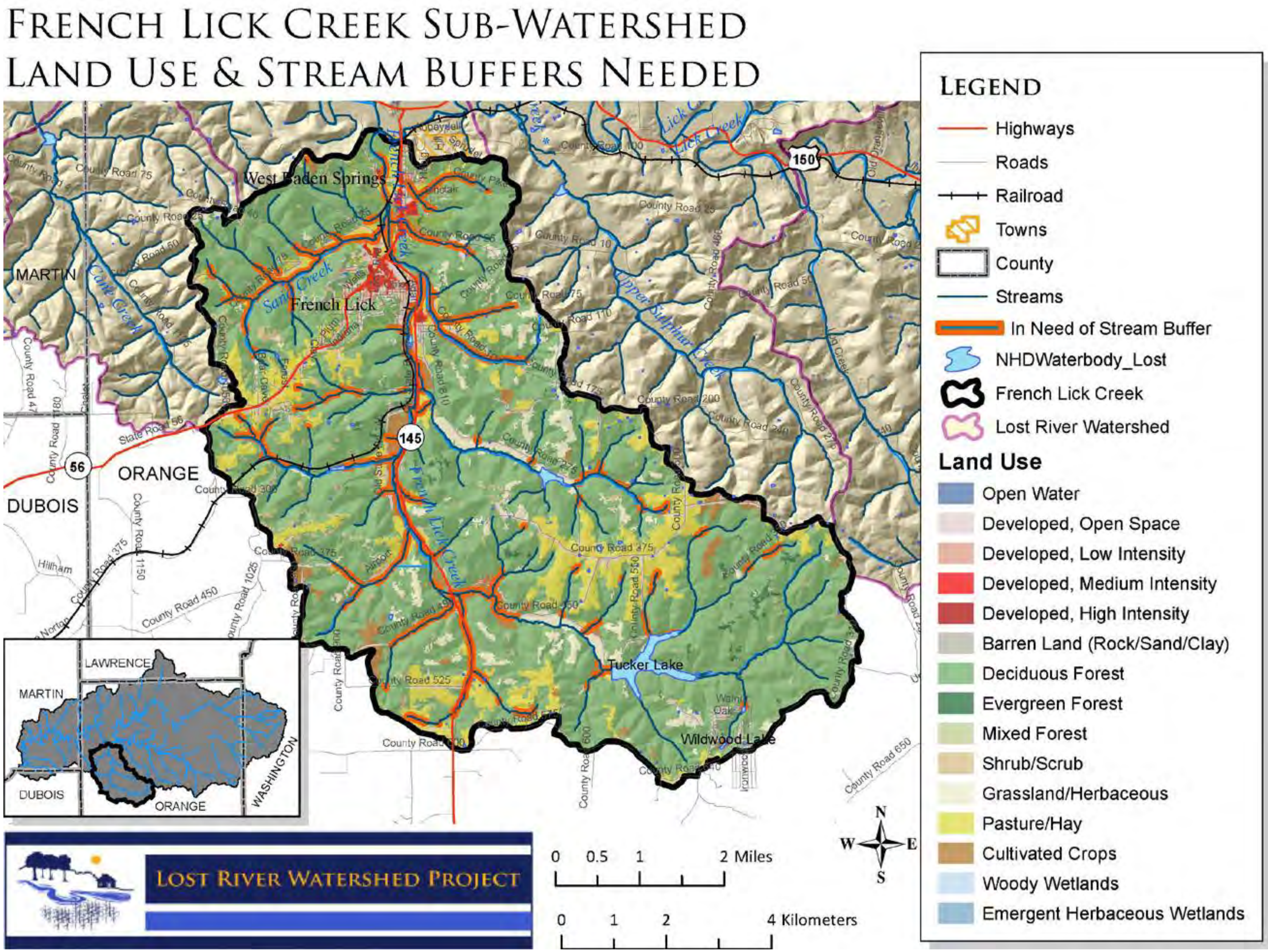


Figure 169: French Lick Creek Subwatershed- Land use (2006) and areas in need of stream buffers

French Lick Creek Sub-Watershed Management Areas

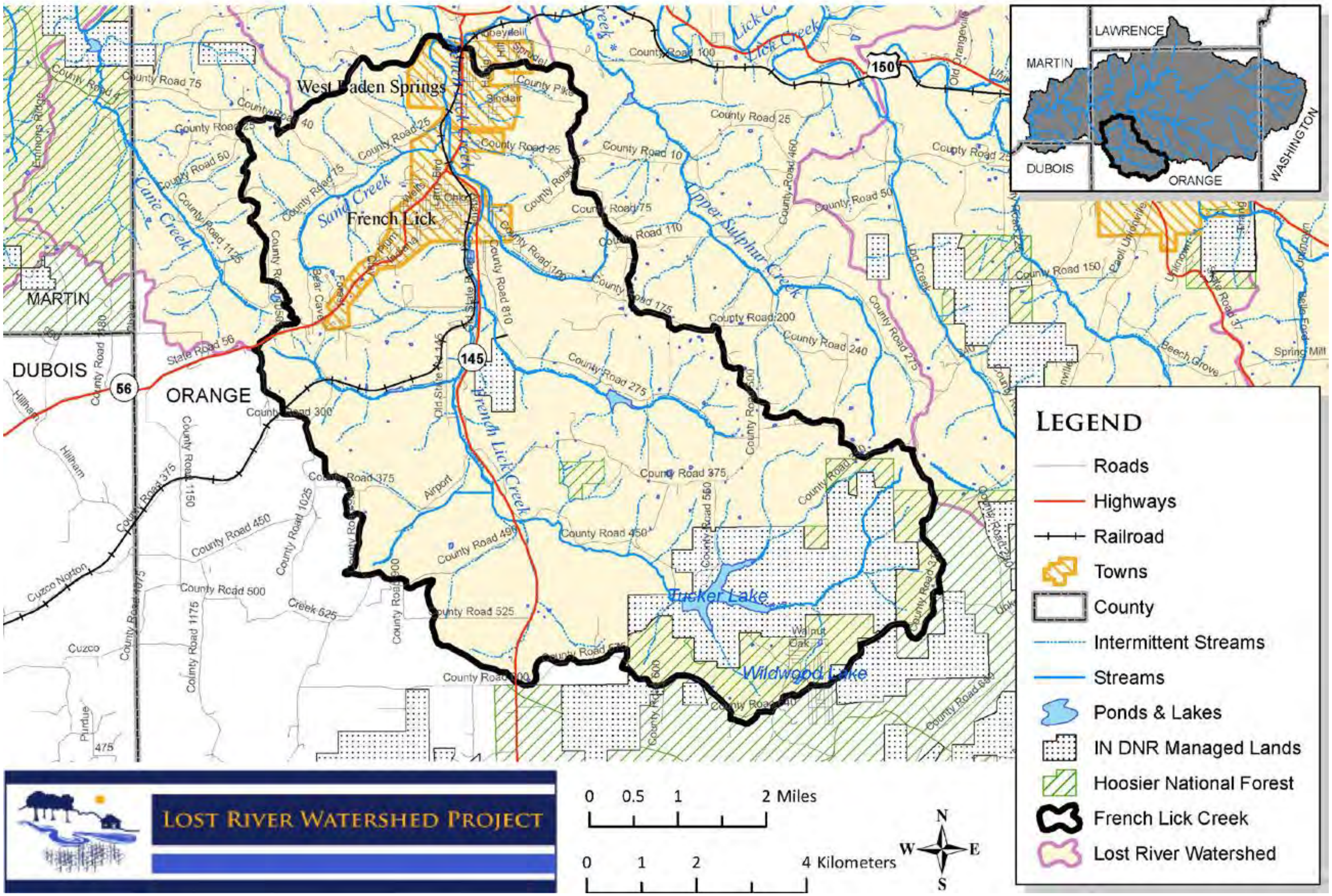


Figure 170: French Lick Creek Subwatersheds- Location of managed areas

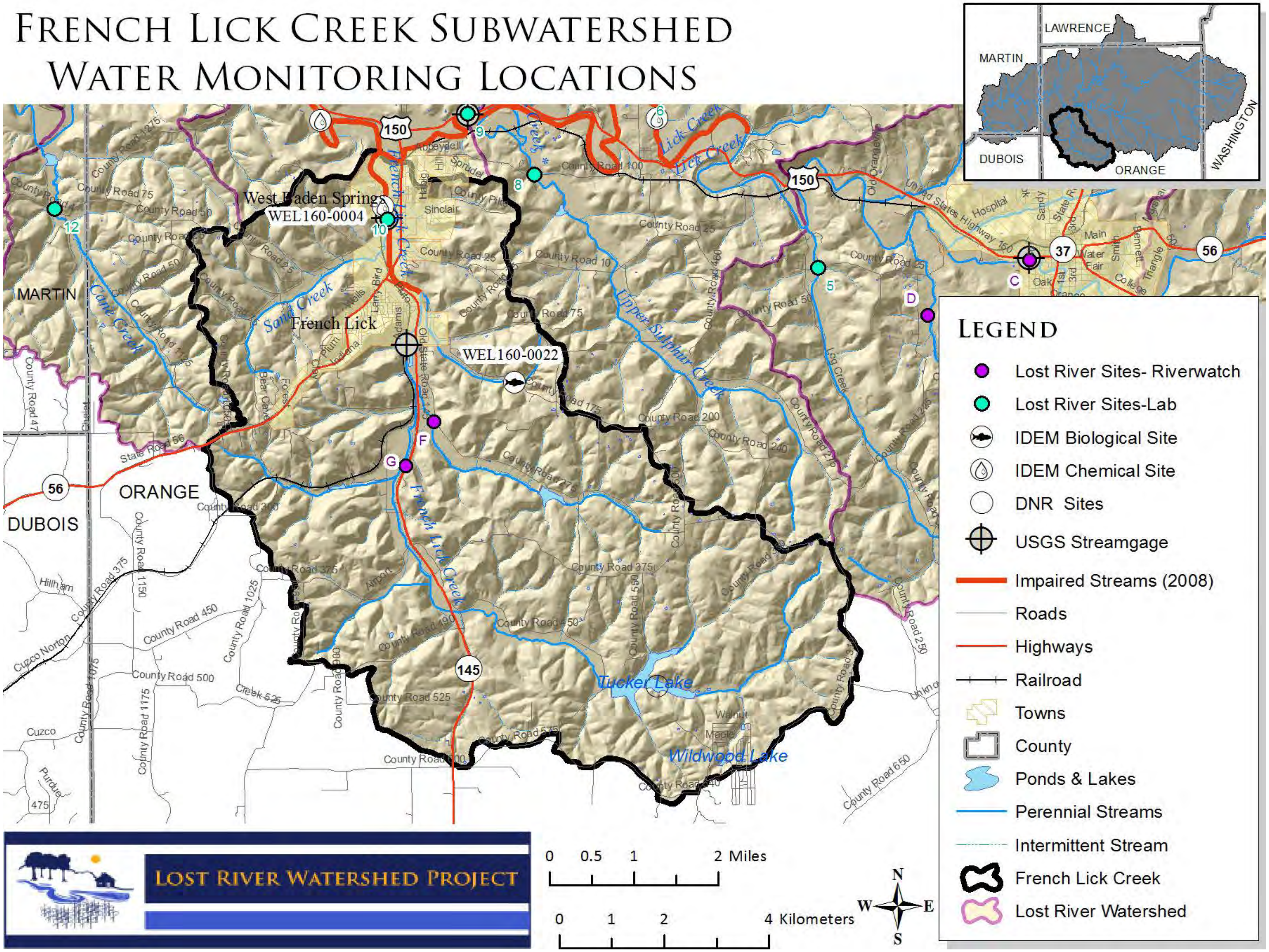


Figure 171: French Lick Creek Subwatershed Water monitoring locations (current and historical) within the area and locations of impaired streams.

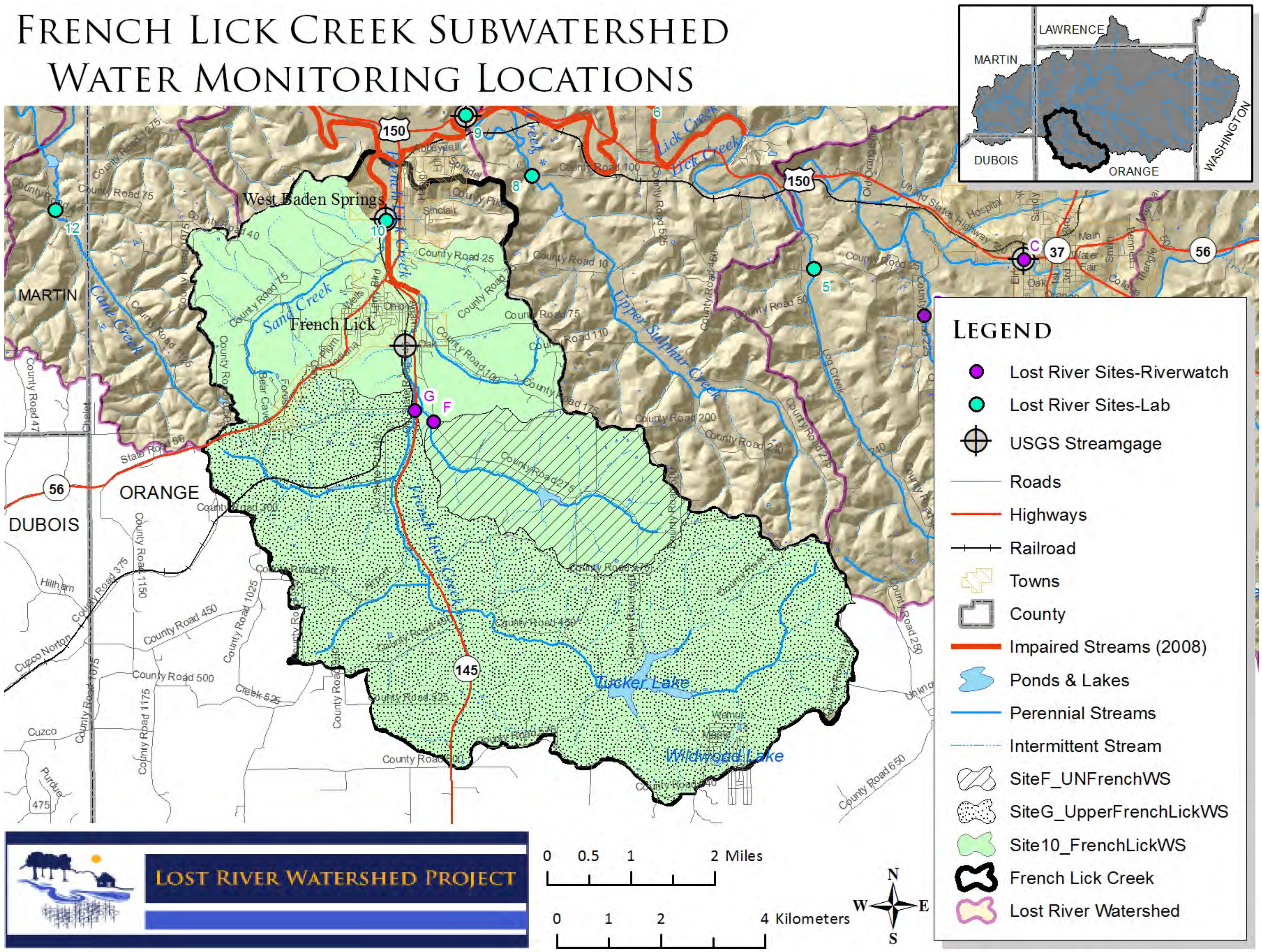


Figure 172: Sample Site subwatersheds in the French Lick Creek subwatershed- based on 2011-2012 sampling period

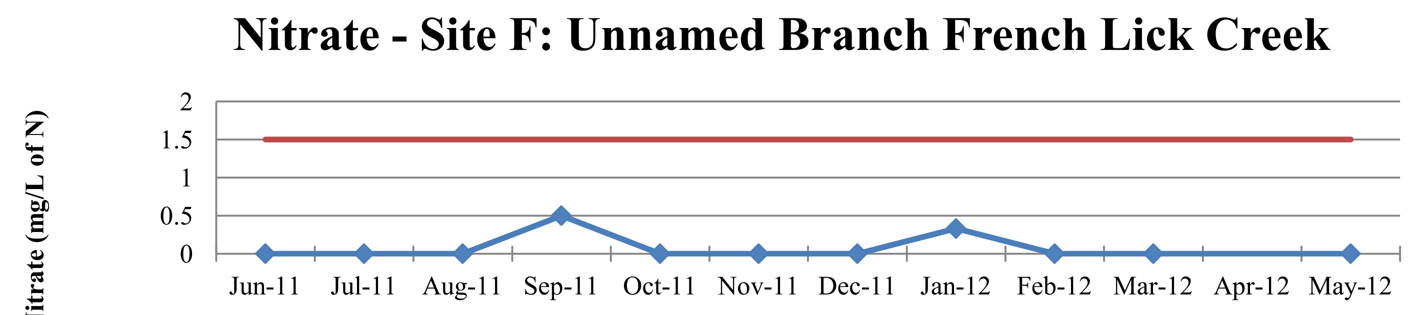
Five locations have been monitored within the French Lick Creek subwatershed for chemical, physical, and biological parameters (Figure 171). Of these locations, two are on the main branch of French Lick Creek. Two separate unnamed side tributaries have been monitored in this area. Biological monitoring has been conducted in Tucker Lake. There are also two USGS gaging stations within the watershed at French Lick Creek in West Baden and French Lick. Figure 172 shows locations of current monitoring and the relative size of drainage to each of the sample points.

Tucker Lake Monitoring

The upstream most monitored site is the biological monitoring that occurs at Tucker Lake, or Springs Valley Lake. DNR Department of Fish and Wildlife conducted a general fish survey of Tucker Lake on May 4 and June 1 to 2, 2009 and a survey of submersed aquatic vegetation on July 13, 2009. The 2009 general survey revealed low numbers of largemouth bass and a decreased bluegill population. A total of 551 fish, representing ten species, was collected that weighed an estimated 182 lbs. Largemouth bass ranked first by number, followed by redear sunfish, and longear sunfish. Largemouth bass ranked first by weight, followed by redear sunfish, and channel catfish. Submersed vegetation was found to a maximum depth of 11.0 ft. Six native species, American pondweed, brittle naiad, coontail, American elodea, small pondweed, and southern naiad were collected. Brittle naiad was the most frequently occurring, followed by American elodea, small pondweed, and coontail. DNR identified *Oscillatoria spp*. (blue-green algae) for the first time in Springs Valley Lake during their 2009 general survey. Oscillatoria and many other species of blue-green algae have the potential to produce toxins that are harmful to humans, fish, and other animals. Blue-green algae are common in nutrient rich environments. Watershed stakeholders are interested in investigating methods to reduce nutrient loading in the lake’s watershed.

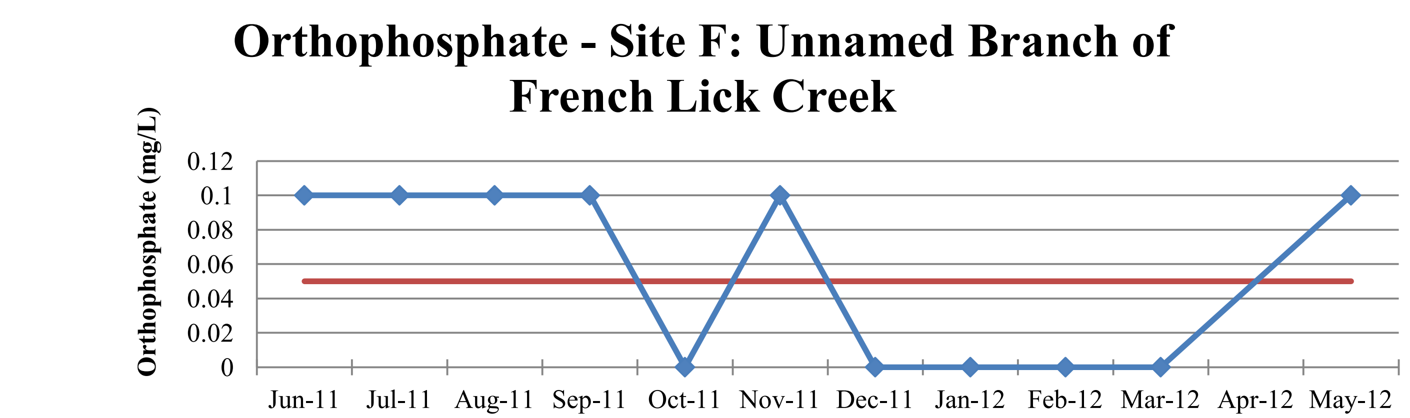
Unnamed Tributary of French Lick Creek Monitoring Site F

The Hoosier Riverwatch Lost River Team monitored an unnamed branch to French Lick Creek (Site F) on a monthly basis. Nitrates at this location fell well below target levels of 1.5 mg/L during the entire 2011- 2012 sampling period (Figure 173). The highest measured value was in September with 0.5 mg/L. Orthophosphate was above target values 6 times during the sampling event (Figure174). All months measured values of 0.1 mg/L, which is twice the target values of 0.05 mg/L. Dissolved Oxygen levels did hit a low of 4 mg/L in August (Figure 175), but this is likely due to stagnant water at this site in that month. Biochemical Oxygen Demand 5-Day (BOD5) did rise above our target value of 2 mg/L change (Figure 176) in three of the months sampled indicating that there may be a organic or chemical influence that is reducing the availability of oxygen to the system. Sources for this were not identified and need further investigation. Turbidity spiked to 40 NTU in September, the only month that did not meet target values (Figure 177). pH also dropped below target levels of 6 standard units in three months from December through January (Figure 178). This is also unusual and further investigation of this potential source should be investigated. *E. coli* values fell within normal levels for all samples collected except in September. *E. coli* counts were 400 CFU/100mL in this month (Figure 179). Figure 179 also shows high levels of total coliforms in September and October of 2011 along with January 2012.



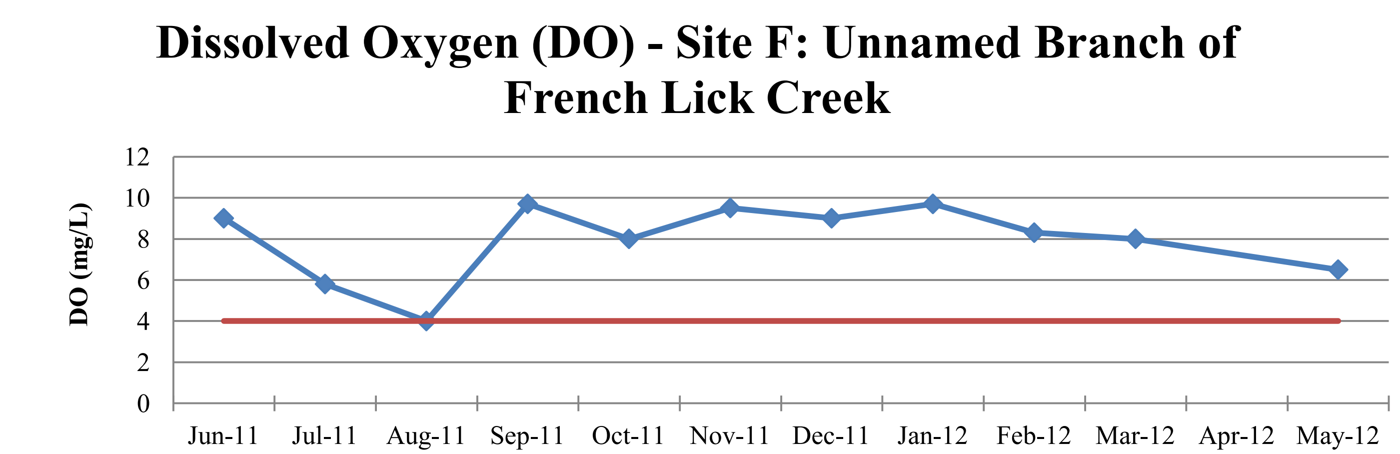
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0	0	0.5	0	0	0	0.33	0	0	0

Figure 173: Nitrate Levels at Site F (2011-2012 testing period)



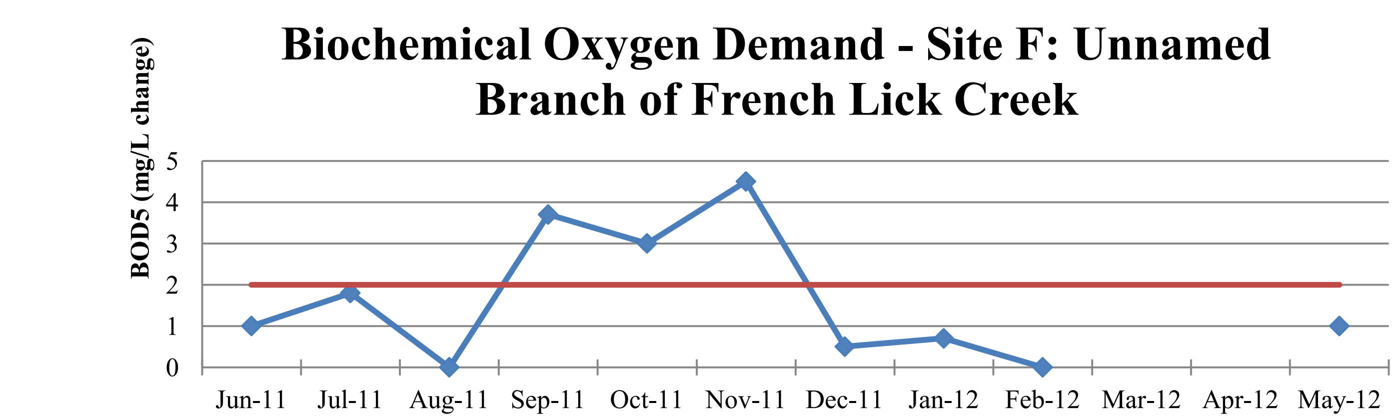
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.1	0.1	0.1	0.1	0	0.1	0	0	0	0	0.1

Figure 174: Orthophosphate Levels at Site F (2011-2012 testing period)



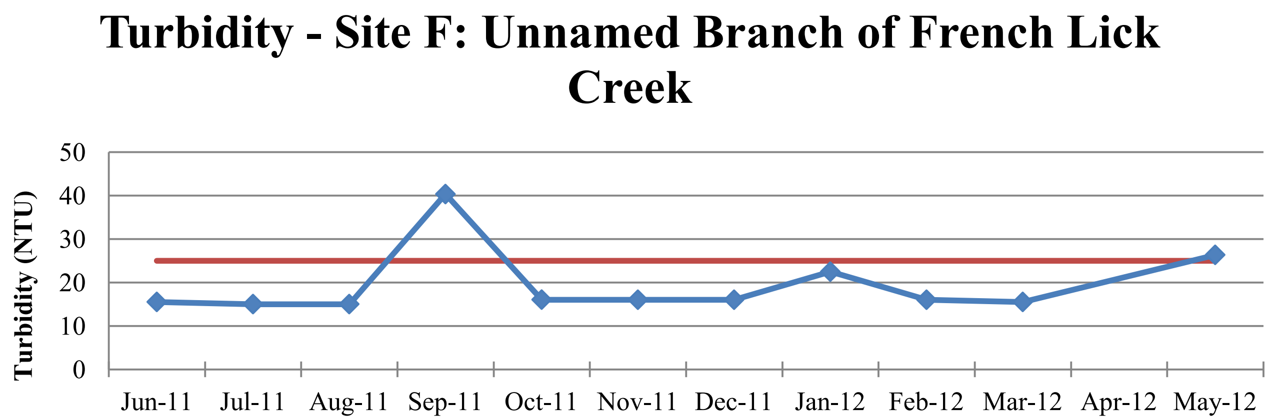
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
DO	9	5.8	4	9.7	8	9.5	9	9.7	8.3	8	6.5
DO Min	4	4	4	4	4	4	4	4	4	4	4

Figure 175: Dissolved Oxygen (DO) Levels at Site F (2011-2012 testing period)



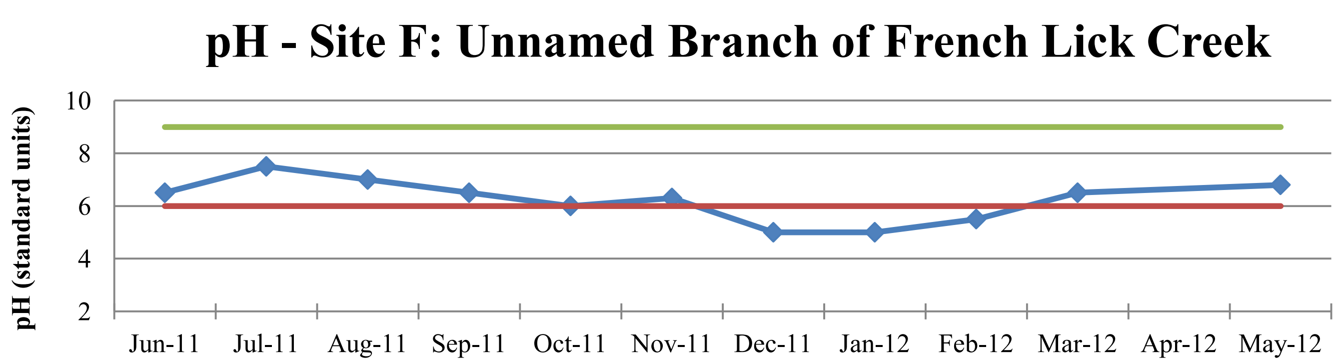
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
BOD5	1	1.8	0	3.7	3	4.5	0.5	0.7	0		1
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 176: 5-Day Biochemical Oxygen Demand (BOD5) Levels at Site F (2011-2012 testing period)



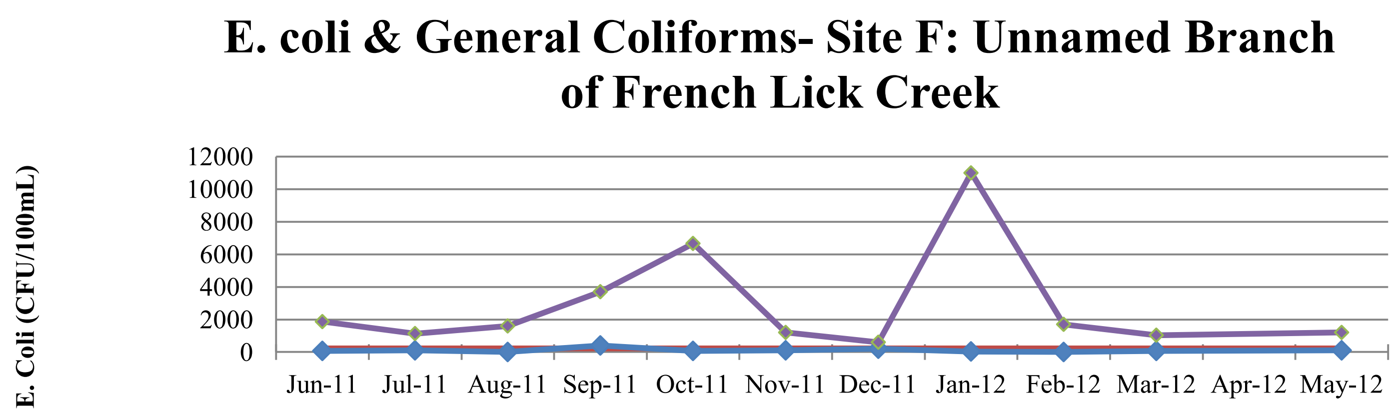
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15.5	15	15	40	16	16	16	22	16	16	26

Figure 177: Turbidity Levels at Site F (2011-2012 testing period)



	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.5	7.5	7	6.5	6	6.3	5	5	5.5	6.5	6.8
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 178: pH Levels at Site F (2011-2012 testing period)



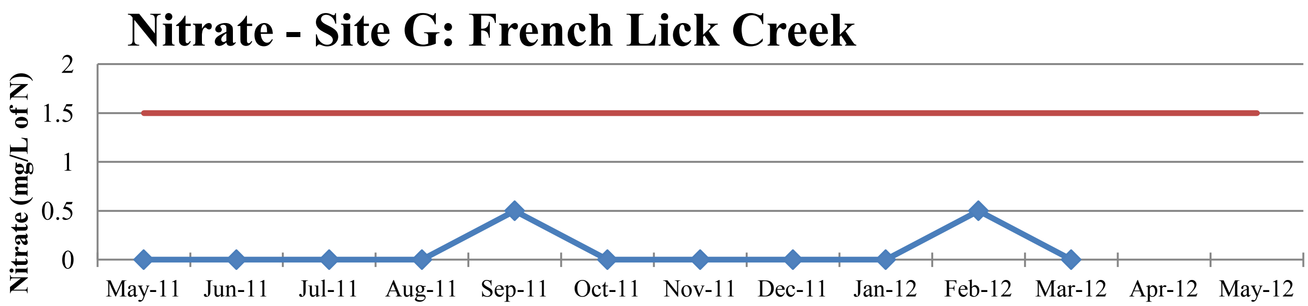
	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	66.7	99.9	0	400	66.6	100	200	33.3	0	66.6	100
General Coliforms	1864.8	1132.2	1598.4	3700	6660	1200	600	10989	1698.3	1032.3	1200

Figure 179: E. coli and General Coliform Levels at Site F (2011-2012 testing period)

Biological samples have only been collected at this site through current sampling efforts at Site F. The habitat in the unnamed branch of French Lick Creek was determined to be fair with a citizens QHEI score of 60. This is because the stream is highly channelized and silted at this site. The macroinvertebrate scores indicate that this unnamed branch of French Lick Creek is impaired for aquatic life. The Pollution Tolerance Index score at this site was 10 points. This low score is likely due to the low habitat score and poor water quality. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

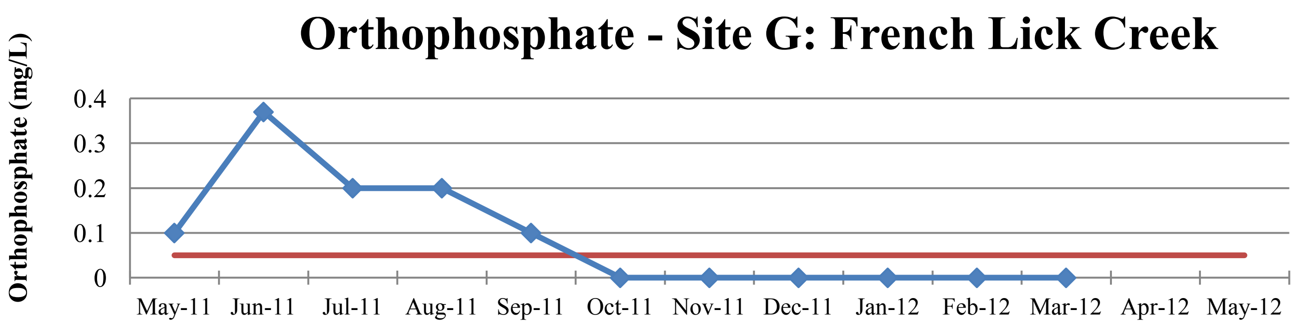
French Lick Creek Monitoring Site G

The Hoosier Riverwatch Lost River Team on a monthly basis monitored French Lick Creek (Site G). This portion of French Lick Creek drains much of Highway 145 and the rural lands south of French Lick (Figure 172). Nitrates at this location fell well below target levels of 1.5 mg/L during the entire 2011- 2012 sampling period (Figure 180). The highest measured value was in September and February with 0.5 mg/L. Orthophosphate was above target values 5 times during the sampling event (Figure 181). Orthophosphate levels peaked with a value of 0.37 mg/L in June 2011, which is 7.4 times the target value of 0.05 mg/L. Turbidity spiked to 56 NTU and 53 NTU in September and October, respectively (Figure 182). These were the only months that did not meet target values of 25 NTU. pH also dropped below target levels of 6 standard units in three months from December through January (Figure 183). This is similar to the results seen at Site F and further investigation of this potential source of acidity should be investigated. *E. coli* values fell within normal levels for most samples collected except in September 2011 and May 2012 (Figure 184). *E. coli* counts spiked at 4800 CFU/100mL in September which is a significant increase from other months. Figure 184 also shows high levels of total coliforms in September 2011 along with January and May of 2012.



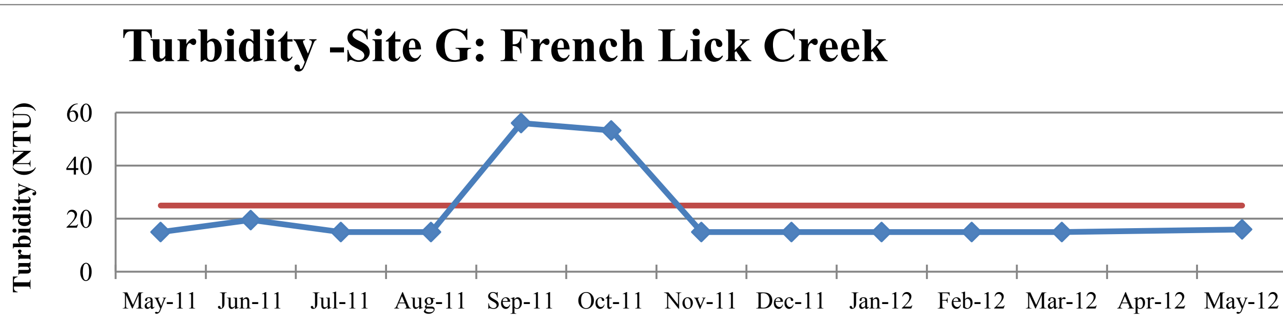
	5/13/11	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0	0	0	0.5	0	0	0	0	0.5	0	

Figure 180: Nitrate Levels at Site G (2011-2012 testing period)



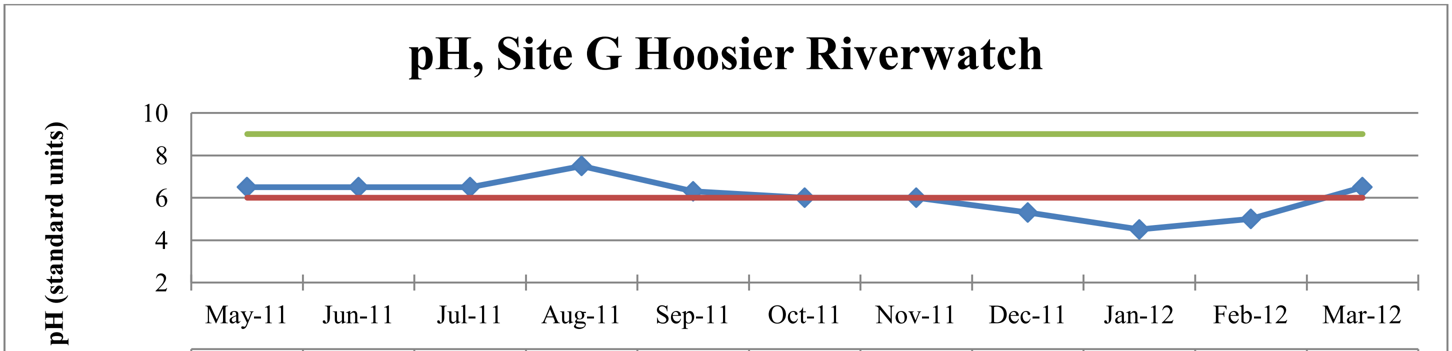
	5/13/11	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.1	0.37	0.2	0.2	0.1	0	0	0	0	0	0	

Figure 181: Orthophosphate Levels at Site G (2011-2012 testing period)



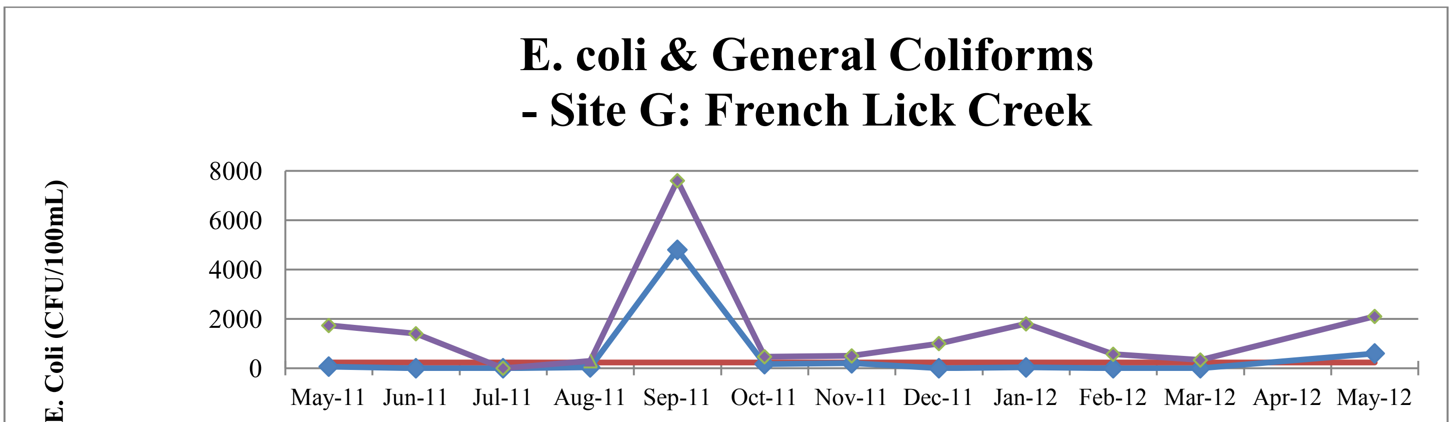
	5/13/11	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	19.5	15	15	56	53	15	15	15	15	15	16

Figure 182: Turbidity Levels at Site G (2011-2012 testing period)



	5/13/11	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.5	6.5	6.5	7.5	6.3	6	6	5.3	4.5	5	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 183: pH Levels at Site G (2011-2012 testing period)



	5/13/11	6/13/11	7/28/11	8/28/11	9/26/11	10/29/11	11/19/11	12/28/11	1/28/12	2/26/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235
E.coli	66.7	0	0	33.3	4800	166.6	200	0	33.3	0	0	600
General Coliforms	1731.6	1398.6	0	299.7	7600	466.6	500	1000	1798.2	566.1	333	2100

Figure 184: E. coli and General Coliform Levels at Site G (2011-2012 testing period)

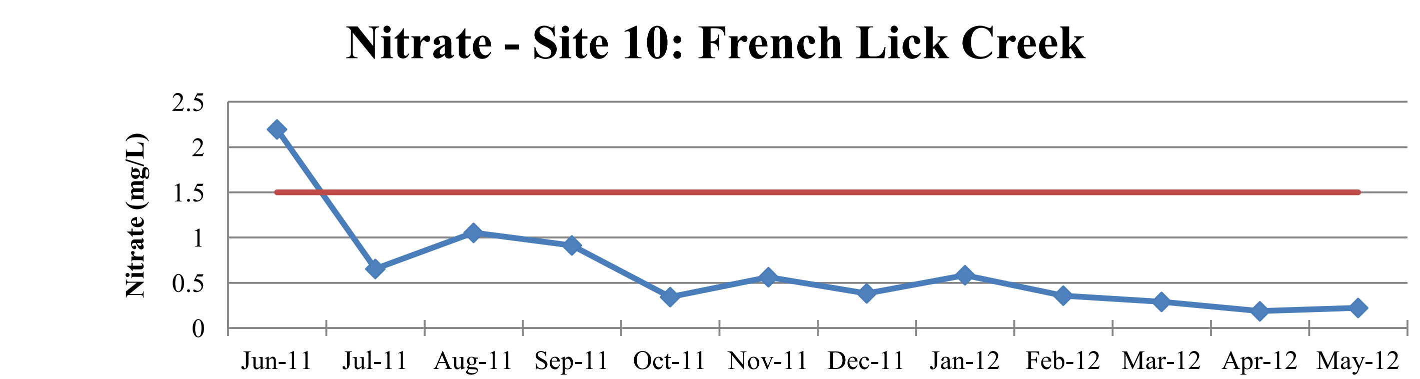
Biological samples have only been collected at Site G through current sampling efforts. The habitat in this portion of French Lick Creek was determined to be excellent with a citizens QHEI score of 71. This is because the stream has good riffles, pools and substrate. The macroinvertebrate scores indicate that this portion of French Lick Creek is not impaired for aquatic life. The Pollution Tolerance Index score at this site was 18 points. This good score is likely due to the quality habitat score and fair water quality. Biological samples have not been collected at this site before either by IDEM or through either of the LARE diagnostic studies.

IDEM Monitoring Site WEL160-0022

IDEM monitored site WEL160-0022 for biological species in 2007 (Figure 171). The study showed that three species of fish were present in the stream with a total count of 41. They are the orangethroat darter (Etheostoma spectabile) , western blacknose dace (Rhinichthys obtusus), and bluegill (Lepomis macrochirus). The most abundant fish was the western blacknose dace with 37 of the 41 fish counted. Water quality monitoring performed by IDEM in 2007 at the same location indicates that the river was not over any target value for temperature, conductivity, dissolved oxygen, nitrogen, or pH at the time of sampling.

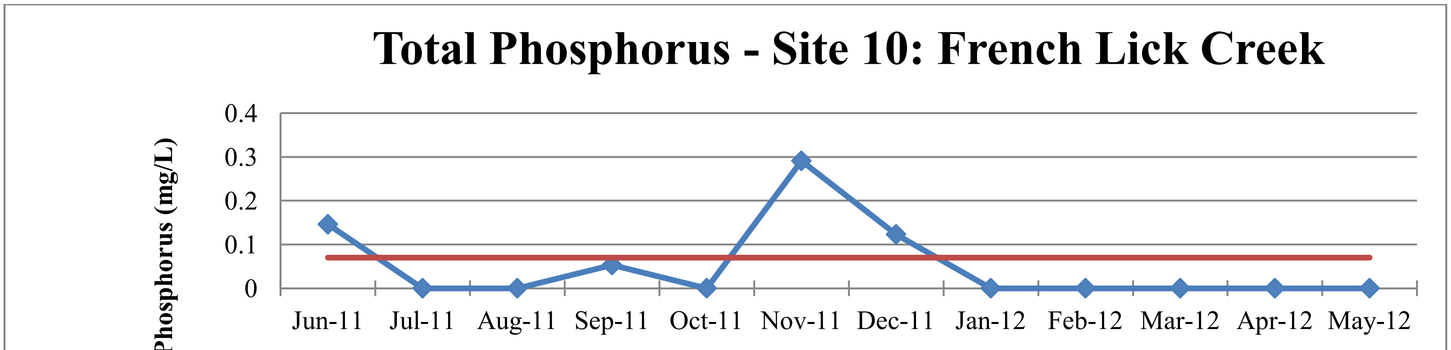
French Lick Creek Monitoring Site 10

The Lab and IDEM monitored French Lick Creek in the town of West Baden at Site 10 (IDEM station WEL160-0004). The Lab monitored French Lick Creek in the 2011-2012 sampling event. This site is roughly a mile from the confluence with Lost River and drains the majority of the French Lick Creek subwatershed (Figure 172). The river showed elevated levels of nitrates (2.196 mg/L) in June of 2011 (Figure 185). This was the only time during the 2011-2012 sampling event that nitrates exceeded target levels. Total phosphorus exceeded target levels in June (0.146 mg/L), November (0.291 mg/L), and December (0.123 mg/L) of 2011 (Figure 186). Dissolved oxygen was below minimum levels in July 2011 (3.5 mg/L) (Figure 187). Conductivity was extremely above target values in July and August 2011 (1436 µS/cm and 1323 µS/cm, respectively), and below target levels in December of 2011 (123.5 µS/cm) (Figure 188). Turbidity exceeded target levels of 25 NTU in five out of the 12 samples collected at this site (Figure 189). Turbidity levels spiked in November 2011 with 222 NTU or 8.9 times target levels. Total suspended solids (TSS) exceeded target levels of 25 mg/L in 3 out of the 12 samples collected at this site (Figure 190). TSS levels spiked in November 2011 with 306 mg/L or 12.4 times target levels. *E. coli* (1986.3 MPN/100mL), and total suspended solids (49 mg/L) exceeded targets in samples collected in June 2011 (Figure 191). IDEM samples taken in 2002 found high levels of turbidity all times sampled and high levels of *E. coli* in two of the three samples.



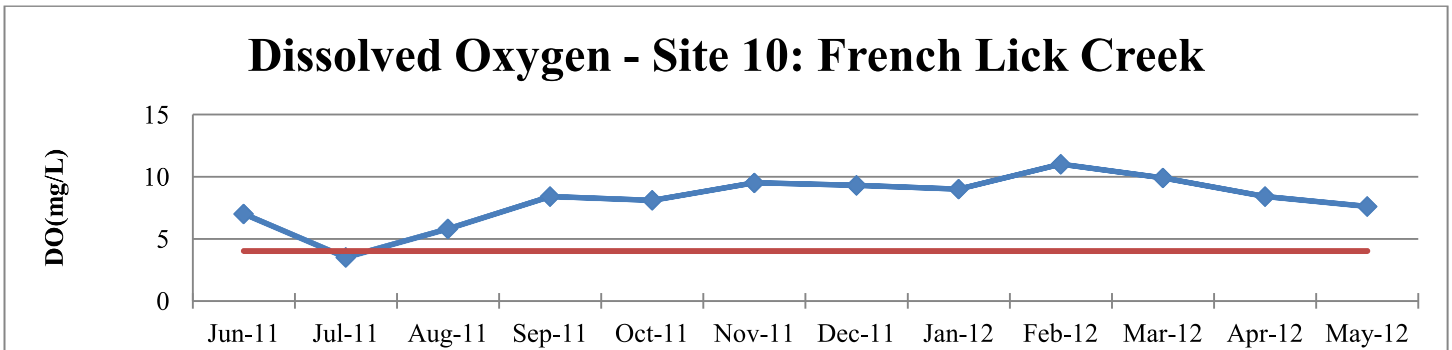
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	2.196	0.654	1.053	0.914	0.343	0.563	0.384	0.585	0.359	0.29	0.186	0.223
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 185: Nitrate Levels at Site 10 (2011-2012 testing period)



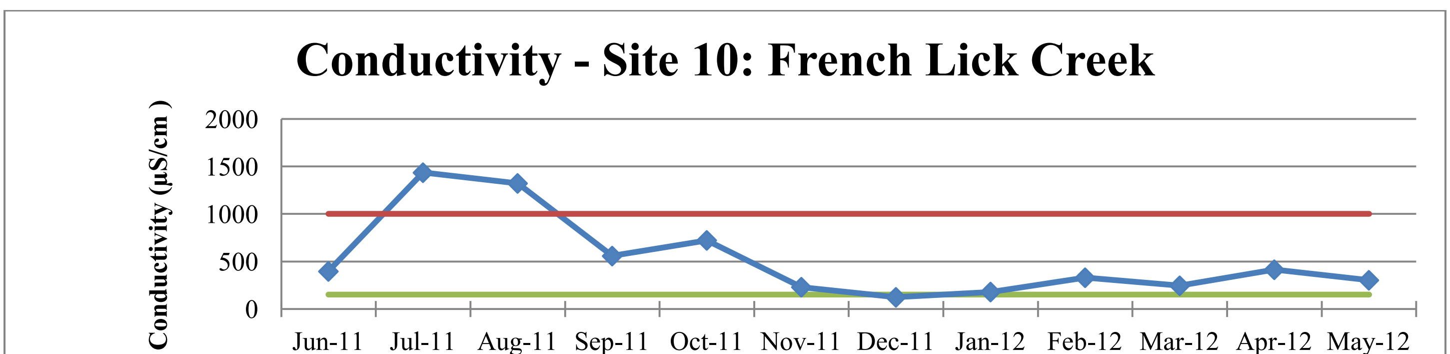
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.146	0	0	0.053	0	0.291	0.123	0	0	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 186: Total Phosphorus Levels at Site 10 (2011-2012 testing period)



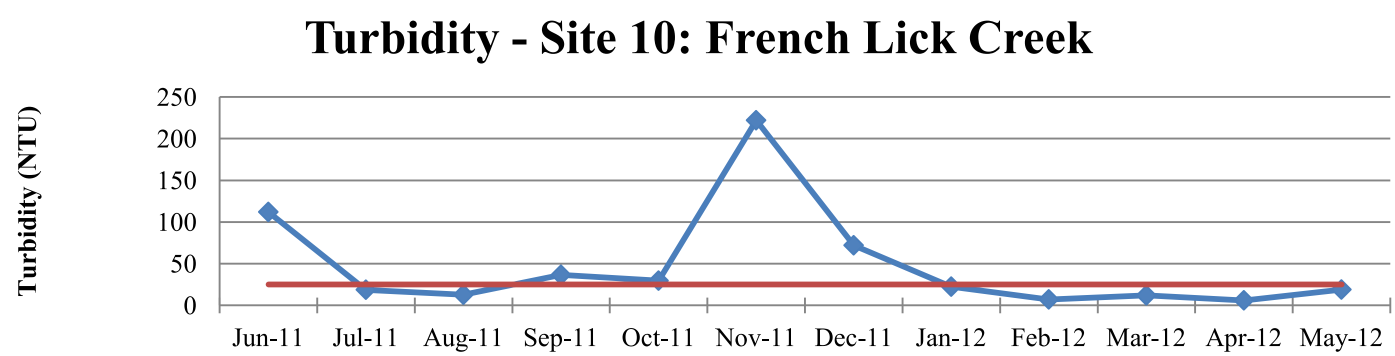
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
DO	7	3.5	5.8	8.4	8.1	9.5	9.3	9	11	9.9	8.4	7.6
DO Min	4	4	4	4	4	4	4	4	4	4	4	4

Figure 187: Dissolved Oxygen (DO) Levels at Site 10 (2011-2012 testing period)



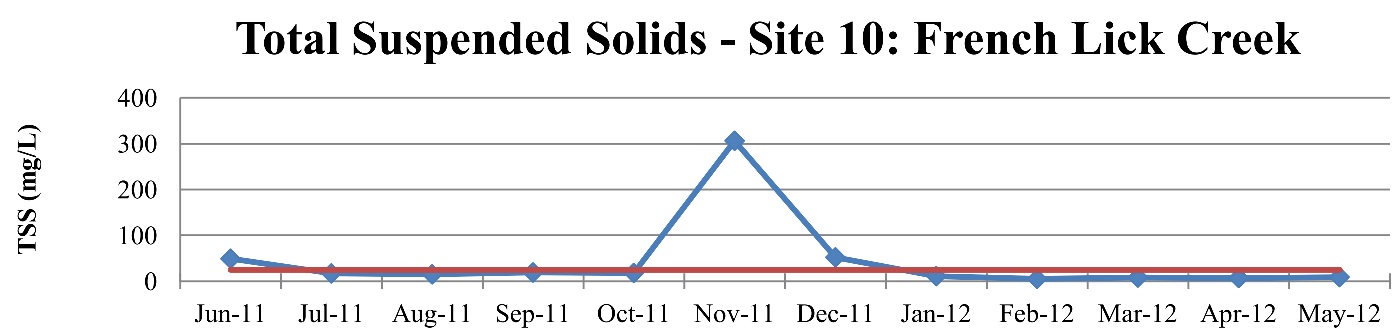
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Conductivity Min	150	150	150	150	150	150	150	150	150	150	150	150
Conductivity	396	1436	1323	558	723	230.2	123.5	179.4	330	244.9	414	303
Conductivity Max	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Figure 188: Specific Conductivity Levels at Site 10 (2011-2012 testing period)



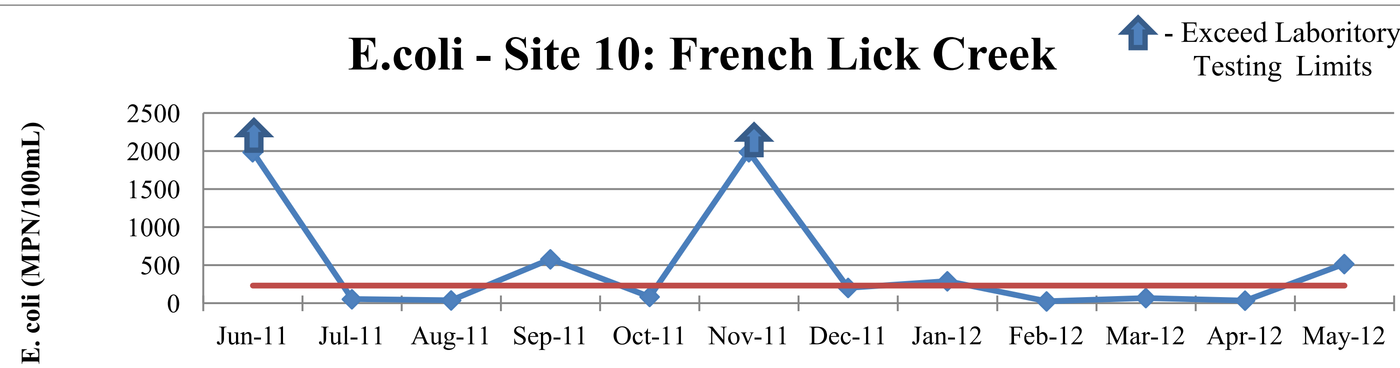
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	112	18.7	12.7	36.6	29.6	222	72	22.4	7.08	11.9	5.97	18.9
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 189: Turbidity Levels at Site 10 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	49	17	15	19	18	306	52	11	5	8	7	9
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 190: Total Suspended Solid (TSS) Levels at Site 10 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	1986.3	54.5	38.9	579.4	85.7	1986.3	203.7	290.9	26.2	70.6	36.4	517.2
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 191: E. coli Levels at Site 10 (2011-2012 testing period)

Biological samples have only been collected at this Site 10 through current sampling efforts. The habitat in this section of French Lick Creek was determined to be fair with a QHEI score of 54. This just squeaked by with a habitat score just above the target score of 51 points. The macroinvertebrate scores, however, indicate that this section of French Lick Creek is impaired for aquatic life. The mIBI score at this site was 32 points which is lower than the target score of 36. This low score is likely due poor water quality in the river and fair habitat.

French Lick Creek is on the 303 (d) list impaired for *E. coli* in this section of the river. Water tests show that other portions of the creek may also be impaired for *E. coli* as well as other parameters. IDEM collected water quality samples in 1997 and 2002 at this location. Four out of the 8 samples collected during these 2 years showed high levels of E. coli above water quality standards of 235 CFU or MN/100mL. E.coli spiked in 1997 with a value of 5200 CFU/100mL. In 2002, the highest value for *E. coli* was 920.8 MPN/100mL. During the 1997 sampling year, total phosphorus spiked above target levels with 0.28 mg/L, which is 4 times our target levels. This is one of two samples that exceeded our target levels out of the 6 samples collected in 1997. TSS spiked once during the 1997 sampling year with 900 mg/L, which is 36 times our target levels. This was the only sample that exceeded our target levels in the 6 samples collected. Turbidity was also high in that same sample with 720 NTU. There was one other instance where turbidity exceeded our target levels in the 11 samples that were collected over those two sampling years. Dissolved oxygen, temperature, specific conductivity, and pH were all within target values for these sampling events.

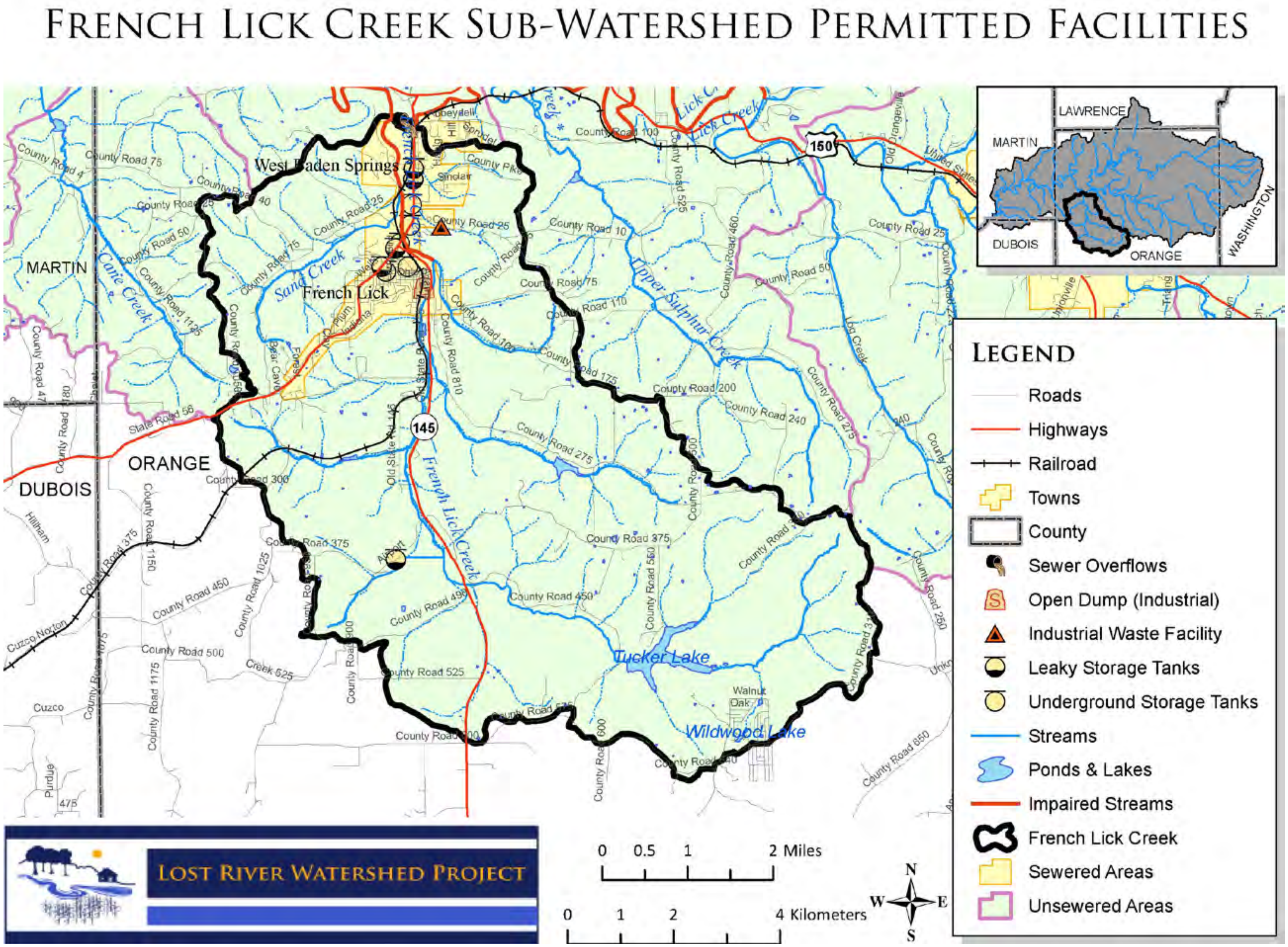


Figure 192: French Lick Creek Subwatershed-Locations of permitted facilities and areas that are sewered.

Permitted Facilities

All but one permitted facilities and sites are within the towns of French Lick and West Baden (Figure 192). The only one not within town limits is the underground storage tank at French Lick Airport. This Storage tank is on the list of Leaky Underground Storage Tanks. There are no confined feeding operations (CFOs) within this subwatershed.

Several dry dams have been constructed and are used for flood control in the area. Springs Valley Conservancy District regularly checks the dams for structural integrity along with maintaining the lands surrounding the dammed area.

Within the town boundaries of French Lick and West Baden lie one open dump and one industrial waste site seen in Figure 193. There are 10 underground storage tanks of those four are leaky underground storage tanks within the towns boundaries. There are two NPDES facilities but they are outside the French Lick Creek subwatershed (see Sulphur Creek subwatershed for details).

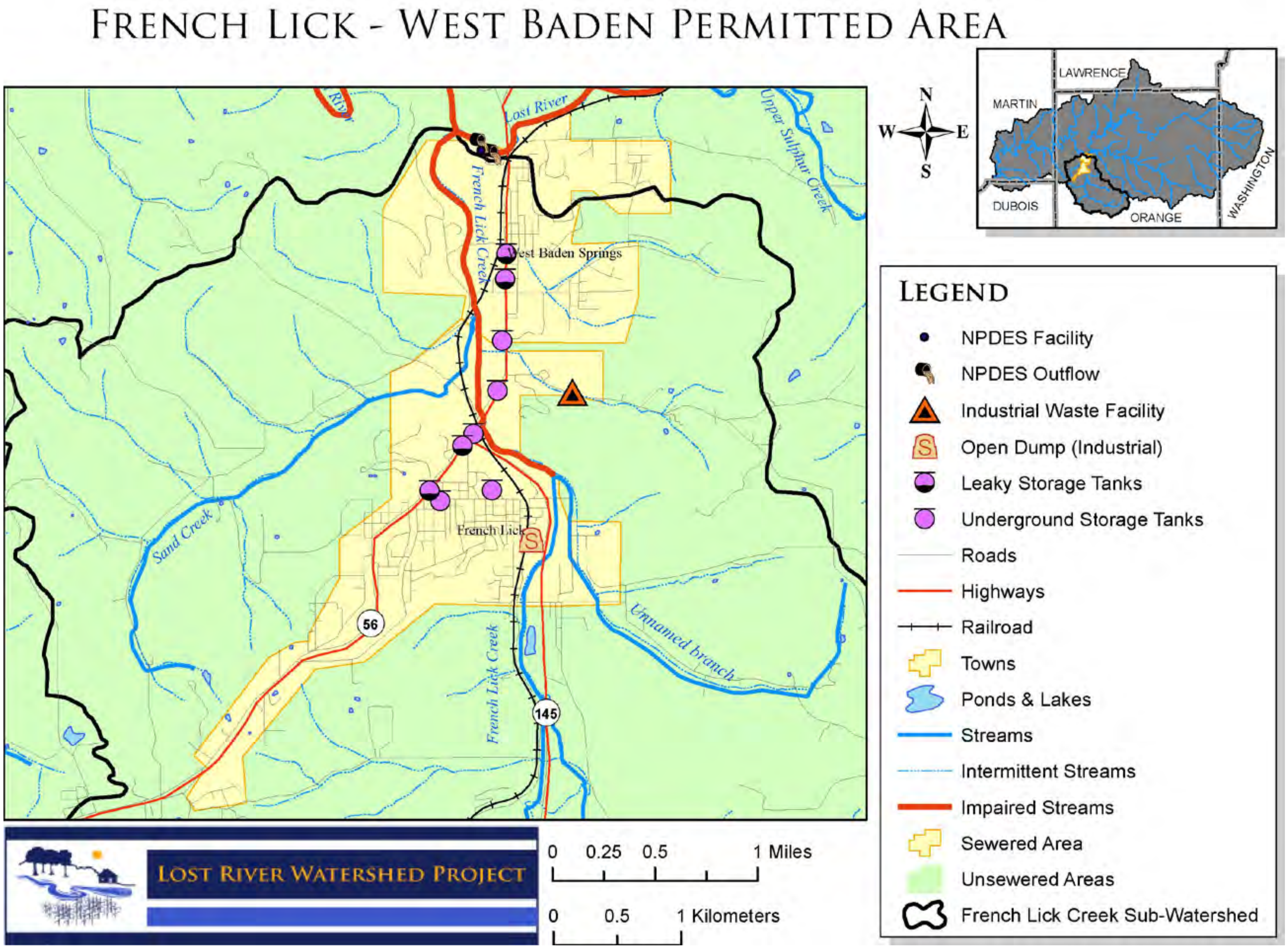


Figure 193: Town of French Lick and West Baden- Location of permitted facilities and sewered boundaries.

5.7 Lower Lost River Subwatersheds

Lower Lost River subwatershed area includes 3 subwatersheds. They are the Sams Creek subwatershed, the Big Creek subwatershed, and the Grassy Creek subwatershed (Figure 69).

Land Use

The total area of the three subwatersheds is 45,806 acres with Sams Creek subwatershed at 12,152 acres, Big Creek subwatershed covering 13,780 acres, and Grassy Creek subwatershed having 19,874 acres. The majority of landuse in these subwatersheds is forested. Forested lands make up 34,593 acres, or 75.5% within the 3 subwatersheds. The majority of cultivated crops (4,624 acres) and pasture or hay lands (2,422 acres) are along stream channels and river bottoms. Some livestock are also present within this area in the form of smaller homestead farms and open pasture livestock. Grasslands comprise of 2,097 acres and shrubs make up 608 acres. The other 1,374 acres is developed. Open space makes up 1,369 acres of the developed area. There are a total of 179.33 miles of stream channels within these three subwatersheds. There are 56.97 miles of channels within Sams Creek subwatershed with 17.01 miles of perennial streams. There are 63.08 miles of channels within Big Creek subwatershed of which 20.22 miles are perennial. Lastly, there are 59.29 miles of stream channels in Grassy Creek subwatershed and 31.895 miles of perennial streams.

Within Sams Creek subwatershed, 5.787 miles of channels representing 128.5 acres are in need of riparian buffers . Of these 2.834 miles of perennial streams are in need of buffers. This is out of the total of 1,200 acres of stream channel corridors. While in Big Creek subwatershed, 9.604 miles of stream channels representing 214 acres of stream corridors are in need of riparian buffers. There are 3.965 miles of perennial channels that are in need of buffers. This is out of the out of the total of 1,327.6 acres of stream corridor. The Grassy Creek subwatershed is in need of 10.580 miles of riparian buffer representing 250 acres out of a total of 1244 acres of stream corridors. There are 5.851 miles of perennial streams within Grassy Creek subwatershed that are in need of buffers. In general, stakeholders are concerned over the lack of riparian buffers along stream corridors. Grassed filter strips may be in place in many of these areas. However, they do not provide the shade or protection that a forested riparian buffer can provide.

Hoosier National Forest and DNR manage much of the forestland within Sams Creek, Big Creek, and Grassy Creek subwatersheds (Figure 246). There are several newly completed wetland complexes within Big Creek subwatershed. These wetlands cover 121 acres that were installed and are maintained by Hoosier National Forest. This wetland complex may be responsible for some of the water quality improvements seen downstream.

Windshield Survey

Windshield surveys performed in this area indicated high levels of algae visible within Lost River. This may be due to the increased levels of nitrogen and phosphorus found within the area. There are 12 sections of stream banks identified as in need of stabilization in the Lost River corridor and side tributaries. This represents 7.34 miles of stream banks that see frequent erosion. One of these locations is associated with a severe log jam that was removed in the Spring of 2012. It was approximated that 12 acres of land was eroded out from this log jam. Several small side tributaries to the Lost River are also showing signs of destabilization and increased erosion from these areas will disrupt the ecosystem function. There are 12 locations where livestock had access to the stream channel. Livestock and hobby farms are spread out around these subwatersheds. There at least 19 homestead farms identified within this area. Timber harvesting is occurring in this area and several locations showed severe signs of erosion from the recently logged forests. Conventional tilled fields are witnessed in this subwatershed in three fields, likely due to the river bottom nature of the cropped ground. These river bottoms are more susceptible to runoff and contributions of soil, sediment, and nutrients due to their proximity within floodplains. The area north of Natchez is a popular off road vehicle area along with many stream channels along Big Creek and Sams Creek and Grassy Creek. Erosion is significant in these areas and may contribute to poor water quality and habitat values in these areas. Trash along streams and roadside ditches are seen in many areas throughout these subwatersheds.

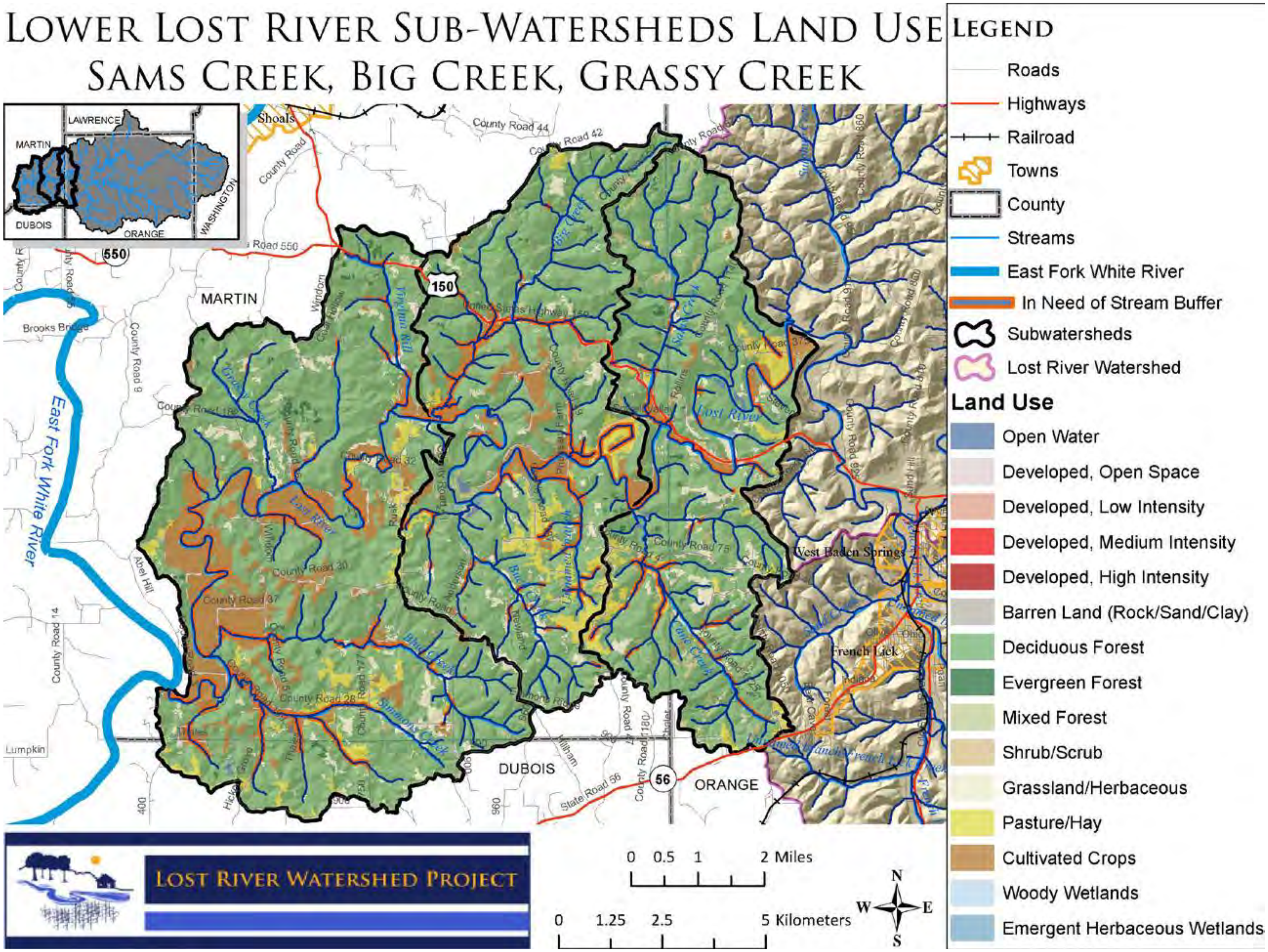


Figure 194: Lower Lost River Subwatersheds: Land use (2006) and areas in need of stream buffers

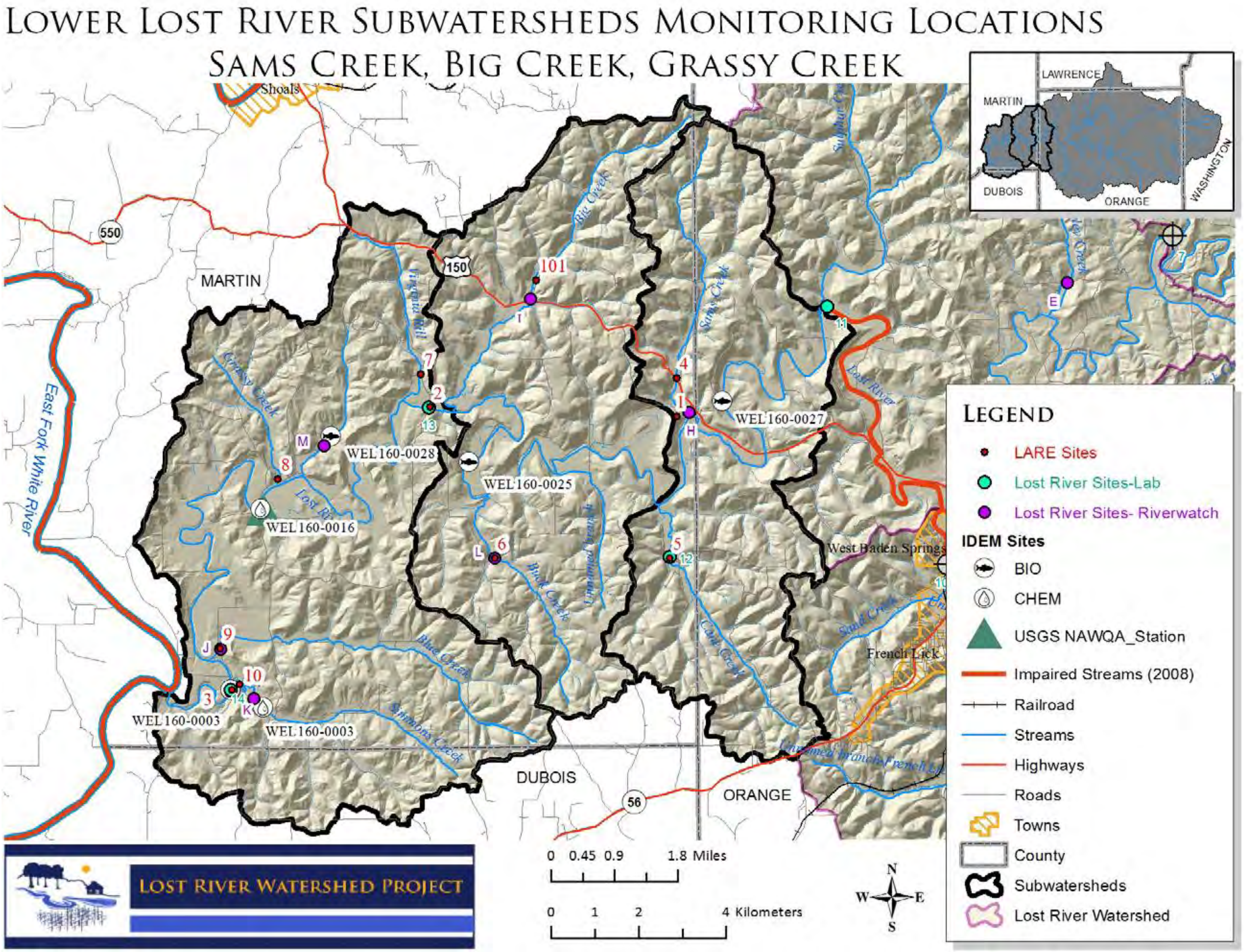


Figure 195: Lower Lost River subwatersheds-Location of Monitoring Stations (current and historical) and location of Impaired Streams

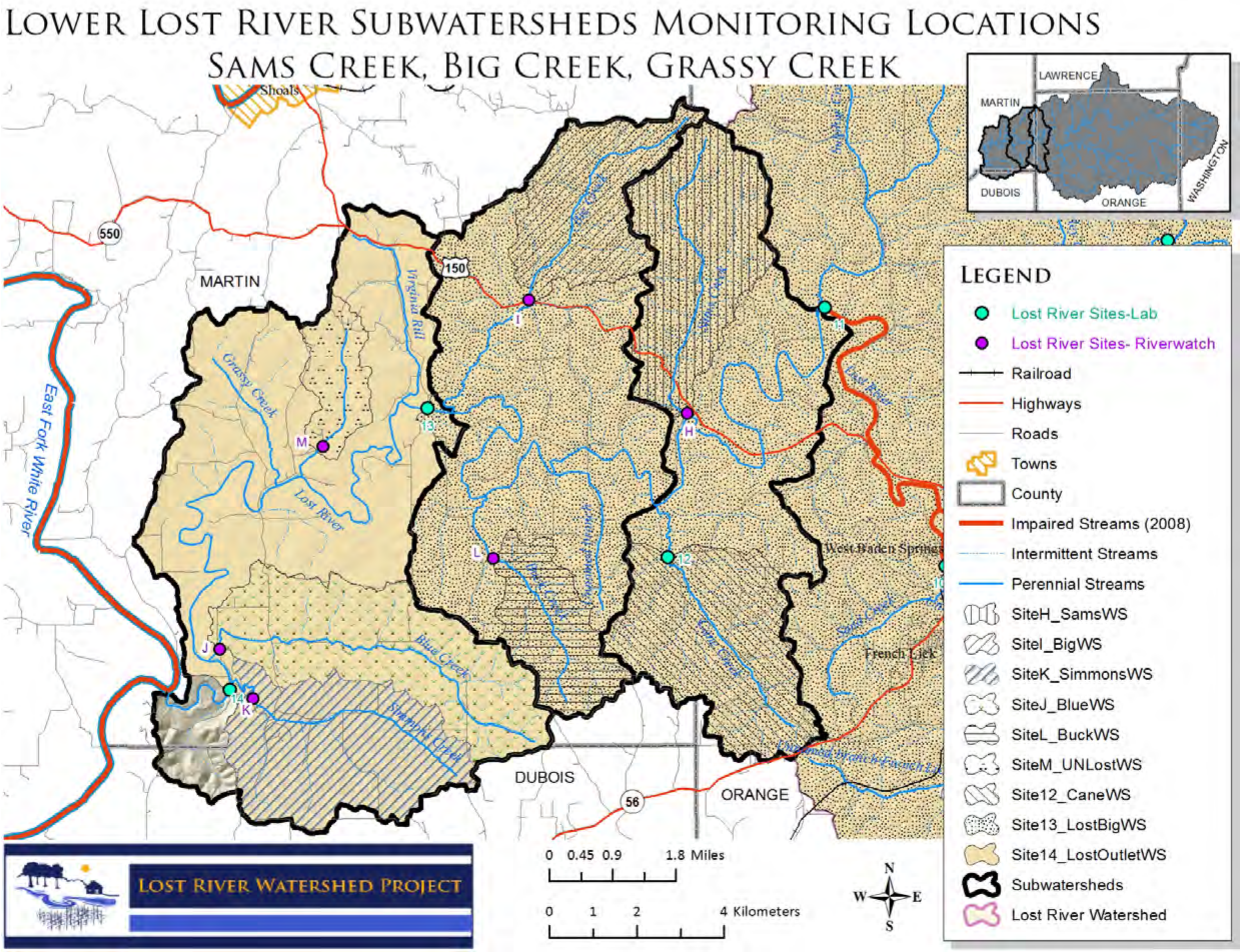


Figure 196: Sample Site subwatersheds in the Lower Lost Subwatershed Area- based on 2011-2012 sampling period

Monitoring stations are located at 16 places throughout the Lower Lost River region (Figure 195). The locations represent different positions along Lost River, as well as, locations on smaller streams that enter into Lost River. The upstream most location is on Lost River as it enters Sams Creek subwatershed (IDEM WEL160-0027). The next two sites downstream are also on Lost River prior to the confluence with Sams Creek (Davey Site 1). Two monitoring stations are located on Sams Creek prior to it entering Lost River (LARE Site 4 & Current Monitoring Site H). A monitoring station is located on Cane Creek prior to its confluence with Lost River (LARE Site 5 & Current Monitoring Site 12). Buck Creek is also monitored prior to its confluence with Lost River (LARE Site 6 & Current Monitoring Site L). A biological monitoring station is located along Lost River downstream of Cane Creek confluence but upstream of the Big Creek confluence (IDEM WEL160-0025). Big Creek is monitored at two locations a ¼ mile apart (LARE Reference Site 101 & Current Monitoring I). Another monitoring station on Lost River is located at the outlet of Big Creek subwatershed (LARE Site 2 & Current Monitoring Site 13). Virginia Rill is monitored near its confluence with Lost River (LARE Site 7). A station is located on an unnamed branch of Lost River between Virginia Rill Creek and Grassy Creek, where both IDEM biological sampling and current monitoring takes place (IDEM WEL160-0028 & Current Monitoring Site M). Grassy Creek was monitored near its outlet to Lost River through the LARE study (LARE Site 8). Lost River has been monitored between Grassy Creek and Blue Creek by both IDEM and USGS in the past (IDEM WEL160-0016 & USGS 383430086474901). Blue Creek is monitored near its outlet currently and in the past (LARE Site 9 & Current Monitoring Site J). Simmons Creek is monitored near its outlet to Lost River (LARE Site 10 & Current Monitoring Site K). Lastly, Lost River is monitored near its outlet to East Fork White River (IDEM WEL160-0003, LARE Site 3, & Current Monitoring Site 14). Figure 196 shows the relative size and locations land that drains to sample site locations for the current monitoring study.

IDEM Station WEL160-0027 Monitoring

Lost River in Sams Creek subwatershed was monitored by IDEM in 2007 for biological components (fish, macroinvertebrates, and habitat) along with basic chemistry. IDEM's station WEL160-0027 found small numbers of fish in their 2007 biological assessment in June of 2007. The IBI score for this station was 16 points, which indicates that this stream has very poor fish community characteristics. Attributes of this rating include few species and individuals present, tolerant species dominant, diseased fish frequent. They counted eight fish from seven species found in the Lost River. Five species come from the sunfish family. The remaining species came were from the drum and sucker families. At that time the QHEI score was 48 which is below our target level of 52 points. Macroinvertebrates were collected at the end of July 2007. The mIBI score at this site was 34 points, which is 2 points below target levels for the Lost River watershed. The macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life.

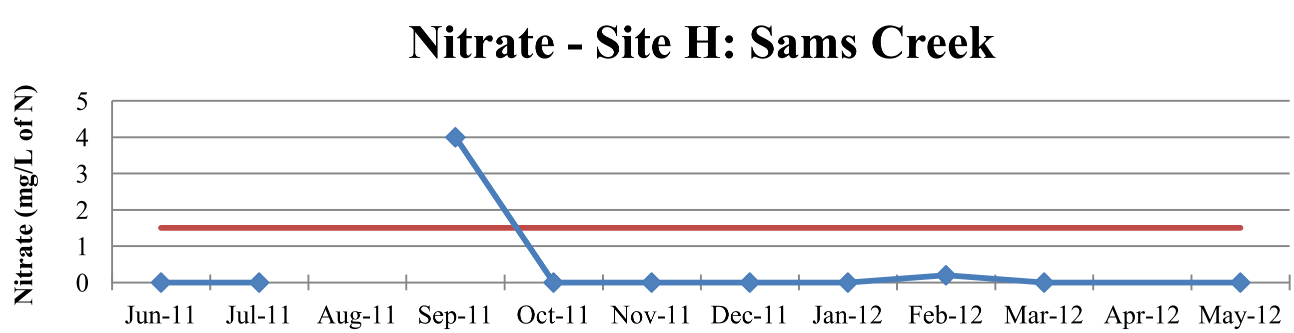
LARE Study Lost River Monitoring Station 1

LARE study Station 1 on Lost River showed elevated levels of total suspended solids (41 mg/L) during the storm event in 2010. The station had high levels of *E. coli* at this station for both the base flow (260.3 cfu/100mL) and storm flow (648.8 cfu/100mL). Temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, turbidity, and nitrate were all within current target levels. Biological information was not collected at this site.

Sams Creek Monitoring Site H

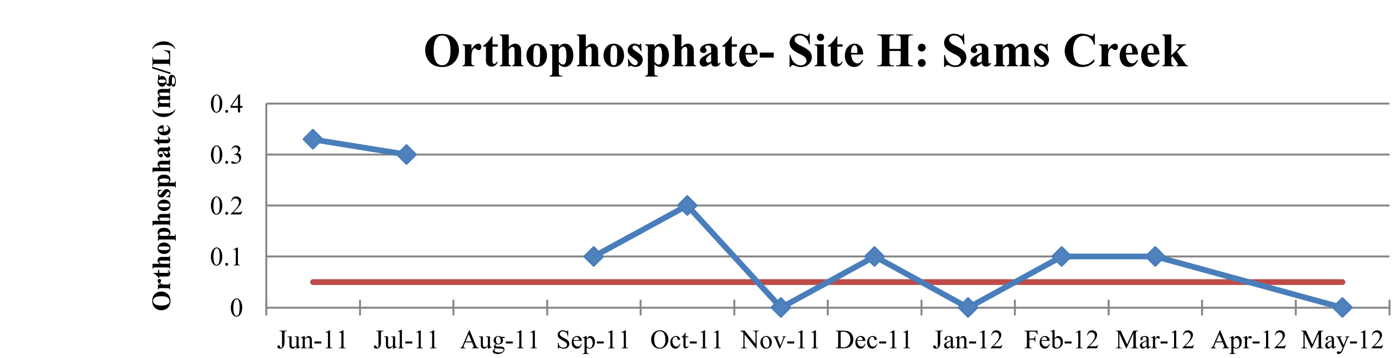
Davey Resource Group (Station 4) as well as the Hoosier Riverwatch Lost River Team (Site H) monitored Sams Creek. The Hoosier Riverwatch Lost River Team monitored Sams Creek (Site H) on a monthly basis. The channel went dry in August of 2011 so no data was collected for that month. Nitrates at this location fell well below target levels of 1.5 mg/L during all but one month of the 2011- 2012 sampling period. The highest measured value was in September with 4 mg/L, which is 2.7 times the target levels (Figure 197). Orthophosphate was above target values 7 times during the 2011-2012 sampling event. Orthophosphate spiked in June 2011 with a value of 0.33 mg/L (Figure 198). Dissolved Oxygen levels were within acceptable levels. However, Biochemical Oxygen Demand 5-Day (BOD5) did rise above our target value of 2 mg/L change in three of the months sampled (Figure 199) indicating that there may be an organic or chemical influence that is reducing the availability of oxygen to the system. Turbidity spiked in June and September with 42 NTU and 41 NTU, respectively (Figure 200). These two months were the only months above target values. pH also dropped below target levels of 6 standard units in three months from December through February (Figure 201). This is also unusual and further investigation of this potential source should be investigated. *E. coli* values did exceed target levels three times during the sampling period (Figure 202). The exceeded E. coli values occurred in September (600 CFU/100mL), March (432.9CFU/100mL), and May (700 CFU/100mL) (Figure 202). Figure 202 also shows high levels of total coliforms in September 2011 along with January and May of 2012.

Davey's Station 4 is just slightly upstream from the current monitoring station Site H on Sams Creek. The 2010 LARE study by the Davey Resource Group did not find any levels for their Station 4 exceeding our target levels in 2009 or 2010. Temperature, pH, Specific Conductance, dissolved oxygen, total phosphorous, nitrate, TSS, or turbidity all were within acceptable levels. They also tested for ammonia nitrogen at this site. The report suggests that the ammonia levels were higher than maximum standards during baseflow.



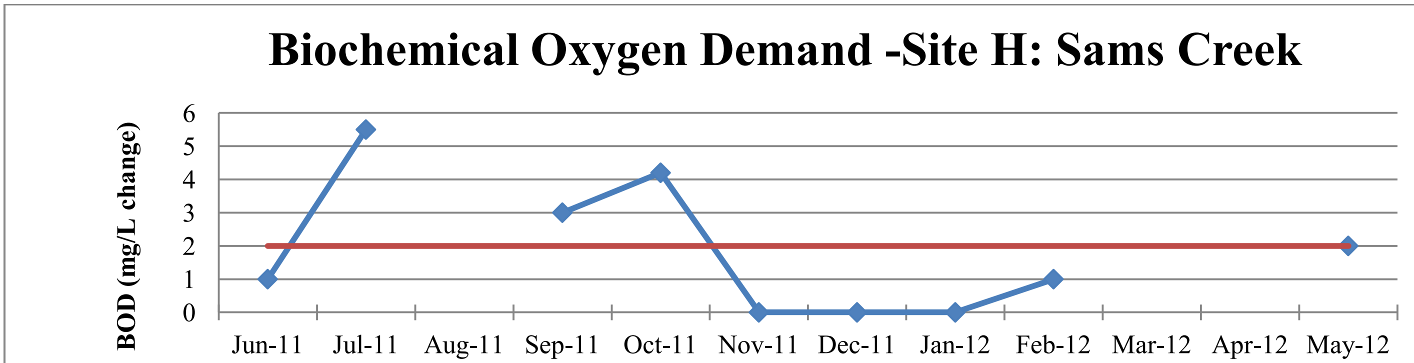
	6/13/11	7/29/11	8/27/11	9/26/11	10/27/11	11/17/11	12/29/11	1/28/12	2/26/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0		4	0	0	0	0	0.2	0	0

Figure 197: Nitrate Levels at Site H (2011-2012 testing period)



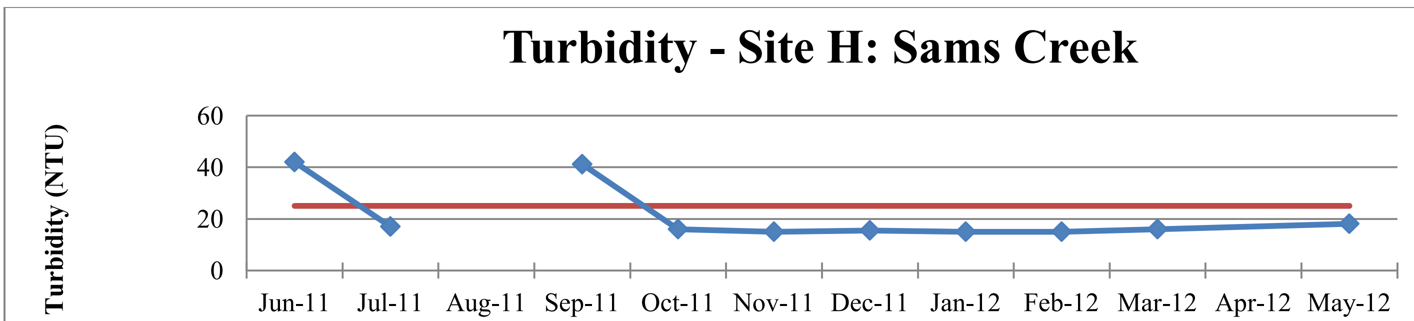
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0.33	0.3		0.1	0.2	0	0.1	0	0.1	0.1	0

Figure 198: Orthophosphate Levels at Site H (2011-2012 testing period)



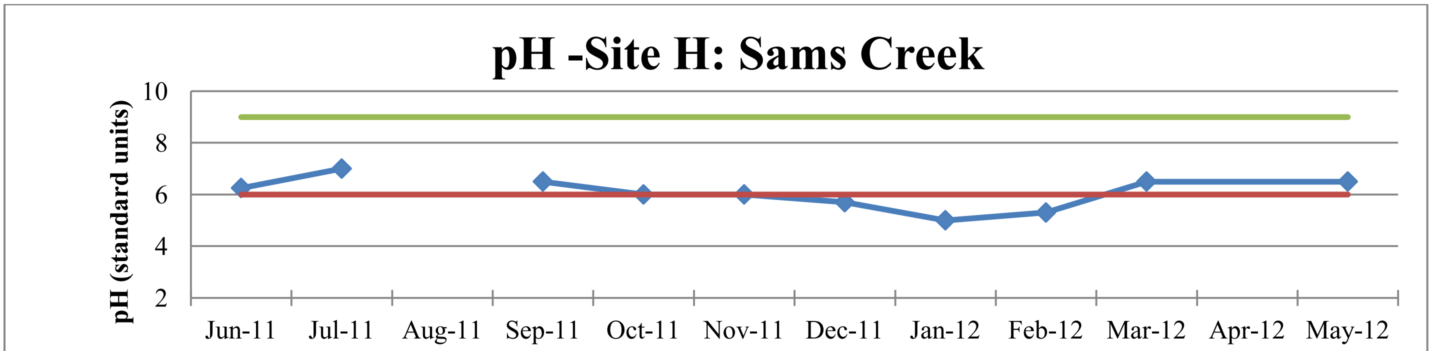
	6/13/11	7/29/11	8/27/11	9/26/11	10/27/11	11/17/11	12/29/11	1/28/12	2/26/12	3/30/12	5/2/12
BOD5	1	5.5		3	4.2	0	0	0	1		2
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 199: Biochemical Oxygen Demand (BOD) Levels at Site H (2011-2012 testing period)



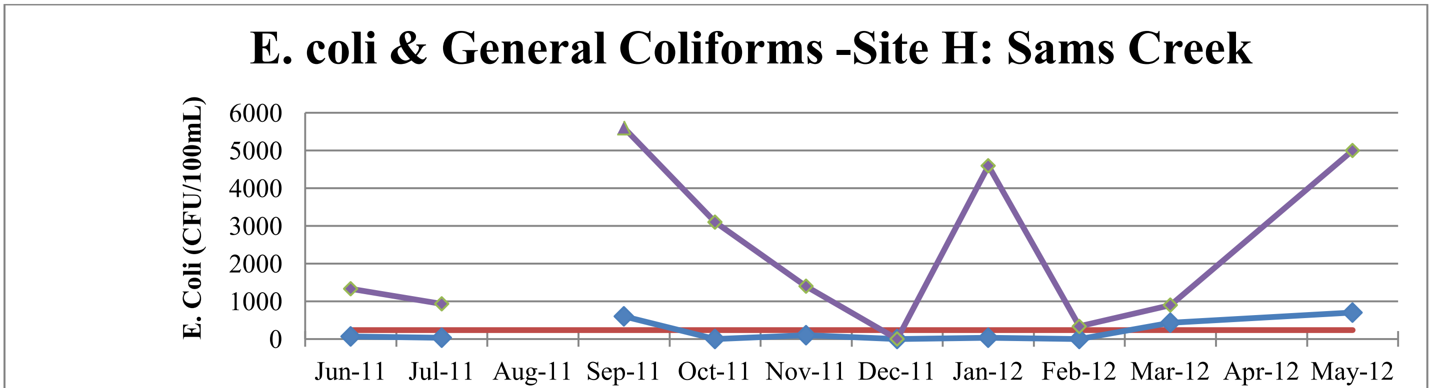
	6/13/11	7/29/11	8/27/11	9/26/11	10/27/11	11/17/11	12/29/11	1/28/12	2/26/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	42	17		41	16	15	16	15	15	16	18

Figure 200: Turbidity Levels at Site H (2011-2012 testing period)



	6/13/11	7/29/11	8/27/11	9/26/11	10/27/11	11/17/11	12/29/11	1/28/12	2/26/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.25	7		6.5	6	6	5.7	5	5.3	6.5	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 201: pH Levels at Site H (2011-2012 testing period)



	6/13/11	7/29/11	8/27/11	9/26/11	10/27/11	11/17/11	12/29/11	1/28/12	2/26/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	66.7	33.3		600	0	100	0	33.3	0	432.9	700
General Coliforms	1332	932.4		5600	3100	1400	0	4595.4	333	899.1	5000

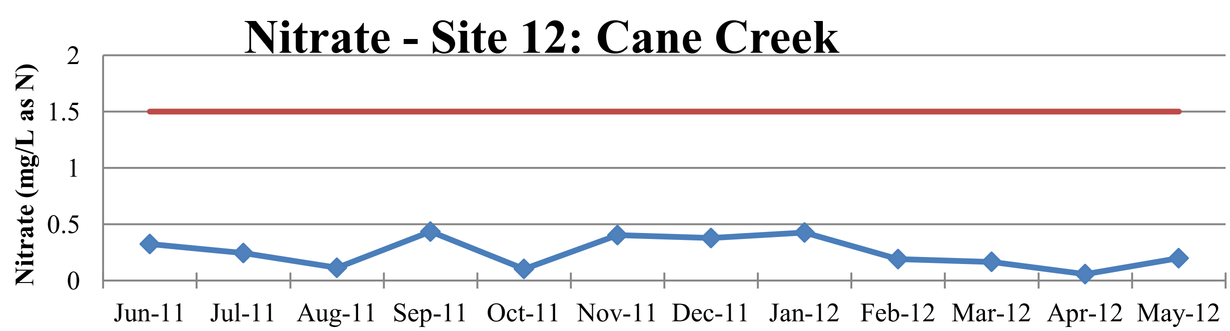
Figure 202: E. coli and General Coliform Levels at Site H (2011-2012 testing period)

Biological samples have been collected at Site H through current sampling efforts. The habitat in Sams Creek was determined to be poor with a citizens QHEI score of 33. The site shows highly channelized streams, numerous tile drains and lack of sufficient substrate to support life. The macroinvertebrate scores indicate that this section of Lost River is severely impaired for aquatic life. The Pollution Tolerance Index score of 3 at this site indicated that there was a bad population and diversity of macroinvertebrates at this site. The HRLR team commented on how poor the populations and species of macroinvertebrates were at this site. This low score is likely due to the quality of habitat and possibly influence from pesticides that may make it through the tile drains. Biological samples have been collected upstream of this site before by the LARE diagnostic study. The LARE study found a quality habitat (QHEI = 63 points) and an excellent macroinvertebrate score which indicates that the influence of headcutting and channelization that is occurring in the field separating the two sites may be causing the difference in aquatic life.

Cane Creek Monitoring Site 12

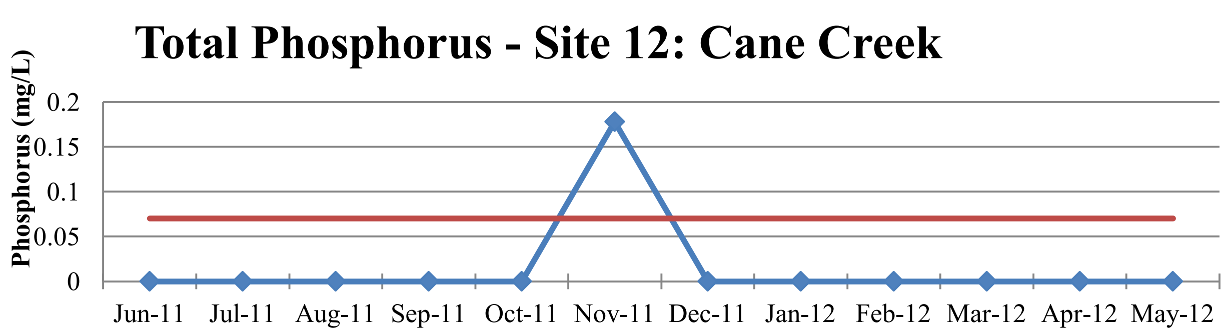
Davey Group (Station 5) and the Lab (Site 12) monitored Cane Creek. The Lab monitored this site in the current water monitoring event in 2011-2012. This site is located in the middle of the streams course to Lost River. Nitrate levels on Cane Creek constantly fell below target levels (Figure 203). This site has low nitrate levels that will not be a problem for the area. Total phosphorus exceeded target levels once in November 2011 with 0.178 mg/L, which is 2.5 times the target level of 0.07 mg/L (Figure 204). Turbidity exceeded target levels of 25 NTU once during the 2011-2012 sampling year (Figure 205). Turbidity levels spiked in November 2011 with 81.7 NTU or 3.3 times target levels. Total suspended solids (TSS) exceeded target levels of 25 mg/L at the same time that turbidity exceeded target levels (Figure 206 & 205). TSS levels exceeded target levels in November 2011 with 92 mg/L or 3.7 times target levels (Figure 206). *E. coli* exceeded target levels 4 months out of the 12 months sampled (Figure 207). The highest value recorded was 1986.3 MPN/100mL in November 2011. Dissolved oxygen, specific conductivity, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.

LARE study Station 5 on Cane Creek showed no elevated levels for any of the samples collected. Temperature, pH, specific conductivity, E. coli, dissolved oxygen, total phosphorus, TSS, turbidity, and nitrate were all within current target levels.



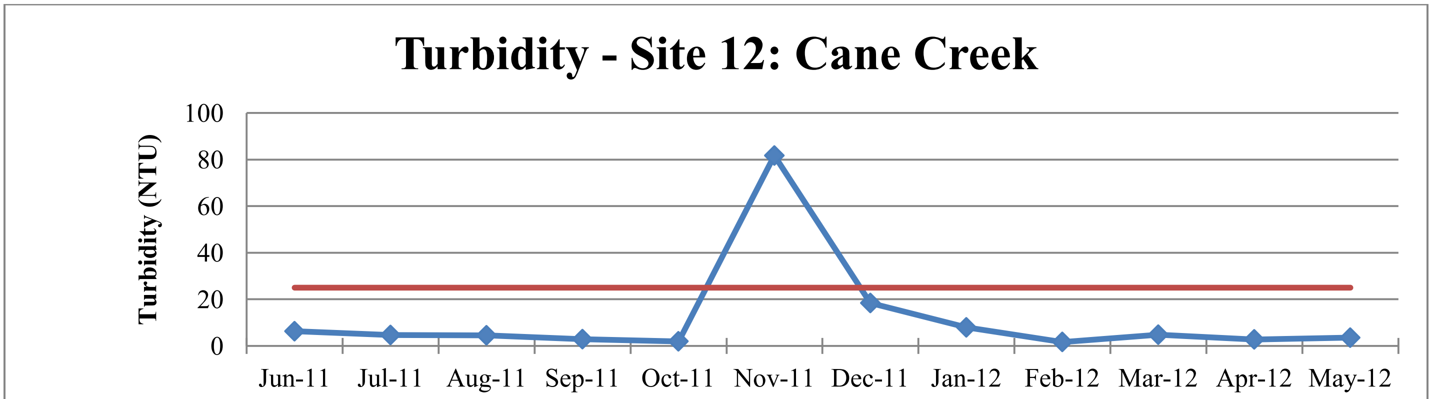
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	0.324	0.244	0.113	0.434	0.103	0.403	0.377	0.426	0.19	0.166	0.057	0.198
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 203: Nitrate Levels at Site 10 (2011-2012 testing period)



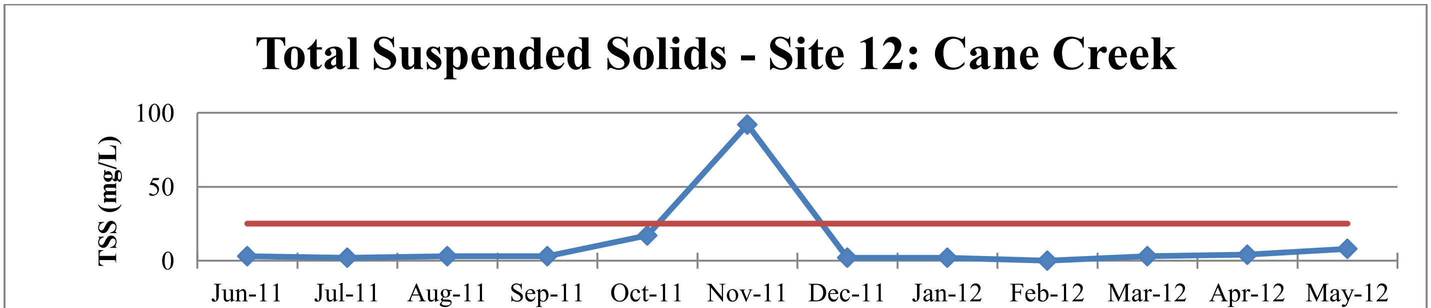
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0	0	0	0	0	0.178	0	0	0	0	0	0
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 204: Total Phosphorus Levels at Site 12 (2011-2012 testing period)



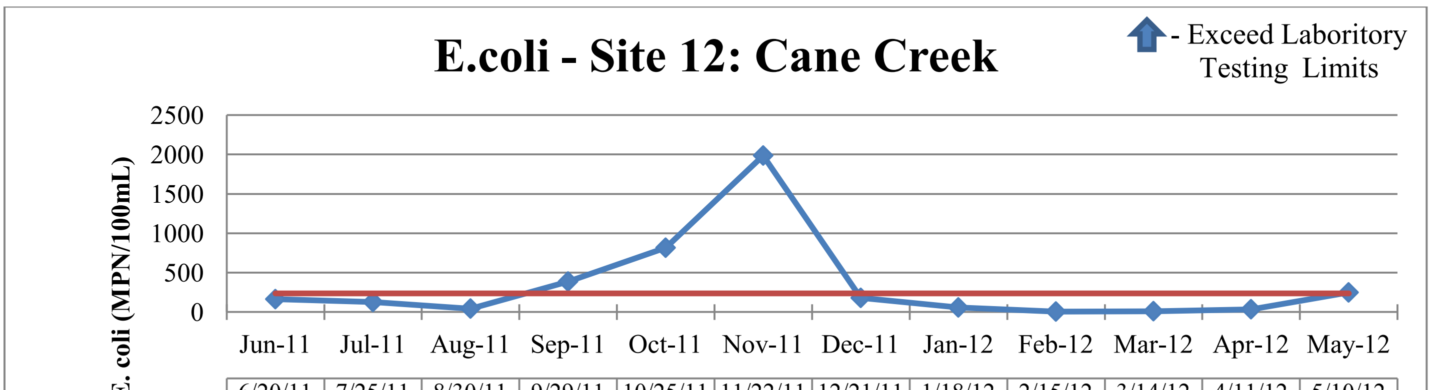
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	6.28	4.66	4.53	2.88	1.95	81.7	18.4	7.93	1.69	4.8	2.78	3.52
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 205: Turbidity Levels at Site 12 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	3	2	3	3	17	92	2	2	0	3	4	8
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 206: Total Suspended Solid (TSS) Levels at Site 12 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	163.8	128.1	44.1	387.3	816.4	1986.3	179.9	58.1	6.3	11	35.5	248.9
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 207: E. coli Levels at Site 12 (2011-2012 testing period)

Biological samples have been collected at Site 12 on Cane Creek through current sampling efforts. The habitat in Cane Creek was determined to be good with a QHEI score of 60. The site shows good quality habitat and good quality aquatic life. The macroinvertebrate scores indicate that this section of Lost River is not impaired for aquatic life. The mIBI score at this site was 40 points, which is above the target score of 36. This high score is likely due to the quality of habitat and lack of significant water quality problems. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat and macroinvertebrate data on this portion of Cane Creek as well during the LARE diagnostic study. Biological information indicated a quality habitat (QHEI=74), and very good population of macroinvertebrates.

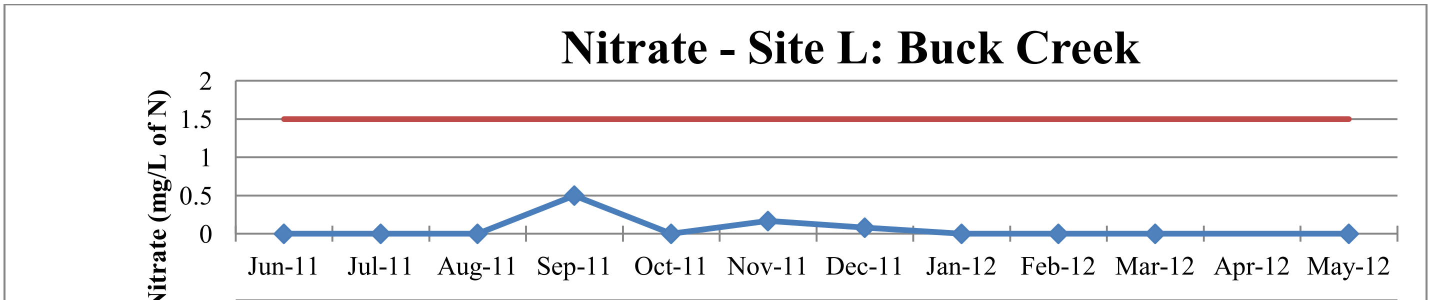
IDEM Station WEL160-0025 Monitoring

Biological monitoring performed by IDEM at stations WEL 160-0025 in 2007 found 12 species of sunfishes, shads, minnows, suckers, drums, and gars with a total count of 21. The most predominant fish was longear sunfish (Lepomis megalotis) accounting for 19% of the fish count. A close second was the golden redhorse (Moxostoma erythrurum), which accounted for another 14% of the fish counted. The site was given a score of 20 for Index of Biology Integrity. This indicates very poor fish community characteristics and indicates few species and individuals present, tolerant species dominant, and diseased fish frequent. The habitat was assessed with QHEI for a score of 53, which indicates a fair quality habitat. The macroinvertebrate mIBI score for the site was 38, which indicates it is not impaired for aquatic life. At this site *E. coli* was just slightly (275.5 cfu/100mL) over target levels. Both nitrates+nitrites nitrogen and total phosphorus exceeded target levels twice out of the three samples collected. Dissolved oxygen was below water quality standards in September with a value of 3.2 mg/L. This was the only sample out of ten samples where dissolved oxygen was low. Turbidity was above target levels in three out of the nine samples collected. The highest value of turbidity was 60.7 NTU. pH and temperature fell within normal levels for each sample collected.

Buck Creek Monitoring Site L

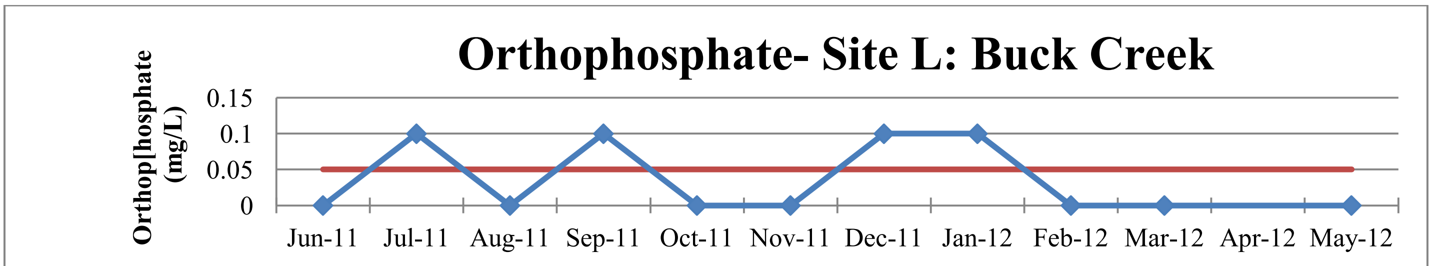
Buck Creek is monitored by the Hoosier Riverwatch Lost River (HRLR) Team (Site L) and by the Davey group (Station 6). The HRLR team monitored this site for the current water monitoring event in 2011-2012. This site is located in the middle of the streams course to Lost River. Nitrate levels on Buck Creek constantly fell below target levels (Figure 208). This site has low nitrate levels that will not be a problem for the area. Orthophosphate levels at Site L exceeded target levels of 0.05 mg/L four times during the 2011-2012 sampling period (Figure 209). Dissolved oxygen levels did fall below target levels to 3.7 mg/L in August of 2011(Figure 210). This may have been due to the relatively stagnant water at the site during this testing period. pH levels fell below target levels indicating the water was too acidic in November through January in Buck Creek (Figure 211). Turbidity levels increased in September, but they remained below target levels through the testing period (Figure 212). *E. coli* levels exceeded target values of 235 CFU/100ml once during the year in September with a value of 1500 CUF/100mL (Figure 213). Figure 213 also shows high levels of total coliforms in September 2011 and January 2012. Temperature and BOD5 were within target levels at this site throughout the testing period.

The Davey group conducting LARE study showed that Station 5 found high *E. coli* readings (2419.6 cfu/100 mL) from the stormflow event in 2010. LARE study showed no elevated levels for any other parameters collected. Temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, TSS, turbidity, and nitrate were all within current target levels.



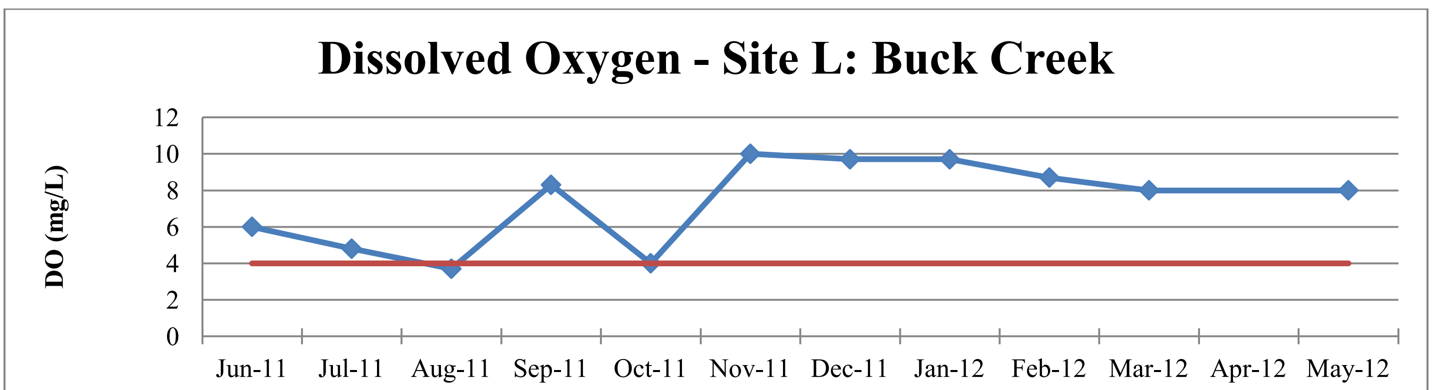
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0	0	0.5	0	0.17	0.08	0	0	0	0

Figure 208: Nitrate Levels at Site L (2011-2012 testing period)



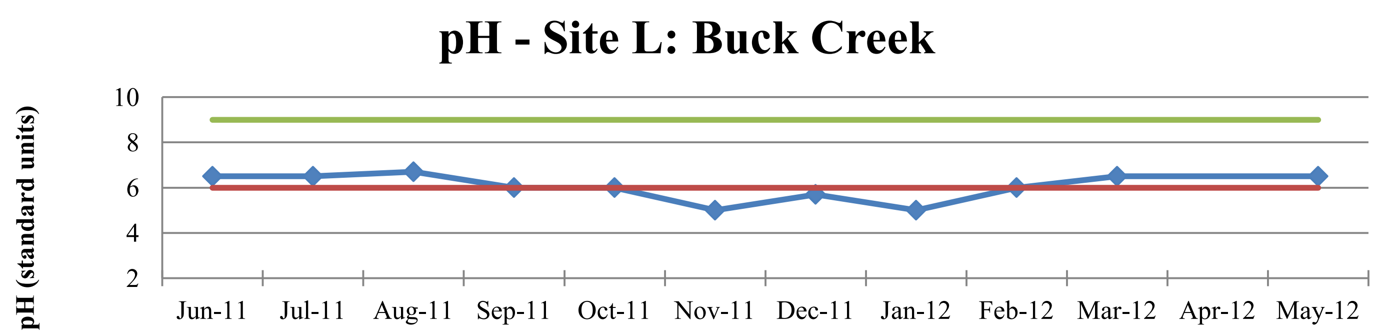
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0	0.1	0	0.1	0	0	0.1	0.1	0	0	0

Figure 209: Orthophosphate Levels at Site L (2011-2012 testing period)



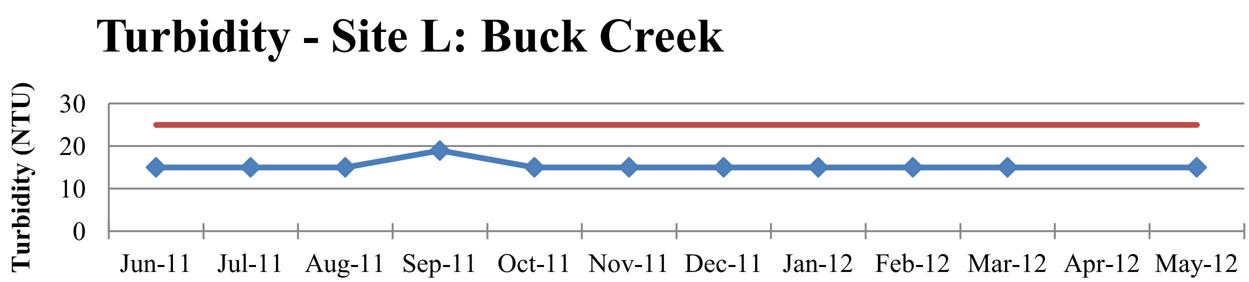
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
DO	6	4.8	3.7	8.3	4	10	9.7	9.7	8.7	8	8
DO Min	4	4	4	4	4	4	4	4	4	4	4

Figure 210: Dissolved Oxygen Levels at Site L (2011-2012 testing period)



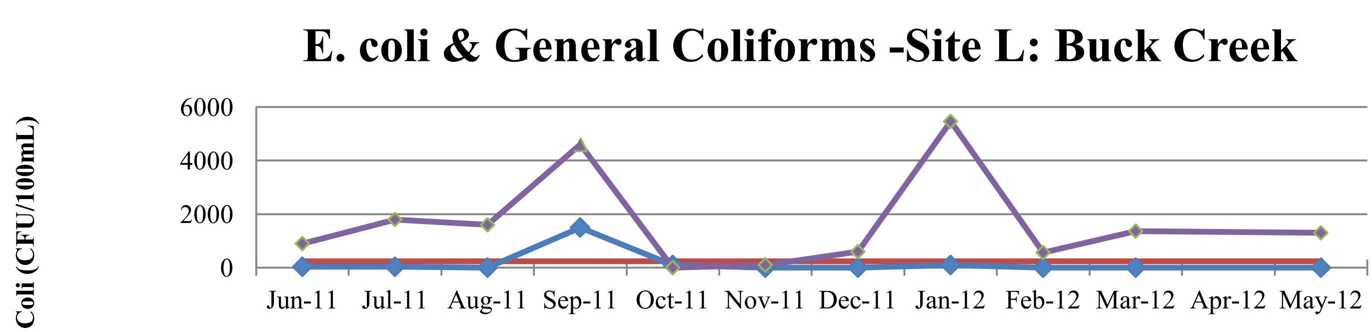
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.5	6.5	6.7	6	6	5	5.7	5	6	6.5	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 211: pH Levels at Site L (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	15	15	19	15	15	15	15	15	15	15

Figure 212: Turbidity Levels at Site L (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	33.3	33.3	0	1500	100	0	0	99.9	0	0	0
General Coliforms	899	1798.2	1598.4	4600	0	100	600	5461.2	566.1	1365.3	1300

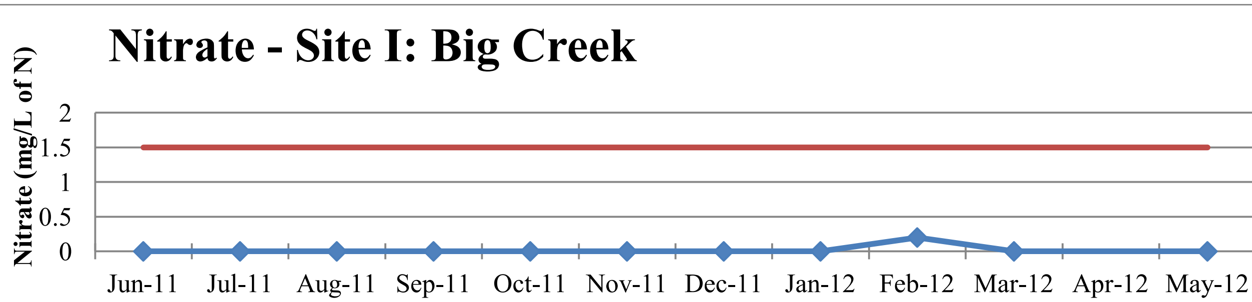
Figure 213: E. coli & General Coliform Levels at Site L (2011-2012 testing period)

Biological samples have been collected at Site L through current sampling efforts. The habitat in Buck Creek was determined to be excellent with a citizens QHEI score of 79. The site shows good quality habitat and good quality aquatic life. The macroinvertebrate scores indicate that this section of Lost River is not impaired for aquatic life. The Pollution Tolerance Index score of 19 at this site indicated that there was a good population and diversity of macroinvertebrates at this site. This high score is likely due to the quality of habitat and lack of significant water quality problems. The low dissolved oxygen levels and low pH levels detected at this site must not have been significant enough to affect macroinvertebrate populations. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat and macroinvertebrate data on this portion of Buck Creek as well during the LARE diagnostic study. Biological information indicated a high quality habitat (QHEI=86), and an excellent population of macroinvertebrates.

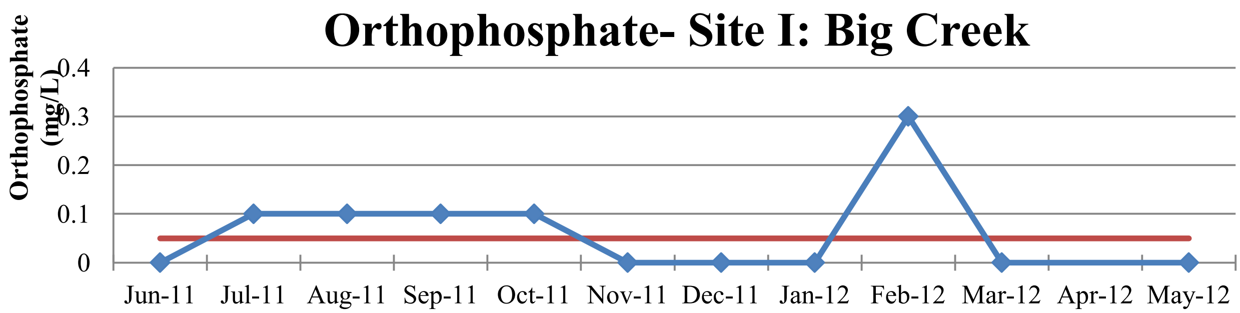
Big Creek Monitoring Site I

The Hoosier Riverwatch Lost River Team (Site I) and the Davey group (Station R, 101 on Figure 195) monitor Big Creek. The Davey Group considered this their reference stream for the area. They found no problems within any parameters collected at this stream. However, some target levels were not reached during the current 2011-2012 monitoring study. Nitrate levels on Big Creek constantly fell below target levels (Figure 214). Orthophosphate levels at Site I exceeded target levels of 0.05 mg/L five times during the 2011-2012 sampling period (Figure 215). The highest level observed was in February 2012 with an orthophosphate level of 0.3 mg/L, or 6 times target levels. Dissolved oxygen levels did not fall below target levels. However, BOD levels exceeded the target of 2 mg/L change twice in July (4.8 mg/L change) and September (3.3 mg/L change) (Figure 216). pH levels fell below target levels to a low of 5 standard units, indicating the water was too acidic in December through February in Big Creek (Figure 217). Turbidity levels increased in September to 37 NTU, which is above target levels (Figure 218). *E. coli* levels exceeded target values of 235 CFU/100ml three times during the year in June, July and September with a value of 765.9 CUF/100mL, 333.3 CUF/100mL, and 700 CUF/100mL, respectively (Figure 219). Figure 219 also shows high levels of total coliforms in August and September of 2011 and May 2012. Temperature was within target levels at this site throughout the testing period.



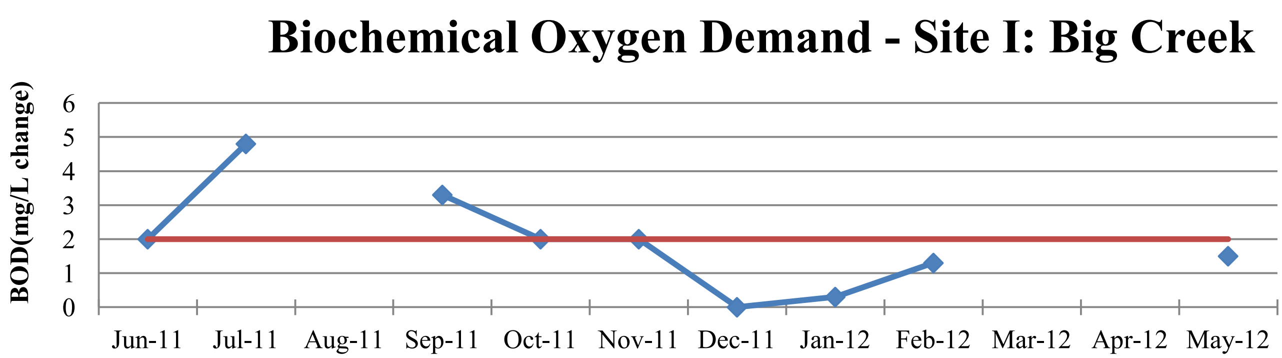
	6/13/11	7/29/11	8/27/11	9/29/11	10/27/11	11/17/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0	0	0	0	0	0	0	0	0.2	0	0

Figure 214: Nitrate Levels at Site I (2011-2012 testing period)



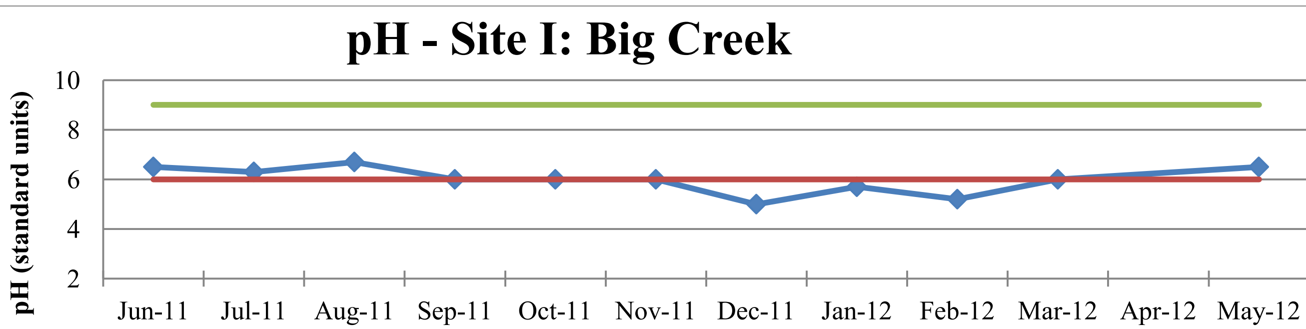
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0	0.1	0.1	0.1	0.1	0	0	0	0.3	0	0

Figure 215: Orthophosphate Levels at Site I (2011-2012 testing period)



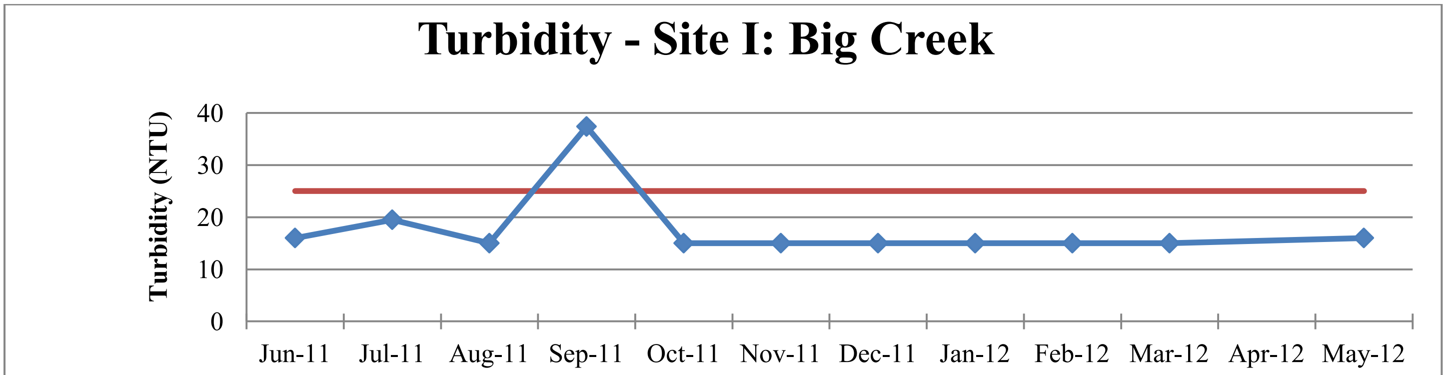
	6/13/11	7/29/11	8/27/11	9/29/11	10/27/11	11/17/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
BOD5	2	4.8		3.3	2	2	0	0.3	1.3		1.5
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 216: Biochemical Oxygen Demand (BOD) Levels at Site I (2011-2012 testing period)



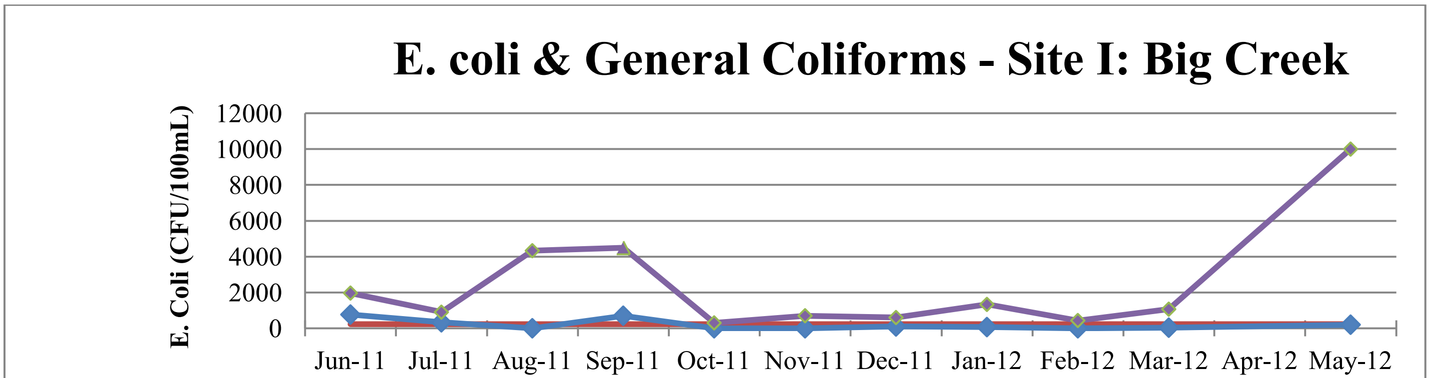
	6/13/11	7/29/11	8/27/11	9/29/11	10/27/11	11/17/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.5	6.3	6.7	6	6	6	5	5.7	5.2	6	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 217: pH Levels at Site I (2011-2012 testing period)



	6/13/11	7/29/11	8/27/11	9/29/11	10/27/11	11/17/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	16	19.5	15	37	15	15	15	15	15	15	16

Figure 218: Turbidity Levels at Site I (2011-2012 testing period)



	6/13/11	7/29/11	8/27/11	9/29/11	10/27/11	11/17/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	765.9	333.3	0	700	0	0	100	66.6	0	33.3	200
General Coliforms	1964.7	899.1	4329	4500	300	700	600	1332	432.9	1065.6	10000

Figure 219: E. coli & General Coliform Levels at Site I (2011-2012 testing period)

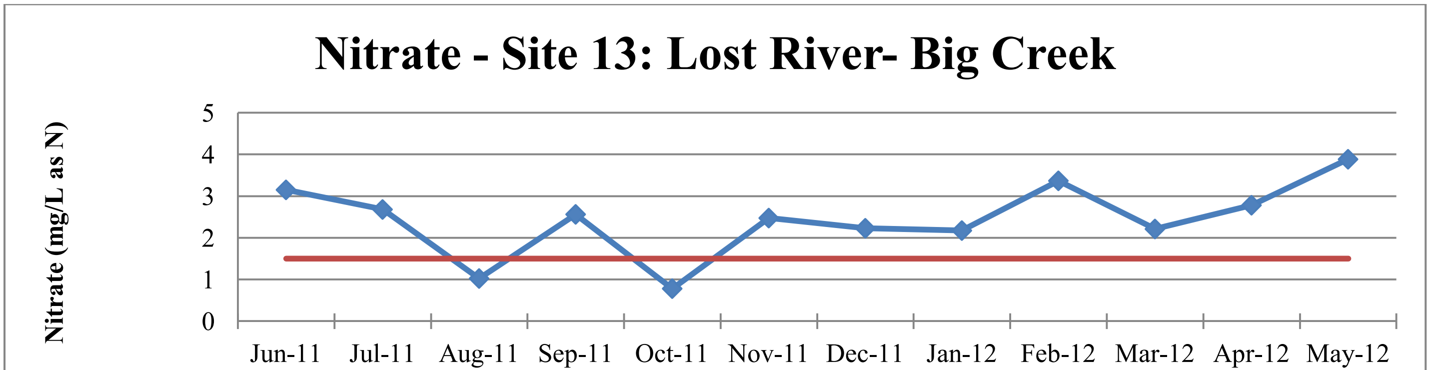
Biological samples have been collected at Site I through current sampling efforts. The habitat in Big Creek was determined to be poor with a citizens QHEI score of 47. The site shows poor quality habitat. This is likely due to the extreme siltation of substrate, which smothers aquatic life. The macroinvertebrate scores indicate that this section of Big Creek is impaired for aquatic life. The Pollution Tolerance Index score of 13 at this site indicated that there was a fair population and diversity of macroinvertebrates at this site. This low score is likely due to the lack of quality of habitat. The stream may have low levels of oxygen in early morning hours due to the high BOD. This could be the cause of some of the lower macroinvertebrate populations. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collect habitat and macroinvertebrate data slightly upstream of current sampling efforts on Big Creek Biological information indicated a good quality habitat (QHEI=64), and good population of macroinvertebrates.

Lost River Monitoring Site 13

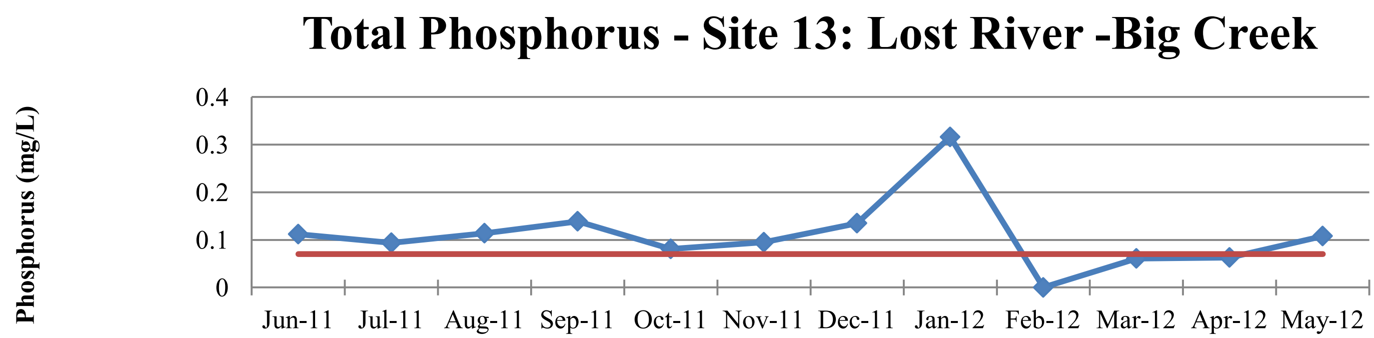
Lost River is monitored as it leaves Big Creek subwatershed (Figure 196). This sample site's watershed is very large and covers a large majority of the Lost River watershed (Figure 240). This shows the collective land that drains all the water from all tributaries and streams entering into Lost River prior to Grassy Creek. This site is also downstream from the 121 acre wetland complex managed by Hoosier National Forest. Wetlands are able to filter and decrease pollutants from the stream system. Data was collected at this location by Davey Group (Station 2) and through the current 2011-2012 monitoring by the Lab (Site 13). Nitrate levels were above target levels in most months. Only two times were levels of nitrate below target levels. Nitrate levels hit a high of 3.884 mg/L in May of 2012 (Figure 220). Total phosphorus levels were also above target levels for the majority of the sampling period (Figure 221). The highest total phosphorus level was 0.316 mg/L, which is 4.5 times the target level. Three times turbidity levels exceeded target levels of 25 NTU. They were in June (26.6 NTU), December (53.4 NTU), and January (133 NTU)(Figure 222). Total suspended solids had similar results with target levels not reached in June (27 mg/L), December (42 mg/L), and January (141 mg/L) (Figure 223). Temperature levels exceeded target levels in March of 2012 with a 16.1°C, which is half degree higher than target levels of 15.6°C for the month of March (Figure 224). This may be due to the warm weather and quicker than usual warm up that spring. *E. coli* counts exceeded target levels half of the time (Figure 225). *E. coli* levels did exceed testing detection levels in January 2012. Dissolved oxygen, specific conductivity, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.

The Davey group found elevated levels of total suspended solids (59 mg/L) and *E. coli* (387.3 CFU/100mL) during their storm sampling. LARE study showed no elevated levels for any other parameters collected. Temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, turbidity, and nitrate were all within current target levels.



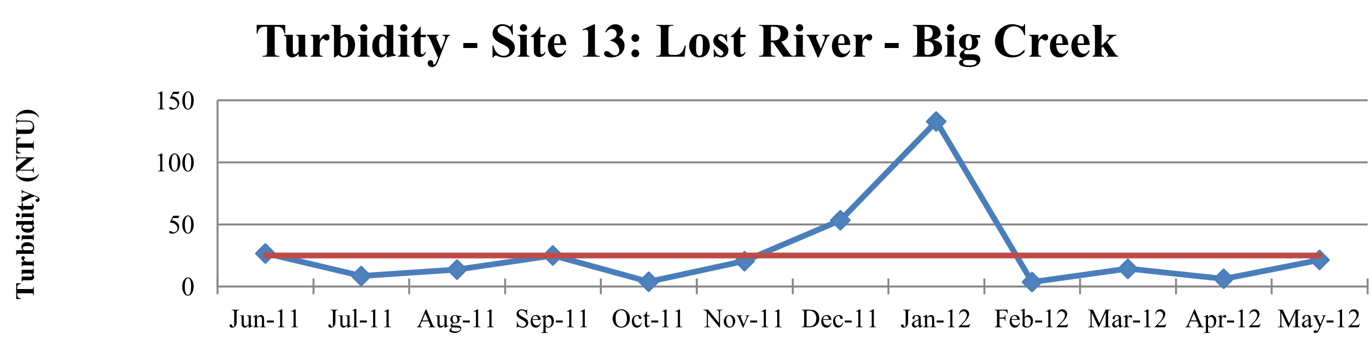
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	3.15	2.679	1.023	2.562	0.78	2.473	2.228	2.173	3.367	2.211	2.781	3.884
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 220: Nitrate Levels at Site 13 (2011-2012 testing period)



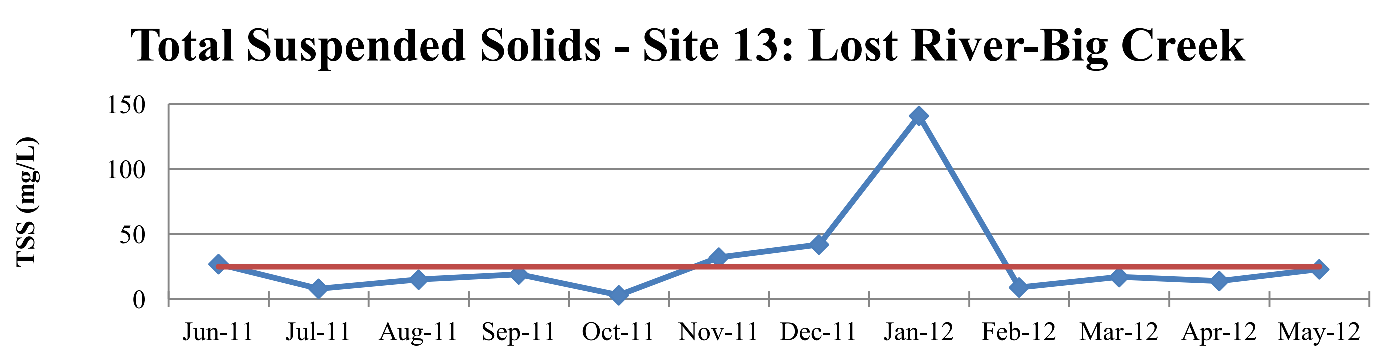
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.112	0.094	0.114	0.139	0.081	0.095	0.135	0.316	0	0.061	0.063	0.108
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 221: Total Phosphorus Levels at Site 13 (2011-2012 testing period)



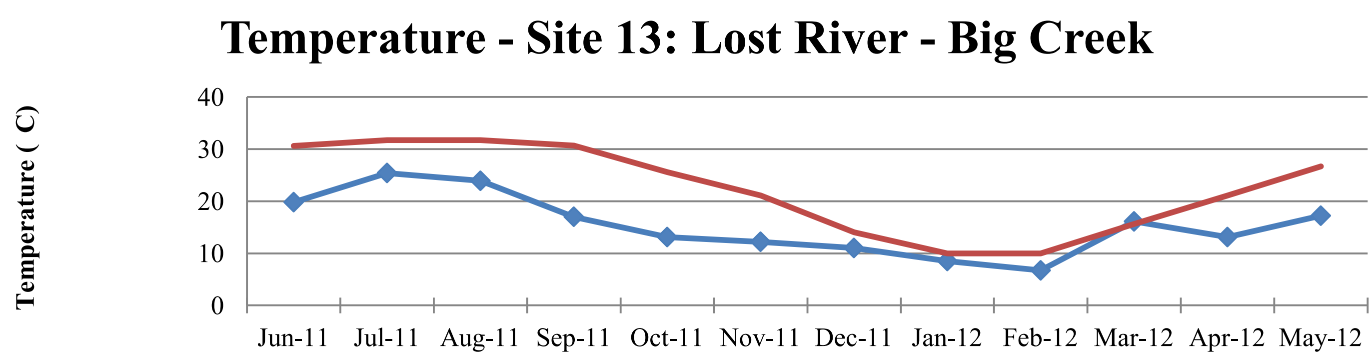
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	26.6	8.43	13.6	25	3.8	20.4	53.4	133	3.6	14.2	6.18	21.4
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 222: Turbidity Levels at Site 13 (2011-2012 testing period)



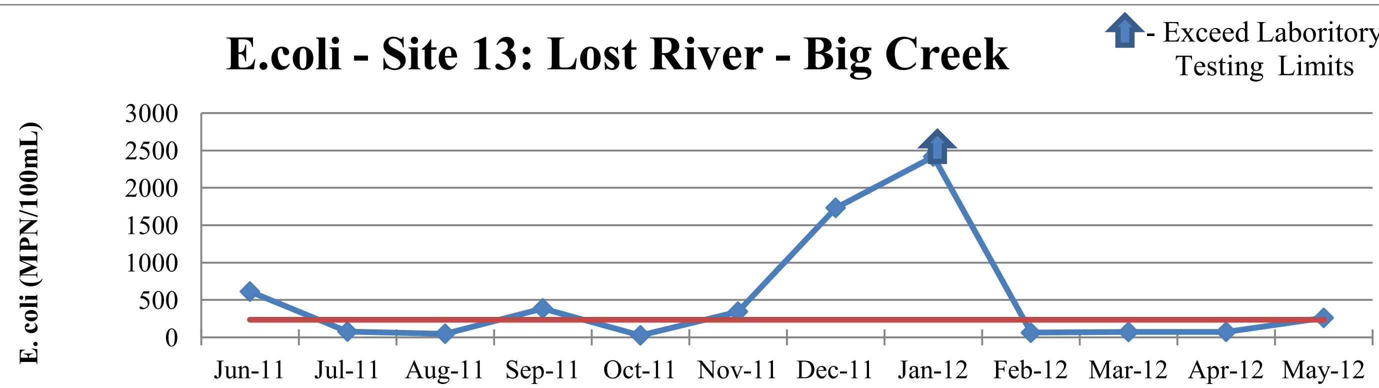
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	27	8	15	19	3	32	42	141	9	17	14	23
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 223: Total Suspended Solids (TSS)Levels at Site 13 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Temperature (C)	19.8	25.4	23.9	17	13.1	12.2	11	8.5	6.7	16.1	13.1	17.2
Temp Max	30.6	31.7	31.7	30.7	25.6	21.1	14	10	10	15.6	21.1	26.7

Figure 224: Temperature Levels at Site 13 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	613.1	77.6	48.8	387.3	27.2	344.8	1732.9	2419.6	63.1	72.8	74.9	261.3
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 225: E. coli Levels at Site 13 (2011-2012 testing period)

Biological samples have been collected at Site 13 on Lost River through current sampling efforts. The habitat in Lost River was determined to be good with a QHEI score of 73. The site shows good quality habitat but less than desirable aquatic life. The macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 32 points, which is below the target score of 36. This low score is likely due to the relatively poor water quality. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat but not macroinvertebrate data on this portion of Lost River during the LARE diagnostic study. Habitat information indicated a good quality habitat with a QHEI score of 63. Macroinvertebrate information was not collected at this site during this study.

LARE Study Virginia Rill Monitoring Station 7

Davey Resource Group sampled Virginia Rill in 2009 and 2010 at Station 7. There was high levels of *E.coli* (1119.9 CFU/100ml) during the storm event. Temperature, pH, dissolved oxygen, total phosphorus, nitrate, TSS, and turbidity were all within target levels for this site during both stormflow and baseflow. Virginia Rill upstream of HWY 150 shows signs of acid mine drainage. Streams have an orange tinge to their bottoms during low flow periods. DNR Division of Reclamation has conducted some treatments in areas close to this stream and may be treating this stream as well. A series of waterfalls from driveways and other cascading sites may be oxygenating the water sufficiently to remove metals by the time it reached this sampling location. No evidence of metal deposits or acidity remains by the time water reaches the sample site.

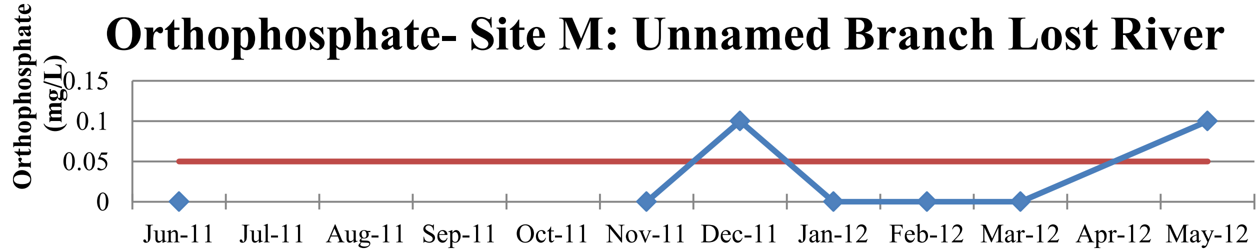
The site scored excellent for its habitat with a QHEI score of 78. However, this was one of the lower quality macroinvertebrate stations collected by Davey with still a good rating on aquatic life. The effects of upstream water quality may be still affecting populations at this point in the streams course.

Unnamed Branch Lost River Monitoring Site M

The Hoosier Riverwatch Lost River Team monitored an unnamed branch of Lost River (Site M) in the 2011-2012 current monitoring study. This site is approximately 2.5 miles downstream of the abandoned mine site where only pH was tested. During the months of July through November, there was no flow within this section of the stream channel. Data was only collected for seven months out of the year at this station. At the upstream site or mine drainage site, flow occurred in September and October, but did not make it down to Site M. Due to the lack of water at Site M in September and October, biological assessments were not performed by the HRLR Team.

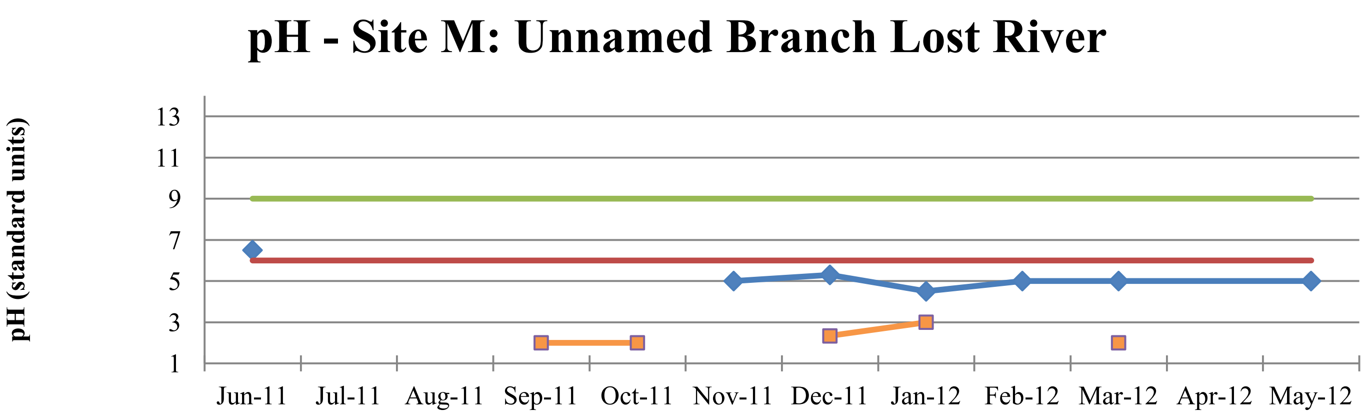
Nitrates were below detection limits in every sample tested at Site M. Orthophosphate was the only parameter besides pH that exceeded target levels more than one month (Figure 226). The highest amount or orthophosphate found at this site was 0.1 mg/L, which is 0.05 mg/L over the standard. BOD had one sample that exceeded target levels of 2 mg/L of change in 5 days. That was in February with a BOD measurement of 2.7 mg/L change. *E. coli* never got over 33.3 CFU/100mL in any sample, and most (5) samples had zero *E. coli*. Total coliforms did spike in May 2012 with a value of 2500 cfu/100mL while all other months tested showed very low values. pH, on the other hand, dropped below target values for most samples collected (Figure 227). pH stayed in the 4.5 to 6.5 range for all samples. This is a large improvement on pH from upstream where samples ranged between 2 and 3 (Figure 227).

IDEM monitored station WEL 160-0028 on unnamed branch of Lost River in the summer of 2007 for biological components (fish, macroinvertebrates, and habitat) along with chemistry. They collected water chemistry samples during 9 different days. Most field measurements were made on each sampling day. They found reduced conductivity at the station. The values ranged from 219 to 278 µS/cm , this is below our target values of 500 µS/cm, which is a desirable level for fish communities. Dissolved oxygen levels were below target levels of 4 mg/L three out of the nine samples collected with a low of 1.31 mg/L. Turbidity was above target levels three out of the eight samples collected for this parameter. Highest turbidity was 53.8 NTU. E. coli levels exceeded water quality standards twice out of the five samples collected for this parameter. Nitrogen (nitrate + nitrite), total phosphorous, and total suspended solids were only collected twice at this site and all samples for these parameters were within target levels.



	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0					0	0.1	0	0	0	0.1

Figure 226: Orthophosphate Levels at Site M (2011-2012 testing period)



	6/13/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/28/12	2/28/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.5					5	5.3	4.5	5	5	5
pH upstream				2	2		2.3	3		2	
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 227: pH Levels at Site M and Upstream at the Mine Drainage Site (2011-2012 testing period)

IDEM's station WEL160-0028 found small numbers of fish in their 2007 biological assessment in June of 2007. The IBI score for this station was 28 points, which indicates that this stream has poor fish community characteristics. Attributes of this rating include few species and individuals present, tolerant species dominant, diseased fish frequent. They counted thirty-nine fish from nine species found at this site. Five species come from the carp and minnow family. The remaining species came were from the perches, sunfish, bullhead, and chubsucker families. At that time the QHEI score was 52 which is at our target level. Macroinvertebrates were collected at the end of July 2007. The mIBI score at this site was 32 points, which is 4 points below target levels for the Lost River watershed. The macroinvertebrate scores indicate that this stream is impaired for aquatic life.

LARE Study Grassy Creek Monitoring Station 8

The Davey Resource Group at Station 8 monitored Grassy Creek. The sampling results show elevated *E.coli* values for the base and storm flow samplings. The *E.coli* value during base flow was 547.5 cfu/100mL and the value during the storm flow exceeded the detection limits of the test making the value greater than 2419.6 cfu/100mL. Temperature, pH, dissolved oxygen, total phosphorus, nitrate, TSS, and turbidity were all within target levels for this site during both stormflow and baseflow.

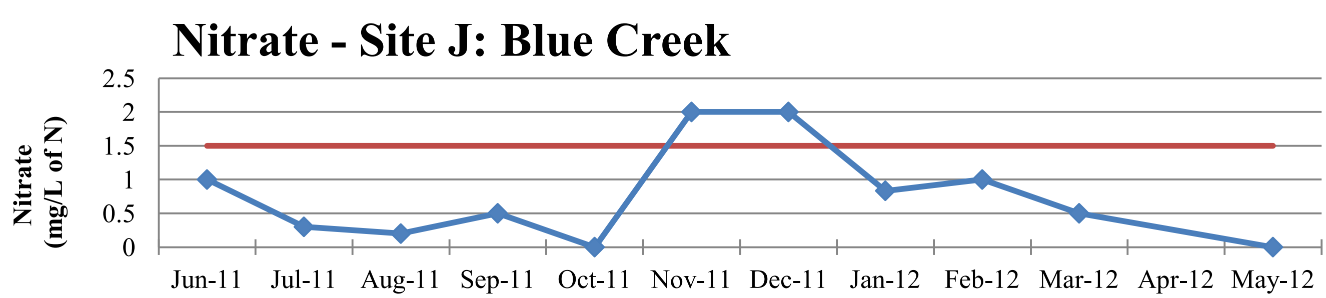
IDEM Station WEL160-0016 Monitoring and USGS NAWQA Site

Lost River in Grassy Creek subwatershed was monitored by IDEM in 2002 for chemistry. The site was monitored for E. coli general coliforms, dissolved oxygen, pH, specific conductivity, temperature, and turbidity. All parameters monitored were within target levels during the five sampling events at the end of July and August 2002.

USGS monitored this same site as a NAWQA station USGS 383430086474901 in 1994. This data did not show any significant water quality concerns from the 2 events.

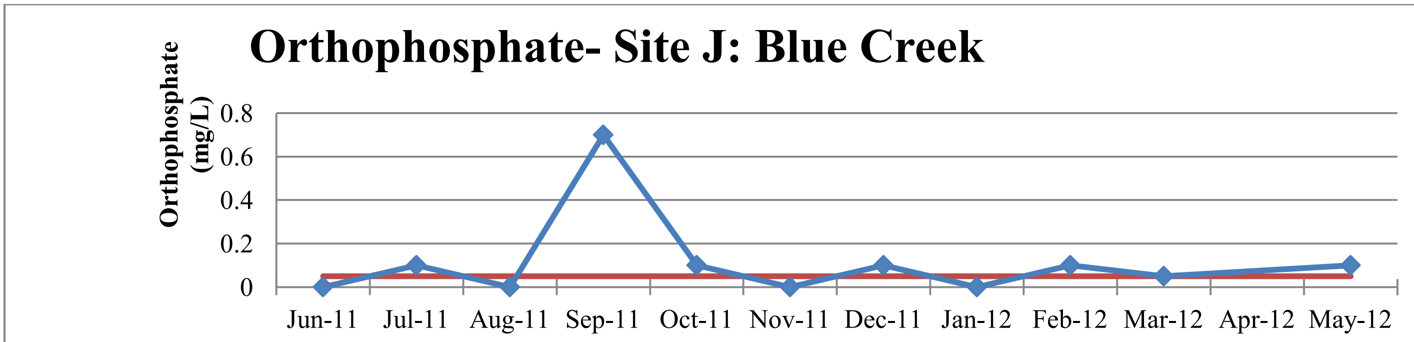
Blue Creek Monitoring Site J

The Hoosier Riverwatch Lost River Team (Site J) and the Davey group (Station 9) monitor Blue Creek. The Davey Group found no problems within this stream. Nitrates exceeded water quality targets twice during the 2011-2012 monitoring study (Figure 228). The site peaked at 2 mg/L in both November and December 2011, which is 0.5 mg/L above target levels. Orthophosphate levels exceeded target levels six times with a peak of 0.7 mg/L in September 2011 (Figure 229). Dissolved oxygen levels dipped below target levels in August (3.5 mg/L) largely due to the stagnant water at the site (Figure 230). Turbidity levels stayed below target levels except after a rain event in September when turbidity measured 28 NTU (Figure 231). pH dropped below target levels twice with a low of 5 standard units in November (Figure 232). *E. coli* counts stayed below target values in all months except in September when counts jumped to 3,600 CFU/100mL (Figure 233). Figure 233 also shows high levels of total coliforms in September 2011 and January 2012.



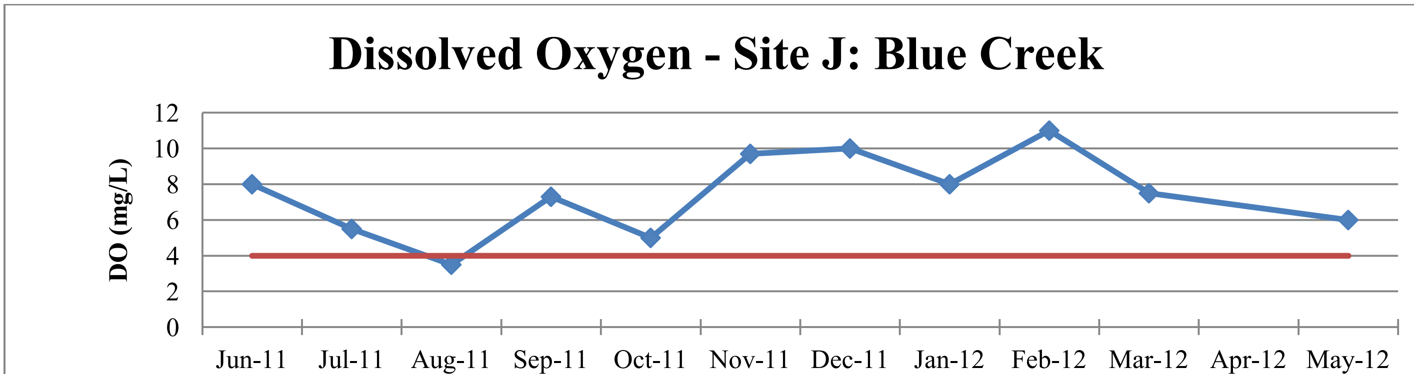
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	1	0.3	0.2	0.5	0	2	2	0.8	1	0.5	0

Figure 228: Nitrate Levels at Site J (2011-2012 testing period)



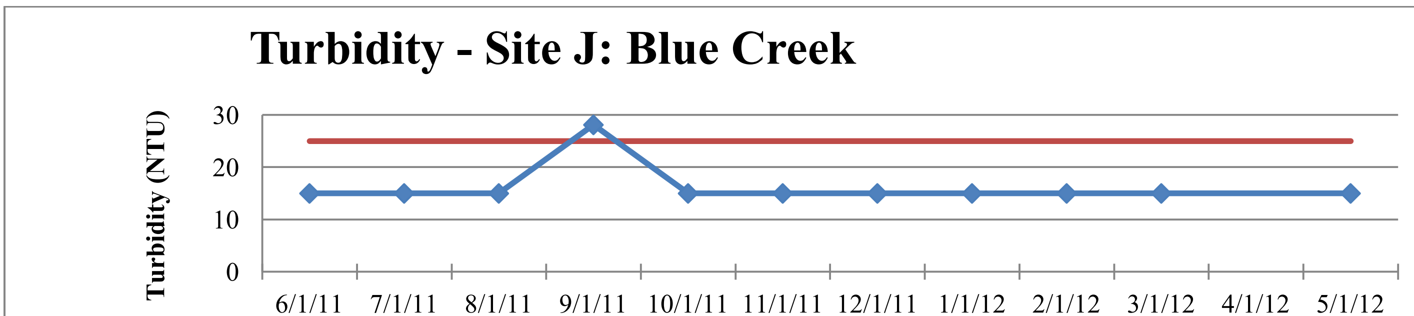
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0	0.1	0	0.7	0.1	0	0.1	0	0.1	0.05	0.1

Figure 229: Orthophosphate Levels at Site J (2011-2012 testing period)



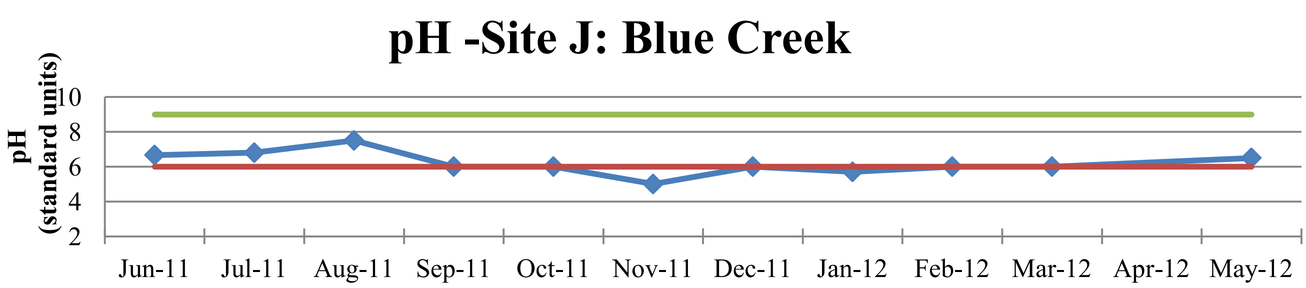
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
DO	8	5.5	3.5	7.3	5	9.7	10	8	11	7.5	6
DO Min	4	4	4	4	4	4	4	4	4	4	4

Figure 230: Dissolved Oxygen Levels at Site J (2011-2012 testing period)



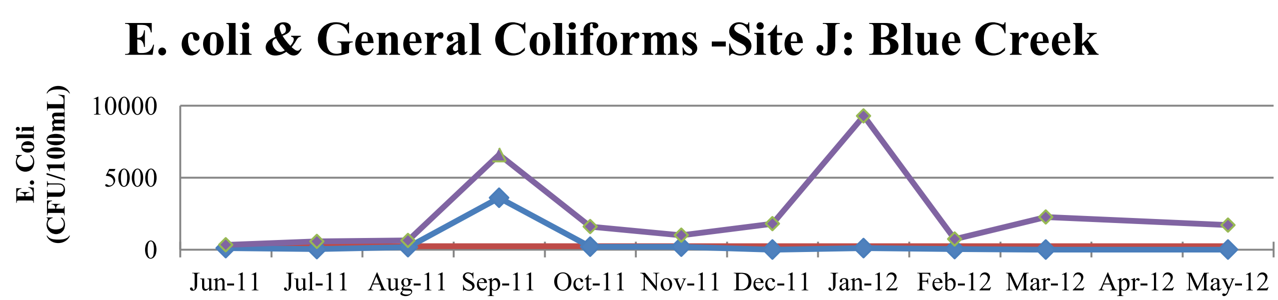
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	15	15	15	28	15	15	15	15	15	15	15

Figure 231: Turbidity Levels at Site J (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.667	6.8	7.5	6	6	5	6	5.7	6	6	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 232: pH Levels at Site J (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	99.9	33.3	166.5	3600	200	200	0	99.9	33.3	0	0
General Coliforms	333	566.1	632.7	6600	1600	1000	1800	9290.7	732.6	2264.4	1700

Figure 233: E. coli and General Coliform Levels at Site J (2011-2012 testing period)

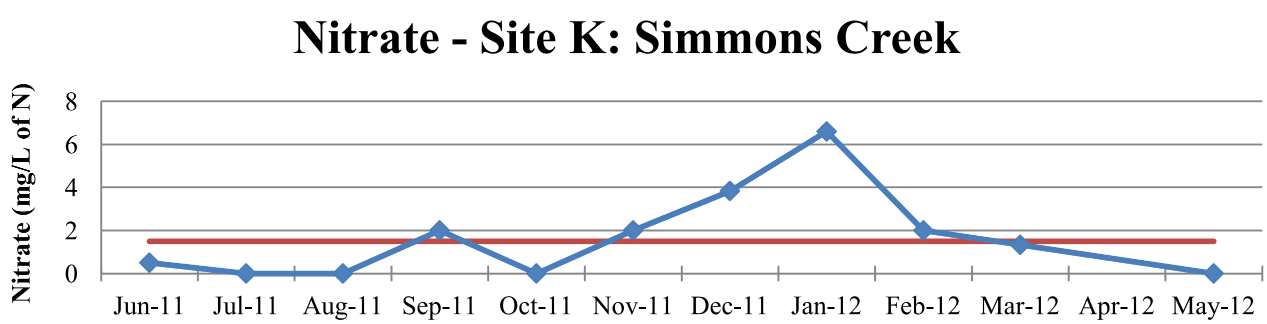
Biological samples have been collected at Site J through current sampling efforts. The habitat in Blue Creek was determined to be excellent with a citizens QHEI score of 73.5. The site shows great quality habitats, however just upstream the channel characteristics are much different and would likely score much lower. The macroinvertebrate scores indicate that this section of Blue Creek is impaired for aquatic life. The Pollution Tolerance Index score of 15 at this site indicated that there was a fair population and diversity of macroinvertebrates at this site. This low score is likely due to the lack of quality of habitat upstream. Numerous mussels were located at this location. It is unsure at this time whether these are zebra mussels (an invasive mussel). Because it is illegal to remove mussel shells from streambeds, a expert should go with to determine whether this is the case. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat and macroinvertebrate data from Blue Creek. Biological information indicated a good quality habitat (QHEI=78), but a fair population of macroinvertebrates. They suggest this may be due to a fairly substantial degree of organic pollution.

Simmons Creek Monitoring Site K

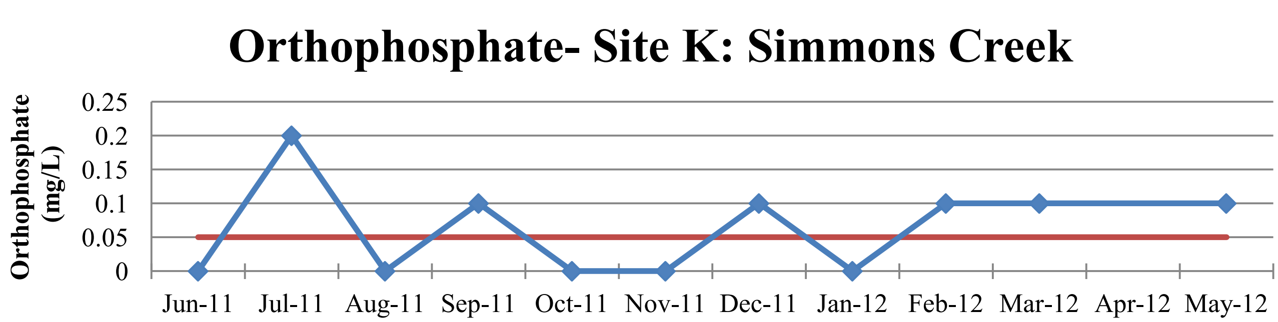
The Hoosier Riverwatch Lost River Team (Site K), the Davey group (Station10), and IDEM (WEL160-0008) monitor Simmons Creek. Nitrate levels exceeded target levels of 1.5 mg/L five times during the 2011-2012 sampling study (Figure 234). Nitrate levels were highest in January with a value of 6.6 mg/L. Orthophosphate levels exceeded target levels six times with the highest value of 0.2 in July (Figure 235). Biochemical oxygen demand exceeded target levels 4 times with the highest at 4.7 mg/L of change in 5 days (Figure 236). Turbidity levels only exceeded target values once in September with 33 NTU (Figure 237). pH levels dropped below target levels in November through January and in March (Figure 238). The lowest pH measurement was 4.3 standard units in January 2012. *E. coli* levels peaked in September with 5900 CFU/100mL (Figure 239). The only other month that *E. coli* was above target levels of 235 CFU/100mL was in March (366.6 CFU/100mL). Figure 239 also shows high levels of total coliforms in September 2011 along with January and March of 2012. Dissolved oxygen and temperature levels were within acceptable ranges during the 2011-2012 sampling period.

The Davey Group found elevated levels of *E.coli* (461.1 cfu/100mL) during the storm sampling in 2010. In July of 2011, the site had water temperatures exceeded allowable limits (34.3°C, or 93.7°F). Biochemical oxygen demand was low in June with a value of 2 mg/L. Orthophosphate was high in July with a value of 0.2 mg/L.



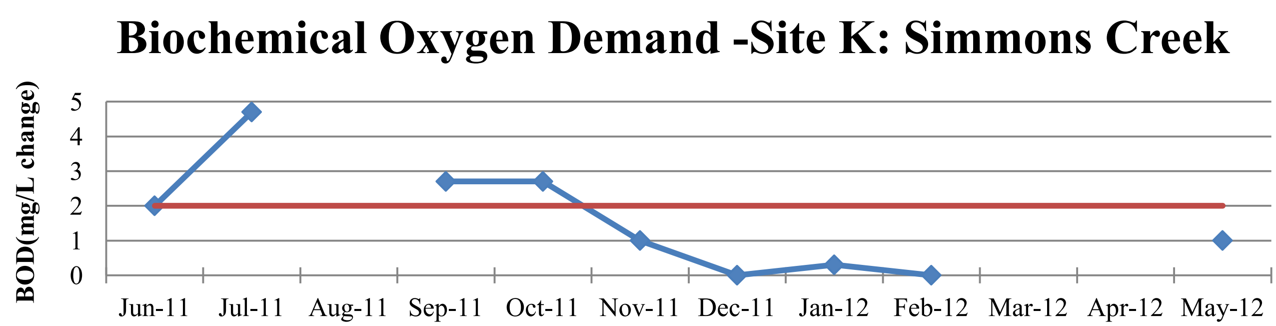
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Nitrate	0.5	0.0	0.0	2.0	0.0	2.0	3.8	6.6	2.0	1.3	0.0

Figure 234: Nitrate Levels at Site K (2011-2012 testing period)



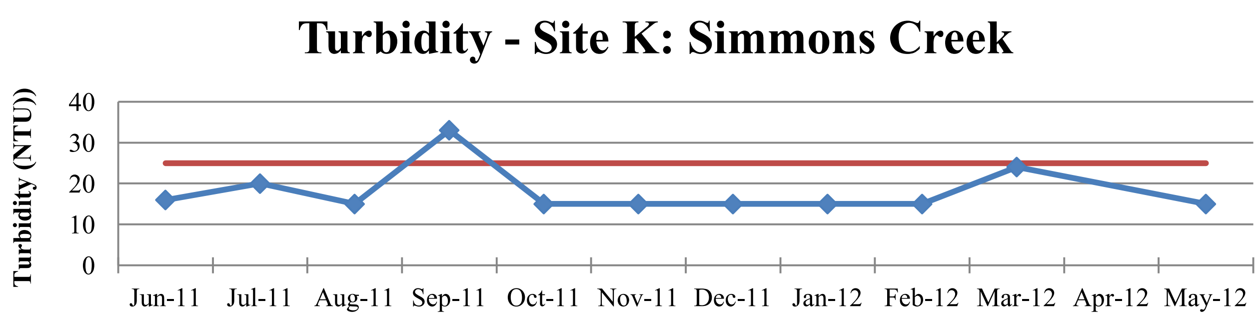
	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12
Phos Max	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Orthophosphate	0	0.2	0	0.1	0	0	0.1	0	0.1	0.1	0.1

Figure 235: Orthophosphate Levels at Site K (2011-2012 testing period)



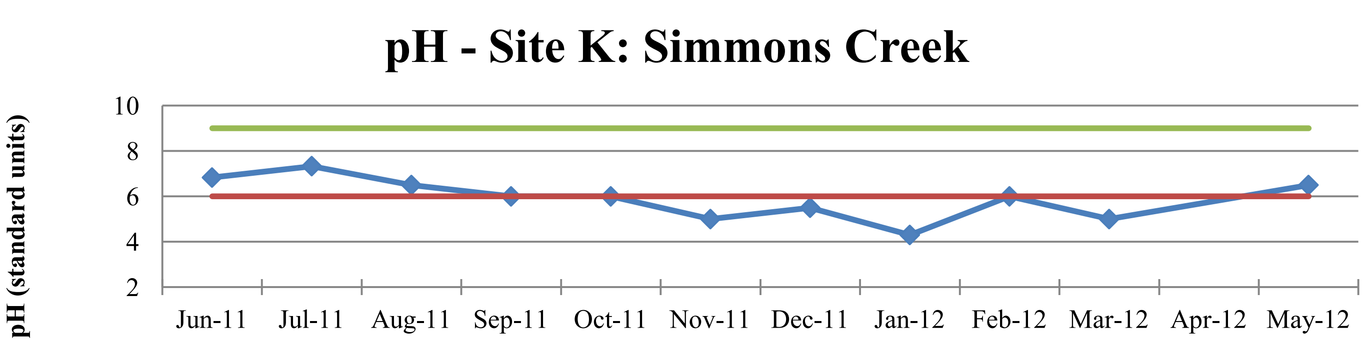
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
BOD5	2	4.7		2.7	2.7	1	0	0.3	0		1
BOD5 Max	2	2	2	2	2	2	2	2	2	2	2

Figure 236: Biochemical Oxygen Demand (BOD) Levels at Site K (2011-2012 testing period)



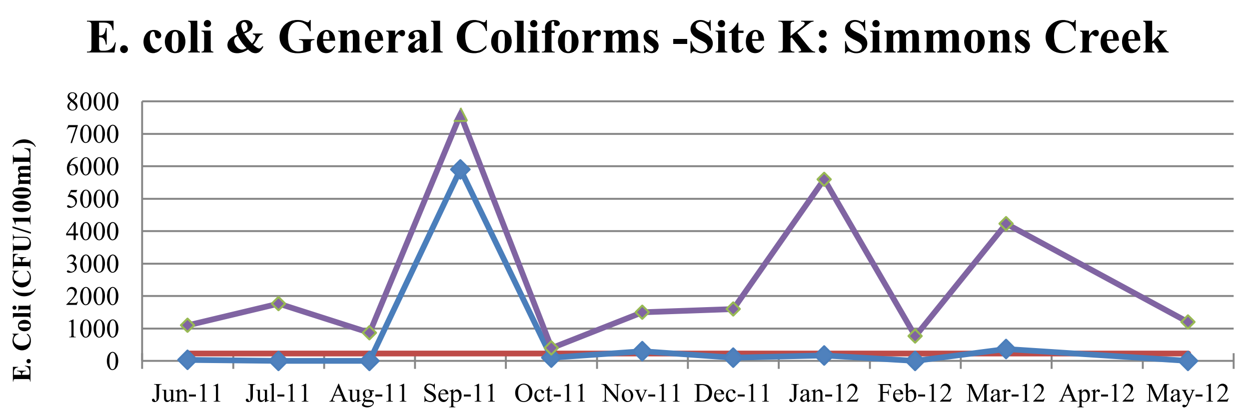
	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25
Turbidity	16	20	15	33	15	15	15	15	15	24	15

Figure 237: Turbidity Levels at Site K (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
pH Max.	9	9	9	9	9	9	9	9	9	9	9
pH	6.8	7.3	6.5	6.0	6.0	5.0	5.5	4.3	6.0	5.0	6.5
pH Min.	6	6	6	6	6	6	6	6	6	6	6

Figure 238: pH Levels at Site K (2011-2012 testing period)



	6/14/11	7/28/11	8/27/11	9/26/11	10/28/11	11/18/11	12/29/11	1/27/12	2/28/12	3/30/12	5/2/12
E.coli Max	235	235	235	235	235	235	235	235	235	235	235
E.coli	33.3	0	0	5900	100	300	100	166.5	0	366.3	0
General Coliforms	1098.9	1764.9	865.8	7600	400	1500	1600	5594.4	765.9	4229.1	1200

Figure 239: E. coli and General Coliform Levels at Site K (2011-2012 testing period)

Biological samples have been collected at Site K through current sampling efforts. The habitat in Simmons Creek was determined to be poor with a citizens QHEI score of 40. This score was based on the deep channelization that has occurred at this site and the lack of cover for aquatic life. However, the macroinvertebrate scores indicate that this section of Simmons Creek is not impaired for aquatic life. The Pollution Tolerance Index score of 25 at this site indicated that there was an excellent population and diversity of macroinvertebrates at this site. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat and macroinvertebrate data from Simmons Creek. Biological information indicated a good quality habitat (QHEI=71), and an excellent population of macroinvertebrates.

IDEM collected samples one day in 1993 at WEL160-0008. The data from this collection showed good levels of dissolved oxygen, pH, specific conductance, and temperature. This was the only chemical data collected at this site. Macroinvertebrate collections were done at that time along with habitat assessments. Biological information indicated a good quality habitat (QHEI=78), and an excellent population of macroinvertebrates.

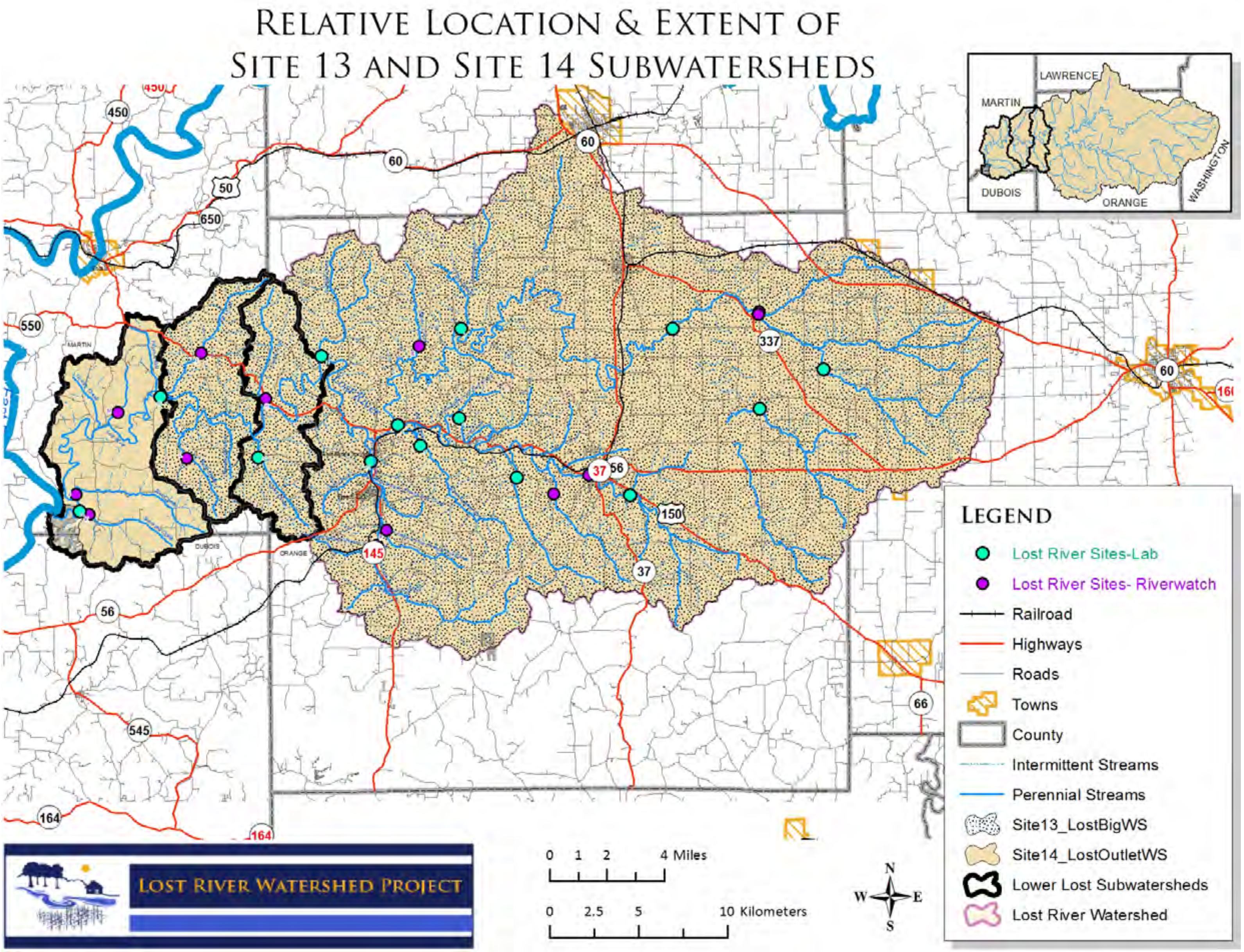
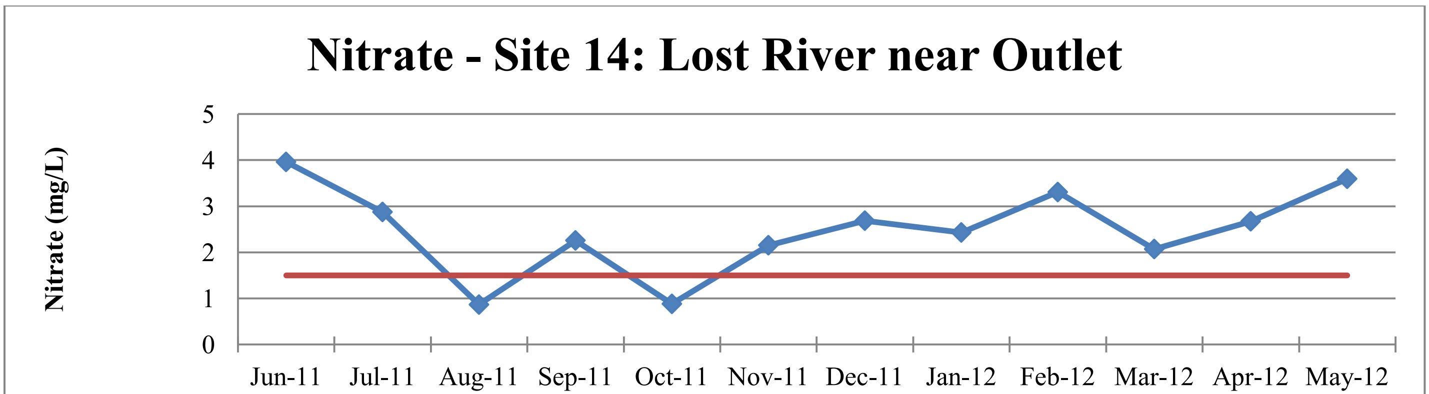


Figure 240: Relative Size and Extent of Watersheds Draining to Site 13 and Site 14 in Relation to Lower Lost Subwatersheds- based on 2011-2012 sampling period

Lost River Monitoring Site 14

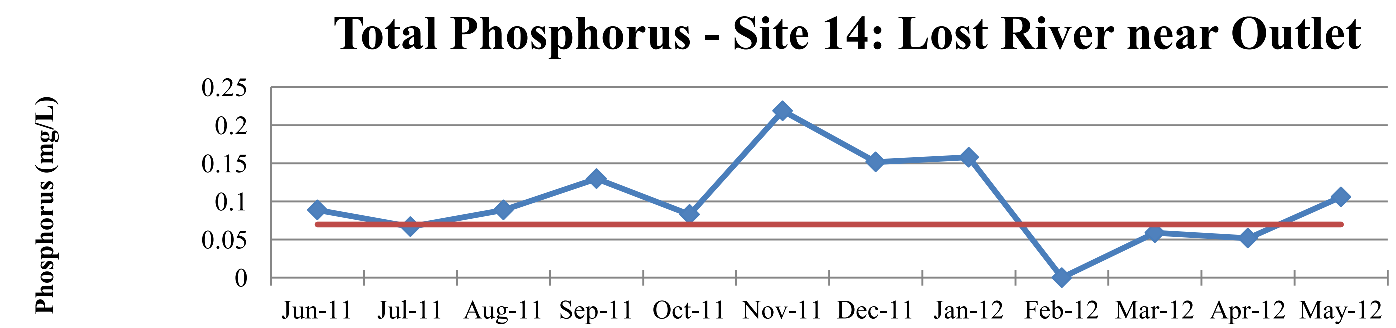
Near the outlet of Lost River, water samples were collected by IDEM (Station WEL160-0003), the Lab (Site 14), and Davey Resource Group (Station 3). IDEM continually monitors the Fixed station and has readings from 2001-2009 that will be used in this assessment. This site is an ideal location to monitor the majority of Lost River watershed. Figure 240 shows the extent of drainage to this sample site. Turbidity exceeded target values 14 times over the 8-year period. Conductivity exceeded target values 13 times over the 8-year period. Davey Group found total suspended solids elevated during the storm event. The Lab collected data at this location (Site 14) during the 2011-2012 monitoring study. Nitrate levels exceeded target levels in all but two samples collected at this site (Figure 241). The highest nitrate sample collected was in June with a value of 3.96 mg/L, which is 2.6 times the target levels of 1.5 mg/L. Total phosphorus exceeded target levels eight times out of the twelve samples collected (Figure 242). The highest level of total phosphorus was in November with a value of 0.219 mg/L, which is 3.1 times the target level of 0.07 mg/L. Turbidity levels exceeded target levels four times with a high of 69.9 NTU in January 2012 (Figure 243). Total suspended solids had similar results as turbidity with the high in January of 80 mg/L (Figure 245). *E. coli* exceeded water quality standards four times during the sampling period (Figure 245). In November the levels of *E. coli* were above the Lab detection limits of 2419.6 MPN/100mL. Dissolved oxygen, specific conductivity, pH and salinity were all within acceptable ranges during the 2011-2012 sampling period.

The Davey group found elevated levels of total suspended solids (59 mg/L) during their storm sampling. LARE study showed no elevated levels for any other parameters collected. Temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, turbidity, nitrate, and *E.coli* were all within current target levels.



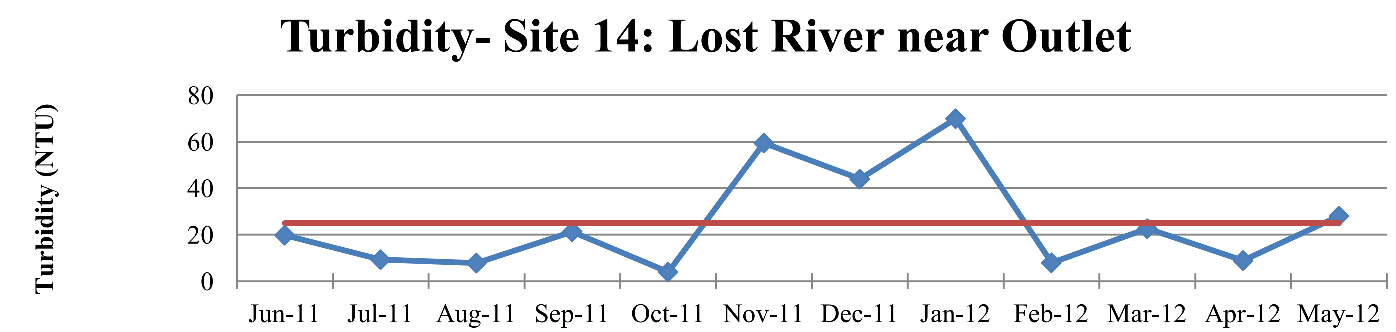
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Nitrate (as N)	3.96	2.874	0.864	2.256	0.88	2.152	2.685	2.429	3.306	2.07	2.672	3.594
Nitrate Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Figure 241: Nitrate Levels at Site 14 (2011-2012 testing period)



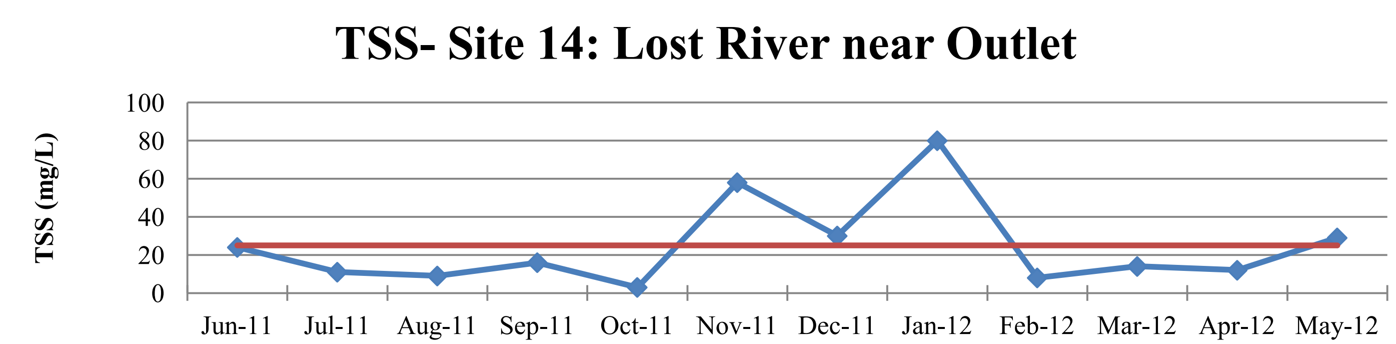
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Phosphorus, Total	0.089	0.067	0.089	0.13	0.083	0.219	0.152	0.158	0	0.059	0.052	0.106
Phos Max	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Figure 242: Total Phosphorus Levels at Site 14 (2011-2012 testing period)



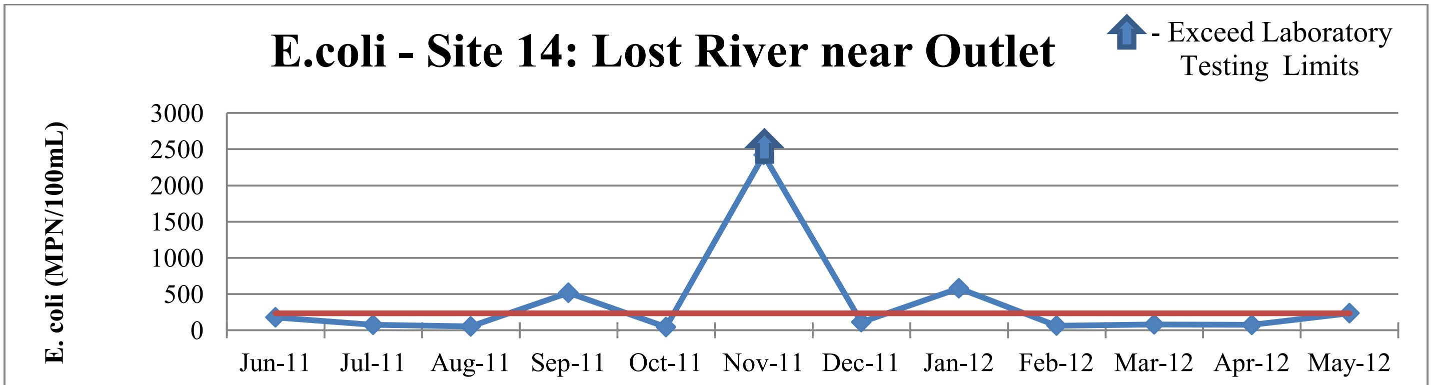
	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
Turbidity	19.8	9.27	7.81	21.3	3.95	59.4	43.9	69.9	7.92	22.6	8.9	28
Turbidity Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 243: Turbidity Levels at Site 14 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
TSS	24	11	9	16	3	58	30	80	8	14	12	29
TSS Max	25	25	25	25	25	25	25	25	25	25	25	25

Figure 244: Total Suspended Solids (TSS) Levels at Site 14 (2011-2012 testing period)



	6/20/11	7/25/11	8/30/11	9/29/11	10/25/11	11/22/11	12/21/11	1/18/12	2/15/12	3/14/12	4/11/12	5/10/12
E.coli, MPN	178.5	74.9	52	517.2	44.1	2419.6	112.3	579.4	64.4	81.3	73.8	235.9
E.coli Max	235	235	235	235	235	235	235	235	235	235	235	235

Figure 245: E. coli Levels at Site 14 (2011-2012 testing period)

Biological samples have been collected at Site 14 on Lost River through current sampling efforts. The habitat in Lost River was determined to be good with a QHEI score of 70. The site shows good quality habitat but less than desirable aquatic life. The macroinvertebrate scores indicate that this section of Lost River is impaired for aquatic life. The mIBI score at this site was 34 points, which is below the target score of 36. This low score is likely due to the relatively poor water quality. Biological samples have been collected at this site before by the LARE diagnostic study.

Davey Resource group collected habitat but not macroinvertebrate data on this portion of Lost River during the LARE diagnostic study. Habitat information indicated a good quality habitat with a QHEI score of 73. Macroinvertebrates were not collected at this site.

IDEM site WEL160-003 is the fixed monitoring station for the Lost River watershed. Data from this site was analyzed in Section 4. For results of testing please refer to Table 10.

Permitted Facilities

The only permitted facilities within this region are the five confined feeding operations (CFOs) (Figure 246). Of these, only two are active CFOs. These operations are a layer hen facility and a turkey facility. There are more turkey and chicken houses in the area, but they must not hold enough livestock to be considered a CFO.

Lower Lost River Subwatersheds Managed & Permited Areas
Sams Creek, Big Creek, Grassy Creek Drainage

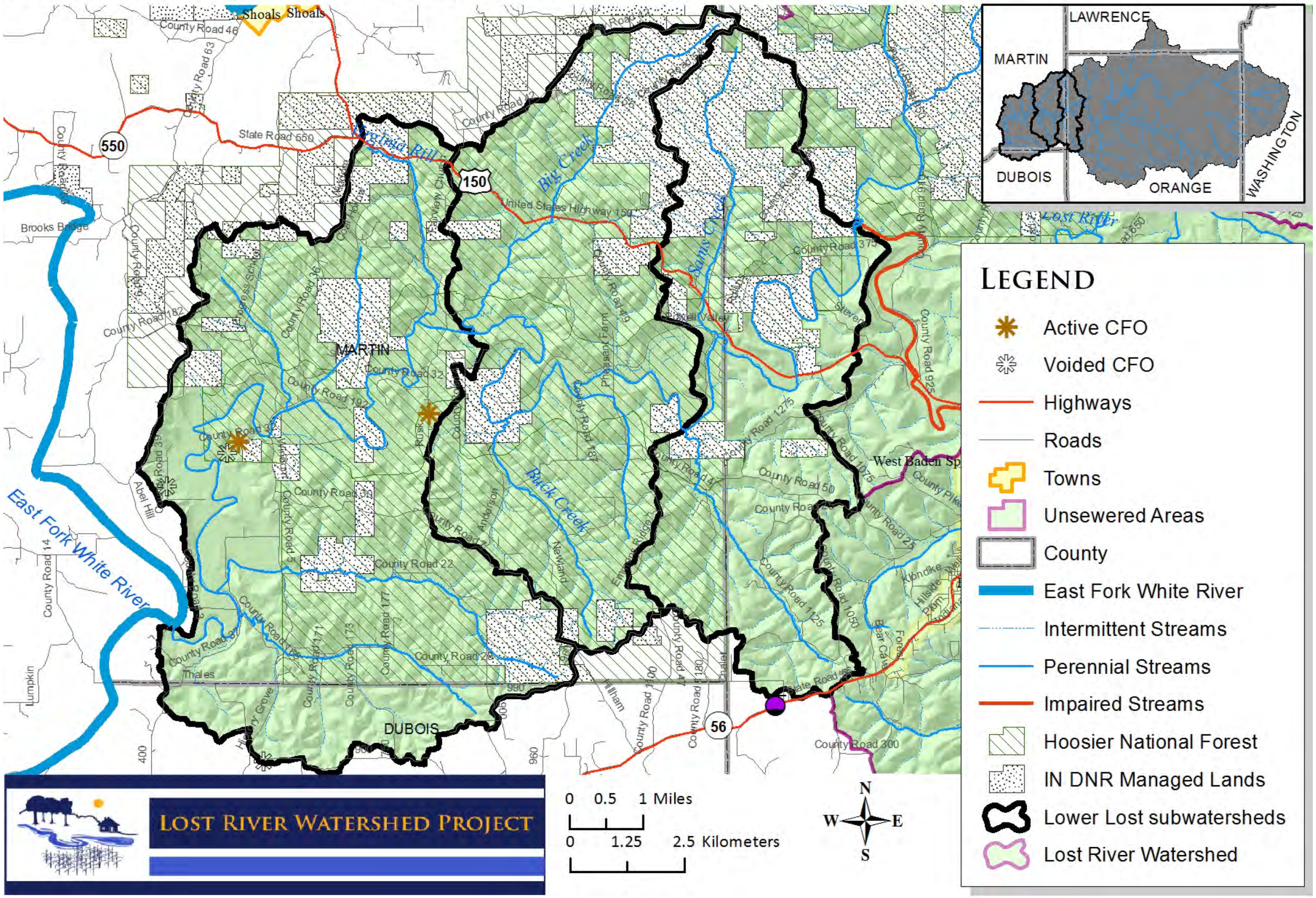


Figure 246: Lower Lost River Subwatersheds- Location of Managed lands and permitted facilities

Section 6 – Watershed Inventory Summary

6.1 Water Quality Data Summary

Multiple water quality parameters were tested at 27 sites in the Lost River Watershed. Each site had a form of Nitrogen (Nitrates), Phosphorus (Total, and Orthophosphate), Dissolved Oxygen, pH, Turbidity, Temperature, and E. coli collected. These parameters values varied depending on its location, the weather conditions (stormflow & baseflow), the time of year the sample was collected, and the methods used to collect the data. Figures 247 through 254 show the frequency that target levels were exceeded in the main parameters that were tested in the current water monitoring study.

Several water quality impairments were identified during the watershed inventory process. These include elevated nitrate-nitrogen, total phosphorus, total suspended solids or turbidity, and E. coli concentrations. Figures 247 through 254 show the frequency that target levels were exceeded for these parameters in the current water monitoring study. Sample sites are mapped as red only if over half of samples collected at those sites exceeded the target concentration. Elevated nitrate concentrations were observed in South Fork Lost River, Carters Creek, Lost River Sink, Orleans Karst Area, Mt Horeb Drain, Headwaters Lick Creek, Log Creek, Scotts Hollow, Sulphur Creek, Sams Creek, Big Creek, and Grassy Creek subwatersheds (Figure 247). Similarly, South Fork Lost River, Carters Creek, Lost River Sink, Orleans Karst Area, Mt Horeb Drain, Headwaters Lick Creek, Log Creek, Scotts Hollow, Sulphur Creek, Sams Creek, Big Creek, Grassy Creek, and French Lick Creek contained elevated phosphorus concentrations (Figure 248). Dissolved Oxygen concentrations dropped below target levels very infrequently throughout the watershed, but it did occur in French Lick Creek, Buck Creek, and Blue Creek.(Figure 249). Turbidity levels rose during stormflow periods in most areas, but smaller storms caused peaks in turbidity more frequently. Turbidity exceedance frequency is seen more often in the karst areas, the downstream sections of Lick Creek and French Lick Creek and toward the outlet of Lost River (Figure 250). pH is only a big concern in some of the smaller tributaries in the western portion of the watershed and the areas where known abandoned mine lands occur (Figure 251). *E. coli* seems to occur more frequently in areas with populated towns (Figure 252). However, spikes of 10 times target levels and likely more occurred at almost every location within the watershed. Many sampling locations have good quality habitats throughout the watershed (Figure 253) but aquatic life populations (Figure 254) are not representative of these quality habitats. Most areas within the watershed have lower than desired macroinvertebrate populations and fish populations.

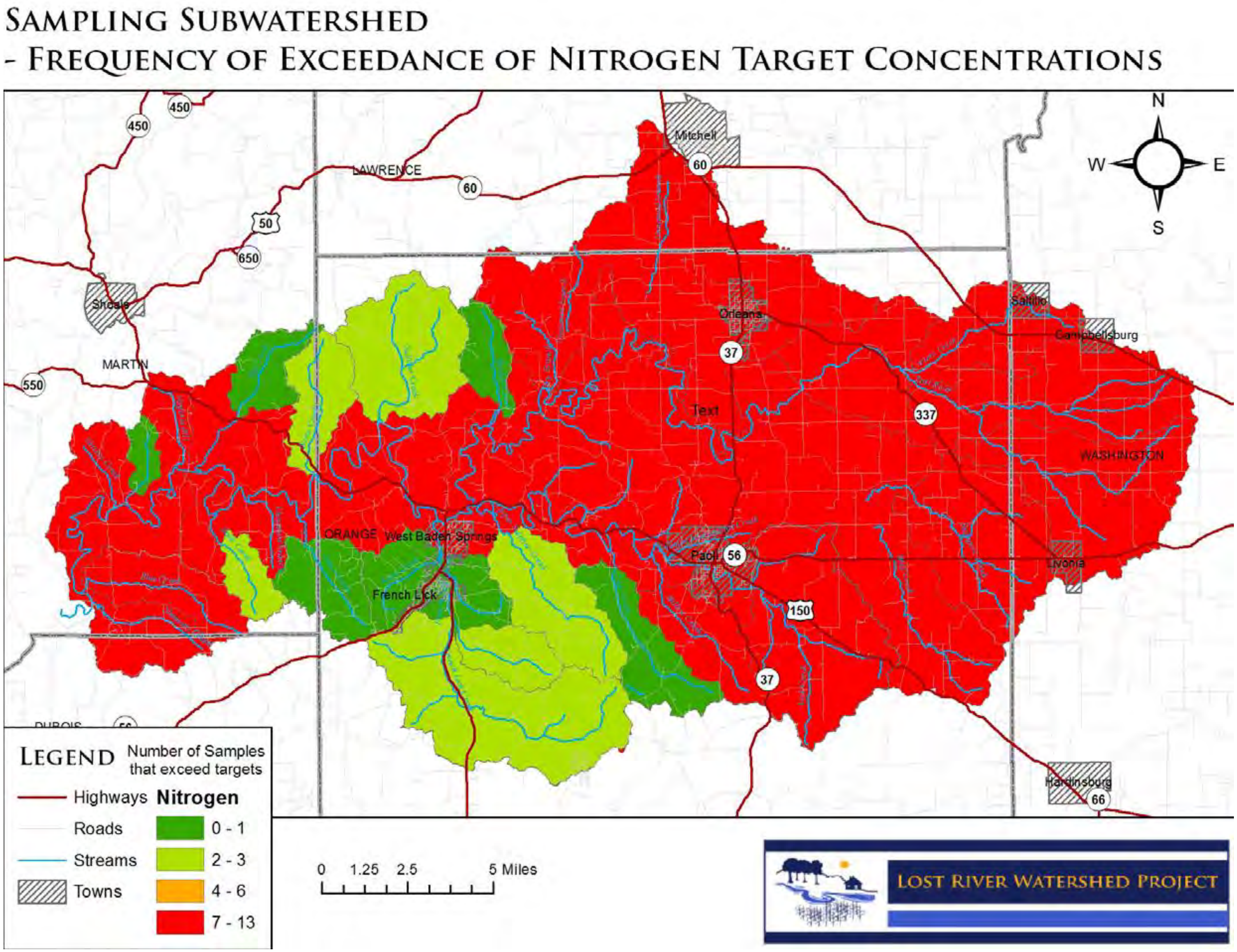


Figure 247: Frequency of Sample Subwatershed to Exceed Nitrogen Targets

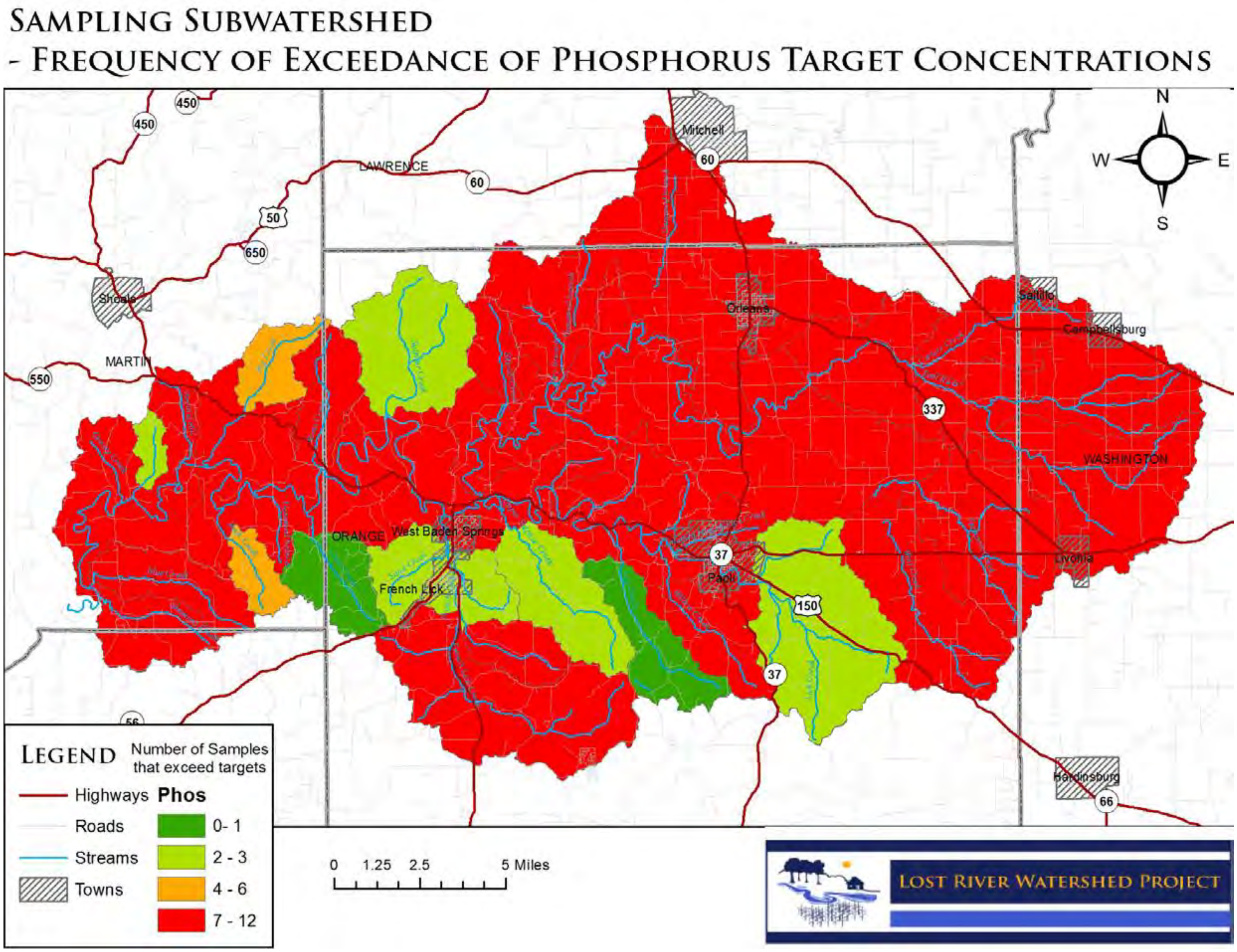


Figure 248: Frequency of Sample Subwatershed to Exceed Phosphorus Targets

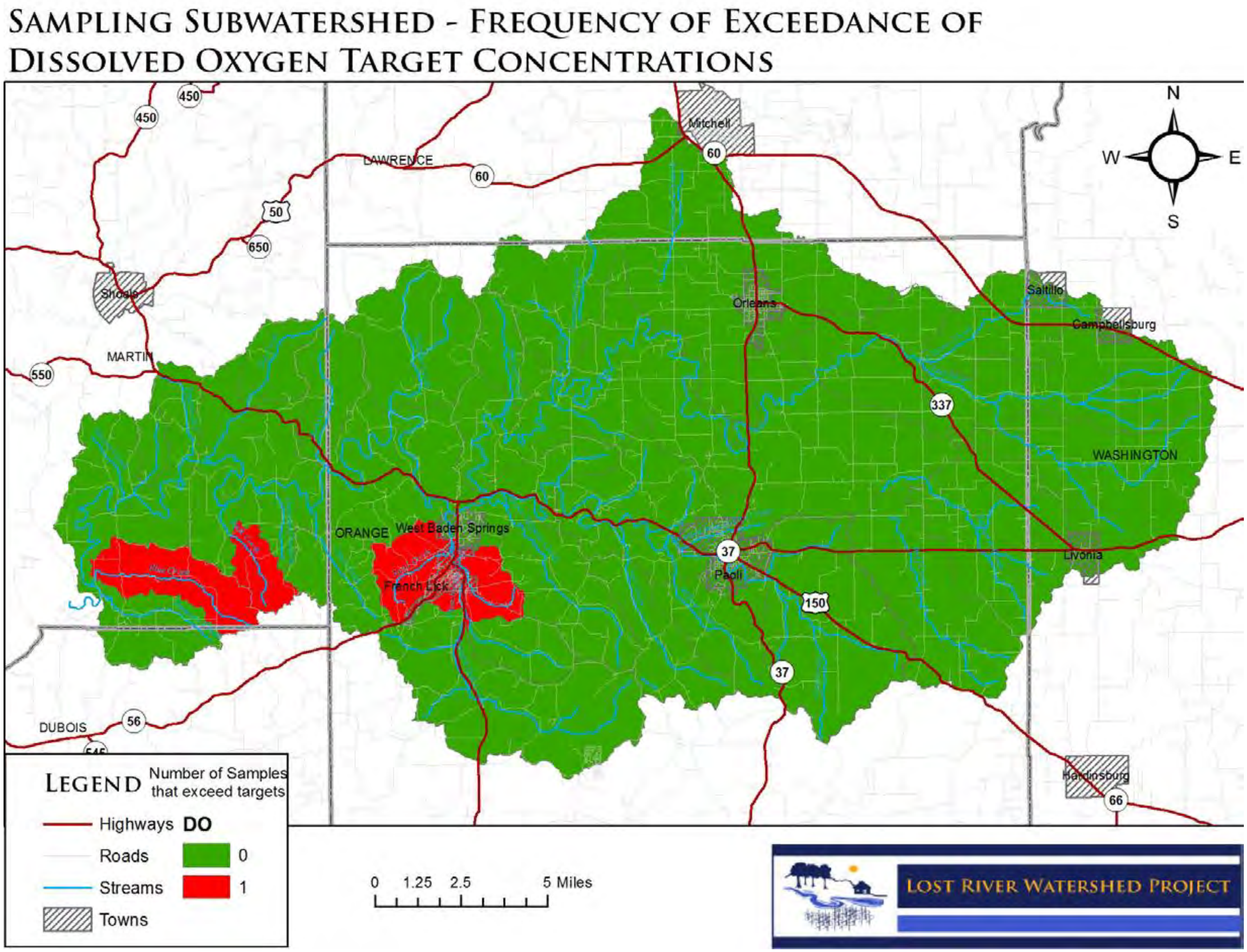


Figure 249: Frequency of Sample Subwatershed to Exceed Dissolved Oxygen Targets

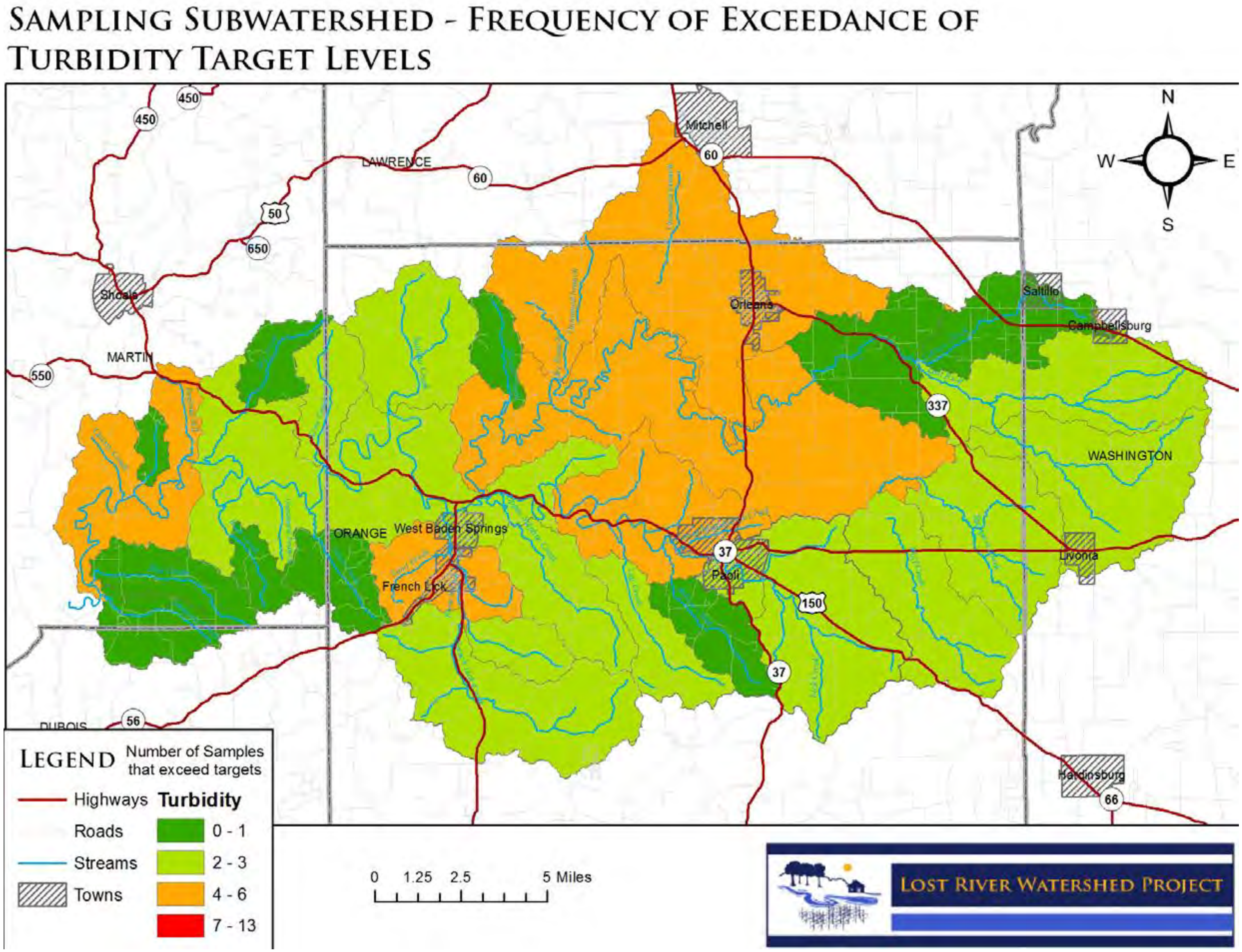


Figure 250: Frequency of Sample Subwatershed to Exceed Turbidity Targets

SAMPLING SUBWATERSHED - FREQUENCY OF EXCEEDANCE OF pH TARGET LEVELS

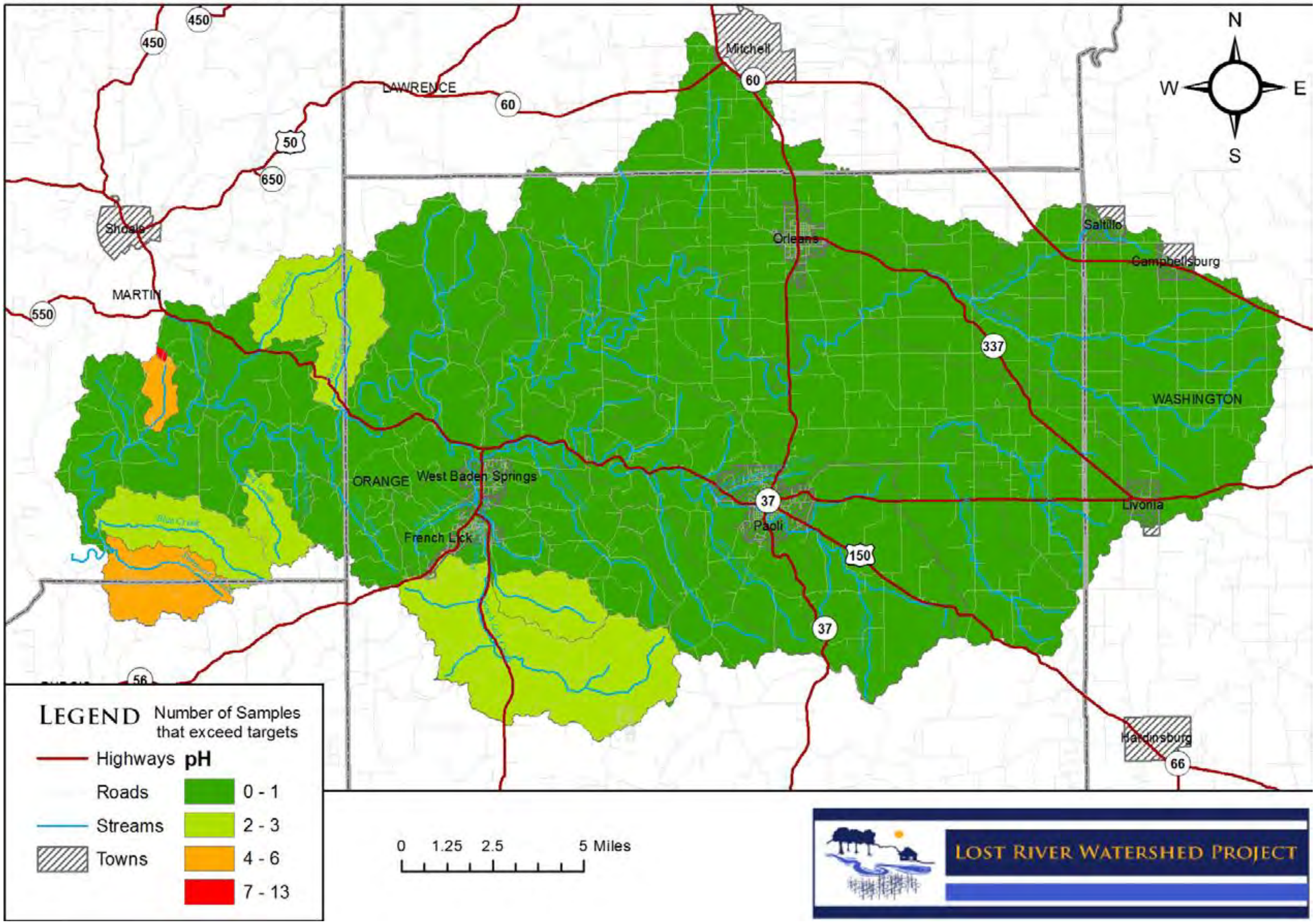


Figure 251: Frequency of Sample Subwatershed to Exceed pH Targets

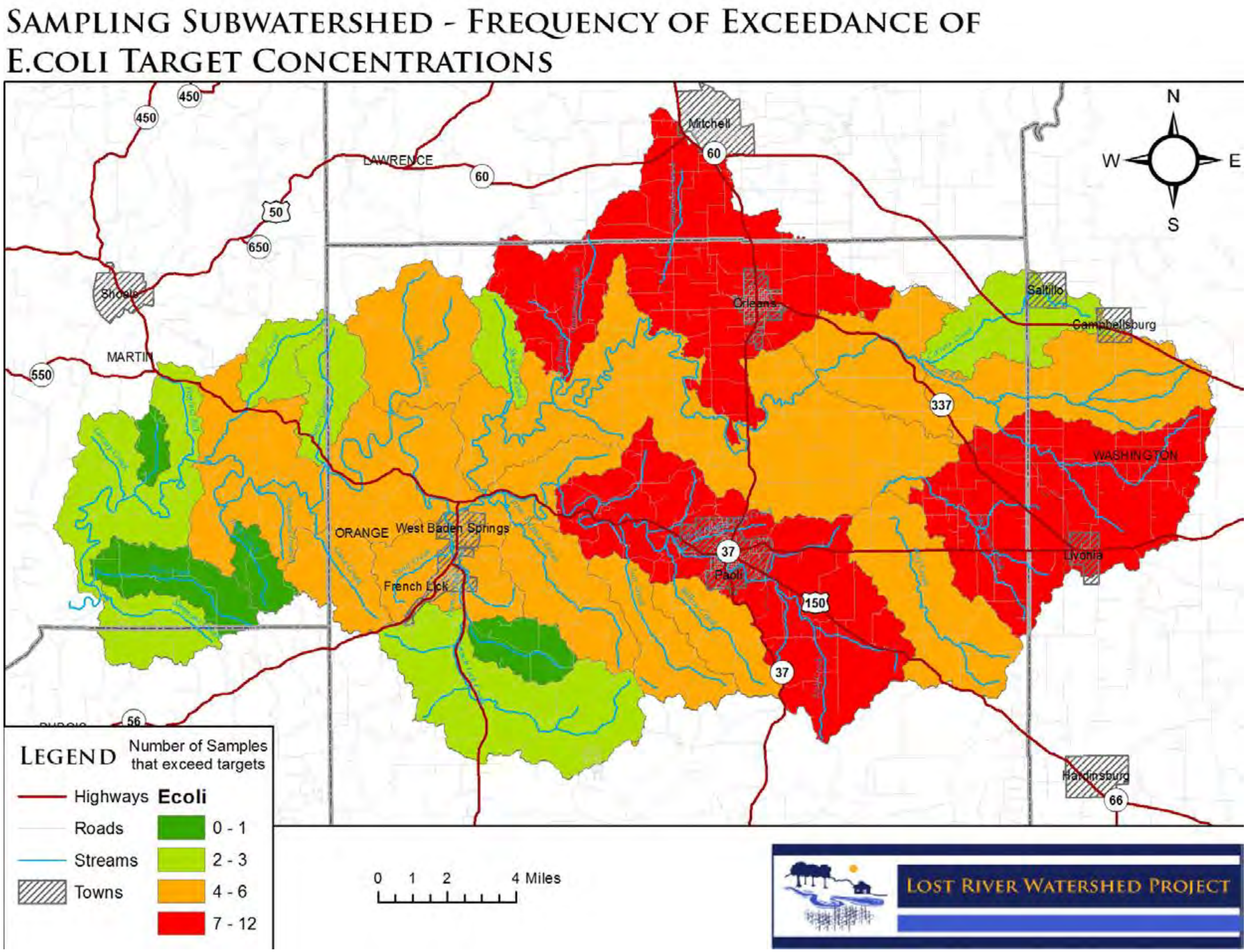


Figure 252: Frequency of Sample Subwatershed to Exceed E. coli Targets

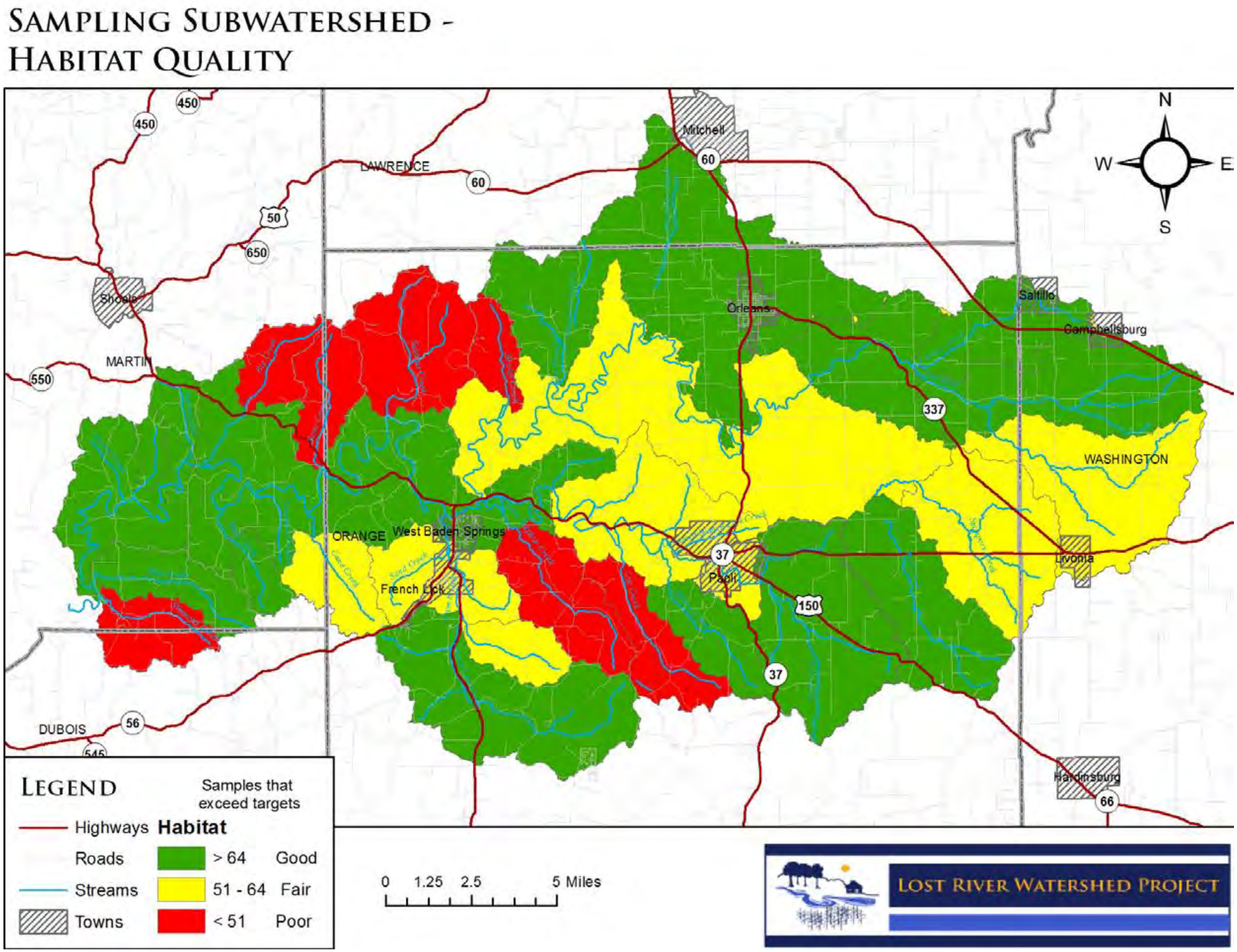


Figure 253: Display of Sample Subwatershed Habitat Quality

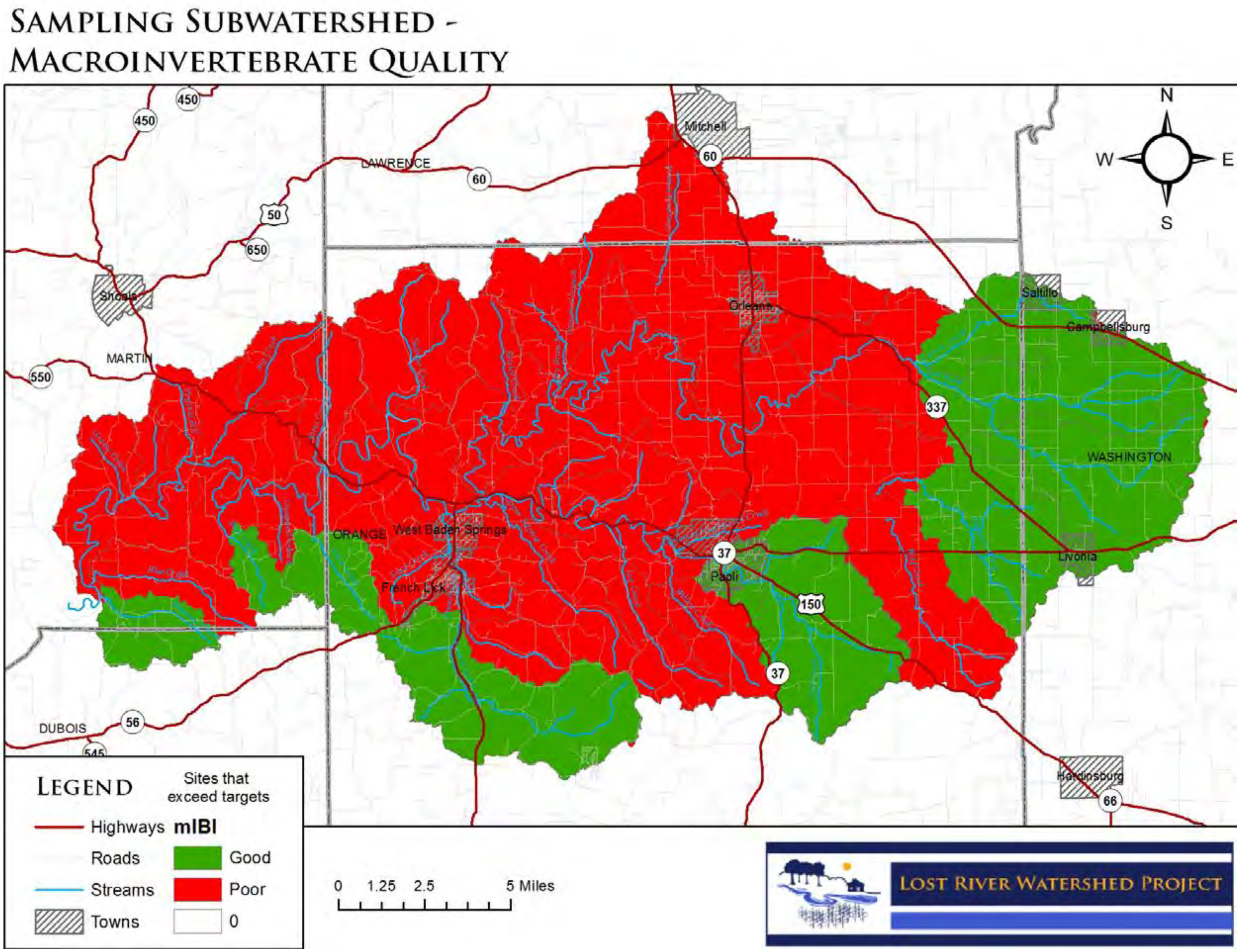


Figure 254: Display of Sample Subwatershed Aquatic Life Quality

6.2 Analysis of Stakeholder Concerns

All stakeholder concerns generated through public outreach meetings and steering committee meetings are listed in Table 17. The steering committee determined whether the available data and evidence supports each concern. The steering committee also determined whether or not each concern was within their scope of consideration and whether or not it was a concern on which they wished to focus. Stream maintenance by adjacent landowners was an expressed concern on which the steering committee ultimately decided not to focus on, because fell trees can provide valuable habitat for terrestrial and aquatic organisms along with protection of the streambanks. The committee decided that this issue could be re-evaluated with the production of a log jam preventative maintenance program in the future. The lack of trails and access points along the karst corridor was brought up as a concern; however, experts agree that access to these areas by the public would likely cause further water quality problems. Meanwhile, available public access sites highlighting the unique karst aspects are believed to be underutilized at this point. The committee also agreed that the continuousness of natural lands is not a significant problem in this area. Programs such as Indiana Classified Forest and Wildlands Program through the Indiana Department of Natural Resources (DNR) and Wildlife Habitat Incentive Program (WHIP) through the Natural Resource Conservation Services (NRCS) currently address this need. Gas Drilling is another concern that is not focused on at this time due to the lack of actual drilling occurring in the area. The committee leaves this open for review if gas drilling including the procedure of fracking is proposed in the future. Draining of wetted lands will not be focused on due to the complex nature of drainage in this area and the local increase in these types of lands by Hoosier National Forest and other local programs.

Table 17: Stakeholder Concerns Analysis

Concerns	Supported by data?	Evidence	Quantifiable?	Within Scope?	Group wants to focus on?
Trash in streams	Yes	Anecdotal evidence	No	Yes	Yes
Trash in sinkholes	Yes	Discussion of Past practices; Anecdotal evidence	No	Yes	Yes
Trash, refuse, & vehicles on property	Yes	Windshield Surveys, anecdotal evidence	No	Yes	Yes
Stream Bank Erosion	Yes	Modified Bank Hazard Erosion Index data; Photographs and location descriptions supplied by landowners; Turbidity and TSS data in some locations	Yes	Yes	Yes
Build-up of sediment/gravel bars	Yes	Windshield Survey; Photographs; Anecdotal evidence	No	Yes	Yes
Improper filling of sinkholes	Yes	Anecdotal evidence	No	Yes	Yes
Erosion from conventional cropping system	Yes	NRCS Tillage Transects & Reports; Windshield survey	Yes	Yes	Yes
Waterbodies without filter strips or riparian buffers	Yes	Windshield & Desktop surveys	Yes	Yes	Yes
Unlimited access of off road vehicles to streams	Yes	HNF Reports; Windshield Surveys	Yes	Yes	Yes
Off-road vehicles destroying soils infiltration capacity	Yes	HNF Reports; Photographs	No	Yes	Yes

Concerns	Supported by data?	Evidence	Quantifiable?	Within Scope?	Group wants to focus on?
Mismanagement or lack of management in forest lands	Yes	Windshield Survey	Yes	Yes	Yes
Pesticides entering stream water	Yes	Proximity of spraying to streambank; Lowered Levels of Life/Habitat downstream	No (Not without costly analyses on additional samples)	Yes	Yes
Road salts entering streams and cave systems	No	Low salinity in study samples	Yes	Yes	No
Acid Mine Drainage from abandoned mined lands	Yes	Sample Data, Landowner Reports	Yes	Yes	Yes
Gas drilling proposed for the area	Yes	Landowner reports	Yes	Yes	No
Pharmaceuticals & Personal Care Products (PPCP) altering stream biology	No	Anecdotal evidence; reports of failing septic; frequency of combined sewer overflows	No (Not without costly analyses on additional samples)	Yes	Yes
Tile drainage to sinkholes & streams	Yes	Landowner Discussions; Windshield surveys	No	Yes	Yes
Farming on/over sinkholes	Yes	Anecdotal evidence	Yes	Yes	Yes
Untreated & Excess urban runoff	Yes	Increased pollutant levels at sample locations within urbanized areas; USGS gauges; Flashy discharges downstream of impervious areas	Yes	Yes	Yes
Combined Sewer Overflow frequency	Yes	NPDES Discharge Monitoring Reports	Yes	Yes	Yes
Contamination from septic systems	Yes	High E. coli levels sampled during storm flows and/or in cold waters suggest septic system sources; Reports from Health Department on failing septic systems & straight piping wastewater from homes	No (Not without costly analyses on additional samples)	Yes	Yes
Safeness of full-body contact of local streams and rivers	Yes	303d list; Historic IDEM E. coli levels; Current E. coli levels	Yes	Yes	Yes
Winter manure application	Yes	Local Reports	Yes	Yes	Yes
Unhealthy drinking water from shallow wells and springs	Yes	Driller's Accounts, IDEM Well Data	No (Not without costly analyses on additional samples)	Yes	Yes
Excess fertilizer is entering streams	Yes	Nutrient levels in water samples	No	Yes	Yes

Concerns	Supported by data?	Evidence	Quantifiable?	Within Scope?	Group wants to focus on?
Runoff from pasture ground	Yes	Stream Bank Erosion adjacent to pasture lands; E. coli levels in streams draining pasture	Yes	Yes	Yes
Livestock unlimited access to streams	Yes	Windshield survey observations	Yes	Yes	Yes
Natural areas are not continuous	Yes	HNF Reports; DNR Reports	Yes	Yes	No
Draining of wet land losing storage & filtration	Yes	Desktop survey; landowner reports	Yes	Yes	No
Invasive and exotic species	Yes	DNR Eradication Program	Yes	Yes	Yes
Need for protection & rehabilitation of wildlife habitat	Yes	Endangered & Threatened species, Indiana Karst Conservancy Reports	Yes	Yes	Yes
Density and diversity of fish is lower than in the past	No	IDEM Data; Lack of sufficient past data to determine	Yes	Yes	Yes
Stream cleaning by adjacent landowners	Yes	Log Jams Occurrence	No	Yes	No
Flooding	Yes	USGS gauges; Landowner Reports; Photographs	Yes	No	Yes
Lack of understanding of pollution prevention options	Yes	Social surveys	Yes	Yes	Yes
Lack of Pride and ownership of streams	Yes	Surveys at events	Yes	Yes	Yes
Lack of use of public spaces along karst corridor	No	Insufficient data	No	Yes	No
Lack of public's knowledge about river system and it's water quality	Yes	Social surveys	Yes	Yes	Yes
Partnerships between existing organizations are under-utilized.	Yes	Correspondence with Agency personnel	Yes	Yes	Yes
Small homestead farms are overlooked for traditional conservation programs and are in need of conservation planning.	Yes	Surveys at events; personal correspondence	Yes	Yes	Yes

[1]Not Available; USGS-United States Geological Survey, NPDES- National Pollutant Discharge Elimination System; IDEM- Indiana Department of Environmental Management; NRCS-Natural Resource Conservation Service; HNF-Hoosier National Forest; DNR-Indiana Department of Natural Resources; IKC-Indiana Karst Conservancy

Section 7 - Water Quality Problems and Causes

Several water quality problems have been identified within the Lost River watershed. Concerns that were brought up during the initial stages of the project often reflect problems identified through water monitoring, windshield surveys and watershed inventories. This section tries to connect the concerns with their associated problems and identify potential causes to those problems. Problems that are identified through these various methods will be the basis for management and planning to address the causes of each problem.

7.1 Associated Concerns and Water Quality Problems

The steering committee identified specific problems relating to each concern on which the group wished to focus. Problems were defined as issues that exist due to a concern. Identified problems build upon concerns by identifying a condition or actions that need to be changed, improved, or investigated in greater depth. Specific problems were then consolidated into problem categories. Table 18 links stakeholder concerns to specific water quality problems and generalized water quality problem categories

Table 18: Stakeholder Concerns and Related Problems

Concerns	Specific Problems	Problem Category
Trash in streams, sinkholes, & on property	Trash may contain hazardous materials; reinforces public perception that trash in natural areas is acceptable	Trash Degraded habitat Decrease in biodiversity
Stream Bank Erosion	Sediment influx and associated nutrient inputs; loss of land; clogging of gills; disruption of habitats; loss of riparian zone to tree fall-ins	High nutrient levels High TSS and turbidity levels Degraded habitat Reduced aquatic recreation
Improper filling and uses over sinkholes	Continued farming on improperly filled sinkholes likely results in higher contribution of fertilizers, pesticides and sediment to the subsurface system; filling of sinkholes reduces flood water storage in the underground passageways	High nutrient levels High TSS and turbidity levels Degraded habitat Decrease in biodiversity Flooding Trash
Conventional cropping system	Decreases in soil quality reduce filtration property of soils; erosion of topsoil from tillage	High nutrient levels High TSS and turbidity levels
Waterbodies without filter strips or riparian buffers	Nutrients and suspended sediment inputs; poor aquatic habitat; reaches of stream with high temperatures due to lack of shade	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat

Concerns	Specific Problems	Problem Category
Unlimited access of off road vehicles to streams	Destruction of aquatic habitats; degrades natural channel shape and function; introduces toxic materials to the stream (i.e. gasoline and motor oil)	High TSS and turbidity levels Degraded habitat Decrease in biodiversity
Off-road vehicles compacting and rutting soils	Off-road vehicles rut and destroy natural soils causing erosion and limiting infiltration with compaction	High TSS and turbidity levels Degraded habitat Flooding
Mismanagement or lack of management in forest lands	Some logging is done without the use of management plans or forestry BMPs leading to rutting of soils, loss of understory, and other erosion or habitat degradation	High TSS and turbidity levels Degraded habitat Reduced aquatic recreation
Pesticides entering stream water	Reduced macroinvertebrate diversity; waters may be unsafe for human contact	Degraded habitat Decrease in biodiversity Reduced aquatic recreation
Acid Mine Drainage from abandoned mined lands	Drainage water toxic to wildlife; water unsuitable for life; toxic levels of metals in water;	Low pH levels Degraded habitat Decrease in biodiversity Reduced aquatic recreation
Pharmaceuticals & Personal Care Products (PPCP) altering stream biology	Potential for acute/chronic poisoning of wildlife scavengers; chronic low level incidental human exposure	Degraded habitat Decrease in biodiversity Reduced aquatic recreation
Tile drainage to sinkholes & streams	Direct runoff of nutrients and pesticides may be degrading water quality	High nutrient levels Low oxygen levels Decrease in biodiversity
Untreated & excess urban runoff	High nutrient input; Untreated pet waste potentially causing high *E. coli* levels in streams; potentially toxic chemicals entering cave system and streams from roads and parking areas; excess runoff degrading streams; flooding	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat Flooding
Combined Sewer Overflow frequency	High nutrient input; untreated sewage carrying pathogens entering streams; high *E. coli* levels in streams; potentially toxic chemicals entering streams	High nutrient levels Reduced aquatic recreation High *E. coli* levels High TSS and turbidity levels Degraded habitat Flooding
Contamination from septic systems	untreated sewage carrying pathogens entering streams; *E. coli* and nutrient inputs	High nutrient levels High *E. coli* levels
Safeness of full-body contact of local streams and rivers	Reduction of recreation in streams due to health concerns	High *E. coli* levels Reduced aquatic recreation
Unhealthy drinking water from shallow wells and springs	People relying solely on water from shallow aquifers or springs have muddy water after heavy rains, and/or have high levels on nitrogen; unsafe drinking water	High nutrient levels High *E. coli* levels

Concerns	Specific Problems	Problem Category
Lack of storage, poor timing, and/or over application of manure and fertilizer	Poor timing or over application of manure and/ or fertilizers contributes to nutrient loading of surface waters; Over abundance of algae and degraded habitat caused from excess nutrients	High nutrient levels High *E. coli* levels Low oxygen levels Degraded habitat
Runoff from pasture ground	Reduced vegetation erodes pasture ground and increases suspended sediments; nutrient and *E. coli* inputs; pesticide inputs; untreated livestock waste potentially causing high E. coli levels in streams	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat Reduced aquatic recreation
Livestock unlimited access to streams	Erosion from trampled banks increases suspended sediments; degraded stream habitat; nutrient and *E. coli* inputs; Pesticide inputs from Cow Dips	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat Reduced aquatic recreation
Invasive and exotic species	Invasives displace native species; Creating monoculture that reduces nutrient uptake capability and reduces varied root depths and structure	High nutrient levels High TSS and turbidity levels Degraded habitat Decrease in biodiversity Reduced aquatic recreation
Need for protection & rehabilitation of wildlife habitat	Protection & rehabilitation of natural and wildlife habitat is needed	Degraded habitat Decrease in biodiversity
Density and diversity of fish is lower than in the past	People are concerned that fish populations are decreasing in the area; Accounts of parasites and other apparent health problems in fish populations; Certain species are not found in the area any more	Degraded habitat Decrease in biodiversity Reduced aquatic recreation
Lack of pride/ownership of streams	Disregard for public's influence on water quality; public not claiming ownership causes disregard for the environment	Trash Degraded habitat Reduced aquatic recreation
Lack of understanding of pollution prevention options	There is a lack of pollution prevention options readily available to the general public in the area; Most of the community is unaware of pollution prevention strategies	High nutrient levels High *E. coli* levels High TSS and turbidity levels Low oxygen levels Low pH levels Degraded habitat Decrease in biodiversity Reduced aquatic recreation Flooding Trash

Potential causes for each problem category were also identified. Table 18 links stakeholder concerns to water quality problems and potential causes of those problems. A cause is an event, agent, or series of actions that produce a problem. For the purpose of watershed management planning, causes of water quality problems are defined as specific pollutant parameters. Table 19 looks at those problem categories and associates some potential causes.

Table 19: Problem Categories and Potential Causes

Problem Categories	Potential Causes
Trash	Peoples learned behavior and lack of knowledge of the pollution consequence to the environment
High TSS and turbidity levels	TSS and turbidity levels exceed water quality targets; Erosion; Lack of knowledge; Lack of planning; Inadequate or improperly designed systems including current sinkhole filling methods
High E. coli levels	E. coli levels exceed water quality Standards; Inadequate or improper septic system designs & maintenance; Inadequate buffers; Inadequate storage of manure; Insufficient knowledge of E. coli sources
High nutrient levels	Nutrient levels exceed water quality targets; Insufficient public understanding of nutrient sources; Lack of holistic planning; Disregard for consequences of excess fertilizer use; Lack of targeted education on nutrient reduction strategies; Insufficient public understanding of nutrient sources
Low oxygen levels	Chemical pollution; Over abundance of algae; Excess organic material
Low pH levels	Acid Mine Drainage; Illegal dumping
Degraded habitat	Siltation of habitats; Degraded cover; Unstable substrate; Degraded or missing stream morphology; Erosion; Lack of Riparian Vegetation; Increase in flashiness of flow
Decrease in aquatic biodiversity	Organic pollution (decomposition); Inorganic pollution (TSS & TDS); Toxic pollution (Heavy Metals & lethal organic compounds); Thermal Pollution (heated runoff); Biological Pollution (non-natives species)
Reduced aquatic recreation	Streams are impaired for recreational contact by IDEM because of high E.coli levels; log jams; thick sediment deposits; low biodiversity; aesthetics
Flooding	Increased Peak Flows; Lack of stream maintenance; Lack of planning (low impact development); Inadequate or improperly designed systems including current sinkhole filling methods

Section 8 - Linkage of Pollutant Loads to Water Quality

8.1 Potential Sources

The steering committee linked identified water quality problems and causes of those problems to sources based on windshield survey data and other observations made in the watershed (Table 20). Sources can be any cause of nonpoint source pollution.

Table 20: Potential Pollutant Sources per Problem Category

Problem Categories	Potential Causes	Potential Sources
Trash	-Peoples learned behavior and lack of knowledge of the pollution consequence to the environment	• Illegal dumping of materials into ditches, streams, and sinkholes (all subwatersheds)
High TSS and turbidity levels	-TSS and turbidity levels exceed water quality targets	• Off road vehicles access to stream (Sulphur Creek - Lost River, Sams Creek- Lost River, Carters Creek - Lost River, Big Creek - Lost River, and Grassy Creek - Lost River subwatersheds)
	-Insufficient public understanding of Sediment sources	• Livestock access to streams (**ten** pastures in Carters Creek - Lost River; **nine** pastures Log Creek; **eight** pastures in Headwaters Lick Creek; **seven** pastures in Stampers Creek; **five** pastures in each subwatershed of South Fork Lost River, French Lick Creek, and Grassy Creek - Lost River; **four** pastures in both Scotts Hollow and Sams Creek; and **three** pastures in Big Creek subwatershed)
	-Erosion	• Eroded sediments from streambanks (**43** sections identified as either high, very high, or extreme on the Modified Bank Erosion Hazard Index), fields (approximately 6,125 acres of conventionally tilled cropland across all subwatersheds), and development sites (**10** sites in French Lick Creek, Orleans Karst Area, Log Creek- Lick Creek, and Lost River Sink subwatersheds)
	-Inadequate or improperly designed sinkhole fill systems	• Filling of karst sinkholes with whatever material is available(Mt Horeb Drain, Orleans Karst Area, Lost River Sink, Carters Creek, South Fork- Lost River, and Stampers Creek subwatersheds)
	-Lack of holistic planning	• Streams lacking riparian buffers (**240.95 miles** total over all subwatersheds)

Problem Categories	Potential Causes	Potential Sources
High E. coli levels	-E. coli levels exceed water quality Standards -Inadequate or improper septic system designs & maintenance -Inadequate storage of manure -Insufficient knowledge of E. coli sources -Inadequate buffers	• Failing septic systems(all subwatersheds; specific neighborhoods identified in French Lick Creek subwatershed); Septic systems draining directly to karst features (Orleans Karst Area, Mt. Horeb Drain- Lost River, Lost River Sink; Carters Creek- Lost River, South Fork- Lost River, and Stampers Creek subwatersheds) • Excess fertilizer or manure application to commercial and residential properties (Orleans Karst Area, South Fork Lost River, Carters Creek - Lost River, Lost River Sink, Stampers Creek, Log Creek-Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds where manure is used) • Livestock access to streams (**ten** pastures in Carters Creek - Lost River; **nine** pastures Log Creek; **eight** pastures in Headwaters Lick Creek; **seven** pastures in Stampers Creek; **five** pastures in each subwatershed of South Fork Lost River, French Lick Creek, and Grassy Creek - Lost River; **four** pastures in both Scotts Hollow and Sams Creek; and **three** pastures in Big Creek subwatershed) • Manure storage facilities are non- existent for many farms that use or produce manure (all subwatersheds); Influx of poultry farms causing an influx of manure storage and use (all subwatersheds) • Sewer Overflows during storms (Orleans Karst Area, Log Creek- Lick Creek, and French Lick Creek subwatersheds) • Streams lacking riparian buffers (**240.95 miles** total over all subwatersheds)

Problem Categories	Potential Causes	Potential Sources
High nutrient levels	-Nutrient levels exceeded the targets set by this project -Insufficient public understanding of Nutrient sources -Targeted nutrient reduction education does not exist -Disregard for consequences of excess fertilizer use -Lack of holistic planning	• Excess fertilizer or manure application to commercial and residential properties (Orleans Karst Area, South Fork Lost River, Carters Creek - Lost River, Lost River Sink, Stampers Creek, Log Creek-Lick Creek Headwaters Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds) • Livestock access to streams (**ten** pastures in Carters Creek - Lost River; **nine** pastures Log Creek; **eight** pastures in Headwaters Lick Creek; **seven** pastures in Stampers Creek; **five** pastures in each subwatershed of South Fork Lost River, French Lick Creek, and Grassy Creek - Lost River; **four** pastures in both Scotts Hollow and Sams Creek; and **three** pastures in Big Creek subwatershed) • Eroded sediments from streambanks (**43** sections identified as either high, very high, or extreme on the Modified Bank Erosion Hazard Index), fields (approximately 6,125 acres of conventionally tilled cropland across all subwatersheds), and development sites (**10** sites in French Lick Creek, Orleans Karst Area, Log Creek- Lick Creek, and Lost River Sink subwatersheds) • High sensitivity and mobility of nutrients through karst system (Mt Horeb Drain, Orleans Karst Area, Lost River Sink, Carters Creek, South Fork- Lost River, and Stampers Creek subwatersheds) • Failing septic systems(all subwatersheds; specific neighborhoods identified in French Lick Creek subwatershed); Septic systems draining directly to karst features (Orleans Karst Area, Mt. Horeb Drain- Lost River, Lost River Sink; Carters Creek- Lost River, South Fork- Lost River, and Stampers Creek subwatersheds) • Streams lacking riparian buffers (**240.95 miles** total over all subwatersheds)
Low oxygen levels	-Oxygen levels below the targets set by this project -Over abundance of algae -Excess organic material	• Excess fertilizer or manure application to commercial and residential properties (Orleans Karst Area, South Fork Lost River, Carters Creek - Lost River, Lost River Sink, Stampers Creek, Log Creek-Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds) • Excess nutrients entering streams from fertilizers and septic systems (Orleans Karst Area, Log Creek-Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds) • Leaf litter and grass clippings and other organic material carried into streams during storm events (Orleans Karst Area, Log Creek-Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds)

Problem Categories	Potential Causes	Potential Sources
Low pH levels	-Acid Mine Drainage -Illegal dumping	• Abandoned Mine Land exposing iron sulphates to air and water causing acidic leaching from spoils (Grassy Creek-Lost River subwatershed) • Illegal dumping of materials into ditches, streams, and sinkholes (all subwatersheds)
Degraded habitat	-Degraded cover / Lack of Riparian Vegetation -Degraded or missing stream morphology -Increased Flashiness of Flow -High TSS and turbidity levels - Unstable substrate	• Increasing impervious surface (Orleans Karst Area, Log Creek-Lick Creek, and French Lick Creek Subwatersheds) • Streams lacking riparian buffers (**240.95 miles** total over all subwatersheds) • Livestock access to streams (**ten** pastures in Carters Creek - Lost River; **nine** pastures Log Creek; **eight** pastures in Headwaters Lick Creek; **seven** pastures in Stampers Creek; **five** pastures in each subwatershed of South Fork Lost River, French Lick Creek, and Grassy Creek - Lost River; **four** pastures in both Scotts Hollow and Sams Creek; and **three** pastures in Big Creek subwatershed) • Off road vehicles access to stream (Sulphur Creek - Lost River, Sams Creek- Lost River, Carters Creek - Lost River, and Big Creek - Lost River subwatersheds)
Decrease in aquatic biodiversity	-Organic pollution (decomposition) -Inorganic pollution (Turbidity, TSS, & TDS) -Toxic pollution (Heavy Metals & lethal organic compounds) -Thermal Pollution (heated runoff) -Biological Pollution (non-natives species)	• Leaf litter and grass clippings and other organic material carried into streams during storm events (Orleans Karst Area, Log Creek-Lick Creek & French Lick Creek subwatersheds) and farm fields (all subwatersheds) • Eroded sediments from streambanks (**43** sections identified as either high, very high, or extreme on the Modified Bank Erosion Hazard Index), fields (approximately 6,125 acres of conventionally tilled cropland across all subwatersheds), and development sites (**10** sites in French Lick Creek, Orleans Karst Area, Log Creek- Lick Creek, and Lost River Sink subwatersheds) • Abandoned Mine Land exposing iron sulphates to air and water causing acidic leaching from spoils (Grassy Creek-Lost River subwatershed) • Streams lacking riparian buffers (**240.95 miles** total over all subwatersheds) • Invasive species threaten area by competing for habitat and food sources (Grassy Creek- Lost River Subwatershed)

Problem Categories	Potential Causes	Potential Sources
Reduced aquatic recreation	-Streams are impaired for recreational contact because of high E.coli levels -Log jams -Thick sediment deposits -Low biodiversity -Aesthetics are unpleasing according to social surveys	• Severe Log Jams (**7** Type 4 and Type 3 Log Jams migrating throughout the watershed as of 2011; more created each major rain event) • Eroded sediments from streambanks (**43** sections identified as either high, very high, or extreme on the Modified Bank Erosion Hazard Index), fields (approximately 6,125 acres of conventionally tilled cropland across all subwatersheds), and development sites (**10** sites in French Lick Creek, Orleans Karst Area, Log Creek- Lick Creek, and Lost River Sink Subwatersheds) • Excess fertilizer or manure application to commercial and residential properties (Orleans Karst Area, South Fork Lost River, Carters Creek - Lost River, Lost River Sink, Stampers Creek, Log Creek-Lick Creek & French Lick Creek Subwatersheds) and farm fields (all subwatersheds) • Livestock access to streams (**ten** pastures in Carters Creek - Lost River; **nine** pastures Log Creek; **eight** pastures in Headwaters Lick Creek; **seven** pastures in Stampers Creek; **five** pastures in each subwatershed of South Fork Lost River, French Lick Creek, and Grassy Creek - Lost River; **four** pastures in both Scotts Hollow and Sams Creek; and **three** pastures in Big Creek subwatershed) • Leaf litter and grass clippings and other organic material carried into streams during storm events (Orleans Karst Area, Log Creek-Lick Creek & French Lick Creek Subwatersheds) and farm fields (all subwatersheds) • Streams lacking riparian buffers (240.95 miles total over all subwatersheds) • Surveys indicate that the streams within the watershed are reduced for recreation use because of aesthetics
Flooding	-Lack of stream maintenance -Increased Peak Flows -Lack of planning (low impact development)	• Increasing impervious surface (Orleans Karst Area, Log Creek-Lick Creek, and French Lick Creek Subwatersheds) • Agricultural drainage improvements (all subwatersheds) • Filling of karst sinkholes with whatever material is available (Mt Horeb Drain, Orleans Karst Area, Lost River Sink, Carters Creek, South Fork- Lost River, and Stampers Creek subwatersheds)

8.2 Estimation of Pollutant Loads & Load Reduction Targets

Estimating the total amount of a contaminant in a stream is a challenging task. Load estimation is very useful for any watershed plan to determine how much reduction in pollutants is needed to achieve water quality standards or targets. Load is the amount of a pollutant (usually in pounds, kilograms, or tons) that passes through a point on a stream or river in a certain amount of time (often in one day or one year). In order to estimate load on a particular day (instantaneous load), two things are needed:

- Concentration of the pollutant, usually in units of mass per volume (often mg/liter or parts per million), and
- Flow rate, or the amount of water that flows during a certain amount of time. This flow rate is in units of volume per time (for example, cubic feet per second.)

What is difficult, however, is to estimate the total load over a longer period, during which the daily load varies considerably. Annual load, the total load in an average year, is typically needed to estimate current loads and therefore load reduction needed to meet target loads in a watershed plan. Therefore, to calculate annual load both concentration and flow are needed each day. This is where estimating annual load becomes difficult, because they are rarely available. Daily flow is available at USGS gaging stations, but concentration is usually only measured periodically (monthly) by most studies.

USGS has developed a tool called LOADEST for estimating the daily concentration and using it to calculate load. LOADEST estimate loads for each day, which you can sum to get total annual loads. The method is based on the assumption that concentration varies with flow. This works particularly well for phosphorus and suspended sediment concentration, which tend to be much higher during high flows. Nitrogen concentrations can also be calculated using this method, but they are not as accurate due to the ability of nitrogen to flow with groundwater.

To obtain a statistically significant and more accurate estimate of pollutant loads based on field data, more than monthly pollutant concentration samples and corresponding flow measurements as are currently available are needed. Purdue's Web-Based Load Calculation Using LOADEST program was used to calculate existing loads, the amount of loads desired to meet targets, and the amount of load reduction needed to meet targets at sites where discharge data was available or able to be calculated.

Consistent discharge data is only available for the sites that are co-located with a USGS stream gage station. These include Site B, Site C, Site 9, Site 7, and Site 10. For some stations, discharge can be calculated using the gage station data and the ratio method. The ratio method can be used to estimate flow at an ungaged station using a nearby gage if the drainage ratio was between 0.5 and 1.5. For this method, flow at the gage site is multiplied by the ratio of the gaged to ungaged watersheds. This method may lose some accuracy with karst hydrology, so some caution is used when selecting a representative watershed. Due to the large number of gages available in Lost River watershed, a representative watershed could be selected to calculate flow at additional stations. Discharge from Sites 1, 2, & 3 were calculated using the USGS 03373530 LOST RIVER NEAR LEIPSIC, IN, which is co-located with Site B. This gage is upstream from Site 3 and downstream from Site 1. Stampers Creek flow will respond summarily to flow in Lost River until flooding occurs. At this point Stampers Creek has nowhere to go, unlike Lost River, which can navigate through the Dry Branch of Lost River. Discharge at Site 6 and 8 were calculated using USGS 03373610 LICK CREEK AT PAOLI, IN. This gage is co-located with Site C and upstream of Site 6.

Discharge for Site 13- Lost River at the outlet of the Big Creek- Lost River subwatershed and Site 14- Lost River near the outlet to East Fork White River were harder to develop. Gages in the area that have a watershed that is 0.5 to 1.5 in ratio to these sites are unavailable. Instead, discharge for these locations was developed using hydrologic routing along with the ratio method for a smaller subset of the watershed. Hydrologic routing is calculated by determining the travel time for discharges at sites 6, 9, 10, & 8 and routing flow into the downstream area. This along with the ratio method used on the remaining unrepresented land and discharge from a representative watershed USGS 03373508 BEAVER CREEK NEAR SHOALS, IN.

Figure 225 and Table 21 depicts average pollutant loads from the 2011-2012 monthly monitoring at selected sample site on a watershed basis. Load data suggests that subwatersheds draining to Sites 9 on Lost River contribute the highest load of Nitrogen to the watershed. Nitrogen loads seem to decrease toward the outlet of Lost River. This may be due to the large wetland complex installed by Hoosier National Forest along Lost River between sites 9 and 13. Load data also suggests that Lick Creek is contributing the largest amount of sediment and phosphorus to the system as seen from data collected at Site 6. Again loads reduce as water approaches the outlet of Lost River for phosphorus and sediment. Developed areas in Paoli drain to Lick Creek upstream of Site 6. Developed areas in Orleans drain through the subsurface to Lost River via Orangeville Rise at Site 7. Developed areas of French Lick and West Baden drain to French Lick Creek near Site 10. Two gravel quarries that drain directly to the Lick Creek upstream of site C and upstream of Site 6 along with cultivated cropland, pasture land, and eroding stream banks draining to this stream are likely sources of TSS and phosphorus.

E. coli concentrations should remain less than or equal to 235 CFU/100 mL at any given time based on water quality standards. Consequently, calculation of an E. coli annual load reduction is not appropriate.

Total loads determined for the watershed are used in the goal development in Section 9. The addition of loads from sites 6, 8, 9 and 10 give a general value of overall load reductions needed from the headwaters of Lost River. Site 13 can be used to determine the loads near the outlet of Lost River. At Site 14, just upstream of the outlet to White River, concentrations of pollutants may have been influenced by backwater from White River. Do to this the loads from this site may be underestimating the actual loads from the watershed. Due to the nature of load calculations, it is believed that values taken from major tributaries as they enter the system may determine actual loads that need reduction within the watershed. For this reason, total load reduction needed were calculated by adding the load reduction needed at sites 6, 8, 9, and 10, the outlets of Lick Creek, Upper Sulphur Creek, Upper Lost River, and French Lick Creek, respectively.

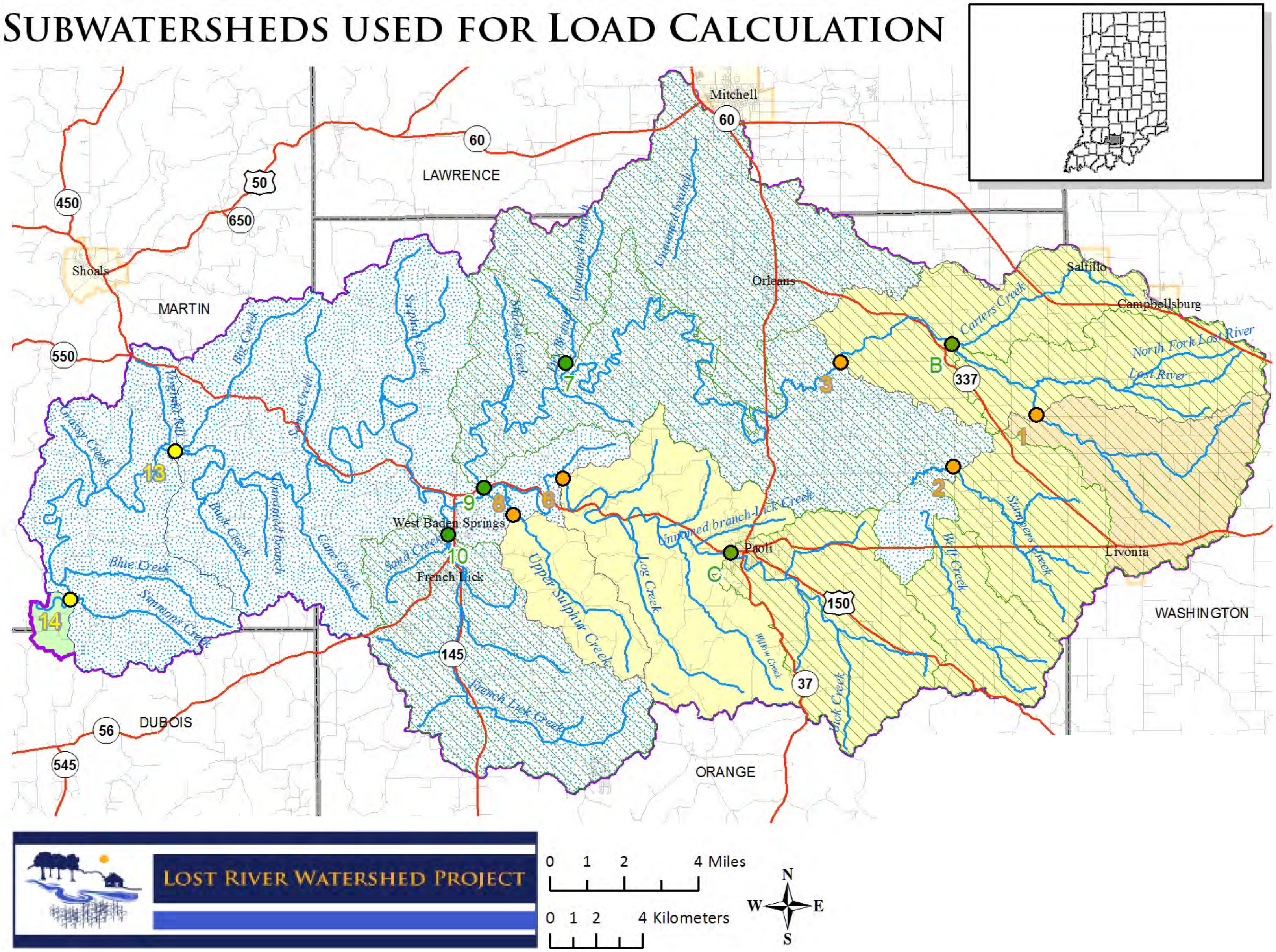


Figure 255: Subwatershed and Method for each Load Calculation

Table 21: Load data for Nitrogen, Phosphorus, and Total Suspended Sediment- includes load amounts to meet targets and load reductions needed.

Site	Sub-watershed Area (acres)	Nitrogen Estimated Annual Load (lbs/year)	Maximum Nitrogen Annual Load to Meet Target (lbs/year)	Nitrogen Load Reduction Needed to Meet Target (lbs/year)	Phosphorus Estimated Annual Load (lbs/year)	Maximum Phosphorus Annual Load to Meet Target (lbs/year)	Phosphorus Load Reduction Needed to Meet Target (lbs/year)	TSS Estimated Annual Load (tons/year)	Maximum TSS Annual Load to Meet Target (tons/year)	TSS Load Reduction Needed to Meet Target (tons/year)
1*	11,793	299,146	119,327	**179,818**	28,550	5,568	**22,981**	1,762	902	**860**
B	22,790	627,435	130,377	**497,057**	19,089	4,345	**14,743**	-	-	**-**
2*	10,005	516,110	311,694	**204,415**	90,837	14,545	**76,291**	8,351	2,358	**5,992**
3*	35,897	1,147,560	362,044	**785,515**	65,028	16,895	**48,133**	5,558	2,739	**2,819**
C	13,922	175,565	163,402	**12,162**	18,976	5,446	**13,529**	-	-	**-**
6*	32,513	1,105,220	1,146,521	**0**	231,366	53,504	**177,861**	123,275	8,675	**114,599**
7	26,880	1,220,925	408,091	**812,833**	46,723	19,044	**27,679**	7,712	3,087	**4,624**
8*	6,034	126,180	160,399	**0**	7,716	7,485	**230**	1,383	1,213	**169**
9	102,482	2,452,435	769,860	**1,682,574**	78,624	35,926	**42,697**	16,100	5,825	**10,274**
10	21,073	40,890	116,153	**0**	5,945	5,420	**525**	1,967	878	**1,088**
13**	214,459	2,566,315	1,577,578	**988,736**	212,455	73,620	**138,835**	45,132	11,937	**33,195**
14**	233,172	2,018,450	1,107,946	**910,503**	89,899	53,189	**36,709**	14,406	8,383	**6,023**

* Ratio Method was used to determine flow

** Hydrologic routing using estimated travel time with the addition of ratio method to determine flow

\- No data available

Section 9 - Watershed Goals and Objectives

Goals were developed to address the ten identified problem categories and improve water quality in Lost River watershed. Identified problem categories trash, high TSS and turbidity levels, high E. coli levels, high nutrient levels, low oxygen levels, low pH levels, degraded habitat, decrease in aquatic biodiversity, reduced aquatic recreation, and flooding.

Some of the primary goals address more than one problem category. For instance, achieving the goal to reduce sediment will not only address the problem of high stream TSS and turbidity levels, it will also improve degraded aquatic habitat, reduce flooding risks, improve aesthetics for aquatic recreation value, reduce stream nutrient levels, and create potential for an increase in aquatic biodiversity. Reducing nutrient loads will also create potential for increased aquatic biodiversity by making habitat more suitable for sensitive species. Reducing E. coli levels will make the streams safer for citizens to participate in aquatic recreation. Trash reaching streams and sinkholes is expected to diminish as citizens become more knowledgeable about water quality and the factors that influence it through the efforts undertaken as part of an educational campaign to increase public awareness.

The seven goals selected are not listed in any particular order. The order does not indicate a level of importance. The seven primary goals selected are listed here:

GOAL #1- Stream and sinkhole buffers are not sufficient enough to reduce nutrients, pathogens, and sediment in the watershed. There is approximately 241 miles of streams and thousands of sinkholes that are in need of a buffer. We would like to see a:

- 5% increase (12.05 miles) in stream or sinkhole buffers in 5 years,
- 10% increase (24.1 miles) in stream or sinkhole buffers in 10 years, and
- 25% increase (60.25 miles) in stream or sinkhole buffers in 20 years.

GOAL #2- Nutrients need to be reduced within the watershed. There are 1.68 million pounds of Nitrogen and 221,313 pounds of Phosphorus per year above the target levels within the streams. We would like to see a:

- 20% decrease (336,510 lbs N & 44,263 lbs P) in of nutrient loads above target levels in 5 years ,
- 30% decrease (504,772 lbs N & 66,340 lbs P) in of nutrient loads above target levels in 10 years ,and
- 50% decrease (841,287 lbs N & 110,657 lbs P) in of nutrient loads above target levels in 20 years.

GOAL #3- Sediment loads needs to be reduced within the watershed by 126,130 tons within the watershed with a large majority of that coming from Lick Creek (114,600 tons). Total Suspended Solids (TSS) will be reduced within the Lick Creek and the watershed as a whole. We would like to see a:

- 10% decrease (11,460 tons) in TSS loads in 5 years from Lick Creek,
- 20% decrease (22,920 tons) in TSS loads in 10 years from Lick Creek and 5% decrease (6,306.5 tons) in the watershed, and
- 30% decrease (34,380 tons) in TSS loads in 20 years from Lick Creek and 10% decrease (12,613 tons) in the watershed.

GOAL #4- A total of 40% of samples tested for E. coli as part of this study exceeded the 235 CFU/100 mL water quality standard. The overall goal is to reduce E. coli concentrations throughout the watershed to meet water quality standards. We would like to see that:

- 70% of samples collected do not exceed state standards for *E. coli* in 5 years,
- 75% of samples collected do not exceed state standards for *E. coli* in 10 years, and
- 80% of samples collected do not exceed state standards for *E. coli* in 20 years.

GOAL #5- Aquatic organisms' diversity and populations have been declining and are impaired in some watersheds. High nutrient levels may be causing low Dissolved Oxygen (DO) levels within the watershed affecting these populations. We would like to see:

- an increase in macroinvertebrate populations and diversity in the next 20 years (mIBI Scores >35),
- delisting the critical watersheds from the IDEM 303(d) list for impaired biotic communities, and
- DO levels meet State water quality standards with minimums above 4 mg/L within 20 years.

GOAL #6- Stormwater runoff often causes high velocity flows during rain events carrying vehicle and residential non point sources of pollution into our waterways. Stormwater runoff may be causing some of the bank erosion, decline in macroinvertebrate populations, and spikes in E.coli populations within our streams. The goal is to reduce stormwater runoff from urban, industrial, and residential areas within the watershed using data from gauging stations to see attenuation in peak flows. We would like to see an increase in stormwater runoff filtration and attenuation within these areas in the next 20 years. We would like to see that 25% of impervious surfaces have stormwater control structures or practices to reduce runoff of polluted waters within the next 5 years.

GOAL #7- The steering committee believes that many problems in Lost River watershed stem from the fact that the general public has an insufficient understanding of water quality issues and how their actions can make a difference as well as general apathy. The steering committee wishes to gradually increase the general knowledge and understanding of water quality issues held by the general public over the next 20 years while increasing the capacity of the LRWP.

The steering committee determined sub-goals to work toward with timelines in order to achieve each primary goal as well as indicators that can be used to determine if progress is being made toward achieving the goal.

9.1 Management Objectives

Based on identified stakeholder concerns, water quality data, and potential sources of pollution, goal statements were developed for each problem. Implementation of policies, programs, and practices will improve water quality and watershed conditions within the Lost River watershed. The goals detailed above represent both the ultimate goal of reaching target pollutant concentrations identified by the steering committee and the realistic potential for reaching a target goal within a generation (20 years). For each goal a list of both short term (5 years) and long term (10-20 years) strategies necessary to meet the goal are detailed. Some strategies identified for individual goals may be applicable to other goals, and in such cases, these strategies are listed under each goal.

The seven primary goals selected include a reduction in *E. coli* concentrations to below the state standard, a reduction in sediment to below the water quality target, a reduction in nutrient loads to below water quality targets, an increase in public awareness of water quality issues, and a reduction in flood damages. The steering committee determined sub-goals to work toward with timelines in order to achieve each primary goal as well as indicators that can be used to determine if progress is being made toward achieving the goal.

Install Buffers

Conservation buffers are areas or strips of permanent vegetation established in and around row crops. They include filter strips, riparian buffers, field borders, shallow water areas for wildlife, grassed waterways, field windbreaks, shelterbelts, designated wellhead protection areas, living snow fences, and contour grass strips. Buffers are designed to intercept sediment and nutrients and reduce soil erosion; however, they also help enhance air and water quality plus fish and wildlife habitats, which encourages biodiversity and beautifies agricultural landscapes. Current stream and sinkhole buffers are not sufficient to reduce nutrients, pathogens, and sediment in the Lost River watershed. There is approximately 241 miles of streams and thousands of sinkholes that are in need of a buffer. We would like to see a 5% increase in stream or sinkhole buffers in 5 years, a 10% increase in stream or sinkhole buffers in 10 years, and a 25% increase in stream or sinkhole buffers in 20 years. Table 22 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 22: Increase Buffer Goals and Indicators

Sub Goal	Indicator
Short term (1-5 years)	
Educate watershed residents & landowners on the function and value of buffer strips	• Number of educational events (workshops, field days, etc)
Educate watershed residents & landowners on the function and value of stream bank stabilization	• Number of articles, and educational material generated
Implement stream buffers BMPs	• Number of installed buffers
Educate landowners on sinkhole & karst development and connection to our surface waters	• Number promotional materials generated
Work with county and town officials on incorporating stream buffers into development plans	• Number of follow up interviews of BMP implementation for determining success & lessons learned
Educate producers on value of fencing out livestock from streams	• Number of landowners installing fence, etc. who apply for funding
Fence livestock out of streams, ditches, and riparian areas	• Load Reductions achieved with BMP implementation
Medium-term (6-10 years)	• Linear feet of installed fence adjacent to stream
Continued education and BMP implementation	• Stream length in linear feet with stream buffers
Stream buffers continuous along stream reaches	• Number and feet of streambanks stabilized
Investigate funding sources for further BMP implementation	• How much of the watershed is affected by installed practices
Long-term (11-20 years)	
Continued education and BMP implementation	• Number of installed practices (without cost-share)
Keep abreast of new and updated technology to improve riparian area treatment	• Number of grants or leveraged funding sources investigated

Reduce Nutrients

In balance, nutrients are essential for healthy terrestrial and aquatic ecosystems. However, nutrients in excess, particularly nitrogen and phosphorus, are harmful to the environment. Excess nutrients stimulate algal blooms that deplete the oxygen in natural waters, resulting in conditions that cannot sustain aquatic life. Nutrients need to be reduced within the watershed. There are 1.6 million pounds of Nitrogen and 220,000 pounds of Phosphorus per year above the target levels within the streams. We would like to see a 20% decrease in nutrient loads above target levels in 5 years, a 30% decrease in of nutrient loads above target levels in 10 years ,and a 50% decrease in of nutrient loads above target levels in 20 years. Table 23 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 23: Decrease Nutrients Goals and Indicators

<table>
<tr><th>Sub Goal</th><th>Indicators</th></tr>
<tr><td>Short term (1-5 years)</td><td rowspan="20">• Number of educational events
• Number of articles, and educational material generated
• Number of urban and agricultural installed BMPs
• Amount of stream length with stream buffers
• Number of landowners installing fence, etc. who apply for funding
• Number of follow up interviews of BMP implementation for determining success & lessons learned
• Number of partners developed for wetland placement
• Number of septic maintenance workshops, databases, and reminders developed
• Load Reductions achieved with BMP implementation
• Measured reduction nitrogen and phosphorus concentrations

• Number of karst literature resources uncovered
• Survey data tracking changes in attitude and behaviors of agricultural producers, livestock owners, pet owners, land managers, and/or homeowners</td></tr>
<tr><td>Educate watershed landowners on methods of reducing nutrient runoff</td></tr>
<tr><td>Implement nutrient reducing BMPs</td></tr>
<tr><td>Install stream buffers in potentially high nutrient production areas</td></tr>
<tr><td>Fence livestock out of critical areas</td></tr>
<tr><td>Educate agricultural producers on how manure management, no-till, cover crops, and precision ag can reduce nutrient inputs</td></tr>
<tr><td>Implement stormwater filtration BMPs for reducing non-point source pollution runoff from urban, industrial, and residential areas</td></tr>
<tr><td>Develop a septic maintenance educational program</td></tr>
<tr><td>Educate watershed landowners on function and value of wetlands</td></tr>
<tr><td>Connect landowners and businesses with agencies/entities for wetland remediation</td></tr>
<tr><td>Seek resources to Investigate sinkhole and karst influence on nutrient loading to waterways and groundwater</td></tr>
<tr><td>Medium-term (6-10 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Research methods for treating farm runoff within or around sinkholes</td></tr>
<tr><td>Investigate standard for sinkhole treatment BMP</td></tr>
<tr><td>Work with county on updating septic ordinances</td></tr>
<tr><td>Long-term (11-20 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Continued investigation of new and alternative methods for treating nutrient runoff in karst</td></tr>
<tr><td>Continued investigation of new and alternative funding sources for failing septic replacement & alternative systems</td></tr>
</table>

Reduce Sediment Loads

Reduction of sediment to stream will help improve aquatic habitats and aquatic life within streams. Soil erosion along with stream bank erosion may be two significant sources of sediment to our streams. Soil erosion is a gradual process that occurs when the impact of water or wind detaches and removes soil particles, causing the soil to deteriorate. Soil erosion by water, and the impact of sediment-attached nutrients (i.e., phosphorus) on lakes and streams, creates problems for both agricultural land and water quality. Sediment loads needs to be reduced within the Lost River watershed by 155,000 tons with a large majority of that coming from Lick Creek. Total Suspended Solids (TSS) or turbidity will be reduced within the Lick Creek and the watershed as a whole. We would like to see a 10% decrease in TSS loads in 5 years from Lick Creek, a 20% decrease in TSS loads in 10 years from Lick Creek plus a 5% decrease in the entire watershed, and a 30% decrease in TSS loads in 20 years from Lick Creek plus a 10% decrease in the entire watershed. Table 24 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 24: Decrease Sediment Goals and Indicators

Sub Goal	Indicator
Short term (1-5 years)	• Number of educational events
Educate agricultural producers and livestock owners on the function and value of BMPs as beneficial practices for crop production and water quality	• Survey data tracking changes in attitude and behaviors of agricultural producers, livestock owners, pet owners, land managers, and/or homeowners
Educate watershed residents on the function and value of BMPs to reduce erosion	• Number of articles, and educational material generated
Increase utilization of native plants/wildlife habitat for erosion control	• Number of urban, forest, and agricultural BMPs installed
Identify/map for the primary purpose of identifying areas in need of stream restoration	• Feet of stream length with stream buffers
Educate forest landowner the function and value of managed forest lands	• Number of forested acres with forest management plans
Develop a Log Jam Preventive Maintenance Program with town and county officials and Flood Task Force to join riparian health with removal of log jam risk	• Number of landowners and linear feet of installed fence who apply for funding
Remove large log jams if major erosion is occurring or if public infrastructure and safety are at risk	• Number of cropped acres covered during off season
Continue log jam education workshops	• Acres of pastures with healthy cover
Implement stormwater attenuation BMPs for reduced stormflow velocities that may be causing stream bank erosion	• Number of follow up interviews of BMP implementation for determining success & lessons learned
Investigate sinkhole filling methods and look for alternatives	
Medium-term (6-10 years)	• Number of Karst literature resources uncovered
Continued education and BMP implementation	• Acres of forests enrolled into classified forest
Increase utilization of native plants/wildlife habitat for erosion control	• Sediment Load Reductions achieved with BMP implementation
Long-term (11-20 years)	• Amount of reduction in stormwater runoff
Continued education and BMP implementation	• Measured reduction in High Hazard Banks
Increase utilization of native plants/wildlife habitat for erosion control	• Production of Log Jam Preventative Maintenance Plan
Increased recreational value and wildlife habitat quality	• Implementation of Log Jam Preventative Maintenance Plan

Reduce Bacterial (E. coli) Loads

E. coli is a type of fecal coliform bacteria that comes from human and animal waste. The Environmental Protection Agency uses *E. coli* measurements to determine whether fresh water is safe for recreation. Disease-causing bacteria, viruses, and protozoan may be present in water that has elevated levels of *E. coli*. A total of 40% of samples tested for E. coli as part of the Lost River Watershed monitoring study exceeded the 235 CFU/100 mL water quality standard. The overall goal is to reduce E. coli concentrations throughout the watershed to meet water quality standards. We would like to see that 70% of samples collected do not exceed state standards for *E. coli* in 5 years, 75% of samples collected do not exceed state standards for *E. coli* in 10 years, and 80% of samples collected do not exceed state standards for *E. coli* in 20 years. Table 25 lists sub goals and indicators that can be measured in reaching those goals.

Table 25: Decrease E. coli Goals and Indicators

<table>
<tr><th>Sub Goal</th><th>Indicator</th></tr>
<tr><td>Short term (1-5 years)</td><td rowspan="14">• Increased septic system awareness and changing attitudes measured by survey data
• Number of landowners installing use exclusion, waste storage or manure management plans who apply for funding
• Number of residences upgrading on-site septic systems indicated by county permit trends
• Residences participating in group discount maintenance programs if such a program is offered
• Linear feet of riparian buffers installed
• Number of homes connected to municipal sewer
• Measured reduction in E. coli concentrations
• Number of pet waste receptacles
• Removal from 303(d) list for E. coli impairments</td></tr>
<tr><td>Educate homeowners so that they understand how failing septic systems impact water quality, they believe changes are important, and they become willing to take action by conducting regularly scheduled maintenance and necessary upgrades</td></tr>
<tr><td>Educate livestock owners so that they understand how livestock wastes impact water quality, they believe changes are important, and they become willing to take action by implementing BMPs to exclude livestock access from streams, utilize waste more conservatively, and use better waste storage practices</td></tr>
<tr><td>Educate pet owners so that they understand how pet wastes impact water quality, and install pet waste receptacles in public areas</td></tr>
<tr><td>Implementation of Waste Utilization , Storage, and Handling BMPs</td></tr>
<tr><td>Medium-term (6-10 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Voluntary maintenance and upgrades are made to suitable on-site septic systems</td></tr>
<tr><td>Develop a local ordinance requiring upgrades to failing systems at the time of real estate transactions</td></tr>
<tr><td>Town annexation of neighborhoods that are not suitable for on-site septic systems</td></tr>
<tr><td>Long-term (11-20 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Lost River is removed from the 303d list for E. coli impairment and is safe for recreation</td></tr>
</table>

Improve Aquatic Organism Diversity and Population

Aquatic organisms' diversity and populations have been declining and are impaired in some of the Lost River watersheds. High nutrient levels may be causing low Dissolved Oxygen (DO) levels within the watershed affecting these populations. We would like to see an increase in macroinvertebrate populations and diversity in the next 20 years (mIBI Scores >35), delisting the critical watersheds from the IDEM 303(d) list for impaired biotic communities, and DO levels meet State water quality standards with minimums above 4 mg/L within 20 years. Table 26 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 26: Aquatic Organism Goals and Indicators

Sub Goal	Indicator
Short term (1-5 years)	• Increased awareness and changing attitudes measured by survey data • Number of articles, and educational material generated • Number of urban, forest, and agricultural BMPs installed • Amount of stream length with stream buffers • Number pharmaceutical take back events • Number of landowners and feet of installed fence who apply for funding • Number of treatment sites for acid mine drainage • Presence of invasive species program • Number of follow up interviews of BMP implementation for determining success & lessons learned • Amount of reduction in stormwater runoff • Future development includes non-structural BMPs in their planning and designs • Sediment Load Reductions achieved with BMP implementation • Increase in fish populations and diversity • Increase in mussel populations and diversity • Increase in QHEI score • Number of installed practices (without cost-share)
Educate landowners on effects that runoff has on aquatic organisms	
Educate agriculture producers of the value and function of nutrient and pest management plan	
Educate residents on the influence that pharmaceuticals and personal care products have on organisms	
Work with partners to have a prescription take-back event	
Work with town and highway departments on salt alternatives for slick roadways	
Implement acid mine drainage treatment BMPs for abandoned coal mines	
Work to connect natural areas with stream buffers and other land set-asides	
Establish invasive species control programs to prevent spread of exotics.	
Incorporate Low Impact Development planning techniques throughout the watershed to reduce habitat isolation and improve overall health of the biosystem.	
Medium-term (6-10 years)	
Continued education and BMP implementation	
Determine if BMPs are having a positive effect on biologic populations	
Investigate alternative BMPs for improving aquatic life	
Long-term (11-20 years)	
Increase Habitat quality within the watershed	
Continued education and BMP implementation	
Lost River is removed from the 303d list for Impaired Biotic Communities	• Measured increase in macroinvertebrate populations and diversity

Reduce Stormwater Runoff

Stormwater runoff often causes high velocity flows during rain events carrying vehicle and residential non point sources of pollution into our waterways. Stormwater runoff may be causing some of the bank erosion, decline in macroinvertebrate populations, and spikes in E.coli populations within our streams. The goal is to reduce stormwater runoff from urban, industrial, and residential areas within the watershed. We would like to see an increase in stormwater runoff filtration and attenuation within these areas in the next 20 years. Table 27 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 27: Stormwater Goals and Indicators

Sub Goal	Indicator
Short term (1-5 years)	• Number of educational events • Number of articles, and educational material generated • Number of development plans and town plans that incorporate non-structural stormwater BMPs • Number of urban, residential and industrial stormwater BMPs installed • Reduction in stormwater runoff • Amount of stream length with stream buffers • Number of follow up interviews of BMP implementation for determining success & lessons learned • Number of partners developed • Separation of storm and sewer systems • Water Quality considerations in any zoning and planning work
Education on Stormwater runoff from construction & industrial sites (Rule 5 & 6)	
Incorporate Low Impact Development planning techniques and non-structural BMPs throughout the watershed to reduce flash flows, high runoff potential, temperature extremes, habitat isolation, and improve overall health of the watershed.	
Educate homeowners in backyard conservation practices	
Educate stakeholders on effects and risks of stormwater runoff	
Work with towns to reduce combined sewer overflows	
Implement stormwater attenuation and filtration BMPs in reduce the influence stormwater runoff has on the system	
Implement stream buffers BMPs	
Medium-term (6-10 years)	
Continued education and BMP implementation	
Investigation of new and alternative methods for treating stormwater runoff	
Work with potential zoning plans to ensure stormwater considerations are made	
Look for alternative funding mechanisms for separating storm and sewer systems	
Long-term (11-20 years)	
Continued education and BMP implementation	
Work to separate sewer system and storm drains	

Increase Knowledge & Capacity

The steering committee believes that many problems in Lost River watershed stem from the fact that the general public has an insufficient understanding of water quality issues and how their actions can make a difference as well as general apathy. The steering committee wishes to gradually increase the general knowledge and understanding of water quality issues held by the general public over the next 20 years while increasing the capacity of the LRWP. Table 28 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 28: Knowledge and Capacity Goals and Indicators

<table>
<tr><th>Sub Goal</th><th>Indicator</th></tr>
<tr><td>Short term (1-5 years)</td><td rowspan="15">• Number of educational events
• Number of articles, and educational material generated
• Increased number of urban, forest, and agricultural BMPs installed over time
• Number of grants applied for and awarded
• Completion of Plan of Work
• Completion of Financial Plan
• Working, filterable volunteer database in place
• Number of clean water signs placed within watershed demonstrating pr ide
• List of partners developed and utilized
• Percent of applications that are completed through conservation programs
• Statistics from interviews
• Statistics from all surveys</td></tr>
<tr><td>Increase the capacity of the Watershed Partnership</td></tr>
<tr><td>Establish education, outreach, and clean-up programs to reduce stream, sinkhole, and roadside dumping.</td></tr>
<tr><td>Develop appropriate planning to insure the long-term viability and effectiveness of the LRWP</td></tr>
<tr><td>Provide human and intellectual resources required to further the goals and mission of the LRWP.</td></tr>
<tr><td>Build and Utilize Partnerships</td></tr>
<tr><td>Educate stakeholders on pollution prevention options</td></tr>
<tr><td>Develop a pride program for keeping the local community clean</td></tr>
<tr><td>Medium-term (6-10 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Look for alternative funding mechanisms for increasing knowledge and concern of water quality</td></tr>
<tr><td>Continued increase in capacity for Lost River Watershed Partnership</td></tr>
<tr><td>Long-term (11-20 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Sustainability and Growth in Lost River Watershed Partnership</td></tr>
</table>

9.2 Identification of Critical Areas

A critical area as defined for watershed management planning is a place where implementation of watershed management plan guidance can remediate nonpoint source pollution in order to improve water quality or mitigate future pollutant sources to protect water quality.

The Lost River Watershed Partnership used a variety of criteria to develop Critical Areas (i.e. Priority Subwatersheds) in the larger watershed. Nutrient, dissolved oxygen and *E. coli* problem areas were determined using monthly water quality data collected in the 2011-2012 monitoring study. Sediment loads were calculated using concentration and flow data from each site on each sample date. Concentration, habitat, aquatic life, and flow data from each site on each sample date were tabulated and then compared against values recognized by water quality professionals to be indicative of healthy conditions. In addition to relative concentration and load information, the subwatersheds were scored against information collected during windshield and desktop surveys such as lack of buffered streams present and cattle with access to the streams, as well as the presence of CAFO/CFO, urban stormwater, sensitive karst areas, and agricultural land use. Each subwatershed was listed in a spreadsheet and scored against twelve criteria based upon the aforementioned data (Table 29).

The original “1” and “2” scores (yellow and red coding, respectively) came from the relative impact that each subwatershed displayed for each parameter over the 2011-2012 sampling events (Shown as highlighted values in Tables 29). The Steering Committee then applied some discretion when reviewing the weighted scores by adjusting the importance of some parameters relative to others (e.g. double weighting the water quality parameters of Nitrate, phosphorus, E.coli and Sediment; *E.coli* scores were weighted with 2 additional points if site had 2 or more samples with *E.coli* levels above detection limit). The scores for each subwatershed were totaled across the parameters to arrive at a total relative score. Subwatersheds associated with sample sites that showed elevated concentrations for multiple parameters, especially parameters that grossly exceeded state standards, targets, or were representative of multiple ecological concerns received the top scores (20-27 points) in the score table. Those sampling subwatersheds that showed a moderate concern received a middle range score (13-18 points), and those of little to no concerns received a low impairments score (3-10 points). Watersheds were then ranked from 1-16 based on their score. Natural divides revealed themselves based on the ranking. Those that ranked from 1 to 5 were identified as priority watersheds and should receive a higher priority when applying for BMP implementation. Those that ranked from 6 to 10 were identified as secondary priority watersheds and should receive a lower priority when applying for BMP implementation.

For the purposes of visual depiction and communication, the subwatersheds with highest concern (weighted score) were assigned a “rose” status/color, while those with ‘moderate’ concern were assigned a “green” status/color. All remaining subwatersheds with lesser or limited concerns are white (with hatch marking in Figure 256). Figure 256 is a map of the watershed indicating the areas of top- ranked, middle-ranked, and non-priority areas for implementation based off the above scoring techniques.

Sources for the pollutants and causes for high ranking for each of the Critical Areas can be found in the descriptions of the Subwatershed and windshield survey for each subwatershed in Section 5. Sources for lower water quality for each subwatershed can also be found in Section 8.1 Pollutant Sources. In that section the steering committee linked identified water quality problems and causes of those problems to sources based on windshield survey data and other observations made in the watershed (Table 20).

Table 29: Watershed Priority Ranking and Critical Area Selection

Subwatershed	Nitrate*	Phosphorus*	*E.coli**	Sediment*	Dissolved Oxygen*	Habitat	Macro-invertebrates	Urban Stormwater	CFO/ CAFO	Livestock in Stream	Karst	Agricultural Land Use	**SCORE**	**Rank**	**Subwatershed**
1	4	2	6	2				1	2	2	2	2	23	**4**	**1**
2	4	4	6	4					2	2	2	2	26	**2**	**2**
3	4	2	4	4			2	1	2	2	2	2	25	**3**	**3**
4	4	2	6	2	1					2	1		18	**6**	**4**
5			2	2	1	1	2			2			10	**11**	**5**
6	4	4	4	4		1	2	2	1	1	1	1	25	**3**	**6**
7	4	4	6	4			2	2	2		2	1	27	**1**	**7**
8	2	2	2	2		2	2			2		1	15	**9**	**8**
9	4	4	2	4			2	2	2	2	2	1	25	**3**	**9**
10		2	2	4	2	1	2	2		1			16	**8**	**10**
11	2	2	2	2		2	2				1		13	**10**	**11**
12			2			1				2			5	**15**	**12**
13	4	4	2	4			2		2		1	1	20	**5**	**13**
14	4	4	2	4			2		2		1	1	20	**5**	**14**
A	4	4	2		1		1			2	2	1	17	**7**	**A**
B	4	4	4	2				1	2	2	2	2	23	**4**	**B**
C	2	4	4	2		1	2	2			1		18	**6**	**C**
D	2	4	4				2			2	1	1	16	**8**	**D**
E		2	2		1	2	2				1		10	**11**	**E**
F		2		2	1	1	2						8	**13**	**F**
G		2	2	2	1		2			1			10	**11**	**G**
H		4	2	2	1	2	2						13	**10**	**H**
I		2	2		1	2	2						9	**12**	**I**
J	2	2			2		2						8	**13**	**J**
K	2	2	2			2	2						10	**11**	**K**
L		2			2		2						6	**14**	**L**
M		2			1								3	**16**	**M**

*Based on Monthly Water Quality Sampling data from June 2011-May 2012

20-27	Top Ranked
13-18	Middle Range
3-10	Low Impairments

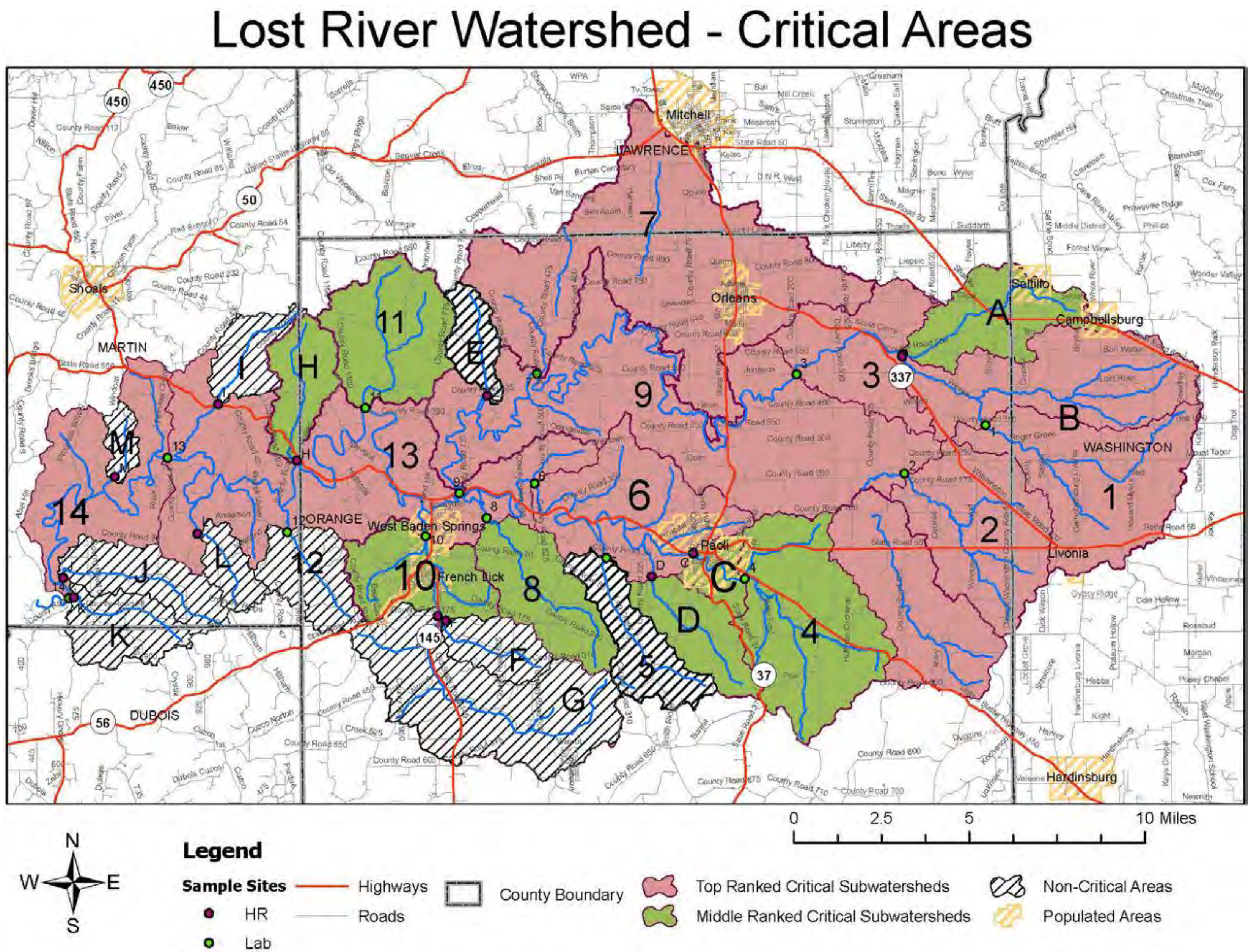


Figure 256: Critical Areas of the Lost River Watershed

Section 10 - Identification of Management Strategies

Management Strategies to address water quality issues come in the form of Best Management Practices or BMPs.

BMPs are effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, bacteria, and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of various land use activities. These practices are developed to achieve a balance between water quality protection and the production of land within natural and economic limitations.

A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPs, which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining both water quality and the productivity of the land.

10.1 Best Management Practices (BMPs)

Numerous Best Management Practices (BMPs) were selected by the steering committee for implementation in Lost River Watershed to address the key issues identified as a result of this study. In addition to structural BMPs, multiple topics for educational programming and potential local ordinances are recommended in the action register Section 11.2. Implementation of these recommendations should result in a demonstrable improvement in water quality and habitat conditions in the watershed. It is important to note that no single recommendation will address all principle issues; rather, it will be necessary to implement a combination of most, if not all, in order to achieve the highest level of results.

10.1.1 Agricultural Best Management Practices

Agricultural best management practices are implemented on agricultural lands, typically row crop agricultural lands, in order to protect water resources and aquatic habitat while improving land resources and quality. These practices control nonpoint source pollutants reducing their loading to the Lost River by minimizing the volume of available pollutants. Potential agricultural best management practices designed to control and trap agricultural nonpoint sources of pollution include:

- Alternate Watering Systems
- Buffer Strip (Shrub/Tree)
- Conservation Tillage (No till end goal)
- Cover Crop
- Drainage Water Management
- Filter Strip (grass)
- Livestock Restriction or Rotational Grazing
- Manure Management
- Nutrient/Pest Management Planning
- Roof runoff & collection structures

Alternate Watering Systems
Alternative watering systems provide an alternate location for livestock to seek water rather than using a surface water source. This removes the negative impacts of livestock access to streams including direct deposit of manure and bank erosion and destabilization, while improving the health of livestock by providing a clean water source and better footing while drinking. This results in less E. coli, phosphorus, nitrogen, and sediment entering a surface waterbody. Two main types of alternative watering systems are used including pump systems and gravity systems. This practice is appropriate for Critical Areas1-4, 6, 8-11, A, B, and D.

Buffer Strip/Filter Strip
Installing natural buffers or filters along major and minor drainages and sinkholes in the watershed helps reduce the nutrient and sediment loads reaching surface and subsurface waterbodies. Buffers provide many benefits including restoring hydrologic connectivity, reducing nutrient and sediment transport, stabilizing sinkhole edges, improving recreational opportunities and aesthetics, and providing wildlife habitat. Sediment, phosphorus, nitrogen, and E. coli are at least partly removed from water passing through a naturally vegetated buffer. The percentage of pollutants removed depends on the pollutant load, the type of vegetation, the amount of runoff, and the character of the buffer area. The most effective buffer width can vary along the length of a channel. Adjacent land uses, topography, runoff velocity, and soil and vegetation types are all factors used to determine the optimum buffer width. This practice is appropriate for all subwatersheds.

Many researchers have verified the effectiveness of filter strips in removing sediment from runoff with reductions ranging from 56-97% (Arora et al., 1996; Mickelson and Baker, 1993; Schmitt et al., 1999; Lee et al, 2000; Lee et al., 2003). Most of the reduction in sediment load occurs within the first 15 feet of installed buffer. Smaller additional amounts of sediment are retained and infiltration is increased by increasing the width of the strip (Dillaha et al., 1989). Filter strips have been found to reduce sediment-bound nutrients like total phosphorus but to a lesser extent than they reduce sediment load itself. Phosphorus predominately associates with finer particles like silt and clay that remain suspended longer and are more likely to reach the strip's outfall (Hayes et al., 1984). Filter strips are least effective at reducing dissolved nutrients like those of nitrate and phosphorus, and atrazine and alachlor, although reductions of dissolved phosphorus, atrazine, and alachlor of up to 50% have been documented (Conservation Technology Information Center, 2000). Simpkins et al. (2003) demonstrated 20-93% nitrate-nitrogen removal in multispecies riparian buffers. Short groundwater flow paths, long residence times, and contact with fine textured sediments favorably increased nitrate-nitrogen removal rates. Additionally, up to 60% of pathogens contained in runoff may be effectively removed. Computer modeling also indicates that over the long run (30 years), filter strips significantly reduce amounts of pollutants entering waterways.

Both filter strips and buffer strips should be designed as permanent plantings to treat runoff and should not be considered part of the annual rotation of adjacent cropland. Filter strips should receive only sheet flow, and they should be installed on stable banks. A mixture of grasses, forbs, and herbaceous plants should be used. In more permanent plantings, shrubs and trees should be intermingled to form a stable riparian community.

Conservation Tillage
Conservation tillage refers to several different tillage methods or systems that leave at least 30% of the soil covered with crop residue after planting (Holdren et al., 2001). Tillage methods encompassed by conservation tillage include no-till, mulch-till, ridge-till, zero till, slot plant, row till, direct seeding, or strip till. The purpose of conservation tillage is to reduce sheet and rill erosion, maintain or improve soil organic matter content, conserve soil moisture, increase available moisture, reduce plant damage, and provide habitat and cover for wildlife. The remaining crop residue helps reduce soil erosion and runoff volume.

Several researchers have demonstrated the benefits of conservation tillage in reducing pollutant loading to streams and lakes. A comprehensive comparison of tillage systems showed that no-till results in 70% less herbicide runoff, 93% less erosion, and 69% less water runoff volume when compared to conventional tillage (Conservation Technology Information Center, 2000). Reductions in pesticide loading have also been reported (Olem and Flock, 1990). Conservation tillage is widely used throughout the watershed, however many landowners are still reluctant to adopt these practices. This practice is appropriate for Critical Areas 1-3, 6-10, 13-14, B, and D.

Cover Crops

Cover crops include legumes, such as clover, hairy vetch, field peas, alfalfa, and soybean, and non-legumes, such as rye, oats, wheat, radishes, turnips, and buckwheat which are planted prior to or following crop harvest. Cover crops are typically grown for one season and are typically grown in non-cropping seasons. Cover crops are used to improve soil quality and future crop harvest by improving soil tilth, reducing wind and water erosion, increasing available nitrogen, suppressing weed cover, and encouraging beneficial insect growth. Cover crops reduce phosphorus transport by reducing soil erosion and runoff. Both wind and water erosion move soil particles that have phosphorus attached. Sediment that reaches water bodies may release phosphorus into the water. The cover crop vegetation recovers plant-available phosphorus in the soil and recycles it through the plant biomass for succeeding crops. Runoff water can wash soluble phosphorus from the surface soil and crop residue and carry it off the field. Cover crops are a familiar conservation practice throughout the watershed. Additional operators will likely consider this practice beneficial as information on benefits of reduced fertilizer use become available. Cover Crops are appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Drainage Water Management

Subsurface tile drainage is an essential water management practice on highly productive fields. As a result of tile drainage, nitrate carried in drainage water enters adjacent surface waterbodies. Drainage water management is necessary to reduce nitrate loads entering adjacent surface waterbodies from tile drainage networks. Drainage water management uses water control structures within lateral drains to vary the depth of tile outlets. Typically, the outlet is raised after harvest to limit outflow from the tile and reduce nitrate transport to adjacent waterbodies; lowered in the spring and fall to allow tile water to flow freely from the field to adjacent waterbodies; and raised in the summer to help store water making it available for crops (Frankenberger et al., 2006). Drainage water management can be used in concert with a suite of other conservation practices including cover crops and conservation tillage. This practice is not applicable in the karst regions of the watershed, but would be applicable on river bottoms of Lower Lost River, French Lick Creek, and possibly even Lick Creek. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Grassed Waterway

Grassed waterways are natural or constructed channels established for transport of concentrated flow at safe velocities using adequate channel dimensions and proper vegetation. They are generally broad and shallow by design to move surface water across farmland without causing soil erosion. Grassed waterways are used as outlets to prevent rill and gully formation. The vegetative cover slows the water flow, minimizing channel surface erosion. When properly constructed, grassed waterways can safely transport large water flows downslope. These waterways can also be used as outlets for water released from contoured and terraced systems and from diverted channels. This BMP can reduce sediment concentrations of nearby waterbodies and pollutants in runoff. The vegetation improves the soil aeration and water quality due to its nutrient removal through plant uptake and absorption by soil. The waterways can also provide wildlife corridors and allows more land to be natural areas. Grassed waterways are a familiar conservation practice throughout the watershed. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Livestock Restriction or Rotational Grazing

Livestock that have unrestricted access to a stream or wetland have the potential to degrade the waterbody's water quality and biotic integrity. Only 30% of agricultural landowners responding to the social indicator survey indicate that they have livestock. Of those agricultural landowners that own livestock, nearly 30% use grazing management plans. Livestock can deliver nutrients and pathogens directly to a waterbody through defecation. Livestock also degrade stream ecosystems indirectly. Trampling and removal of vegetation through grazing of riparian zones can weaken banks and increase the potential for bank erosion. Trampling can also compact soils in a wetland or riparian zone decreasing the area's ability to infiltrate water runoff. Removal of vegetation in a wetland or riparian zone also limits the area's ability to filter pollutants in runoff. The degradation of a waterbody's water quality and habitat typically results in the impairment of the biota living in the waterbody.

Restoring areas impacted by livestock grazing often involves several steps. First, the livestock in these areas should be restricted from the waterbody or stream to which they currently have access. If necessary, an alternate source of water should be created for the livestock. Second, the wetland or riparian zone where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. Minimally, it involves installing filter strips along banks or wetland edge and replanting any denuded areas. Finally, if possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading, particularly nitrate-nitrogen loading, to the adjacent waterbody. Complete restoration of aquatic areas impacted by livestock will help reduce pollutant loading, particularly nitrate-nitrogen, sediment, and pathogens. This practice is appropriate for Critical Areas 1-4, 6, 8-11, A, B, and D.

A livestock exclusion system is a system of permanent fencing (board, barbed, etc) installed to exclude livestock from streams and areas, not intended for grazing. This will reduce erosion, sediment, and nutrient loading, and improve the quality of surface water. Education and outreach programs focusing on rotational grazing and exclusionary fencing are important in the success of this BMP.

Manure Management

Large volumes of manure are generated by both small, unregulated animal operations and by confined feeding operations located throughout the Lost River watershed. With new rules in place by Indiana State Chemist Office, manure management plans are going to be required for anyone planning on spreading manure on fields. The new rules will determine the need for waste utilization plans, use and length of staging areas, and setbacks for applications. Many entities have manure management plans in place and are currently using these plans to manage the volume of manure produced on their facility. Manure management planning includes consideration of the volume and type of manure produced annually, crop rotations by field, the volume of manure and nutrients needed for each crop, field slope, soil type and manure collection, transportation, storage, and distribution methods. Manure management planning uses similar techniques to nutrient management planning concerning nutrient budgets. Managing manure also includes facilities and proper storage of manure. Structures to assist with the protection of manure runoff may be offered to producers with a resource need.

Animal waste is a major source of pollution to waterbodies. To protect the health of aquatic ecosystems and meet water quality standards, manure must be safely managed. Good management of manure keeps livestock healthy, returns nutrients to the soil, improves pastures and gardens, and protects the environment, specifically water quality. Poor manure management may lead to sick livestock, unsanitary and unhealthy conditions for humans and other organisms, and increased insect and parasite populations. Proper management of animal waste can be done by implementing BMPs, through safe storage, by application as a fertilizer, and through composting. Proper manure management can effectively reduce E.coli concentrations, nutrient levels, and sedimentation. Manure management can also be addressed in education and outreach to encourage farmers to participate in this BMP. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Nutrient/Pest Management Planning

Nutrient management is the management of the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments to minimize the transport of applied nutrients into surface water or groundwater. Several producers in the watershed still do not use this planning technique for their nutrient and pest applications. Nutrient management seeks to supply adequate nutrients for optimum crop yield and quantity, while also helping to sustain the physical, biological, and chemical properties of the soil. A nutrient budget for nitrogen, phosphorus, and potassium is developed considering all potential sources of nutrients including, but not limited to, animal manure, commercial fertilizer, crop residue, and legume credits. Realistic yields are based on soil productivity information, potential yield, or historical yield data based on a 5-year average. Nutrient management plans specify the form, source, amount, timing, and method of application of nutrients on each field in order to achieve realistic production levels while minimizing transport of nutrients to surface and/or groundwater. Nutrient management plans may consider the use of Nitrogen Stabilizers as a method to retain nitrogen in the fields for crop production and decrease the amount of nitrogen leaving fields through leaching and runoff to nearby surface or subsurface channels.

The advances in technology have made it possible to improve accuracy in planting and applying fertilizers, manure, and pesticides. Upgrading systems to these newer technologies would give the added benefit of reduced use of these products and would allow for the reduction of runoff of these products to the streams and sinkholes within the watershed. Equipment upgrades to existing equipment would include variable rate technology system and equipment upgrades, GPS system upgrades or variable rate manure application upgrades. Other possible benefits would be from auto swath and auto steer equipment upgrades. These systems would prevent over applications and prevent applications from going in undesirable areas. With setbacks from sinkholes, and streams in effect producers must be more careful where products are applied in the fields. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Roof runoff and collection structures

Runoff from impervious surfaces like roofs can carry a significant amount of nonpoint source pollutants to nearby streams and karst features. It is recommended that structures that collect, control, and transport precipitation from roofs be installed to reduce this effect. A container that collects and stores rainwater from rooftops (via gutters and downspouts) for later use for irrigation, livestock watering, or slow release during dry periods is recommended. Rain is a naturally soft water and devoid of minerals, chlorine, fluoride, and other chemicals. Collection structures, like cisterns, help to reduce peak volume and velocity of stormwater runoff to streams and karst features. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

10.1.2 Urban and Residential Best Management Practices

Development and the spread of impervious surfaces are occurring throughout the Lost River watershed. The highest concentrations of development are located in and around French Lick and West Baden Springs. Some development is occurring around Paoli and Orleans, as well. As impervious surfaces continue to spread throughout the watershed, the volume and velocity of stormwater entering the Lost River will also increase. The best way to mitigate stormwater impacts is to infiltrate, store, and treat stormwater onsite before it can run off into the karst system or streams in the area. Urban best management practices designed to complete these actions are as follows:

- Bioretention Practices
- Detention Basin
- Grass Swale
- Green Roof
- Infrastructure Retrofit
- Low Impact Development
- Pervious Pavement
- Pet Waste Control
- Phosphorus-free Fertilizers
- Rain Barrels/ Cisterns
- Rain Garden
- Street Sweeping
- Trash Control and Removal
- Urban Wildlife Population Control

Bioretention Practices

Bioretention practices use biofiltration or bioinfiltration to filter runoff by storing it in shallow depressions. Bioretention uses plant uptake and soil permeability mechanisms in a variety of manners typically in combination. Potential practices include sand beds, pea gravel, overflow structures, organic mulch layers, plant materials, gravel underdrains, and an overflow system to promote infiltration. Bioinfiltration can also be used to treat runoff from parking lots, roads, driveways and other areas in the urban environment. Bioretention should not be used in highly urbanized areas or karst areas rather, it should be used in areas where onsite storage space is available, and there is no risk of subsurface collapse. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Detention Basin

Detention basins are large, open, unvegetated basins designed to hold water for short periods following a rain event (dry detention basin) or continuously (wet detention basin). Detention basins are designed to hold water for longer periods with the goal of reducing sediment flow from the basin or provide filtration of stormwater before it enters the basin through the use of urban pond buffers. Additionally, oils, grease, nutrients, and pesticides can also settle in the basin. The nutrients are then used by the plants for growth and development. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Grass Swale

Grass swales are used in urban areas and are often considered landscape features. Swales are graded to be linear with a shallow, open channel of a trapezoidal or parabolic shape. Vegetation that is water tolerant is planted within the channel which promotes the slowing of water flow through the system. Swales reduce sediment and nutrients as water moves through the swale and water infiltrates into the groundwater. This practice can be used in all Critical Areas.

Green Roof

A green roof is a building partially or completely covered with vegetation and a growing medium planted on top of a waterproof membrane. Irrigation and drainage systems carry water from the roof through the plant material and medium to the building drainage system. Green roofs absorb rainwater, provide insulation, reduce air temperatures, and provide habitat for wildlife. Green roofs can retain up to 75% of rainwater gradually releasing it via condensation and transpiration while retaining sediment and nutrients. Green roofs can be installed on any type of roof – slanting to flat – with an ideal slope of 25%. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Infrastructure Retrofit

Typical stormwater infrastructure includes pipe and storm drains, or hard infrastructure, to convey water away from hard surfaces and into the stormwater system. Retrofitting these structures to implement low impact development techniques, use green practices, and introduce plants and filters to reduce sediment and nutrient concentrations contained in stormwater. Many of the treatments listed in this section can be utilized to retrofit infrastructure including pervious pavement, green roofs, constructed wetlands, rain gardens, and more. In order for the installation to meet a "retrofit" requirement, existing infrastructure must already be in place, subsequently removed, and replaced with green infrastructure. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Low Impact Development

Several techniques can be used for protecting natural areas and open space in both public and private ownership. Open space can be protected using conservation design development techniques. Low Impact Development (LID) is a land development or re-development process that works in concert with nature to manage stormwater at the source, or as close as possible to the source. Preservation of open space, recreation of natural landscape features, reduction of impervious surface coverage, and utilization of on-site drainage to treat stormwater are the key features of low impact development. This technique uses a suite of practices highlighted above including bioretention, rain gardens, green or vegetated roofs, rain barrels, pervious pavement, and more. LID can be used anywhere as part of a new development, redevelopment, or retrofit of existing development or infrastructure. If used correctly, LID can restore a watershed's hydrologic and ecological function. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Pervious Pavement

Pervious pavement comes in many forms including porous pavement and modular block pavement. Both types of pervious pavement can be installed on most any travel surface with a slope of 5% or less.

Pervious pavement has the approximate strength characteristics of traditional pavement with the ability to percolate water into the groundwater system. The pavement reduces sediment and nutrient transmission into the groundwater as water moves through the pores in the pavement. When installed, porous pavement includes a stone layer, filter fabric, and a filter layer covered by porous pavement. Correctly, mixed porous pavement eliminates fine aggregates found in typical pavements. Porous asphalt is a type of porous pavement, which includes a mix of Portland cement, coarse aggregates, and water that results in the formation of interconnected voids.

Modular pavement consists of individual blocks made of pervious material such as sand, gravel, or sod interspersed with strong structural material such as concrete. The blocks are typically placed on a sand or gravel base and designed to provide a load-bearing surface that is adequate to support personal vehicles, while allowing infiltration of surface water into the underlying soils. They usually are used in low-volume traffic areas such as overflow parking lots and lightly used access roads. An alternative to pervious and modular pavement for parking areas is a geotextile material installed as a framework to provide structural strength. Filled with sand and sodded, it provides a completely grassed parking area. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Pet Waste Control

Pet waste cannot be considered the predominant waste product within a watershed nor the one that produces the greatest impact. Nonetheless, the cumulative impact of pet waste within a watershed can produce a major impact on water quality. Pet waste contains bacteria and parasites, organic matter, phosphorus, nitrogen, and E. coli and can carry diseases including Campylobacteriosis, Salmonellosis, and Toxocarisis. Studies indicate that the average dog produces 13 pounds of nitrogen, 2 pounds of phosphorus, and 1,200 pounds of sediment annually (Miles, 2007). Given the high number of dogs within the watershed, the impact of this volume of nutrients and sediment on the river system could be detrimental.

Many options for managing pet waste are available with most efforts focusing on educational options to turn pet waste from an ‘out of sight, out of mind’ issue to one that every pet owner considers for their pet. Pet waste can be flushed, resulting in waste traveling to the wastewater treatment plant or through the septic system for treatment, buried, where it gradually breaks down over time with nutrients entering the soil and microorganisms converting diseases and bacteria into less benign forms, or trashed, resulting in potential landfill issues. Some signage and public education is available in the watershed currently, but more is needed to inform the community about options for treating pet waste issues. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Phosphorus-free Fertilizers

Phosphorus-free fertilizers are those fertilizers that supply nitrogen and minor nutrients without the addition of phosphorus. Phosphorus increases algae and plant growth which can cause negative impacts on water quality within aquatic systems. The Clear Choices, Clean Water (2010) program estimates that a one acre lawn fertilized with traditional fertilizer supplies 7.8 pounds of phosphorus to local waterbodies annually. Established lawns take their nutrients from the soil in which they grow and need little additional nutrients to continue plant growth. Fertilizers are manufactured in a variety of forms including that without phosphorus. Phosphorus-free fertilizer should be considered for use in areas where grass is already established. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Rain Barrel/Cisterns

A rain barrel, or larger cistern, is a container that collects and stores rainwater from your rooftop (via your home’s disconnected downspouts) for later use on your lawn, garden, or other outdoor uses. Rainwater stored in rain barrels can be useful for watering landscapes, gardens, lawns, and trees. Rain is a naturally soft water and devoid of minerals, chlorine, fluoride, and other chemicals. In addition, rain barrels help to reduce peak volume and velocity of stormwater runoff to streams and storm sewer systems. Although rain barrels do not specifically reduce nutrient or sediment loading to waterbodies, their presence can reduce the first flush of water reaching storm drains. This impact is great especially in portions of the watershed where combined sewers are still in operation. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, and A-D.

Rain Garden

Rain gardens are small-scale bioretention systems that be can be used as landscape features and small-scale stormwater management systems like single-family homes, townhouse units, some small commercial development, and to treat parking lot or building runoff. Rain gardens provide a landscape feature for the site and reduce the need for irrigation, and can be used to provide stormwater depression storage and treatment near the point of generation. These systems can be integrated into the stormwater management system since the components can be optimized to maximize depression storage, pretreatment of the stormwater runoff, promote evapotranspiration, and facilitate groundwater recharge. The combination of these benefits can result in decreased flooding due to a decrease in the peak flow and total volume of runoff generated by a storm event.

Additionally, rain gardens can be designed to provide a significant improvement in the quality of the stormwater runoff. These systems should not be installed in or near sinkholes. Adding additional drainage to these features can cause further dissolution of limestone, which in turn may cause further collapse. Water storage practices are preferred over rain gardens in the karst areas of the watershed. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Street Sweeping

Street sweeping removes accumulated pollutants including debris, sediment, salt, trash, trace metals, and more while improving aesthetics, controlling dust, and decreasing the volume of materials accumulating in storm drains. Street sweeping is currently practiced in many urban areas including the Towns of Paoli, French Lick and West Baden Springs. Each town maintains a schedule of main roads which undergo routine cleaning. Additional arterial streets within these areas or sweeping of streets within smaller municipalities throughout the watershed could benefit water quality in Lost River. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Trash Control and Removal

Trash and debris located throughout urban areas indicate that these materials can have a significant negative impact on water quality within the Lost River. A majority of trash observed occurs adjacent to streets, road right of ways, and sidewalks in the watershed. Surveys in larger urban areas indicate that plastic bottles, Styrofoam cups, and paper are the most common trash items found in or adjacent to storm drains. It is necessary to quantify the impacts of trash on Lost River and the town's wastewater treatment facilities to determine if it is necessary to address trash in additional efforts. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Urban Wildlife Population Control

Wildlife populations located within urban areas can negatively impact water quality. Deer, Canada geese, raccoons, squirrels, and other animals can reach nuisance levels within urban areas. To control the population, a survey of the types of animals present, the volume of each species, the health and wellness of the populations, and habitat availability must be surveyed. Within the towns of Paoli, French Lick and West Baden Springs, nuisance populations of stray cats, dogs, raccoons, and squirrels are present in various locations. This practice is appropriate for Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

10.1.3 Forestry Practices

Forestry best management practice that may be beneficial to the water quality and aquatic life are included here. These forestry best management practices are as follows:

- Forest Management Plans
- Forest Stand Improvements
- Forest Roads
- Log Landings
- Riparian Management Zones

Forest Management Plans

Forest management is the application of appropriate technical forestry principles, practices, and business techniques (e.g., accounting, cost/benefit analysis, etc.) to the management of a forest to achieve the owner's objectives. Forest management provides a forest the proper care so that it remains healthy and vigorous and provides the products and the amenities the landowner desires. Forest management is the development and execution of a plan integrating all of the principles, practices, and techniques necessary to care properly for the forest.

Forests are an important tool in long-term, low-cost protection of water supplies. Maintaining forest cover in critical locations such as floodplains, seeps, steep slopes, karst features, headwaters, and close to streams can help avoid major deterioration in water quality and increases in treatment difficulty and cost. Forests adjacent to consistent nutrient sources (such as fertilized crops or lawns) can reduce nitrogen before it reaches the streams, especially on shallower soils where tree roots reach the groundwater. The condition of the forest also affects ability to protect water quality. Forest condition includes characteristics such as tree health, distribution of tree and stand sizes and ages, and number of layers of vegetation (e.g., herbaceous, shrub, subcanopy, midcanopy, upper canopy). Disturbances such as windstorms or hurricanes are infrequent but inevitable. Stands with multiple layers of vegetation and a range of ages and sizes of trees can withstand loss of trees most susceptible to damage without losing all of its functions for erosion control and infiltrating water. Forest management near reservoirs takes into account the potential for multiple canopy layers, matching species to site conditions, and opportunities to maintain actively growing forests next to nutrient sources. Landowners can help improve water quality by planting trees on their own land. This practice is appropriate for all forested lands in Critical Areas.

Forest Stand Improvement

Forest stand improvement is the manipulation of species composition, stand structure, and stocking by cutting or killing selected trees and understory vegetation. This method of managing forests will increase the quantity and quality of forest products by manipulating stand density and structure. This practice is appropriate for Critical Areas 1-4, 6-11,13-14, A-D, and H.

Forest Roads

Forest trails and landings are described as a temporary or infrequently used route, path or cleared area. Forest roads are managed to provide adequate access to lands for timber management, fire suppression, wildlife habitat improvement and a variety of dispersed and developed recreational activities. Generally, these low volume roads must carry heavy loads for short periods. The potential for adverse impacts from forest roads exist in areas where steep slopes, erodible soils, or where forest roads are located near water. Forest roads cause more erosion than any other forestry activity. Most of this erosion can be prevented by locating, constructing, and maintaining roads to minimize soil movement and pollution of streams. The need for higher standard roads can be alleviated through better road-use management. Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

Access roads are a travel-way for equipment and vehicles constructed as part of a conservation plan to provide a fixed route for vehicular travel for resource activities involving the management of timber while protecting the soil, water, air, fish, wildlife, and other adjacent natural resources.

The type of drainage structure used will depend on the intended use and runoff conditions. Culverts, bridges, fords, or grade dips for water management will be provided at all natural drainage ways. The capacity and design will be consistent with sound engineering principles and will be adequate for the class of vehicle, type of road, development, or use. When a culvert or bridge is installed in a drainage way, its minimum capacity will convey the design storm runoff without causing erosion or road overtopping. This practice is appropriate for Critical Areas 6-11, 13, 14, and H.

Log Landings
Well planned and managed log landings minimize impacts to the site, protect water quality, enhance visual quality, and often increase operation efficiency and safety. They also can be attractive, long-term assets to a property. This practice is appropriate for Critical Areas 6-11, 13, 14, and H.

Riparian Management Zones
Riparian Management Zones (RMZs) are natural buffer areas between logging and forestry activities and waterways. An RMZ begins at the watercourse bank or sinkhole opening and extends inland. Trees may be harvested within the RMZ. The goal is to maintain a stable forest floor to filter sediment and other pollutants before runoff enters the main watercourse. This practice is appropriate for all Critical Areas

10.1.4 Other Beneficial Practices

Other practices that may be beneficial to the water quality and aquatic life that are not specific to agricultural, urban, or forestry land uses are include here. These other best management practices are as follows:

- Acid Mine Drainage Treatment
- Indiana Rule 5 and Rule 6 Compliance
- Live Stakes
- Log Jam Preventative Maintenance Plan
- Riparian Buffers
- Septic System Care and Maintenance
- Sinkhole Treatment
- Streambank Stabilization
- Stream Crossings
- Threatened and Endangered Species Protection

Acid Mine Drainage Treatment
Acid mine drainage is a byproduct of abandoned mined lands. The effects on water quality and aquatic life are quite extensive. Locations with these characteristics should be addressed through landowner education and then aggressive treatment. Acid mine drainage treatment options can be made available through the Department of Natural Resources Division of Reclamation. Many forms of treatment exist and each treatment should be weighed for its cost-benefit for the specific situation. This practice is appropriate for Critical Area 14.

Indiana Rule 5 and Rule 6 Compliance
Land development activities commonly involve the clearing of vegetation followed by land moving and excavation activities. When such activities are conducted and bare soil is exposed, the natural forces of wind and water can cause the transport of small amounts to hundreds of tons of soil and sediment from construction sites to lakes, streams, rivers, wetlands, and other environmentally sensitive areas. In addition to sediment, other pollutants such as oils and greases and a variety of chemicals can be discharged from construction sites, as well.

Indiana Administrative Code 327 IAC 15-5, commonly known as “Rule 5”, affects construction projects that result in the disturbance of 0.40 hectare (1 acre) of land or more. Types of construction projects affected by Rule 5 include roads, residential housing, commercial, industrial, and municipal projects.

Indiana Administrative Code 327 IAC 15-6, commonly known as “Rule 6”, applies to stormwater discharge that has been exposed to manufacturing and processing activities, raw materials, or intermediate product storage areas at an industrial facility.

At the time of this study, there were minor land disturbing activities associated with development being conducted in the watershed study area. However, a significant area of disturbed soils was observed just outside of the watershed study area. It is recommended that all counties be prepared to address soil disturbances in the future associated with clearing land for agricultural purposes or development. This practice is appropriate for all new development within the watershed, specifically within Critical Areas 1, 4, 6, 7, 9, 10, B, and C.

Live Stakes
Live stakes are live shrub or woody plant cuttings driven into the channel bank as stakes. Their purpose is to protect streambanks from the erosive forces of flowing water and to stabilize the soils along the channel bank. This technique is applicable along streambanks of moderate slope, (usually 4:1 or less), in original bank soil (not on fill), and where active erosion is light and washout is not likely. This technique is often applicable in combination with other vegetative or structural stabilization methods. This can be used on all sizes of channels and all character types. It is an economical practice, especially when cuttings are available locally, that can be done quickly with minimum labor. It results in a permanent, natural installation that improves riparian habitat. This practice is appropriate for any stream within the watershed that needs stabilization.

Log Jam Preventative Maintenance Plan
Log jams are naturally occurring phenomena. They influence natural channel morphology and provide valuable habitat for aquatic organisms. Consequently, not every log jam should be removed. Occasionally, very large log jams occur that create a significant threat to public infrastructure and public safety as well as potential for severe economic loss through flooding

and catastrophic streambank failure. Large log jams should be evaluated on a case-by-case basis for removal consideration using public funds. Private landowners may take precaution to prevent potential for catastrophic log jams by using log jam removal practices that minimize damage to streams.

A Log Jam Preventative Maintenance Plan should be developed for the area so that large trees leaning into the stream channels are fell prior to their natural demise bringing root wad and sediment with them, destabilizing stream banks, and causing potential log jams. The Log Jam Preventative Maintenance Plan, however, should include replacement of riparian species, protection of quality habitat species, and consideration of aquatic habitat benefit of woody debris in stream channel. Large trees often will help to protect banks from destabilization when aligned perpendicular with the channel's bank. There should be a plan to replace trees that are removed with smaller undergrowth species that will not generate the risk associated with larger species. Large species should be placed in areas that could benefit from stream shading and increased cover. This practice is appropriate for the entire watershed.

Riparian Buffers

Riparian buffers are important for good water quality. Riparian zones help to prevent sediment, nitrogen, phosphorus, pesticides, and other pollutants from reaching a stream. Riparian buffers are most effective at improving water quality when they include a native grass or herbaceous filter strip along with deep-rooted trees and shrubs along the stream. This practice is appropriate for all channels within the watershed.

Herbaceous Riparian cover includes grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed as the dominant vegetation in the transitional zone between upland and aquatic habitats. Benefits include:

- Provide or improve food and cover for fish, wildlife and livestock,
- Improve and maintain water quality.
- Establish and maintain habitat corridors.
- Increase water storage on floodplains.
- Reduce erosion and improve stability to stream banks and shorelines.
- Increase net carbon storage in the biomass and soil.
- Enhance pollen, nectar, and nesting habitat for pollinators.
- Restore, improve, or maintain the desired plant communities.
- Dissipate stream energy and trap sediment.
- Enhance stream bank protection as part of stream bank soil bioengineering practices.

Forested Riparian Cover is an area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies. The benefits include:

- Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms.
- Create or improve riparian habitat and provide a source of detritus and large woody debris.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.
- Reduce pesticide drift entering the water body.
- Restore riparian plant communities.
- Increase carbon storage in plant biomass and soils.

Septic System Care and Maintenance

Septic, or on-site waste disposal systems, are the primary means of sanitary flow treatment outside of incorporated areas. Because of the prohibitive cost of providing centralized sewer systems to many areas, septic tank systems will remain the primary means of treatment into the future. Annual maintenance of septic systems is crucial for their operation, particularly the annual removal of accumulated sludge. The cost of replacing failed septic tanks is about $5,000-$15,000 per unit based on industry standards.

Property owners are responsible for their septic systems under the regulation of the County Health Department. When septic systems fail, untreated sanitary flows are discharged into open watercourses that pollute the water and pose a potential public health risk. Septic systems discharging to the ground surface are a risk to public health directly through body contact or contamination of drinking water sources. Additionally, septic systems can contribute significant amounts of nitrogen and phosphorus to the watershed. Therefore, it is imperative for homeowners not to ignore septic failures. If plumbing fixtures back up and/or will not drain then the system is failing. Funding for this practice is limited. This practice is appropriate for all septic systems within the watershed.

Sinkhole Treatment

Sinkholes are a direct conduit to sensitive habitats and fresh water resources. Karst sinkholes, epikarst, and sinking streams make water more susceptible to non-point source pollution. Surface water is rapidly channeled into the subsurface in karst landscapes via sinkholes without the benefit of extensive filtration or exposure to sunlight which reduces contaminants. Groundwater is easily contaminated before reemerging as springs. Sinkholes should be protected to reduce the risk of contamination of these resources. The treatment of sinkholes with filtration materials has occurred in recent years around this area and in other states with karst features. Investigation into the viability of conducting treatment in sinkholes for agricultural areas including feed lots, crop fields, and pastures, for urban runoff including stormwater runoff, roadway drainage, and impervious surface drainage, and other areas susceptible to direct nonpoint source inputs should be considered. Vegetative treatments should be the first line of defense, but alternative treatments should be investigated further for situations where this would not be effective. This practice is appropriate for Critical Areas 1-4, 6-7, 9, 11, 13-14, and A-D.

Streambank Stabilization

Streambank stabilization or stream restoration techniques are used to improve stream conditions so they more closely mimic natural conditions. The most feasible restoration options return the stream to natural stream conditions without restoring the stream to its original condition. Restoration and stabilization options are limited by available floodplain, modifications to natural flows, and development structure locations. Reestablishment of riparian buffers, restoration of stream channels, stabilization of eroding stream banks, installation of riffle-pool complexes, and general maintenance can all improve stream function while reducing sediment and nutrient transport into and within the system. This practice is appropriate for all streams within the watershed. Critical Areas 4, 6, 8-11, 13-14, C-D would benefit from this practice.

Stream Crossings

Stream crossings are a stabilized area or structure (temporary or permanent) constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. Streams are long, linear ecosystems. The processes that nourish these ecosystems are interrelated and dependent on "continuity" of the stream corridor. Our transportation and access needs often result in fragmentation of streams. Many stream crossings, such as bridges and culverts, act as barriers to fish and wildlife.

Awareness of the effects of stream crossings plays an important role in maintaining stream continuity. This practice is appropriate for Critical Areas 1-4, 6-11, 13-14, A-D and H.

The design and condition of stream crossings determines whether a stream can function naturally and whether animals can move unimpeded along the stream corridor. These are key elements in assuring the overall health of the system.

Properly constructed stream crossings should be made available for agricultural equipment crossings, recreational vehicle crossings, livestock crossings, and logging activities. Currently, several stream crossings in the watershed are disrupting aquatic habitat, wildlife migration, and stream hydrology. A standard stream crossing practice designed to limit these effects should be constructed in place of failing or improperly constructed crossings.

Threatened and Endangered Species Protection

Threatened and endangered species are those plant and animal species whose survival is in peril. Federally and state listed species identified within the Lost River watershed are highlighted in the Watershed Inventory. Threatened species are those that are likely to become endangered in the foreseeable future. Federally endangered species are those that are in danger of extinction throughout all or a significant portion of their range. A state-endangered species is any species that is in danger of extinction as a breeding species in Indiana. This practice is appropriate for the entire watershed including Critical Areas 1-4, 6-11, 13-14, A-D and H.

Protecting threatened and endangered species requires consideration of their habitat including food, water, and nesting and roosting living space for animals and preferred substrate for plants and mussels. Corridors for species movement are also necessary for long-term protection of these species. Protection of habitat can include providing clean water and available food but likely requires protection of the physical living space and associated corridor. Protection of cave and karst features can protect several species listed due to the significance of this habitat and lack of migration in these species. Conservation management plans should be developed for each species, if they are not already in place. Such plans should consider habitat needs including purchase or protection of adjacent properties to current habitat locations, hydrologic needs, pollution reduction, outside impacts, and other techniques necessary to protect threatened and endangered species.

Section 11 - Implementation Program Design

In order to address the problems associated with degraded water quality in the Lost River watershed, practices must be implemented to ensure that water does not degrade further and the quality improves over time. The goals set previously will address many of the problems identified within the watershed. In order to reach those goals a series of management strategies must be considered. First, an analysis of the most cost-effectiven of Best Management Practices should be considered to efficiently address the issues with the funding available. Secondly, the concerns need to be associated with practices that would be able to achieve the goals listed. Lastly, those practices should be considered for their urgency and feasibility of implementation. Some problems can spiral out of control if not addressed in a timely manner. For example, once a stream bank becomes destabilized, the forces of water can quickly erode away large sections of stream bank. This problem would be of high urgency. On the other hand, the feasibility is the ease of installing practices or addressing concerns. In this same example, stream banks that become destabilized are sometimes extremely expensive to fix and may not hold up to the power the water has on the installed structures. This can be especially true if the cause of this bank destabilization is not addressed first. Additionally, the destabilization may be on a landowner’s property that may not be able to afford such costly repairs. This example shows that this practice might have a low feasibility.

11.1 Management Strategies

A comparison of practice costs and the load reduction one can expect from there installation is presented in Table 30. This table gives cost per unit, and the unit is described within the table. Load reductions are given as a pollutant removal percent per practice applied. This information will be used to determine cost-benefit analysis on proposed practices at time of implementation.

Table 30: Recommended Best Management Practices, pollutant removal efficiencies, and cost-share- costs recommendations

Best Management Practices (BMPs)	Typical Pollutant Removal (Percent per unit)				Cost per unit	Units
	Nitrogen	Phosphorus	Sediment	Pathogens		
Conservation Plan	20	15	30	15	N/A	farm
Fence (NRCS 382)	18/ field	12/field	14/field	35/field	$2.50	ft*
Alternative Water (NRCS 642, 614, 574, 516 & 378)	18	12	14	35	$1,500	unit*
Heavy Use Area Protection (NRCS 561)	6	10	22	15	$1500	unit*
Grass Plantings- Filter Strip (NRCS 393)	50	30	30	30	$397	acre
Conservation Buffers (NRCS SRS-109)	50	30	30	30	$533	acre
Streambank Protection (Live Poles) (NRCS TS-14I) (NRCS 580)	7	25	40	N/A	$50	ft
Critical Area Planting (NRCS 342)	50	30	30	30	$862	acre
Riparian Herbaceous & Forest Buffer (NRCS 390 & 391)	40	30	30	30	$541	acre
Tree and Shrub Plantings (NRCS 612)	40	30	30	30	$523	acre
Cover Crops (NRCS 340)	20	15	40	20	$20	acre
Integrated Pest Management Plans (NRCS 595)	N/A	N/A	N/A	N/A	$30	acre
Nutrient Management (NRCS 590)	33	27	N/A	N/A	$1,000	plan
Drainage Water Management- Blind tile inlet	22	13	10	N/A	$500	each
Waste Management	15	11	N/A	45	$8,750	plan
Waste Facility Cover/ Storage Facility (NRCS 367 & 313)	30	27	N/A	60	$120,000	unit
Composting Facility (NRCS 317)	N/A	N/A	N/A	N/A	$0.74	sq ft
Forage & Biomass Planting (NRCS 512)- Prescribed grazing	15	30	30	30	$142	acre
Grid Sampling/Nitrogen Stabilizers	40	15	N/A	N/A	$30	acre
GPS System Upgrades/ VRT Promotion	40	15	N/A	N/A	$10,000+	system
Auto swath/Auto steer Equipment Upgrades	15	12	N/A	N/A	$7,000+	system
No-Till Equipment Conversion/ Rental	7	40	70	N/A	$600	row

Best Management Practices (BMPs)	Typical Pollutant Removal (Percent)				Cost per unit	Units
	Nitrogen	Phosphorus	Sediment	Pathogens		
Bioreactors	30	20	30	15	$5,804	unit
Stream/Sinkhole Buffers (NRCS 393, 327, 390 & 391)	15	30	30	30	$397	acre
Field Borders (NRCS 386)	15	30	30	30	$427	acre
Roof Runoff Structure (NRCS 558)-gutter	N/A	15	35	10	$3.38	ft
Runoff Capture & Reuse (NRCS 558)-cistern	N/A	15	35	10	$2,006	unit
Porous Pavement	40	45	45	10	variable	
Rain Gardens/Bioretention	30	20	30	15	\	unit
Vegetated Swale/Filter Strip/Roofs	50	50	50	10	$8.50	ft
Infiltration/Seepage Practices	50	35	40	70	variable	
Retention Detention Basins/Wetlands	60	60	70	70	variable	
Forest Management Plan	N/A	30	45	N/A	~$450	
Forest Stand Improvement (NRCS 666)	N/A	30	45	N/A	$78	acre
Forest Trails & Landings (NRCS 655)	N/A	30	60	N/A	$501	acre
Stream Crossings	10	40	40	35	$2,311	unit
Access Roads (NRCS 560)	N/A	30	45	N/A	$7.97	ft
Water Bars (part of 560)	N/A	30	45	N/A		
Temporary Bridges	10	40	40	N/A	~$150	job
Log Landings (NRCS 655)	N/A	30	45	N/A	$501	acre
Riparian Plantings	50	30	30	30	$541	acre
Stream Habitat Improvement & Management (NRCS 395)	N/A	N/A	35	N/A		
Education	N/A	N/A	N/A	N/A	variable	
Stream Channel Stabilization (NRCS 584)	N/A	N/A	35	N/A	variable	
Grassed Waterway (NRCS 412)	50	30	30	30	$3,267	acre
Streambank Soil Bioengineering Bank and Toe Treatments (NRCS TS-14I)	N/A	30	45	N/A	$50	ft
Log Jam Preventative Maintenance-Clearing and Snagging (NRCS 326)*	N/A	30	45	N/A	variable	
Acid Mine Drainage Treatment	N/A	N/A	N/A	N/A	variable	

Table 31: Prioritizing Concerns and Best Management Practices for Implementation

Concerns	Urgency	Feasibility	Practices	Location	Priority
Stream Bank Erosion	High	Medium	Stream Channel Stabilization (NRCS 584) Stream Bank & Shoreline Protection (NRCS 580) Streambank Soil Bioengineering Bank and Toe Treatments (NRCS TS-14I) Critical Area Planting (NRCS 342) Log Jam Preventative Maintenance; Clearing and Snagging (NRCS 326)* Stream Crossing (NRCS 578) Riparian Plantings (see Riparian section below) Stream*A*Syst Participation Education	Trunk Streams Lick Creek (Critical Areas 4, C, D and 6), French Lick Creek (Critical Area 10), and Lost River (Critical Areas 3, 9, 13, and 14)	Medium
Contamination from existing septic systems	High	Low	Maintenance & Regular Septic Pumping Promotion Replacement &-Re Designed Septic System Promotion Education	Unsewered residential areas	Low
Waterbodies without filter strips or riparian buffers	High	High	Tree and Shrub Plantings (NRCS 612) Grass Plantings- Filter Strip (NRCS 393) Conservation Buffers (NRCS SRS-109) Streambank Plantings (Live Poles) (NRCS TS-14I) Riparian Herbaceous & Forest Buffer (NRCS 390 & 391) Critical Area Planting (NRCS 342) Conservation Easement*	Areas identified as needed in Buffer analysis Streams identified with thermal pollution problems	High
Trash in streams, sinkholes, & on property	Medium	High	Clean Up Days Clean Property Pride Development Cleanout of Sinkhole Education	Locations constantly changing, but all streams, sinkholes, and properties	Medium

Concerns	Urgency	Feasibility	Practices	Location	Priority
Livestock unlimited access to streams	High	High	Stream Crossing (NRCS 578), Heavy Use Area Protection (NRCS 561) Fence (NRCS 382) Alternative Water (NRCS 642, 614, 574, 516 & 378) Rotational Grazing Systems (NRCS 528 & 512) Education	Carters Creek-Lost River (Critical Areas A and B), Log Creek -Lick Creek (Critical Area 6and D),and South Fork Lost River (Critical Area 1) subwatersheds	High
Untreated & excess urban runoff	High	High	Porous Pavement Rain Gardens/Bioretention Runoff Capture & Reuse Vegetated Swale/Filter Strip/Roofs Infiltration/Seepage Practices Retention Detention Basins/Wetlands	Orleans Karst Area (Critical Area 7), Headwaters Lick Creek (Critical Areas 4 and C), Log Creek -Lick Creek (subwatershed 5), French Lick Creek (Critical Area 10), and Mt Horeb Drain Lost River (Critical Areas 7 and 9) subwatersheds	High
Combined Sewer Overflow frequency	High	Low	Urban Practices (See urban runoff) Separate Storm Water System * Education	Log Creek -Lick Creek (Critical Area 6 and D), and Orleans Karst Area (Critical Areas 7 and 9) subwatersheds	Low
Lack of storage, poor timing, and/or over application of manure and fertilizer	High	High	Nutrient Management (NRCS 590) Waste Management GPS System Upgrades/ VRT Promotion Auto swath/Auto steer Cover Crops (NRCS 340) Waste Facility Cover/ Storage Facility (NRCS 367 & 313) Stream/Sinkhole Buffers Nitrogen Stabilizers Manure testing (composite & multiple per barn) Grid Sampling Education	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7) , Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), Mt Horeb Drain Lost River (Critical Ares 7 and 9), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6and D), Big Creek Lost River (Critical Area 13), and Grassy Creek Lost River (Critical Area 14) subwatersheds	High

Concerns	Urgency	Feasibility	Practices	Location	Priority
Pesticides entering stream water	High	Low	Integrated Pest Management Plans (NRCS 595) Field Borders (NRCS 386) Filter Strips (NRCS 393) Riparian Plantings Tree and Shrub Plantings (NRCS 612) Grass Plantings- Filter Strip (NRCS 393) Conservation Buffers (NRCS SRS-109) Sinkhole Buffers (NRCS 393) Education	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7) , Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), Mt Horeb Drain Lost River (Critical Ares 7 and 9), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6and D), Big Creek Lost River (Critical Area 13), and Grassy Creek Lost River (Critical Area 14) subwatersheds	Low
Runoff from pasture ground	Medium	High	Waste Facility Cover/ Storage Facility (NRCS 367 & 313) Fence (NRCS 382) Alternative Water (NRCS 642, 614, 574, 516 & 378) Rotational Grazing Systems (NRCS 528 & 512) Filter Strips (NRCS 393) Roof capture and reuse Pasture Renovation Exclusion Fencing (NRCS 382)	Pasture lands within Lost River watershed	Medium
Unlimited access of off-road vehicles to streams	High	Low	Fence (NRCS 382) Barriers Stream Crossing (NRCS 578) Education	Sams Creek- Lost River (Critical Areas H and 13), Big Creek Lost River (Critical Area 13), Sulphur Creek- Lost River (Critical Areas 11, 13, and H), and Carters Creek-Lost River (Critical Areas A and B) subwatersheds	Low
Invasive and exotic species	High	Low	Forest Stand Improvement (NRCS 666) Manual, Physical, Chemical Treatment Education	Where identified through weed watchers, DNR, SICWMA	Low

Concerns	Urgency	Feasibility	Practices	Location	Priority
Safeness of full-body contact of local streams and rivers	High	Medium	Maintenance & Regular Septic Pumping Promotion* Replacement &-Re Designed Septic System Promotion* Waste Facility Cover/ Storage Facility (NRCS 367 & 313) Urban Practices (See urban runoff) Separate Storm Water System * Acid Mine Drainage Treatment Filter Strips (NRCS 393) Integrated Pest Management Plans (NRCS 595)	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7), Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), Mt Horeb Drain Lost River (Critical Ares 7 and 9), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6and D), Big Creek Lost River (Critical Area 13), Sams Creek- Lost River (Critical Areas H and 13), Sulphur Creek- Lost River (Critical Areas 11, 13, and H), and Grassy Creek Lost River (Critical Area 14) subwatersheds	Medium
Pharmaceuticals & Personal Care Products (PPCP) altering stream biology	High	Low	Maintenance & Regular Septic Pumping Promotion* Replacement &-Re Designed Septic System Promotion* Education	Unsewered residential areas, Combined Sewer Areas	Low
Acid Mine Drainage from abandoned mined lands	Medium	Low	Hydrated Lime Treatment Pebble Quicklime Wetland treatment Excavation/Fill Mine	Grassy Creek Lost River (Critical Area 14) subwatersheds	Low

Concerns	Urgency	Feasibility	Practices	Location	Priority
Tile drainage to sinkholes & streams	High	Low	Drainage Water Management Nitrogen Stabilizers Bioreactors	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), and Orleans Karst Area (Critical Area 7) subwatersheds	Low
Conventional cropping system	Medium	High	No-Till Equipment Conversion/Rental Education	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7) , Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), Mt Horeb Drain Lost River (Critical Ares 7 and 9), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6and D), Big Creek Lost River (Critical Area 13), and Grassy Creek Lost River (Critical Area 14) subwatersheds	Medium
Improper filling and uses over sinkholes	High	Medium-High	Reverse Grade Filling with Bioreactor Buffering Sinkholes Education	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7), Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4) subwatersheds	Med High
Off-road vehicles compacting and rutting soils	High	Low	Exclusion Fencing (NRCS 382)	Sams Creek- Lost River (Critical Areas H and 13), Big Creek Lost River (Critical Area 13), French Lick Creek (Critical Area 10) subwatersheds	Low

Concerns	Urgency	Feasibility	Practices	Location	Priority
Need for protection & rehabilitation of wildlife habitat	High	Medium	Land Trusts * Education	Mt Horeb Drain Lost River (Critical Ares 7 and 9), Sulphur Creek- Lost River (Critical Areas 11, 13, and H), Sams Creek- Lost River (Critical Areas H and 13), Big Creek Lost River (Critical Area 13) subwatersheds	Medium
Unhealthy drinking water from shallow wells and springs	High	High	Maintenance & Regular Septic Pumping Promotion Replacement &-Re Designed Septic System Promotion Waste Facility Cover/ Storage Facility (NRCS 367 & 313) Urban Practices (See urban runoff) Separate Storm Water System * Cover Crops (NRCS 340) Tree and Shrub Plantings (NRCS 612) Grass Plantings- Filter Strip (NRCS 393) Conservation Buffers (NRCS SRS-109)	Carters Creek-Lost River (Critical Areas A and B), South Fork Lost River (Critical Area 1), Orleans Karst Area (Critical Area 7) , Lost River Sink (Critical Area 9), Stampers Creek (Critical Areas 2 and 4), Mt Horeb Drain Lost River (Critical Ares 7 and 9), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6 and D), Big Creek Lost River (Critical Area 13), Sulphur Creek- Lost River (Critical Areas 11, 13, and H), Sams Creek- Lost River (Critical Areas H and 13), and Grassy Creek Lost River (Critical Area 14) subwatersheds	High

Concerns	Urgency	Feasibility	Practices	Location	Priority
Density and diversity of fish is lower than in the past	High	Medium	Riparian Habitat Planting Integrated Pest Management Plans (NRCS 595) Stream Habitat Improvement & Management (NRCS 395) Separate Storm Water System *	Lost River Sink (Critical Area 9), Log Creek -Lick Creek (Critical Area 6 and D), Scott Hollow Lick Creek (Critical Area 6), French Lick Creek (Critical Area 10), Big Creek Lost River (Critical Area 13), Sulphur Creek - Lost River (Critical Areas 11, 13, and H), Sams Creek- Lost River (Critical Areas H & 13), and Grassy Creek Lost River (Critical Area 14) subwatersheds	Medium
Knowledge of pollution prevention options	High	High	Education	Entire watershed	High
Mismanagement or lack of management in forest lands	High	High	Forest Stand Improvement (NRCS 666) Forest Roads/ Skid Trails (NRCS 655 & Stream Crossing (NRCS 578) Access Roads (NRCS 560) Water Bars Temporary Bridges Log Landings Riparian Plantings	Mt Horeb Drain Lost River (Critical Ares 7 and 9), Sulphur Creek - Lost River (Critical Areas 11, 13, and H), French Lick Creek (Critical Area 10), Headwaters Lick Creek (Critical Area 4), Scott Hollow Lick Creek (Critical Area 6), Log Creek -Lick Creek (Critical Area 6 and D), Big Creek Lost River (Critical Area 13), Sams Creek- Lost River (Critical Areas H and 13) subwatersheds	High

*Practices may not be funded by 319 Grant Funds

11.2 Action Register

The Action Register is a tool to facilitate implementation of the WMP. It includes specific objectives to be carried out in the process of working toward accomplishing each water quality improvement goal statement for Lost River Watershed. Also included in the Action Register is the target audience for each water quality improvement objective, objective milestones, estimated costs for implementing each objective, and possible partners as well as technical assistance resources that may be beneficial for objective implementation. Cost estimates are approximations only and may vary significantly from actual costs depending on many potential variables associated with each objective.

An Action Register was compiled by the steering committee for each water quality improvement goal statement and included as Tables 32-38. Many Action Register objectives are applicable to more than one goal statement. Similar objectives may be listed under multiple goal statements; however, identical objectives are only referenced in each applicable table and not repeated.

Table 32: Action plan and strategies to address water quality concerns and reach Goal #1- Increasing buffers throughout the watershed.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Buffer 1.1	Develop an educational program on natural stream functions; values of riparian areas for wildlife and erosion control; value of riparian areas for stream bank stabilization; and maintenance of riparian areas to prevent problematic log jams.	Landowners; agricultural producers; residents; county & town officials; business owners	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR; ISDA
			Write a minimum of three educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$6,300	Local newspapers; SWCDs; Nature Conservancy; DNR; Quail Unlimited; Small Mouth Bass Alliance	NRCS; DNR
			Field day demonstrating benefits of maintaining stream function (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife;	NRCS; DNR; ISDA
			Develop and implement a survey before and after events to gage educational objectives (On-going)	$8,000	Purdue Extension	Steering committee; Social Indicators Data Management & Analysis ;SIDMA Tool
			Development of a preventative log jam maintenance plan (Years 6-10)	$50,000	SWCDs; County Commissioners & Council; Flood Task Force; DNR-LARE; HNF; Region 15; Steering Committee	Army Corp of Eng; NRCS; DNR; Fish & Wildlife; SWCD
Buffer 1.2	Develop an educational program on natural sinkhole & karst development; values of sinkhole buffer areas for wildlife and erosion control.	Landowners; agricultural producers; residents; county & town officials; developers	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs; IKC	IKC; DNR; ISDA
			Have field day with USGS to discuss how water moves in karst watershed (Year 2, 5)	$1,200	SWCDs	USGS
			Write a minimum of one educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,100	Local newspapers; SWCDs; The Nature Conservancy; DNR; Indiana Karst Conservancy	NRCS; DNR

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Buffer 1.3	Develop an educational program on benefits and value of fencing livestock out of streams and sinkholes	Agricultural producers; homestead/ hobby livestock farms; rural landowners	Develop and distribute educational brochures on maintenance and cost-benefits of livestock fencing (Year 1)	$1,000	SWCDs; The Nature Conservancy; DNR; Quail Unlimited; Small Mouth Bass Alliance	NRCS; DNR: Livestock Veterinarian
			Field day demonstrating the benefits of stream fencing to livestock producers (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife;	NRCS; DNR; ISDA
			Adapt educational program accordingly based on interviews and survey results (Year 5)	$3,600	NRCS; ISDA; SWCDs; RC&D	NRCS;ISDA
Buffer 1.4	Implement riparian BMPs including but not limited to tree & shrub plantings, grass plantings- filter strip, conservation buffers, streambank plantings, critical area planting, riparian herbaceous & forest buffer, and conservation easements	Agricultural producers; landowners; county and town entities;	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with county and town officials on incorporating stream buffers into development plans (Year 1-5)	$1,000	Watershed Steering Committee; DNR; Engineering Firms	DNR; NRCS
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; DNR-LARE; County & Town Commissioners & Council; Steering Committee	NRCS; DNR; ISDA

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Buffer 1.5	Implement animal exclusion BMPs including but not limited to fence, alternative watering facilities, stream crossings, and critical area planting	Agricultural producers; homestead/ hobby livestock farms; rural landowners	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Fence suppliers; Cave Quarry; Geotextile suppliers; NRCS; ISDA; Steering Committee	NRCS; DNR; ISDA

Table 33: Action plan and strategies to address water quality concerns and reach Goal #2- Reduce nutrient levels within streams to reach water quality targets.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Nutrient 2.1	Develop an educational programs about agricultural BMPs, precision fertilizer, manure utilization, pasture management & conservation cropping systems	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Interview landowners after BMP placement to review techniques and share lessons learned (On-going)	$3,000/yr	SWCD; Purdue Extension	NRCS; ISDA
			Develop and distribute educational brochures (Year 1)	$1,000	Fertilizer companies; Co-op; Farm Bureau	Water Words that Work; DNR; ISDA
			Hold nutrient management plan workshop (Year 1)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Develop and implement a survey (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA;
			Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Conduct field days at a demonstration site for pasture renovation, drainage water management, cover crops, or any other appropriate practice (Year 2, Year 3, Year 4)	$9,000	Local landowners; ISDA; Purdue Extension	Indiana Conservation Cropping Systems (Hans Kok); NRCS; Purdue Extension
Nutrient 2.2	Develop an educational program for urban and recreational landowners including information on water quality and the factors that influence it; including information on phosphorus free fertilizers and other structural, residential BMPs.	Homeowners; Recreational area owners/ operators ; Businesses	Develop and distribute educational brochures (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife; Town Officials;	NRCS; DNR; ISDA
			Write a minimum of two educational articles for inclusion in local newspapers (Years 1-5)	$2,000	Local newspapers; SWCDs; The Nature Conservancy; IDEM	IDEM; DNR; Clean Water Clear Choices
			Conduct field day at a demonstration site for rain gardens, rain barrels, and residential runoff education (Year 3) (See Storm 6.3)	($5,000)	Landowners; SWCD; Purdue Extension	NRCS: Purdue Extension

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Nutrient 2.3	Develop and implement septic educational program (See E. coli 4.1 & 4.2)	Homeowners; Realtors; Septic installers; County Gov; Businesses	Develop and distribute educational brochures (Year 1); Develop an educational workshop; Develop and implement surveys; Actively seek alternative funding sources for installation and maintenance program; Write a minimum of two educational articles for publication in SWCD newsletters or local newspapers; Continue on a 5 year cycle (See E. coli 4.1)	($20,200)	HNF; DNR; SWCDs; Local landowners; Health Department; Purdue Extension; The Nature Conservancy; ISDA; Local newspapers; DNR; Quail Unlimited; Small Mouth Bass Alliance	Water Words that Work; DNR; ISDA; Soil Scientists; State Health Dept; Purdue Extension; NRCS
			Develop and distribute educational brochures; Have field day with USGS to discuss how water moves in karst watershed; Conduct field days at a demonstration site to showcase Alternative septic systems; Write a minimum of one educational articles for inclusion in SWCD newsletters or local newspapers; Continue on a 5 year cycle (See E. coli 4.2)	($9,300)	HNF; DNR; SWCDs; IKC; Local landowners; Health Department; Purdue Extension; Local newspapers; The Nature Conservancy; Indiana Karst Conservancy	IKC; DNR; ISDA; USGS; NRCS; Soil Scientists; State Health Department; Purdue Extension
Nutrient 2.4	Implement agricultural BMPs including but not limited to manure utilization, nutrient management plans, cover crops, no-till, precision ag, waste storage facilities	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with watershed producers to develop conservation plans (Year 1-5)	$1,000/yr	Watershed Steering Committee; Co-op;	NRCS; ISDA

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Nutrient 2.4 continue			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (On-going)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Co-op; Seed Dealers;	NRCS; ISDA; CCSI
Nutrient 2.5	Implement urban, residential, and industrial BMPs including but not limited to Porous Pavement, Rain Gardens, Runoff Capture & Reuse, Vegetated Swale, Filter Strip, Infiltration Practices, Soil Fertility Tests	Homeowners; Businesses; Industrial facilities; areas with large amount of pavement or roof	Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with watershed landowner to develop stormwater plans (Year 1-5)	$1,000/yr	Watershed Steering Committee; Engineering Firms	NRCS; ISDA; IDEM
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs;	NRCS; ISDA; IDEM

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Nutrient 2.6	Implement animal exclusion BMPs	Agricultural producers; landowners	Identify available programs through partner agencies; Develop a cost-share program ; Actively seek alternative funding sources for incentives and cost-share ; Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (See Buffer 1.5)	($1,000+ $2,000/yr & BMP Costs)	ISDA; FSA; NRCS; Fish & Wildlife; DNR; Watershed Steering Committee; Grants Station; IASWCD; community foundations; SWCDs; Fence suppliers; Cave Quarry; Geotextile suppliers; NRCS; ISDA; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D)
Nutrient 2.7	Seek resources to Investigate sinkhole and karst influence on nutrient loading to waterways and groundwater	All Stakeholders	Work with partner agencies to gather information related to karst influence on water quality (Year 1)	$1,000	Purdue Extension; IKC; Steering Committee	Universities; IGS; USGS; IDEM; NRCS
			Determine if additional research is needed (Year 3)	$2,000	Universities	Experts in Karst & Water Quality
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Investigate and develop standard practices for sinkhole water quality treatment (Year 6)	$12,000	INDOT; Environmental Consulting Firms; Geoscientists	NRCS; Universities
Nutrient 2.8	Connect water quality and wetlands	All Stakeholders	Develop and distribute educational brochures (Year 1)	$1,000	Purdue Extension; Steering Committee	Universities; IGS; USGS; IDEM
			Hold nutrient reducing wetland educational program (Year 2)	$2,000	Purdue Extension	Engineering Firms
			Wetland Laws & Regulation education (Year 3)	$2,000	Purdue Extension; County Government	ACoE; DNR; IDEM

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Nutrient 2.8 Continue			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,000/yr	SWCD; Local Newspapers	WOW; IDEM
			Connect mitigation needs with partners willing to install or create wetlands within the watershed (Year 1 and On-going)	Varies based on needs and availability of land	Landowners; HNF; The Nature Conservancy	IDEM; Purdue
Nutrient 2.9	Implement riparian BMPs	Landowners	Identify available programs through partner agencies; Develop a cost-share program; Work with county and town officials on incorporating stream buffers into development plans; Actively seek alternative funding sources for incentives and cost-share; Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (See Buffer 1.4)	($2,000+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; community foundations; SWCDs; DNR-LARE; County & Town Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D

Table 34: Action plan and strategies to address water quality concerns and reach Goal #3- Reduce sediment levels within streams to reach water quality targets.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.1	Develop an educational program about agricultural BMPs including filter strips, cover crops, pasture management & conservation cropping systems	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Interview landowners after BMP placement to review techniques and share lessons learned (On-going)	$3,000/yr	SWCD; Purdue Extension	NRCS; ISDA
			Develop and distribute educational brochures (Year 1)	$1,000	Cattleman; Co-op; Farm Bureau	Water Words that Work; DNR; ISDA
			Hold soil health workshop (Year 3)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
			Write a minimum of three educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Conduct field days at a demonstration site for pasture renovation, drainage water management, cover crops, or any other appropriate practice (Year 2, Year 3, Year 4)	$9,000	Local landowners; ISDA; Purdue Extension	Indiana Conservation Cropping Systems (Hans Kok); NRCS; Purdue Extension
Sediment 3.2	Develop an educational program for urban and residential landowners including information on erosion and preventative measures including structural BMPs and use of native plants.	Homeowners; Recreational area owners/ operators ; Businesses	Develop and distribute educational brochures (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife; Town Officials;	NRCS; DNR; ISDA
			Write a minimum of two educational articles for inclusion in local newspapers (Years 1-5)	$2,000	Local newspapers; SWCDs; The Nature Conservancy; IDEM	IDEM; DNR; Clear Choices Clean Water
			Hold a Rule 5 workshop (Year 1)	$1,000	IDEM; SWCD	IDEM
			Conduct field day at a demonstration site for rain gardens, rain barrels, and residential runoff education (Year 3)- (See Storm 6.3)	($5,000)	Landowners; SWCD; Purdue Extension	NRCS: Purdue Extension

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.3	Develop an educational program for forest landowners including information on forestry BMPs including but not limited to forest management plans, roads and trails, stream crossings, and tree plantings	Forest owners; Wood Harvesting Businesses; Forestry Consultants	Develop and distribute educational brochures (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife; Town Officials;	NRCS; DNR; ISDA
			Write a minimum of two educational articles for inclusion in local newspapers or SWCD newsletter(Years 1-5)	$2,000	Local newspapers; SWCDs; The Nature Conservancy; IDEM	IDEM; DNR;
			Conduct field day at a demonstration site for forest management (Year 3)	$5,000	DNR; HNF; RC&D; Woodland Owners;	DNR; HNF
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
Sediment 3.4	Implement agricultural BMPs including but not limited to cover crops, no-till, precision ag, filter strips, contour farming, sinkhole exclusion, etc.	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with watershed producers to develop conservation plans (Year 1 through 5)	$1,000/yr	Watershed Steering Committee; Co-op;	NRCS; ISDA
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Co-op; Seed Dealers;	NRCS; ISDA; CCSI

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.5	Implement riparian BMPs including but not limited to filter strip, conservation buffers, streambank plantings, critical area planting, riparian herbaceous & forest buffer	Agricultural producers; landowners	Identify available programs through partner agencies; Develop a cost-share program; Work with county and town officials on incorporating stream buffers into development plans; Actively seek alternative funding sources for incentives and cost-share; Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (See Buffer 1.4)	($2,000+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; community foundations; SWCDs; DNR-LARE; County & Town Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D
Sediment 3.6	Implement animal exclusion BMPs including but not limited to fence and stream crossings	Agricultural producers; landowners	Identify available programs through partner agencies; Develop a cost-share program ; Actively seek alternative funding sources for incentives and cost-share ; Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (See Buffer 1.5)	($1,000+ $2,000/yr & BMP Costs)	ISDA; FSA; NRCS; Fish & Wildlife; DNR; Watershed Steering Committee; Grants Station; IASWCD; community foundations; SWCDs; Fence suppliers; Cave Quarry; Geotextile suppliers; NRCS; ISDA; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D)

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.7	Implement urban, residential, and industrial BMPs including but not limited to Porous Pavement, Rain Gardens, Runoff Capture & Reuse, Vegetated Swale, Filter Strip, Infiltration Practices	Homeowners; Businesses; Industrial facilities; areas with large amount of pavement or roof	Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with watershed landowner to develop stormwater plans (Year 1-5)	$1,000/yr	Watershed Steering Committee; Engineering Firms	NRCS; ISDA; IDEM
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (On-going)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs;	NRCS; ISDA; IDEM
Sediment 3.8	Implement forestry BMPs including but not limited to forest management plans, roads and trails, stream crossings, and tree plantings	Forest owners; Wood Harvesting Businesses; Forestry Consultants	Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; DNR
			Work with watershed landowner to develop forest management plans (Year 1-5)	$1,000/yr	Watershed Steering Committee; DNR	NRCS;DNR; IDEM
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	DNR; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (On-going)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs;	NRCS; DNR; IDEM

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.9	Develop and implement Log Jam Preventative Maintenance Plan	All Stakeholders	Work with partner agencies to gather information related to log jams as a sediment source and wildlife habitat (Year 1)	$1,000	Purdue Extension; DNR-LARE; Cardo JFNew;	Universities; HNF IDEM; NRCS
			Determine if additional data is needed for preventative plan (Year 2)	$2,000	Universities	Experts log jams & geomorphology
			Actively seek alternative funding sources for maintenance program (On-going)	$2,000/yr	Grants Station; DNR-LARE; community foundations	NRCS; RC&D
			Develop a preventative log jam maintenance plan (Years 6-10) (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
			Remove large log jams if public infrastructure and safety are at risk and continuing log jam removal education workshops	variable depends on site conditions	SWCD; County surveyors	NRCS; County surveyors; DNR
Sediment 3.10	Seek resources to investigate how filling of sinkhole influences sediment loading to springs and waterways and flooding	All Stakeholders	Work with partner agencies to gather information related to karst as a sediment source (Year 1)	$1,000	Purdue Extension; IKC; Steering Committee	Universities; IGS; USGS; IDEM; NRCS
			Determine if additional research is needed (Year 3)	$2,000	Universities	Experts in Karst & Water Quality
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Investigate the hydraulics of karst systems for flooding potential (Year 4)	$5,000	Purdue Extension; IKC; Steering Committee	Universities; IGS; USGS; IDEM; NRCS
			Investigate and develop standard practices for sinkhole filling (Year 6)	$12,000	Purdue Extension; IKC; Steering Committee	NRCS; Universities

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Sediment 3.11	Connect water quality and wetlands	All Stakeholders	Develop and distribute educational brochures; Hold nutrient reducing wetland educational program; Wetland Laws & Regulation education; Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers; Connect mitigation needs with partners willing to install or create wetlands within the watershed (See Nutrient 2.8)	($5,000+ $2,000/yr & BMP Costs)	Purdue Extension; Steering Committee; County Government; SWCDs; Local Newspapers; Landowners; HNF; The Nature Conservancy	Universities; IGS; USGS; IDEM; Engineering Firms; ACoE; DNR; WoW; Purdue

Table 35: Action plan and strategies to address water quality concerns and reach Goal #4- Reduce E. coli levels within streams to reach water quality standards.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
E. coli 4.1	Develop an educational program for homeowners including information on water quality, public health, and septic system site suitability	Homeowners not connected to town utilities; County Council	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR; ISDA
			Develop an educational workshop	$5,000	Local landowners; Health Department; Purdue Extension	Soil Scientists; State Health Dept; Purdue Extension
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
			Actively seek alternative funding sources for installation and maintenance program (On-going)	$2,000	SWCD; The Nature Conservancy; ISDA	Soil Scientists; State Health Dept; Purdue Extension
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-3)	$4,200	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited; Small Mouth Bass Alliance	NRCS; DNR
			Continue on a 5 year cycle			
E. coli 4.2	Develop an educational program for realtors, installers, and pumpers including information on water quality, public health, and septic system site suitability	Realtors; Installers; and septic contractor	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs; IKC	IKC; DNR; ISDA
			Have field day with USGS to discuss how water moves in karst watershed (Year 2, 5)	$1,200	SWCDs	USGS
			Conduct field days at a demonstration site to showcase Alternative septic systems (Year 2, Year 3, or Year 4)	$5,000	Local landowners; Health Department; Purdue Extension	Soil Scientists; State Health Department; Purdue Extension
			Write a minimum of one educational article for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,100	Local newspapers; SWCDs; The Nature Conservancy; DNR; Indiana Karst Conservancy	NRCS; DNR
			Continue on a 5 year cycle			

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
E. coli 4.3	Develop an educational program on benefits and value of fencing livestock out of streams and sinkholes	Agricultural producers; homestead/ hobby livestock farms; rural landowners	Develop and distribute educational brochures on maintenance and cost-benefits of livestock fencing (Year 1)	$1,000	SWCDs; The Nature Conservancy; DNR; Quail Unlimited; Small Mouth Bass Alliance	NRCS; DNR
			Field day demonstrating the benefits of stream fencing to livestock producers (Year 2)	$3,000	ISDA; NRCS; Fish& Wildlife;	NRCS; DNR; ISDA
			Adapt educational program accordingly based on interviews and survey results (Year 5)	$3,600		
E. coli 4.4	Develop an educational program about agricultural BMPs, precision manure utilization, pasture management & incorporating manure with cover crops	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Interview landowners after BMP placement to review techniques and share lessons learned (On-going)	$3,000/yr	SWCD; Purdue Extension	NRCS; ISDA
			Develop and distribute educational brochures (Year 1)	$1,000	Manure Haulers ; Co-op; Farm Bureau	Water Words that Work; DNR; ISDA
			Hold waste utilization management plan workshop (Year 2)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool
			Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Conduct field days at a demonstration site for pasture renovation, waste storage facilities, cover crops, or any other appropriate practice (Year 2, Year 3, Year 4)	$9,000	Local landowners; ISDA; Purdue Extension	NRCS; ISDA; Purdue Extension

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
E. coli 4.5	Develop an educational program for watershed residents about animal waste and water quality issues	Livestock producers; pet owners; city officials; homeowners	Develop and distribute educational brochures (Year 1)	$1,000	Manure Haulers ; Co-op; Farm Bureau	Water Words that Work; DNR; ISDA
			Adapt educational programs accordingly based on survey results (Year 5)	$3,000	SWCD	
			Write a minimum of three educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Develop educational signs - minimum three, maximum six (Years 1-5)	$16,200	Local Parks; local residences; Towns and County entities	Cartoon artist; Water Words that Work
			Continue on a 5 year cycle			
E. coli 4.6	Implementation of livestock and other agricultural BMPs including but not limited to livestock fencing, stream crossings, alternative watering facilities, rotational grazing, nutrient and pest management plans	Agricultural producers; homestead/ hobby livestock farms; rural landowners	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Fence suppliers; Cave Quarry; Geotextile suppliers; NRCS; ISDA; Steering Committee	NRCS; DNR; ISDA

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
E. coli 4.7	Set-up a possible annexation mechanism for subdivisions or high risk septic systems near towns	Town Councils; homeowners	Conduct testing to identify neighborhoods with a high proportion of septic system failures near current sanitary sewer infrastructure (Year 5)	$28,800	Health departments	Health departments
			Ordinance passed and enforced (Year 12)	$3,600	Local Utilities	Engineering Firms; Water Utility; Town Council
E. coli 4.8	Develop an ordinance requiring upgrades to failing systems at the time of real estate transactions	All parties involved in real estate transactions	Begin planning (Year 5) and continue development through Year 12	$8,700	Health departments, ISDA, septic contractors	County commissioners
			Annexation of neighborhoods not suitable for on-site septic systems by the end of Year 12	$10,000	Real estate agents	County Commissioners
E. coli 4.9	Work with Town of Paoli to separate Stormwater from Sewage System	Towns	Search for economic resources for Separations (Year 1-5)	$8,700	Health departments, ISDA, septic contractors	County commissioners
			Develop Planning to reduce stormwater runoff (Year 1-5) (See Storm 6.3)	($12,200)	Local newspapers; SWCDs; The Nature Conservancy; DNR; Landowners; Purdue Extension; HNF	Water Words that Work; DNR; ISDA; NRCS; Soil Scientists; State Health Dept; Purdue Extension

Table 36: Action plan and strategies to address water quality concerns and reach Goal #5- Increase aquatic life within streams to reach water quality standards.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Life 5.1	Develop an wildlife educational program for landowners including information on effects runoff has on water quality, public health, and aquatic organisms	All Stakeholders	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR; ISDA
			Develop a minimum of two educational workshop (Year 1-5)	$5,000	Local landowners; Purdue Extension	Biologists; Purdue Extension
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool
			Hold Hoosier Riverwatch Sampling events (Monthly: Spring-Fall)	$7,000/ yr	IDEM; Junior Leaders; FFA	Hoosier Riverwatch; IDEM
			Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Develop volunteer stream monitoring network (On-going)	$2,000	Junior Leaders; FFA; Local Landowners	Hoosier Riverwatch; IDEM
			Continue on a 5 year cycle			
Life 5.2	Develop an educational program about how agricultural BMPs including nutrient and pest management plans & conservation cropping systems can improve the water quality for the biological system	Agricultural producers; homestead farms; hobby livestock farms; rural landowners.	Develop and distribute educational brochures (Year 1)	$1,000	Co-op; Farm Bureau	Water Words that Work; DNR; ISDA
			Hold nutrient & pest management plan workshop (Year 3)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Hold a organic alternatives educational workshop (Year 5)	$3,000	Organic Farmers; Lost River Co-op	Orange County Homegrown
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
			Demonstrate runoff from conventional vs. conservation cropping systems (Year 1-5)	$4,000/yr	SWCD; 4-H; FFA	NRCS; CCSI
			Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Continue on a 5 year cycle			

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Life 5.3	Develop an educational program for stakeholders including information on effects chemical runoff has on water quality, public health, and aquatic organisms	All Stakeholders	Educate residents of alternatives to driveway salts (Year 2)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Educate stakeholders on the effects prescriptions and personal care products have on life (Year 2)	$3,000	Farm Bureau; Co-op; ISCO; IDEM	Purdue Extension; TSP; NRCS; ISDA
			Actively seek alternative funding sources for prescription take back program (On-going)	$2,000	Solid Waste; Pharmacies; Sheriff's Department	Pharmacies; Sheriff's Department
			Investigate alternative drainage tools for agricultural fields (two-stage ditches, drainage water management, etc.) (On-going)	$2,000	SWCD; The Nature Conservancy	Purdue Extension
			Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers (Years 1-5)	$12,600	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	
Life 5.4	Develop an invasive weed program	Utilities; county entities; towns; residence; landowners	Develop and distribute educational brochures (Year 1)	$1,000	SICWMA; DNR; White River RC&D	Purdue Extension; SICWMA
			Develop invasive "Weed-Watcher" volunteer network (On-going)	$2,000/yr	SICWMA	Purdue Extension; SICWMA
			Hold invasive removal events on a yearly basis (On-going)	$4,000/yr	SICWMA; DNR; White River RC&D	Purdue Extension; SICWMA
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-3)	$4,200	Local newspapers; SWCDs; Quail Unlimited; SICWMA	NRCS; DNR; Universities

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Life 5.5 .	Reduce Sediment sources to Habitats	All Stakeholders	Implement riparian BMPs including but not limited to tree & shrub plantings, grass plantings- filter strip, conservation buffers, streambank plantings, critical area planting, riparian herbaceous & forest buffer, and conservation easements (See Buffer 1.4)	($2,000+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; SWCDs; community foundations; DNR-LARE; County & Town Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D
			Implement animal exclusion BMPs including but not limited to fence, alternative watering facilities, stream crossings, and critical area planting (See Buffer 1.5)	($1,000+ $2,000/yr & BMP Costs)	ISDA; FSA; NRCS; Fish & Wildlife; DNR; Watershed Steering Committee; Grants Station; IASWCD; community foundations; SWCDs; Fence suppliers; Cave Quarry; Geotextile suppliers; NRCS; ISDA; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D)
			Implement agricultural BMPs including but not limited to cover crops, no-till, precision ag, filter strips, contour farming, sinkhole exclusion, etc. (See Sediment 3.4)	($2,000+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; community foundations; SWCDs; DNR-LARE; County & Town Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Life 5.5 Cont.			Implement urban, residential, and industrial BMPs including but not limited to Porous Pavement, Rain Gardens, Runoff Capture & Reuse, Vegetated Swale, Filter Strip, Infiltration Practices (See Sediment 3.7)	($1,500+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; comm. foundations; SWCDs; DNR-LARE; Local Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D
			Implement forestry BMPs including but not limited to forest management plans, roads and trails, stream crossings, and tree plantings (See Sediment 3.8)	($1,500+ $2,000/yr & BMP Costs)	Watershed Steering Committee; DNR; Engineering Firms; Grants Station; IASWCD; comm. foundations; SWCDs; DNR-LARE; Local Commissioners & Council; Steering Committee	NRCS; DNR; ISDA; SWCDs; RC&D
Life 5.6	Limit the amount of chemicals & trash from reaching streams	All Stakeholders	Educate landowners on proper disposal of hazardous materials, trash, and waste (Year 1)	$2,000	Recycle Co-op; IDEM	IDEM; Solid Waste Management
			Encourage Low Impact Development Planning within the watershed (On-going)	$2,000	Economic Development; Planning Boards	Purdue Extension
			Clean lawn, clean town pride program (Years 5-10)	$3,000	OCCF; Health Department; towns	Recycling Co-op; Economic Dev
			Work with Partnering Agencies on Acid Mine Drainage Treatments on abandoned coal mines (Year 1)	$4,000	DNR; OSM; ACCT	DNR
			Write a minimum of one educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,100	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Life 5.7	Limit the amount of salts reaching streams	Utilities; county entities; towns; residence; landowners	Investigate road salt and driveway salt alternatives (Year 1)	$2,000	INDOT; Hwy Dept	INDOT; Hwy Dept;
			Demonstrate runoff from conventional vs. conservation cropping systems (Year 1-5)	$4,000/yr	SWCD; 4-H; FFA	NRCS; CCSI
Life 5.8	Implement sediment reducing BMPs including but not limited to cover crops, no-till, filter strips, contour farming, sinkhole exclusion, stream buffers, streambank stabilization, stormwater runoff controls, etc.	Agricultural producers; homestead farms; hobby livestock farms; landowners.	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (On-going)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Co-op; Seed Dealers;	NRCS; ISDA; CCSI

Table 37: Action plan and strategies to address water quality concerns and reach Goal #6- Decrease stormwater runoff to reduce non-point source pollution.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Storm 6.1	Develop an educational program for landowners including information on effects of runoff has on water quality, public health, and aquatic organisms	All Stakeholders	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR; ISDA
			Develop a minimum of two educational workshops	$5,000	Local landowners; Health Department; Purdue Extension	Soil Scientists; State Health Dept; Purdue Extension
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; SIDMA Tool;
			Actively seek alternative funding sources for installation and maintenance program (On-going)	$2,000	SWCD; The Nature Conservancy; ISDA	Purdue Extension
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-3)	$4,200	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited; Small Mouth Bass Alliance	NRCS; DNR
			Continue on a 5 year cycle			
Storm 6.2	Develop an educational programs on runoff from construction and industrial sites and BMPs to control runoff	Engineering Firms; Commissioners; County Council; Town Councils; Developers; Economic Development; Businesses; Landowners	Develop and distribute educational brochures (Year 1)	$1,000	County Entities; Towns; Surveyors	IDEM; SWCD
			Hold a Rule 5/ Rule 6 workshop (Year 2)	$4,000	County Entities; Towns; Surveyors	IDEM; SWCD
			Education of Low Impact Development Planning (Year 3)	$7,000	County Entities; Towns; Surveyors	IDEM; SWCD
			Develop guidelines for residential construction (Year 5)	$6,000	County Entities; Towns; Surveyors	IDEM; SWCD
			Write a minimum of one educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,100	Local newspapers; SWCDs; The Nature Conservancy; DNR; Quail Unlimited;	NRCS; DNR
			Continue on a 5 year cycle			

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Storm 6.3	Develop an educational program on benefits and value of backyard conservation	Residents; homeowners, landowners	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR; ISDA
			Develop a minimum of two educational workshops (Year 1-5)	$5,000	Landowners; SWCD; Purdue Extension	NRCS: Purdue Extension
			Actively seek alternative funding sources for installation and maintenance program (On-going)	$2,000	SWCD; The Nature Conservancy; ISDA	Soil Scientists; State Health Dept; Purdue Extension
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-3)	$4,200	Local newspapers; SWCDs; The Nature Conservancy; DNR;	NRCS; DNR
			Continue on a 5 year cycle			
Storm 6.4	Work with partners on implementing plan of action to separating stormwater from sewer systems	Engineering Firms; Commissioners; County Council; Town Councils; Developers; Economic Development	Actively seek alternative funding sources for installation and maintenance program (On-going)	$2,000	SWCD; The Nature Conservancy; IDEM	State Health Dept; Region 15
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 5-9)	$4,200	Local newspapers; SWCDs; The Nature Conservancy; DNR;	NRCS; DNR
Storm 6.5	Work with partners on incorporating Low Impact Development in future planning, development and zoning efforts	Engineering Firms; Commissioners; County Council; Town Councils; Developers; Economic Development; Businesses; Landowners	Develop and distribute educational brochures (Year 1)	$1,000	HNF; DNR; SWCDs;	Water Words that Work; DNR
			Develop a minimum of two educational workshops (Year 1-5)	$5,000	Landowners; SWCD; Purdue Extension	NRCS: Purdue Extension
			Actively seek alternative funding sources for installation and maintenance program (On-going)	$2,000	SWCD; The Nature Conservancy; ISDA	Soil Scientists; State Health Dept; Purdue Extension
			Write a minimum of two educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-3)	$4,200	Local newspapers; SWCDs; The Nature Conservancy; DNR;	NRCS; DNR

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Storm 6.6	Implement stormwater filtration & attenuation BMPs including but not limited to rain gardens, cisterns /rain barrels, filter strips, bioswales, permeable /porous pavement, tree planting, etc.	Urban Landowners; Towns; Residences; Commercial Owners; industrial Owners; Developers; Construction Firms	Identify available programs through partner agencies (Year 1)	$500	ISDA; FSA; NRCS; Fish & Wildlife; DNR	SWCD
			Develop a cost-share program (Year 1)	$500	Watershed Steering Committee	NRCS; ISDA
			Work with landowners to develop stormwater plans (Year 1 - 5)	$7,000/yr	Watershed Steering Committee; SWCD	NRCS;RC&D
			Actively seek alternative funding sources for incentives and cost-share (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and On-going)	Varies based on types and sizes of selected BMPs (Table 30)	SWCDs; Towns	IDEM

Table 38: Action plan and strategies to address water quality concerns and reach Goal #7- Increase knowledge and capacity within the Lost River Watershed.

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Knowledge 7.1	Develop an intense educational and community outreach campaign that includes Action Register Objectives: Buffer 1.1, 1.2, & 1.3; Nutrient 2.1, 2.2, & 2.3; Sediment 3.1, 3.2, & 3.3; E.coli 4.1, 4.2, 4.3, 4.4, & 4.5; life 5.1, 5.2, 5.3, & 5.4; and Stormwater 6.1, 6.2, & 6.3	All Stakeholders	Develop and install three billboard layouts or Public Service Announcements (end of Year 3)	$15,000	Indiana Expeditions	IDEM
			Develop a movie theater/video advertisement to play at local theaters (Year 3)	$9,000	Indiana Association of SWCDs; DNR Division of Forestry; DNR	Natural Resources Education Center
			Install approximately 25 markers annually on storm drains indicating they drain to streams and sinkholes (Years 1-5)	$6,600	Towns of Paoli, Orleans, French Lick. West Baden, and Mitchell	IKC; Surrounding MS4
			Develop Septic Education Campaign (Years 1-5)	$12,000	Local landowners; Health Department; Purdue Extension	Soil Scientists; State Health Dept; Purdue Extension
			Develop a intensive Stream Bank, Stream Buffer, and Log Jam Campaign to coordinate efforts (Year 1)	$25,000	SWCDs; DNR-LARE; HNF; Region 15; Steering Committee	Flood Task Force; Army Corp of Eng; NRCS; DNR; Fish & Wildlife; SWCD
			Increase number of household hazardous waste collection days in Orange County to a minimum of two times annually (Year 2).	$5,100	Orange County SWMD	Orange County Recycling Co-op
			Have free disposal of household hazard waste (Year 3).	$15,000	Orange County SWMD	Orange County Recycling Co-op

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Knowledge 7.2	Develop appropriate planning to insure the long-term viability and effectiveness of the Lost River Watershed Partnership	Steering Committee; Lost River Watershed Partnership	Continue Partnership Development with the Lost River Watershed Partnership (LRWP) (on-Going)	$2,000	Anyone with missions that could work with our mission	IASWCD; Watershed Leadership Academy; IDEM
			Develop a Plan of Work to outline staffing, equipment, financial and other needs required to further the goals and mission of the LRWP (Year 3 and updated every year)	$5,000 + $1,000/yr	County Officials; SWCD; RC&D; IDEM;	LRWP; Steering Committee
			Develop a financial plan and implement funding strategies to insure the viability of the LRWP (Year 3 and updated every year)	$5,000 + $1,000/yr	County Officials; SWCD; RC&D; IDEM;	LRWP; Steering Committee
			Actively seek alternative funding sources for capacity building (On-going)	$2,000/yr	Grants Station; IASWCD; community foundations	ISDA; RC&D
			Gather assistance and resources to increase the frequency of workshops/field days (On-going)	$2,000/yr	Purdue Extension; Steering Committee	IASWCD; CCSI; Indiana Family of Farmers
			Develop and maintain a catalog of volunteer's skills, interests, and availability. (On-going)	$8,000	Interns; SWCD	Indiana Watershed Leadership Academy

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Knowledge 7.3	Establish education, outreach, and clean-up programs to reduce stream, sinkhole, and roadside dumping.	All Stakeholders	Develop an anti-litter outreach and education program (Year 1)	$3,000	School District; 4-H Clubs; Church Organizations; Media; Local Businesses	Water Words that Work; Keep America Beautiful
			Become Keep America Beautiful Affiliate (Year 1)	$4,000	SWCD	Keep America Beautiful
			Develop a hunter education and outreach about proper disposal of animal carcasses. (Year 1)	$3,000	DNR; Hunters; Check Stations; Hunting Supply Shops	Purdue Extension; DNR
			Develop and implement surveys (See Buffer 1.1)	($8,000)	Purdue Extension	Steering committee; Social Indicators Data Management & Analysis Tool;
			Develop public service announcements (Year 2)	$2,000	Local newspapers; local radio stations	Keep America Beautiful; Steering Committee
			Clean Sinkhole Pride program with signs displayed for cleaned up sinkholes (Years 5-10)	$8,000	Fish & Wildlife; IKC; DNR	IKC; DNR
			Organize "clean-up" days based on Adopt a River / Adopt a Highway campaigns. (Year 1 and On-going)	$1,500/yr	INDOT; DNR; IDEM	Keep America Beautiful; Steering Committee

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Knowledge 7.4	Educate watershed stakeholders of the water quality in Lost River Watershed	All Stakeholders	Develop and distribute educational brochures (Year 1)	$1,000	Purdue Extension; Steering Committee	Universities; IGS; USGS; IDEM
			Organize Hoosier Riverwatch stream testing events (Year 1 and On-going)	$1,000/yr	IDEM; Universities;	Hoosier Riverwatch
			Connect water quality to wetlands: (See Nutrient 2.8)	($5,000+ $2,000/yr & BMP Costs)	Purdue Extension; Steering Committee; County Government; SWCDs; Local Newspapers; Landowners; HNF; The Nature Conservancy	Universities; IGS; USGS; IDEM; Engineering Firms; ACoE; DNR; WoW; Purdue
			Hold Public meetings to discuss water quality and methods of reducing our impact on stream life (Year 2, Year 4, Year 6)	$4,000	Purdue Extension; Steering Committee	Universities; Indiana Watershed Leadership Academy
Knowledge 7.5	Educate stakeholders on BMPs that help to improve water quality within the watershed	All Stakeholders	Develop and distribute educational brochures (Year 1)	$1,000	Purdue Extension; Steering Committee	EPA; IDEM
			Work with Early Adopters from interviews to showcase successful BMP installation and treatments (Year 3)	$4,000	Purdue Extension; Steering Committee	NRCS; ISDA; IDEM; Universities
			Write a minimum of five educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$2,000/yr	SWCD; Local Newspapers	WOW; IDEM
			Conduct a minimum of five field days at demonstrating successful BMP placement (Year 2, Year 3, Year 4)	$9,000	Local landowners; ISDA; Purdue Extension	Indiana Conservation Cropping Systems (Hans Kok); NRCS; Purdue Extension

Goal	Objective	Target Audience	Milestones	Cost	Possible Partners	Technical Assistance
Knowledge 7.6	Develop an educational program on natural stream functions; values of riparian areas for wildlife, erosion control, and stream bank stabilization; and maintenance of riparian areas to prevent problematic log jams.	Landowners; agricultural producers; residence; county & town officials; business owners	Develop and distribute educational brochures; Write a minimum of three educational articles for publication in SWCD newsletters or local newspapers; Field day demonstrating the benefits of maintaining stream function; Develop and implement surveys; Development of a preventative log jam maintenance plan (See Buffer 1.1)	($68,300)	HNF; DNR; SWCDs; Purdue Extension; Local newspapers; TNC; DNR; Quail Unlimited; Small Mouth Bass Alliance; ISDA; NRCS; Fish& Wildlife; FSA; Health Departments; Utilities; County Commissioners & Council; Flood Task Force; DNR-LARE; HNF; Region 15; Steering Committee	Water Words that Work; DNR; ISDA; Army Corp of Eng; NRCS; Fish & Wildlife; SWCD Steering committee; Social Indicators Data Management & Analysis Tool;
Knowledge 7.7	Develop and implement septic educational program	Homeowners; Realtors; Septic installers; County Gov; Businesses	Develop and distribute educational brochures (Year 1); Develop an educational workshop; Develop and implement surveys; Actively seek alternative funding sources for installation and maintenance program; Write a minimum of two educational articles for publication in SWCD newsletters or local newspapers; Continue on a 5 year cycle (See E. coli 4.1)	($20,200)	HNF; DNR; SWCDs; Local landowners; Health Department; Purdue Extension; The Nature Conservancy; ISDA; Local newspapers; DNR; Quail Unlimited; Small Mouth Bass Alliance	Water Words that Work; DNR; ISDA; Soil Scientists; State Health Dept; Purdue Extension; NRCS
			Develop and distribute educational brochures; Have field day with USGS to discuss how water moves in karst watershed; Conduct field days at a demonstration site to showcase Alternative septic systems; Write a minimum of one educational articles for inclusion in SWCD newsletters or local newspapers; Continue on a 5 year cycle (See E. coli 4.2)	($9,300)	HNF; DNR; SWCDs; IKC; Local landowners; Health Department; Purdue Extension; Local newspapers; The Nature Conservancy; Indiana Karst Conservancy	IKC; DNR; ISDA; USGS; NRCS; Soil Scientists; State Health Department; Purdue Extension

11.3 Tracking Effectiveness

The success of the WMP can be measured by the progress made toward achieving each stated water quality improvement goal. Progression indicators include social indicators, administrative indicators, and environmental indicators. A watershed coordinator and/or steering committee members will be responsible for tracking all indicators. Administrative indicators will be tracked on a quarterly basis and reported to the steering committee and other appropriate entities quarterly. Social indicators and environmental indicators will be included in quarterly reports, as new data is available. It is estimated that it will cost over $270,000 per year to implement this plan. This includes the cost of two full time staff personnel to track indicators and review the Lost River Watershed Management Plan. Water quality monitoring is estimated to cost $70,700 per year for three years or $212,100. This includes the technical assistance needed from the many federal, state, and local governments along with private businesses and volunteers listed in Table 32 through Table 38. Technical assistance comes in the form of BMP design, management practice standards, updated state of knowledge, and guidance.

Social Indicators

Water quality is significantly influenced by the behaviors and attitudes of the people living and working in a watershed. Education about water quality issues is a substantial component in improving and maintaining water quality over the long-term, and multiple educational initiatives are proposed as part of WMP implementation. Measuring social indicators is one way to gauge changing attitudes and awareness of water quality issues over time and gauge the progress and success of educational initiatives. Specifically social indicators are designed to measure awareness of pollutants, consequences of pollutants, and practices that are used to improve water quality as well as attitudes linked to behavioral change. In addition to the benefit of gauging the long-term sustainability of water quality improvement, measuring social indicators also provides a means to demonstrate WMP success sooner than measuring environmental indicators, which may take numerous years to see fruition.

Social Indicators Data Management and Analysis tool (SIDMA) has been developed to help watershed managers manage, analyze, and monitor social indicators associated with water quality improvement attributed to nonpoint source pollution in USEPA Region 5. A key feature of SIDMA is a survey builder, which includes survey questions worded to reduce ambiguity by respondents that can be used as a template (Institute of Water Research, 2011).

A series of surveys are proposed for development and dissemination in the watershed before and after educational events to track the effectiveness of those events. These surveys are planned to be repeated after three and five years of WMP implementation to gauge progress being made, and to adjust the educational initiatives as appropriate to attain maximum results.

Administrative Indicators

Administrative indicators amount to keeping tally of activities associated with WMP implementation and are best tracked in spreadsheets. They are used to track public participation as well as attainment of basic BMP implementation goals. Administrate indicators that will be tracked as part of WMP may include, but is not limited to:

- Number of each type or acreage of BMP installed
- Modeled pollutant load reductions associated with BMP implementation
- Number of people attending workshops and field days
- Number of newspaper articles published, fact sheets distributed, etc.

Number of specific educational materials distributed

Number of permits for septic system upgrades

Environmental Indicators

Water quality parameters analyzed during development of the WMP provide minimal water quality baseline condition data for Lost River watershed. Continued monitoring will track trends and the progression of actual water quality. Although, it should be expected for there to be lag time between implementation of the WMP and BMPs and detecting consistent, measurable improvements in water quality. Parameters analyzed as part of this study included temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, nitrate nitrogen, BOD5, TSS, turbidity, discharge, E. coli, macroinvertebrate, and habitat data. Monthly sampling is recommended for April through October collections using approved methods at nine locations. Five of these locations will be at USGS gaging stations in the watershed. The gages will be used to collect flow data at time of sampling. Orthophosphate, Nitrate, Nitrite, Dissolved Oxygen, BOD5, Temperature, pH, turbidity, and E.coli will be collected at every station. Habitat and Macroinvertebrates will also be collected at each station once a year in the fall. Samples will be consistently collected at the same sites with a minimum of nine collection points throughout the watershed. Samples may be collected either professionally and analyzed by a laboratory or using Hoosier Riverwatch methods.

If funding allows, the steering committee proposes seven months of water chemistry monitoring through the uses of volunteers and steering committee participation. This monitoring will be every year for three years at 9 sites in Lost River watershed, and sampling macroinvertebrates during two seasons in the first and third years of WMP implementation. Parameters proposed for testing include orthophosphate, nitrate nitrogen, TSS, pH, temperature, BOD5, dissolved oxygen, E. coli, and discharge. Hoosier Riverwatch volunteer monitoring will be encouraged in the watershed beyond the 9 sites mentioned above. It is proposed that Hoosier Riverwatch water monitoring collect data from the same locations from which samples have been collected for laboratory analyses; thus, providing a long-term, cost-effective means of tracking water quality in Lost River watershed.

11.4 Future Activities

As watershed conditions and public opinions change over time, the priority for recommended BMPs will change. Further, implementation of some BMPs may no longer be as important or may no longer be needed at all. As policies change and technologies improve, new BMPs may be identified that should be implemented. An annual steering committee meeting led by the Orange County SWCD or watershed coordinator should be held to evaluate the progress made in implementing WMP recommendations. The WMP is a flexible guidance document and necessary accommodations can be made by the steering committee annually. It is recommended that the plan be thoroughly reevaluated by the steering committee after five years and be adjusted and updated as appropriate to incorporate future unforeseen circumstances. It is recommended that the plan continue to be thoroughly revalued and updated on a 5-year rotation. As the WMP development sponsor Orange County SWCD will be the primary contact for implementation of the WMP and can be reached at the following contact information:

Orange County SWCD

Michael Wilhite, District Administrator

573 SE Main Street, Suite 1

Paoli, Indiana 47454

812-723-3311 x3

APPENDICES Data Inventory

Appendix 1: Threatened and Endangered Species 357

Appendix 2-References 362

Watershed Name: Lost River

Contact Information:

Orange County SWCD

Soil and Water Conservation District

573 SE Main St, Suite 1 Paoli, IN 47454

812-723-3311

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Appendix 1: Threatened and Endangered Species

Indiana Natural Heritage Data Center: Endangered Threatened and Rare species rank definitions

Heritage Global Rank

Basic Ranks

- G1 = Critically imperiled globally
- G2 = Imperiled globally
- G3 = Rare or uncommon
- G4 = Widespread, abundant, and apparently secure, but with cause for long term concern
- G5 = Demonstrably widespread, abundant and secure
- G? = Unranked
- GU = Unrankable
- GH = Historical
- GX = Extinct

Subrank

- T = Taxonomic subdivision (e.g. subspecies) follows numerical ranks as with global ranks above (T1, T2, etc.) for total rank like G3T3 etc.

Qualifiers

- ? = Inexact numeric rank
- Q = Questionable taxonomy

Heritage State Rank

- S1 = Critically imperiled in state (fewer than 5 occurrences)
- S2 = Imperiled in state (6-20 occurrences in state)
- S3 = Rare (typically 21-100 occurrences in state)
- S4 = Apparently secure (many occurrences)
- S5 = Demonstrably secure
- SA = Accidental in state
- SH = Of historical occurrence in state
- SX = Extirpated from state
- SU = Possibly imperiled, need more information
- SRE = Reintroduced in state.
- SZ = Birds – Migrant through state; or present in state but with no identifiable location
- SRF = Reported falsely in state
- SNR = not rank
- SNA = rank not available

Qualifiers

- N = Nonbreeding status (generally for birds)
- B = Breeding status (generally for birds)

Category	Scientific Name	Common Name	Type	Global Rank	State Rank
Invertebrate Animal	Anahita punctulata	Southeastern Wandering Spider	Arachnida	G4	S1
Invertebrate Animal	Apochthonius indianensis	Indiana Cave Pseudoscorpion	Arachnida	G1G2	S1
Invertebrate Animal	Dolomedes scriptus	Lined Nursery Web Spider	Arachnida	GNR	S1?
Invertebrate Animal	Erebomaster flavescens	Golden Cave Harvestman	Arachnida	G3G4	S2
Invertebrate Animal	Hesperochernes mirabilis	Southeastern Cave Pseudoscorpion	Arachnida	G5	S4
Invertebrate Animal	Kleptochthonius packardi	Packard's Cave Pseudoscorpion	Arachnida	G2G3	S1S2
Invertebrate Animal	Porhomma cavernicola	Appalachian Cave Spider	Arachnida	G5	S1
Invertebrate Animal	Cauloxenus stygius	Northern Cavefish Commensal Copepod	Crustacea: Copepod	G1G2	SNR
Invertebrate Animal	Diacyclops jeanneli	Jeannel's Cave Copepod	Crustacea: Copepod	G3G4	S2
Invertebrate Animal	Crangonyx packardi	Packard's Cave Amphipod	Crustacea: Malacostra (Crayfish)	G4	S4
Invertebrate Animal	Orconectes inermis inermis	A Troglobitic Crayfish	Crustacea: Malacostra (Crayfish)	G5T4	S4
Invertebrate Animal	Dactylocythere susanae	An Ostracod	Crustacea: Ostrocod	G2G4	S3
Invertebrate Animal	Sagittocythere barri	Barr's Commensal Cave Ostracod	Crustacea: Ostrocod	G5	S3S4
Invertebrate Animal	Conotyla bollmani	Bollman's Cave Milliped	Diplopoda	G5	S4
Invertebrate Animal	Pseudotremia indianae	Blue River Cave Milliped	Diplopoda	G4	S4
Invertebrate Animal	Arrhopalites bimus	Springtail	Elliplura: Collembola (Springtails)	G3G4	S1
Invertebrate Animal	Arrhopalites lewisi	Lewis' Cave Springtail	Elliplura: Collembola (Springtails)	GNR	S2
Invertebrate Animal	Isotoma caeruleatra	Blue Springtail	Elliplura: Collembola (Springtails)	GNR	SNR
Invertebrate Animal	Isotoma nigrifrons	Dark Springtail	Elliplura: Collembola (Springtails)	GNR	SNR
Invertebrate Animal	Isotoma truncata	Truncated Springtail	Elliplura: Collembola (Springtails)	GNR	S1
Invertebrate Animal	Onychiurus casus	Fallen Springtail	Elliplura: Collembola (Springtails)	GNR	S4
Invertebrate Animal	Onychiurus reluctus	A Springtail	Elliplura: Collembola (Springtails)	GNR	S4
Invertebrate Animal	Onychiurus subtenuis	Slender Springtail	Elliplura: Collembola (Springtails)	GNR	SNR
Invertebrate Animal	Pseudosinella collina	Hilly Springtail	Elliplura: Collembola (Springtails)	GNR	S2?

Category	Scientific Name	Common Name	Type	Global Rank	State Rank
Invertebrate Animal	Pseudosinella fonsa	Fountain Cave Springtail	Elliplura: Collembola (Springtails)	G3G4	S2
Invertebrate Animal	Sensillanura barberi	Barber's Springtail	Elliplura: Collembola (Springtails)	GNR	SNR
Invertebrate Animal	Sinella alata	Springtail	Elliplura: Collembola (Springtails)	G5	S4
Invertebrate Animal	Sinella cavernarum	A Springtail	Elliplura: Collembola (Springtails)	G5	S4
Invertebrate Animal	Atheta annexa	Rove beetle	Insect Coleoptera	G4	S4
Invertebrate Animal	Necrophilus pettiti	A Carrion Beetle	Insect Coleoptera	GNR	S1?
Invertebrate Animal	Pseudanophthalmus stricticollis	Marengo Cave Ground Beetle	Insect Coleoptera	GNR	S3
Invertebrate Animal	Pseudanophthalmus youngi	Young's cave ground beetle	Insect Coleoptera	G3G4	S3
Invertebrate Animal	Tychobythinus bythinioides	Ant beetle	Insect Coleoptera	GNR	S1
Invertebrate Animal	Enallagma divagans	Turquoise Bluet	Insect Odonata	G5	S3
Invertebrate Animal	Cyprogenia stegaria	Eastern Fanshell Pearlymussel	Mollusk	G1Q	S1
Invertebrate Animal	Fusconaia subrotunda	Longsolid	Mollusk	G3	SX
Invertebrate Animal	Pleurobema clava	Clubshell	Mollusk	G2	S1
Invertebrate Animal	Pleurobema cordatum	Ohio Pigtoe	Mollusk	G4	S2
Invertebrate Animal	Quadrula cylindrica cylindrica	Rabbitsfoot	Mollusk	G3G4T3	S1
Invertebrate Animal	Glyphyalinia latebricola	Stone Glyph	Mollusk Gastropod	G1G2	SNR
Invertebrate Animal	Patera laevior	Smooth Bladetooth	Mollusk Gastropod	G4	S1
Invertebrate Animal	Sphalloplana weingartneri	Weingartner's Cave Flatworm	Platyhelminthes	G4	S4
Vascular Plant	Bacopa rotundifolia	Roundleaf Water-hyssop	Vascular Plant	G5	S1
Vascular Plant	Gonolobus obliquus	Angle Pod	Vascular Plant	G4?	S2
Vascular Plant	Isoetes engelmannii	Appalachian Quillwort	Vascular Plant	G4	S1
Vascular Plant	Juglans cinerea	Butternut	Vascular Plant	G4	S3
Vascular Plant	Oxalis illinoensis	Illinois Woodsorrel	Vascular Plant	G4Q	S2
Vascular Plant	Penstemon canescens	Gray Beardtongue	Vascular Plant	G4	S2

Category	Scientific Name	Common Name	Type	Global Rank	State Rank
Vascular Plant	Rudbeckia fulgida var. fulgida	Orange Coneflower	Vascular Plant	G5T4?	S2
Vascular Plant	Spiranthes vernalis	Grassleaf Ladies'-tresses	Vascular Plant	G5	S2
Vascular Plant	Stenanthium gramineum	Eastern Featherbells	Vascular Plant	G4G5	S1
Vascular Plant	Tragia cordata	Heart-leaved Noseburn	Vascular Plant	G4	S2
Vascular Plant	Vittaria appalachiana	Appalachian Vittaria	Vascular Plant	G4	S2
Vertebrate Animal	Rana blairi	Plains Leopard Frog	Amphibian	G5	S1
Vertebrate Animal	Scaphiopus holbrookii	Eastern Spadefoot	Amphibian	G5	S2
Vertebrate Animal	Ardea herodias	Great Blue Heron	Bird	G5	S4B
Vertebrate Animal	Buteo lineatus	Red-shouldered Hawk	Bird	G5	S3
Vertebrate Animal	Buteo platypterus	Broad-winged Hawk	Bird	G5	S3B
Vertebrate Animal	Haliaeetus leucocephalus	Bald Eagle	Bird	G5	S2
Vertebrate Animal	Lanius ludovicianus	Loggerhead Shrike	Bird	G4	S3B
Vertebrate Animal	Mniotilta varia	Black-and-white Warbler	Bird	G5	S1S2B
Vertebrate Animal	Nyctanassa violacea	Yellow-crowned Night-heron	Bird	G5	S2B
Vertebrate Animal	Rallus elegans	King Rail	Bird	G4	S1B
Vertebrate Animal	Tyto alba	Barn Owl	Bird	G5	S2
Vertebrate Animal	Wilsonia citrina	Hooded Warbler	Bird	G5	S3B
Vertebrate Animal	Amblyopsis spelaea	Northern Cavefish	Fish	G4	S1
Vertebrate Animal	Ammocrypta clara	Western Sand Darter	Fish	G3	S2
Vertebrate Animal	Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	Mammal	G3G4	SH
Vertebrate Animal	Lynx rufus	Bobcat	Mammal	G5	S1
Vertebrate Animal	Mustela nivalis	Least Weasel	Mammal	G5	S2?
Vertebrate Animal	Myotis lucifugus	Little Brown Bat	Mammal	G5	S4
Vertebrate Animal	Myotis septentrionalis	Northern Myotis	Mammal	G4	S3

Category	Scientific Name	Common Name	Type	Global Rank	State Rank
Vertebrate Animal	Myotis sodalis	Indiana Bat or Social Myotis	Mammal	G2	S1
Vertebrate Animal	Neotoma magister	Eastern Woodrat	Mammal	G3G4	S2
Vertebrate Animal	Nycticeius humeralis	Evening Bat	Mammal	G5	S1
Vertebrate Animal	Pipistrellus subflavus	Eastern Pipistrelle	Mammal	G5	S4
Vertebrate Animal	Spilogale putorius	Eastern Spotted Skunk	Mammal	G5	SX
Vertebrate Animal	Clonophis kirtlandii	Kirtland's Snake	Reptile	G2	S2
Vertebrate Animal	Crotalus horridus	Timber Rattlesnake	Reptile	G4	S2
Vertebrate Animal	Opheodrys aestivus	Rough Green Snake	Reptile	G5	S3

Appendix 2: References