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The Indian Creek Watershed:

To Preserve and Improve Water Quality

Project No. A7-103

Prepared by

Johnson County Soil & Water Conservation District and
The Indian Creek Steering Committee
March 2009

Sponsored by
The Johnson County
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The Indian Creek Watershed: To Preserve and Improve Water Quality

Project Mission Statement

Adopted by the

Indian Creek Steering Committee

To involve and educate the residents of the Indian Creek Watershed regarding pressing water quality issues, the effects on humans, animals and plant life, and promote the development and implementation of programs and practices that preserve and improve the water quality in the Indian Creek Watershed.

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The Indian Creek Watershed:
To Preserve and Improve Water Quality
Executive Summary

The Indian Creek Watershed is located in the central Indiana counties of Johnson, Morgan, Monroe and Brown. The watershed is included in the larger watershed basin of the Upper White River Basin. The Indian Creek Watershed is an 11-digit watershed that contains seven 14-digit sub-watersheds, and encompasses approximately 60,049 acres (93.8 square miles), primarily in Johnson and Morgan Counties. Indian Creek and several of its tributaries, including Bear Creek, Camp Creek, Robertson Creek and Sand Creek were listed on the 2004 Section 303(d) list of impaired waters for *Escherichia coli* (*E. coli*), however, the citizens of the Watershed also voiced a number of other concerns regarding water quality. This Plan intends to address the impairment for E. coli and those other concerns.

In a word, diversity best characterizes the Indian Creek Watershed. From the urbanized areas of the City of Martinsville to the rolling hills of the Morgan-Monroe State Forest and the vast acres of Johnson County farm land, the Watershed represents a diversity of land uses, geology, soils and water resources. The Watershed encompasses land from Trafalgar south and west in Johnson County to the eastern half of Martinsville and south in Morgan County and includes areas of the Morgan-Monroe State Forest in Monroe County and the Yellowwood State Forest in Brown County. It includes the two lake communities of Lamb Lakes and Lakes of the Painted Hills.

STAKEHOLDER INVOLVEMENT

Throughout this project, Stakeholders were involved through participation on the Indian Creek Watershed Steering Committee, through volunteering to assist with booths at county fairs and through educational programs at area schools and with local community groups. Stakeholders on the Steering Committee met monthly throughout the duration of the grant, voicing initial water quality concerns, developing a mission statement, developing goals, identifying suitable BMPs to address the concerns with watershed land uses in mind and developing a model to help prioritize sub-watersheds. Other Stakeholders participated in cub scout day camp presentations, county fairs and school programs.

PROSPECTS FOR THE FUTURE

The major problem in improving water quality in the Indian Creek Watershed is the same problem for any watershed or water quality program: the delicate balancing act between environmental responsibility and economic feasibility. For the farmer with land eroding into local streams from farmland or livestock pastures or the homeowner with a failing septic system, investments for water quality are hard to justify if no direct economic or health benefit is derived. Farmers won't spend thousands of dollars to remove land from production in favor of a riparian buffer if there is no financial or other gain for them, nor should they. Similarly, homeowners will not spend money to maintain a septic system that improperly diverts raw sewage downstream if it doesn't directly impact their household plumbing or pose a health risk to them. For a small percentage of Stakeholders, a plea to do what is environmentally responsible may be enough to change behaviors or install needed BMPs. But for most, however, compromise will only come with financial incentive. Thus the need for future outside funding will be necessary to implement this Plan, along with continued and expanded educational programs that show a benefit to all through improved water quality.

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Glossary of Terms

Aquifer – any geologic formation containing water, especially one that supplies water for wells, springs, etc.

Best Management Practice (BMP) – practices implemented to control or reduce non-point source pollution.

Canopy Cover – the overhanging vegetation over a given area.

Channelization – straightening of a stream; often the result of human activity.

Clean Water Act, Section 303(d) List – a list identifying waterbodies that are impaired by one or more water quality elements thereby limiting the performance of their designated beneficial uses.

Coliform – intestinal bacteria that indicates fecal contamination in water. Exposure may lead to human health risks.

Designated Uses – state-established uses that waters should support (e.g. fishing, swimming, aquatic life).

Detention Pond – a basin designed to slow the rate of stormwater run-off by temporarily storing the run-off and releasing it at a specific rate.

Dissolved Oxygen – oxygen dissolved in water that is available for aquatic organisms.

Downstream – in the direction of a stream's current.

Dredge – to clean, deepen, or widen a waterbody using a scoop, usually done to remove sediment from a streambed.

Easement – a right, such as a right of way, afforded an entity to make limited use of another's real property.

Ecoregion – a geographic area characterized by climate, soils, geology, and vegetation.

Ecosystem – a community of living organisms and their interrelated physical and chemical environment.

Erosion – the removal of soil particles by the action of water, wind, ice, or other agent.

Escherichia coli (*E.coli*) – a type of coliform bacteria found in the intestines of warm-blooded organisms, including humans.

Glide (Run) – a stretch of fast, smooth current, deeper than a riffle, with little or no turbulence on the surface.

Gradient – measure of a degree of incline; the steepness of a slope.

Groundwater – water beneath the earth's surface usually supplying springs and wells and found between soil particles and rock.

Headwater – the origins of a stream.

Hydrologic Unit Code (HUC) – unique numerical code created by the U.S. Geological Survey to indicate the size and location of a watershed within the United States.

Impervious Surface – any material covering the ground that does not allow water to pass through or infiltrate (e.g. roads, driveways, roofs).

Infiltration – downward movement of water through the uppermost layer of soil.

Macroinvertebrates – animals lacking a backbone that are large enough to see without a microscope.

Maximum Contaminant Level (MCL) – the highest level of a contaminant that is allowed in drinking water.

Municipal Separate Storm Sewer System (MS4) – a publically-owned conveyance or system of conveyances (i.e. ditches, curbs and gutters, underground pipes, etc.) that is designed or used for collecting or conveying stormwater and discharges to surface waters of the State.

National Pollutant Discharge Elimination System (NPDES) – national program in which pollutant dischargers such as factories and treatment plants are given permits with set limits of discharge allowable.

Non-point Source Pollution (NPS) – pollution generated from large areas with no identifiable source (e.g., stormwater run-off from streets, development, commercial and residential areas).

Permeable – capable of conveying water (e.g., soil, porous materials).

Point Source Pollution – pollution originating from a "point," such as a pipe, vent, or culvert.

Pollutant – as defined by the Clean Water Act (Section 502(6)): "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

Pool – an area of relatively deep, slow-moving water in a stream.

Retention Pond – A basin designed to retain stormwater run-off so that a permanent pool is established.

Riffle – an area of shallow, swift moving water in a stream.

Riparian Zone – an area, adjacent to a waterbody, which is often vegetated and constitutes a buffer zone between the nearby land and water.

Run – see Glide.

Run-off – water from precipitation, snowmelt, or irrigation that flows over the ground to a waterbody. Run-off can pick up pollutants from the air or land and carry them into streams, lakes, and rivers.

Sediment – soil, sand, and minerals washed from the land into a waterbody.

Sedimentation – the process by which soil particles (sediment) enter, accumulate, and settle to the bottom of a waterbody.

Soil Association – a landscape that has a distinctive pattern of soils in defined proportions. Typically named for the major soils.

Storm Drain – constructed opening in a road system through which run-off from the road surface flows on its way to a waterbody.

Stormwater – the surface water run-off resulting from precipitation falling within a watershed.

Substrate – the material that makes up the bottom layer of a stream.

Topographic Map – map that marks variations in elevation across a landscape.

Total Maximum Daily Load (TMDL) – calculation of the maximum amount of a pollutant that a waterbody can receive before becoming unsafe and a plan to lower pollution to that identified safe level.

Tributary – a stream that contributes its water to another stream or waterbody.

Turbidity – presence of sediment or other particles in water, making it unclear, murky, or opaque.

Upstream – against the current.

Water quality – the condition of water with regard to the presence or absence of pollution.

Water quality standard – recommended or enforceable maximum contaminant levels of chemicals or materials in water.

Watershed – the area of land that water flows over or under on its way to a common waterbody.

Wetlands – lands where water saturation is the dominant factor in determining the nature of soil development and the types of plant and animal communities.

Zoning – to designate, by ordinance, areas of land reserved and regulated for specific uses, such as residential, industrial, or open space.

Acronyms

BMP	Best Management Practice
BOD	Biological (or Biochemical) Oxygen Demand
CRP	Conservation Reserve Program
CTIC	Conservation Technology Information Center
CWA	Clean Water Act
CWP	Center for Watershed Protection
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GAP	Gap Analysis Program
GIS	Geographic Information System
GPS	Global Positioning System
HUC	Hydrologic Unit Code
IAC	Indiana Administrative Code
ICM	Impervious Cover Model
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ISU	Indiana State University
MRCC	Midwestern Regional Climate Center
NPDES	National Pollutant Discharge Elimination System
NPS	Non-point source
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PCB	Polychlorinated Biphenyls
QHEI	Qualitative Habitat Evaluation Index
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UWA	Unified Watershed Assessment
WHIP	Wildlife Habitat Incentives Program
WWTP	Wastewater Treatment Plant

Section I: Project Introduction

The Johnson County Soil and Water Conservation District (SWCD) successfully submitted an application in 2006 for a Clean Water Act Section 319 grant for the Indian Creek Watershed Management Plan. The Indian Creek Watershed Management Plan project, which began in January 2007, enables the SWCD to identify water quality, land use, and natural resource characteristics within the Indian Creek Watershed. Additionally, the project is designed to involve local stakeholders in identifying water quality threats to local water resources and developing strategies to protect them. The project is scheduled for culmination in April 2009 with the completion of this Watershed Management Plan.

The development of the Watershed Management Plan is based on the watershed approach for environmental management. This approach coordinates public and private sectors in addressing water quality concerns in the watershed. Four major features are integrated in this approach: 1) targeting priority problems, 2) involving stakeholders, 3) developing integrated solutions, and 4) measuring success (USEPA 1995). The watershed approach integrates planning for both hydrological and ecological functions in watersheds encompassing large areas of varied land uses. This approach also ensures that the planning process includes a variety of interests and helps build lasting partnerships to ensure future success.

This Management Plan provides a thorough examination of concerns and issues facing those who live and work in the watershed. It is intended to be a living document to be used as a guide by local decision-makers for outreach, education, implementation and assistance efforts. It is also hoped to be used by local landowners and citizens to further their understanding of watersheds and water quality issues. The recommendations made under this Plan do not establish legal requirements, but do provide a framework for coordinated voluntary efforts to improve and maintain water quality.

A. Designating the Study Area

A watershed is an area of land that water flows over or under on its way to a particular body of water. In the United States, watersheds are identified using a hierarchical coding system, Hydrologic Unit Codes (HUC), developed by the U.S. Geological Survey (USGS) in the mid-1970's. This system uses topographical surface features to divide the U.S. into regions, sub-regions, accounting units, and cataloging units. With a unique number assigned to identify each level, a watershed coding system is provided through a nested hierarchy according to size, with more digits assigned as watershed coverage areas decrease. The Indian Creek Watershed Management Plan focuses its planning efforts in the Indian Creek Watershed (HUC 05120201170). This hydrological unit contains the area of land drained by Indian Creek. The watershed is part of the larger Upper White River Basin (HUC 05120201), and is located in southern Johnson and Morgan Counties and northern Brown and Monroe Counties. In total, the 93.8 square-mile Indian Creek Watershed spans approximately 10% of Johnson County, 12.7% of Morgan County, 2.5% of Brown County, and 0.5% of Monroe County land area. State Forest properties within the watershed cover 4,338.63 acres or to 7.23% of the land in the watershed, 5.17% in the Morgan-Monroe State Forest and 2.06% in the Yellowwood State Forest.

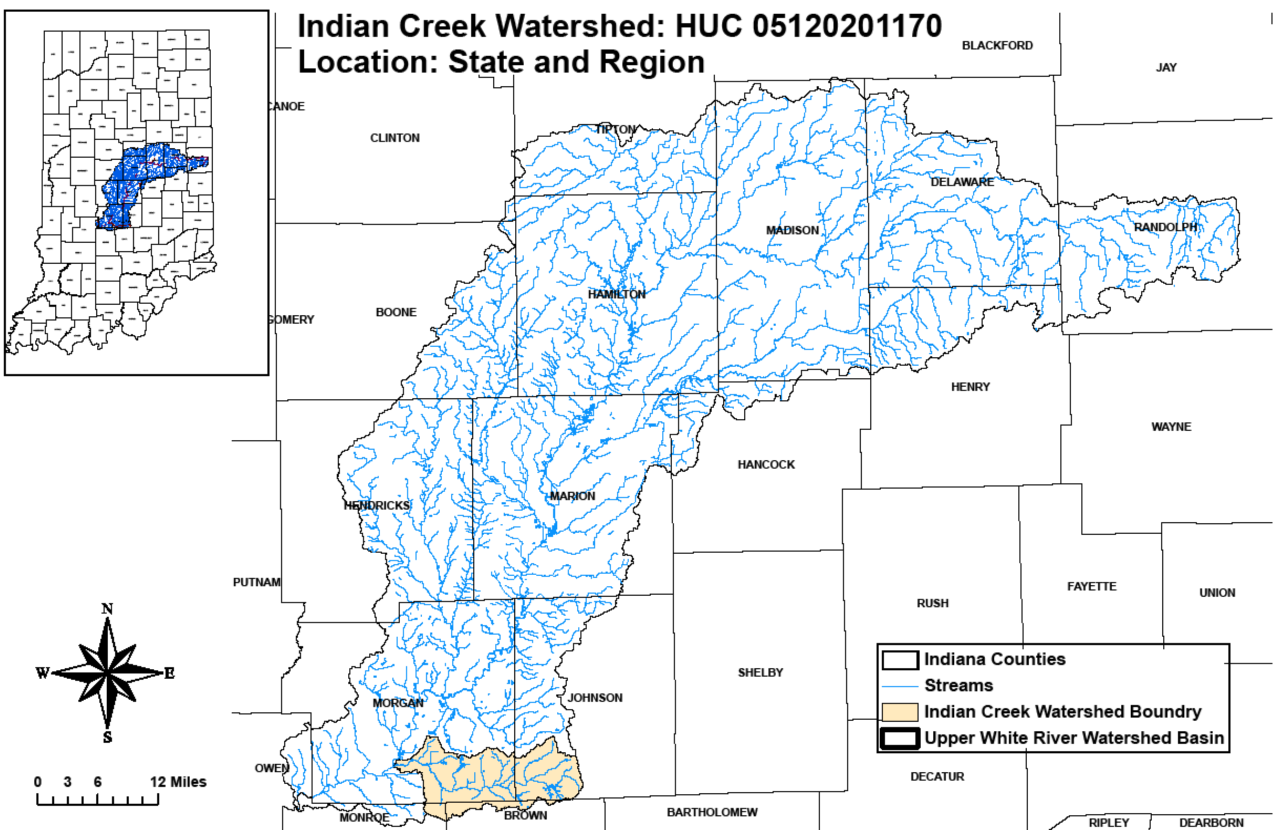

Figure 1. Indian Creek Watershed: state and regional location

The watershed includes the eastern one-half of the city of Martinsville, the town of Morgantown, dense residential areas around Lamb Lake and the Lakes of Painted Hills, as well as areas of the Morgan-Monroe State Forest and the Yellowwood State Forest. Major roadways in the watershed include State Roads 252, 135, and 37. A major challenge for management efforts in the watershed was coordinating partnership efforts from multiple counties.

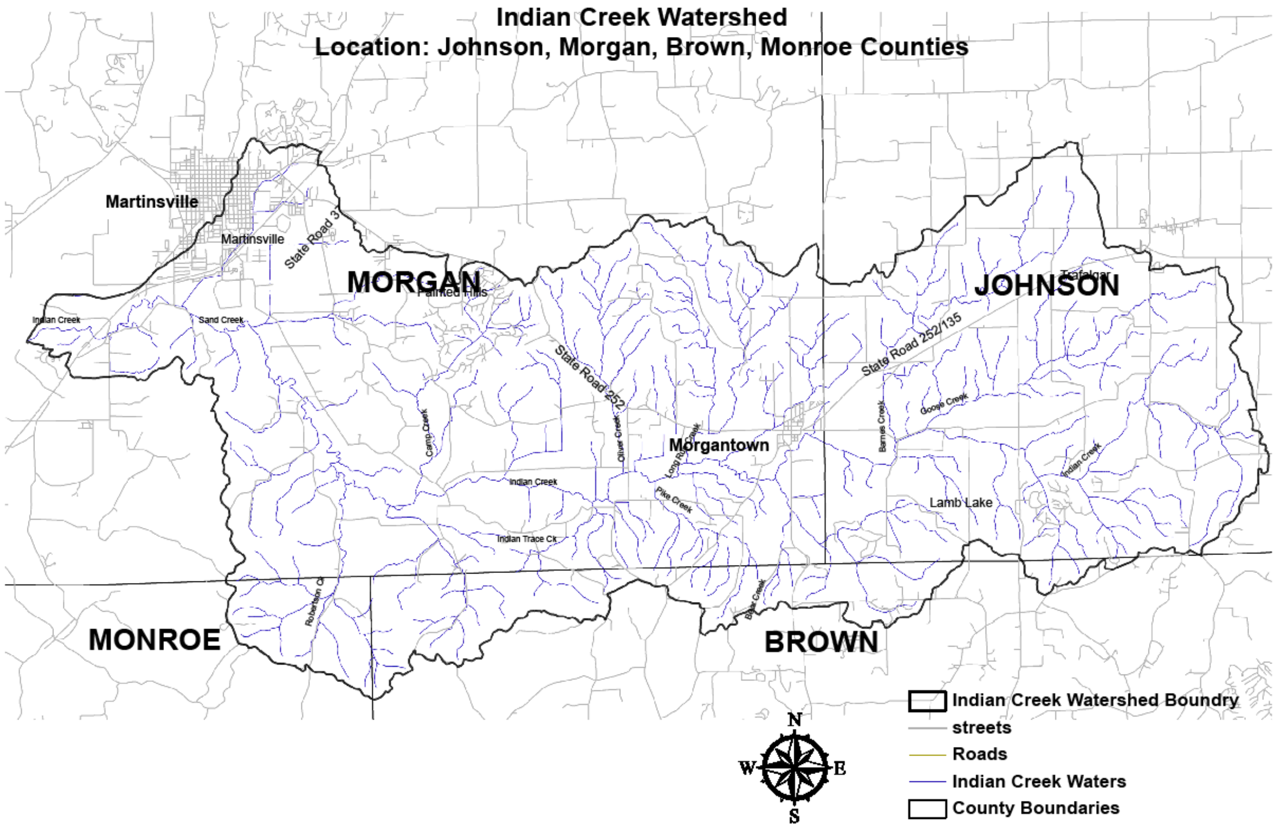

Figure 2. Indian Creek Watershed: county location

B. Building Partnerships Through Stakeholder Involvement

The Management Plan's organizational structure is shown in Figure 3. Assessment efforts were sponsored by the SWCD Board of Supervisors and two watershed planning staff members, the Watershed Coordinator and the Watershed Assistant Coordinator/Resource Conservation Specialist. The SWCD and watershed planning staff led efforts to develop a stakeholder Steering Committee. The stakeholder Steering Committee was formed to help determine the direction of the planning efforts.

Watershed Project Organizational Structure

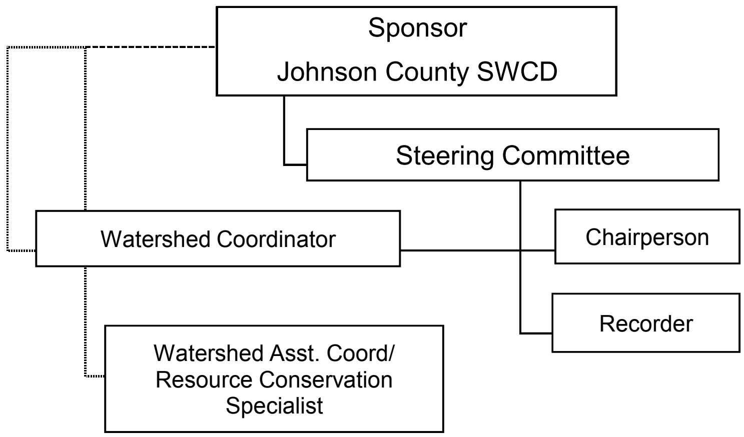

Figure 3. Organizational structure of the Indian Creek Watershed Management Plan Project

The SWCD's planning efforts began with the formation of a watershed stakeholder Steering Committee. In March of 2007, an initial public meeting was held to introduce the Indian Creek Watershed Management Plan project to the public and to form the Indian Creek Watershed Steering Committee (Committee). Stakeholders were encouraged to attend this meeting through press releases in the *Daily Journal* and *Martinsville Reporter-Times*, individual invitations mailed to a list of stakeholders composed by the Johnson County SWCD Board of Supervisors, and announcement flyers posted on community boards in Franklin, Trafalgar, Morgantown and Martinsville. The members of the Committee represent diverse interests and backgrounds within the watershed and include a government official, an educator, foresters, farmers, a GIS specialist and concerned citizens. Appendix A lists the Committee members who participated in developing the management plan. This group is responsible for ensuring local values were taken into account during plan development, carrying out planning activities, and coordinating plan implementation. The Mission Statement adopted by the Indian Creek Steering Committee is:

To involve and educate the residents of the Indian Creek Watershed regarding pressing water quality issues, the effects on humans, animals and plant life, and promote the *development and implementation of programs and practices that preserve and improve the water quality in the Indian Creek Watershed.*

The Committee met monthly beginning in April of 2007 to develop a list of concerns regarding water quality in the watershed. Those concerns were then categorized by how they impact the watershed to help identify a core set of concerns. Table 1 lists those concerns under their determined category.

Watershed Impact Category	Concern
Water Quality	E. coli Soil erosion/runoff Lake water quality Nutrients Failing septic systems/straight pipes Contaminated fish Livestock /livestock manure in streams Pet waste Discharge from Morgantown WWTP Debris in streams Dumping in streams
Land Use Concerns	Aesthetics/property values Potential for economic development Failing septic systems/straight pipes Erosion control Livestock/livestock manure in streams Logging/timber Riparian buffers (or lack thereof)
Flooding	Flooding potential from 2 dams
Other	Exotic species

Table 1. Initial list of concerns identified by the Steering Committee, April-May, 2007

The Committee spent several months prioritizing these concerns, developing problem statements, and determining causes and effects to determine the best measures to address the concerns. Baseline data was analyzed to also help determine an actual foundation for the concerns, the extent or severity, and thus priority, of each concern.

When the Committee initially identified concerns, *Escherichia coli* (*E. coli)* was given priority since a Total Maximum Daily Load Program (TMDL) for *E. coli* had been developed, requiring that it be addressed through the Watershed Management Plan (WMP). Additional concerns were identified and condensed into similar categories. The resulting lists of concerns were soil erosion and sedimentation, excessive aquatic plant growth (due to excessive nutrients in the streams), illegal dumping and litter, and exotic/invasive species. The Committee determined that the identification of those concerns in that order substantiated that same order for prioritization. Additionally, they felt that since all their additional concerns related to one of the five identified above, addressing those five concerns would incidentally address other concerns. Education, or the lack thereof, regarding water quality issues understood by watershed residents, was one such example. After discussion, the Committee decided that education need not be addressed as a separate concern since it could be identified as a Best Management Practice (BMP) for each of the others.

When the Committee began developing problem statements for each concern, it became clearer which issues were the problems and which were causes and effects. Although some of the causes, such as lack of riparian buffers and erosion of stream banks, were initially identified as problems, they were later re-identified as causes of the problems, such as streams becoming turbid during and after storm events. The resulting effects were then identified to qualify the concerns or to establish that a concern was a negative impact on the watershed water quality. Table 2 below shows what causes and effects were initially identified in relation to each concern.

Water Quality Concern	**Cause**	**Effect**
E. coli	Animal waste (livestock, pet, wildlife)	Unhealthy conditions for recreational use
	Human waste (WWTP bypass, failing septic systems , straight pipes	Unhealthy conditions for consumption
Soil erosion/sedimentation	Construction sites	Reduces soil and water quality
	Livestock grazing, feeding, living	Reduces stream channel

	areas	capacity, thus increasing flooding
	Stream bank erosion (natural, undercutting from increased velocity, lack of riparian buffers)	Unhealthy condition for aquatic life
Excessive aquatic plant growth	Agricultural/livestock nutrient-enriched runoff	Unhealthy conditions for aquatic life
	Lawn nutrient-enriched runoff	Reduced water quality for recreational use
Debris and dumping	Roadside littering	Reduces aesthetics, property values, potential for economic development
	Illegal dumping	Reduces safety for recreational uses
	Landowner dumping	Can contain harmful chemicals detrimental to recreational uses and aquatic life
Exotic or invasive species	Transported on boats, trailers, equipment, boots, clothing or wildlife	Can cause ecosystem disruption, economic loss and loss of aesthetics
	Deposited in water as live bait, aquariums	Can be harmful to human health

Table 2. Steering Committee-identified concerns and related causes and effects

From the information in Table 2, the concerns were restated with their resulting effects into problem statements which helped confirm the validity of the concerns. A detailed description of the problem statements and goals and how they were developed by the Steering Committee is provided in Section V: Development of Problem Statements and Goals.

In addition to the members of the Steering Committee, other stakeholders include the Johnson County Health Department, the Morgan County Health Department, the Morgan County Stormwater Department and the Morgan County Soil and Water Conservation District. The involvement of the county health departments will include developing ordinances regarding septic system maintenance. The stormwater department will be involved through ordinances and inspection of construction sites for erosion control compliance. The Soil and Water Conservation District will be a partner in providing educational programs for watershed residents.

The Steering Committee met on a monthly basis from the initial meeting in April 2007 and discussed a variety of topics as they related to the concerns and the progress of the Watershed Management Plan. Input from the Committee included recollection of first-hand accounts of incidents in the watershed where concerns were most obvious, such as incidents of clear-cut logging near the Morgan-Monroe Forestry near the home of one of the members. She and another member also stated that upland invasive species were of concern, but the group found it difficult to fit that into the list of concerns that directly impacted water quality. Discussions also involved looking at land use maps and determining what kind of non-point sources could be coming from the different land uses. The members from the lake communities were mostly concerned with failing septic systems, which one currently monitors. Both communities have programs to test the water from the lakes for E. coli. The initial discussions did involve a much longer list of concerns that were later consolidated under the few headings listed above.

Section II: Physical Description of the Watershed

This section provides an understanding of the physical setting of the watershed. Background information includes descriptions of the area's geologic history, physiography, water supply, soils, hydrologic features, legal drain system, local climatic information, existing wetlands and natural history.

A. Physiographic Regions

The Indian Creek Watershed lies within two distinct physiographic regions: the Central Till Plain and the Norman Uplands. Figure 4 shows these regions and others in Indiana. Flatter areas of the watershed, mostly within the Johnson County area, are part of the Central Till Plain region.

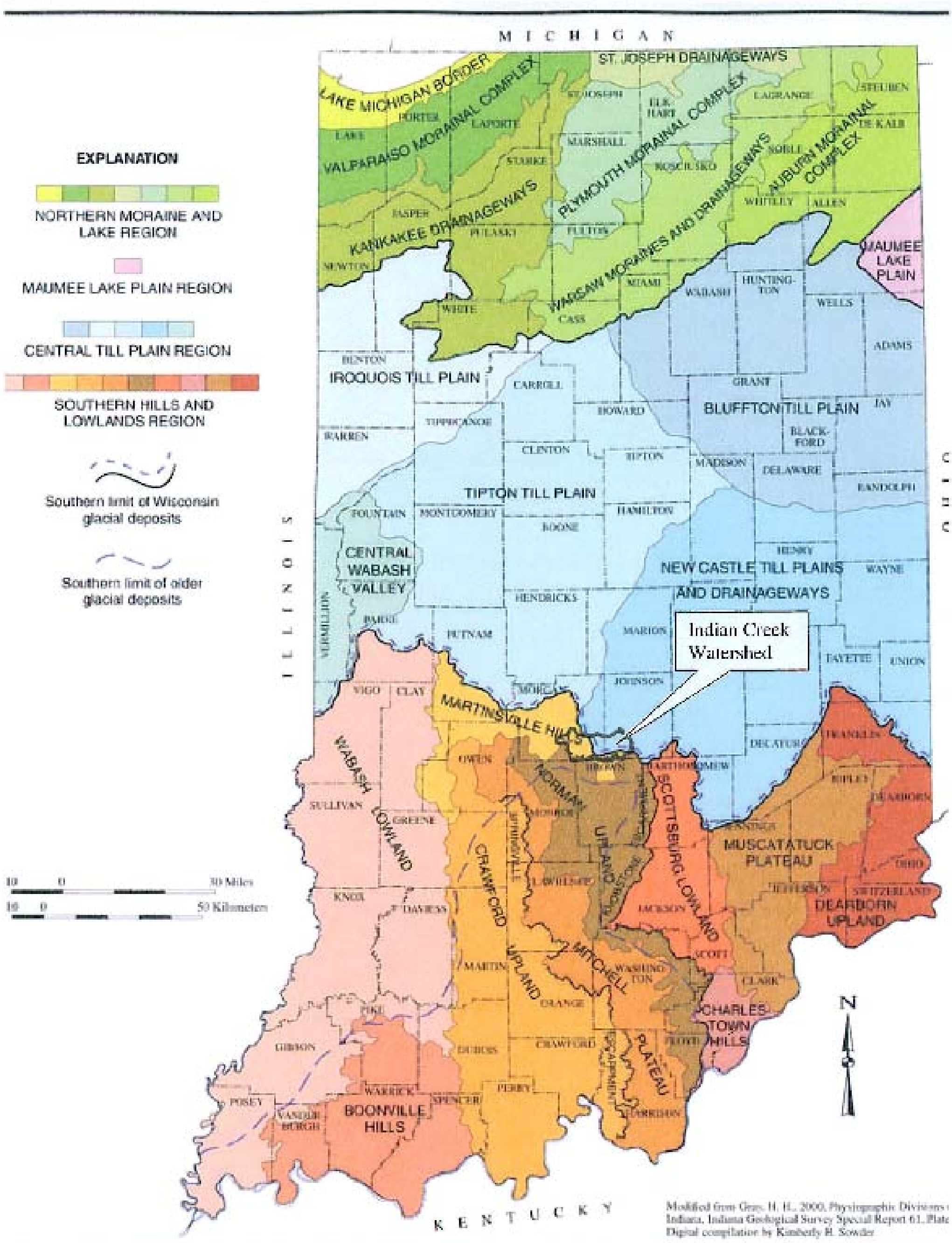

Figure 4. Map showing physiographic divisions of Indiana.

Modified from Gray, H.H., 2000, Physiographic Divisions of Indiana, IGS Special Report 61, Plate 1. Digital compilation by Kimberly H. Sowder

Figure 5 shows the limits of the two glacial ice sheets that moved through the State. The Wisconsin glacier is the younger of two glacial ice sheets advancing over this area, dated at approximately 12,000 years ago, and creating the Central Till Plain. The Wisconsin glacier advanced from the north into the northern region of the watershed in Morgan and Johnson Counties. This region is characterized by almost flat to gently rolling terrain resulting from the deposition of glacial till and outwash by numerous glacial advances and melting.

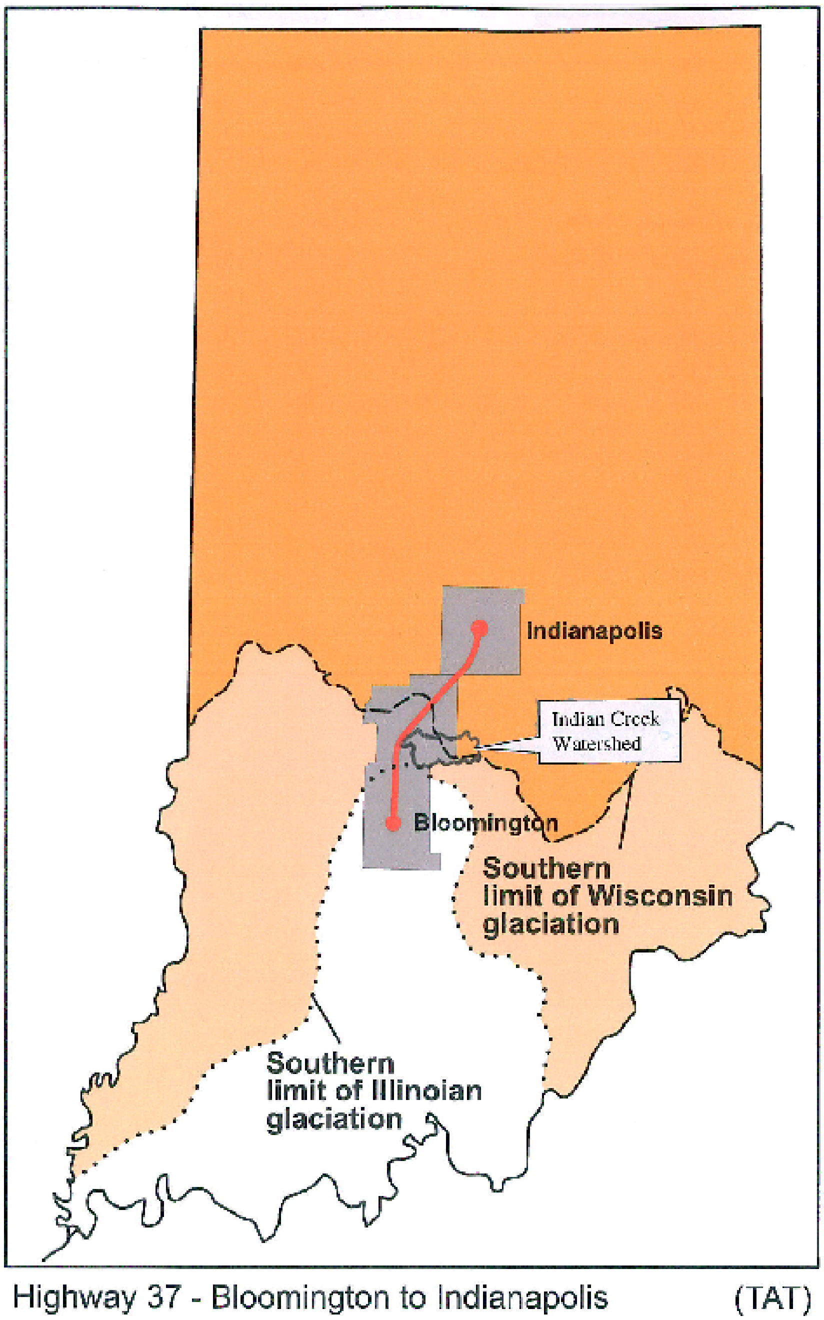

Figure 5. Limits of glaciers in Indiana (Indiana Geological Survey). Morgan County is the middle grayed county area.

The oldest deposits from the Illinoian ice sheet, dated at approximately 100,000 years ago, are found in the southwestern region of the watershed. This ice sheet advanced from Illinois along the Ohio River Valley and formed the Norman Uplands region. The Norman Upland areas are most evident in the steep-sided hills and valleys of Morgan, Monroe, Brown and southern Johnson Counties. This hilly region, most evident in the Brown County Hills area overlooking the watershed from the south, is characterized by narrow, flat-topped divides, steep slopes, and deep, narrow valleys.

The stalling of the two ice sheets in the Martinsville area has resulted in generally mixed tills, outwashes and glacial sediments locally approaching 120 feet in thickness. The distinction of the resulting two physiographic regions, the Central Till Plains and the Norman Uplands, have dominated the natural resources and thus the varied land uses within the Indian Creek Watershed.

B. Geologic History

Johnson and Morgan Counties lie in the region of gray-brown podzolic soils of the east-central portion of the United States. These soils developed under a heavy forest cover of deciduous trees with sufficient rainfall to maintain a moist condition throughout the soil, except for short periods of time.

Beneath the Wisconsinan and Illinoian glacial deposits, the Indian Creek Watershed bedrock geology is composed of swaths of Mississippian-aged limestone, siltstone, shale and sandstone formations rich in silica and minor amounts of limestone known as the Borden Group. These formations range in thickness from 485 to 800 feet. The Borden Group extends from the Ohio River at Floyd County north to Benton County on the Illinois-Indiana border. The scenic views in Brown County have resulted from the erosion of these rocks. Figure 6 shows the distribution of the unconsolidated deposits from the Wisconsinan and Pre-Wisconsinan (Illinoian) glacial ice sheets.

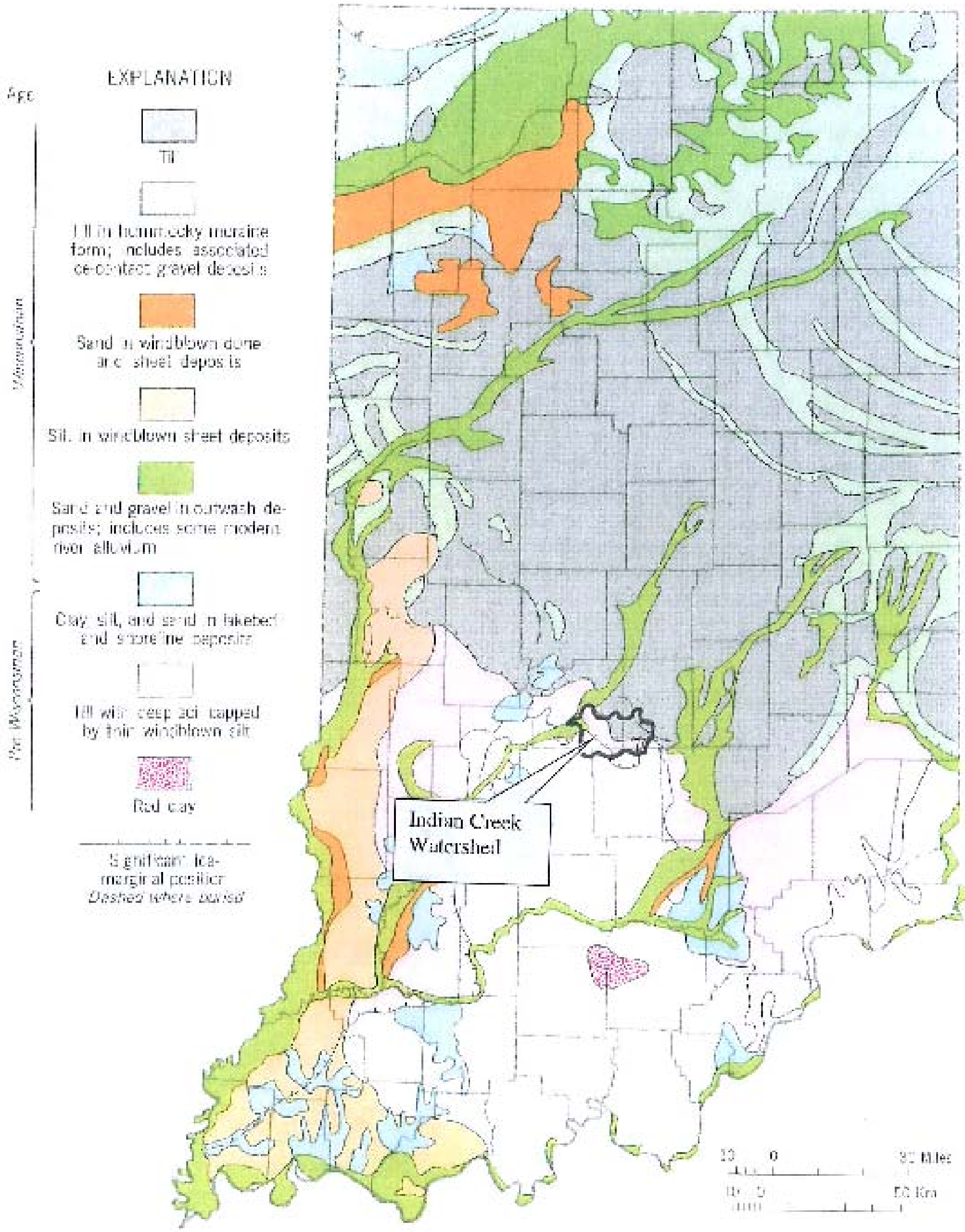

Figure 6. General distribution of unconsolidated deposits. (The uncolored areas in southern Indiana represent areas with little or no unconsolidated deposits.) (Clark, 1980)

C. Topography

The Watershed's glacial history is prominently evident in its topography. Land within the Indian Creek Watershed ranges in elevation from 930 feet above sea level to 580 feet above sea level, providing approximately 350 feet of relief. Digital maps of elevation and slope for the Indian Creek Watershed were developed using a digital topographic map of 2-ft contour lines obtained from the Johnson County Geographic Information System (GIS) Department, as shown in Figure 7. The highest elevations in the watershed are found near Trafalgar, however, variations in slope are less than in the hilly areas of southern Morgan County and northern Monroe and Brown Counties, near and within the Morgan-Monroe and Yellowwood State Forests, and in the north central area of the watershed, including Painted Hills and Mt. Nebo. High points in the State Forests reach elevations of 930 feet above sea level from valley elevations of 620 feet above sea level. The lowest elevation in the watershed occurs in the Indian Creek floodplain at its confluence with the White River in the westernmost area of the watershed.

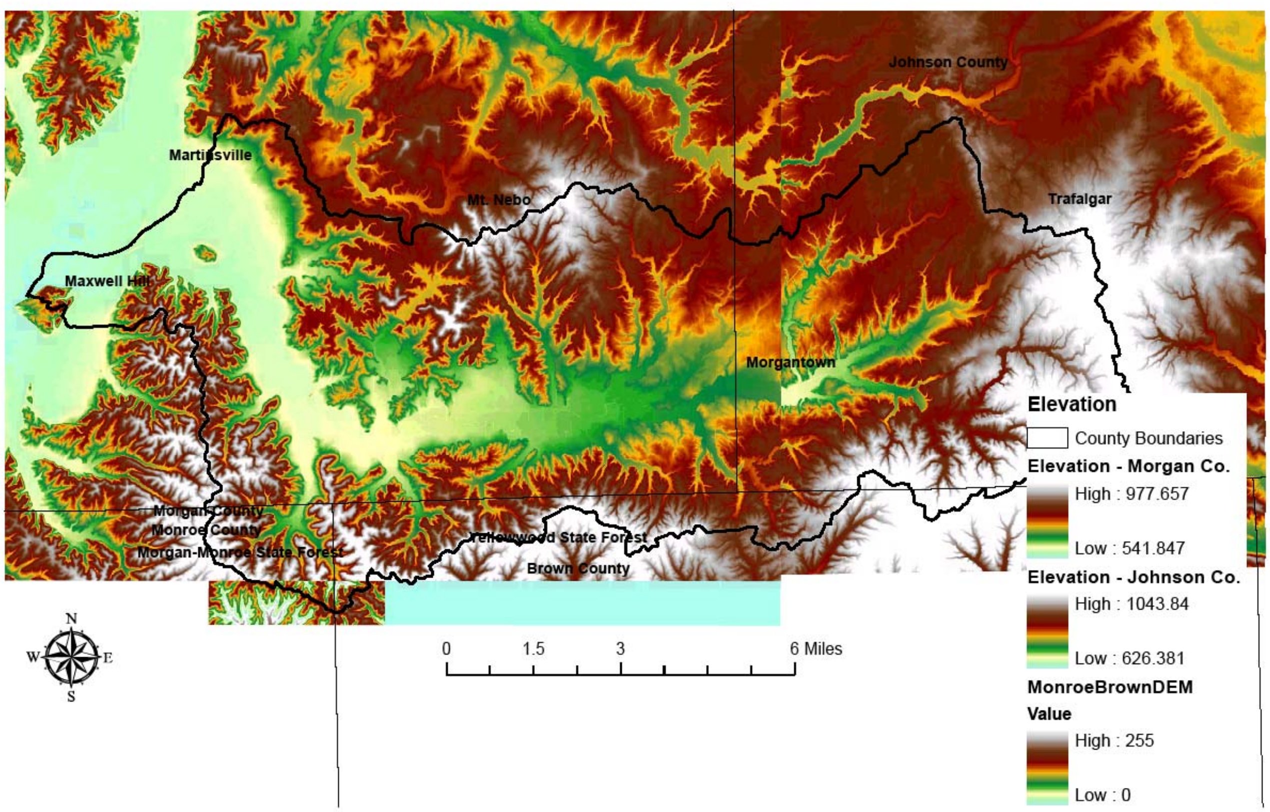

Figure 7. Indian Creek Watershed: Elevation (ft above sea level)

D. Natural History

Early accounts of Indiana describe this area in pre-settlement days as an almost endless canopy of hardwood forests. The hilly topography and underlying bedrock prevented or discouraged the wholesale clearing of hilly, unglaciated forest lands for agricultural uses. Timber extraction around the early 1900's and failed attempts at agriculture striped large areas of the hilly lands in the Watershed of their protective cover, leaving exposed topsoil to erode away as settlers moved to nearby cities for paying jobs in the wake of the Great Depression. In 1929, the State conservation agency purchased the eroded and abandoned land to establish a state forest. State agencies began planting trees to reforest the area and established a sustainable forest management program, allowing the forest to recover. These forest lands, along with adjacent publicly owned forests, now contribute to the greatest concentration of publicly owned land in Indiana.

The dry ridge tops of the forested area are dominated by red and white oak and hickory with oak, hickory, ash, maple, beech, tulip poplar and black cherry trees more prevalent on the lower slopes. The large forested areas of the watershed, mostly within the boundaries of the Morgan-Monroe and Yellowwood State Forests, are part of a larger forest The Nature Conservancy refers to as the "Brown County Hills Project" and includes contiguous forest in Bartholomew, Brown, Jackson, Johnson, Lawrence, Morgan and Monroe Counties. This large forested area provides habitats to plant and animal species that require very large ranges of land and includes threatened or endangered species such as the Timber Rattlesnake and the Cerulean Warbler bird. Also included in the Morgan-Monroe State Forest is the 15-acre Scout Ridge Nature Preserve. Nature preserves in Indiana are so designated to protect the plant, animal and natural communities they contain, including some threatened, endangered or rare species.

Better soils and greater ease of farming on more gently sloped land helped maintain agriculture in the lowlands of the Indian Creek and White River Basins in Morgan County and flatter elevations in Johnson County.

Also important to the natural and cultural history of the Martinsville area was the discovery of mineral water springs in 1885. A search for natural gas in the area lead to the discovery of the springs which were soon promoted for their perceived healing powers made accessible through artesian well spas. Although the discovery of antibiotics resulted in the decline of mineral springs spas that sprang up in the area, the mineral water springs remain a unique natural resource.

D.1. Forests and Tree Species

Abundant tillable land in Johnson County and lowland areas of Morgan County have accounted for the considerable loss of native forests to agriculture since the early 1900's. Much of these areas remain in agricultural use or have been converted to residential communities. The hilly forest within the Morgan-Monroe and Yellowwood State Forests have rebounded with abundant native stands from the clear-cutting of the early 1900's. The maple-beech association is the most common in the State Forests and throughout the watershed. The lesser common, yet very significant, Yellowwood tree is found in scattered stands throughout the Yellowwood State Forest, it's only home in Indiana. (*Understory*, "The Mystery of the Yellowwood Tree", The Nature Conservancy, Spring 2004) A list of native tree species in the watershed is provided in Table 3.

Table 3. Native tree species in Brown, Johnson, Monroe and Morgan Counties by forest type (Branigin, 1913)

Upland	Poorly-drained	Bottomland	Understory
White Oak	Beech	Cottonwood	Blackberry
Black Oak	Maple	Ash or Linn Basswood	Wild Rose
Southern Red Oak	Ash	European White Willow	Black Locust
American Elm	Elm	Sycamore	Persimmon
Yellow Poplar or Tulip Tree			Sassafras
Sugar Maple			Sumac
Silver Maple			Viburnum

D.2. Threatened, Endangered, and Rare Species

The large forested areas within the watershed, especially in the State Forests and Scout Ridge Nature Preserve, provide habitats for unique plant and animal species as well as the variety of native tree species. Table 4 lists both the state and federal species within the watershed that are classified as endangered, threatened, or rare. High quality natural communities are also listed as these areas are significant state natural resources. The State listing of Endangered, Threatened and Rare Species is presented by county without reference to specific locations within the counties. Given the mobility of bird, mammal and insect species, it can be assumed that these may be located within the boundaries of the watershed.

Table 4. State and federal endangered, threatened, or rare species in Johnson and Morgan Counties (Source Indiana Dept of Natural Resources, Division of Nature Preserves, 11/22/05)

Common Name	State Rank	Federal Rank
Vascular Plants		
Yellowwood	T	**
Trailing Arbutus	WL	**
Illinois Blackberry	E	**
Purple Flowering Raspberry	T	**
Yellow Nodding Ladies'-tresses	T	**
American Ginseng	WL	**
Butternut	WL	**
Horned Pondweed	E	**
Mussels		
Eastern Fanshell Pearlymussel	E	E
Pyramid Pigtoe	E	**
Slippershell Mussel	*	**
Northern Riffleshell	E	E
Snuffbox	E	**
Wavy-Rayed Lampmussel	SC	**
Round Hickorynut	SC	**
Clubshell	E	E
Kidneyshell	SC	**
Rabbitsfoot	E	**
Salamander Mussel	SC	**
Lilliput	*	**
Rayed Bean	SC	**
Little Spectaclecase	SC	**
Dragonflies; Damselflies		
Spatterdock Darner	T	**
Brown Spiketail	E	**
Band-Winged Meadowhawk	R	**
Fish		

Gilt Darter	E	**
Harlequin Darter	E	**
Northern Studfish	SC	**
Reptiles		
Kirtlands's Snake	E	**
Timber Rattlesnake	E	**
Smooth Green Snake	E	**
Rough Green Snake	SC	**
Western Ribbon Snake	SC	**
Alligator Snapping Turtle	E	**
Birds		
Bachman's Sparrow	E	**
Henslow's Sparrow	E	**
Great Blue Heron	*	**
Upland Sandpiper	E	**
Northern Harrier	E	**
Edge Wren	E	**
Sharp-shinned Hawk	SC	**
Red-shouldered Hawk	SC	**
Broad-winged Hawk	SC	**
Cerulean Warbler	SC	**
Worm-eating Warbler	SC	**
Black-and-white Warbler	SC	**
Hooded Warbler	SC	**
Bald Eagle	E	T
Osprey	E	**
Least Bittern	E	**
Black-Crowned Night-Heron	E	**
King Rail	E	**
Virginia Rail	SC	**
Barn Owl	E	**
Mammals		
Bobcat	E	**
Least Weasel	SC	**
Indiana Bat	E	E
American Badger	E	**
High Quality Natural Community		
Dry Upland Forest	SG	**
Dry-mesic Upland Forest	SG	**
Mesic Upland Forest	SG	**
Circumneutral Seep	SG	**
*E = Endangered, R = Rare, T = Threatened, SC = Special Concern, SG = State Significant, WL = Watch List, * = No*		

*status but warrants concern, ** = not listed*

E. Soils

Extensive soil surveys for Johnson County were completed in 1948 and updated in 1979, and for Morgan County in 1950 and updated in 1981 by the U.S. Department of Agriculture (USDA), Soil Conservation Service and the Indiana Department of Natural Resources. State Soil Surveys underwent substantial updating and reclassification beginning in the late 1990's with the designation of Major Land Resource Areas (MLRA) as soil survey areas and information becoming available digitally. The reference to MLRA's for soil surveys has resulted in more consistent soil classifications across larger areas of land, with county boundaries considered sub-sets to the MLRA survey area. This change has resulted in the reclassification of several soil associations in Indiana, including within the Indian Creek Watershed. The result is that, while the pre-1990's soil surveys provide an abundance of information, this reclassification has introduced soil series not previously included. Information for the new soil series can be accessed via the Natural Resource Conservation Service (NRCS) website at http://soils.usda.gov/technical/classification/osd/index.html.

The Soil Surveys and website provide information regarding soil characteristics and classifications, suitability for a variety of uses, and distribution maps of soil series throughout the counties. Due to the large number of individual soil series within the Indian Creek Watershed, this Plan discusses soil associations. A soil association is a landscape that is comprised of a distinctive pattern of individual soils in defined proportions. The soil association is named for the most prevalent soil types within the association. The distribution of the Indian Creek Watershed soil associations is shown in Figure 8.

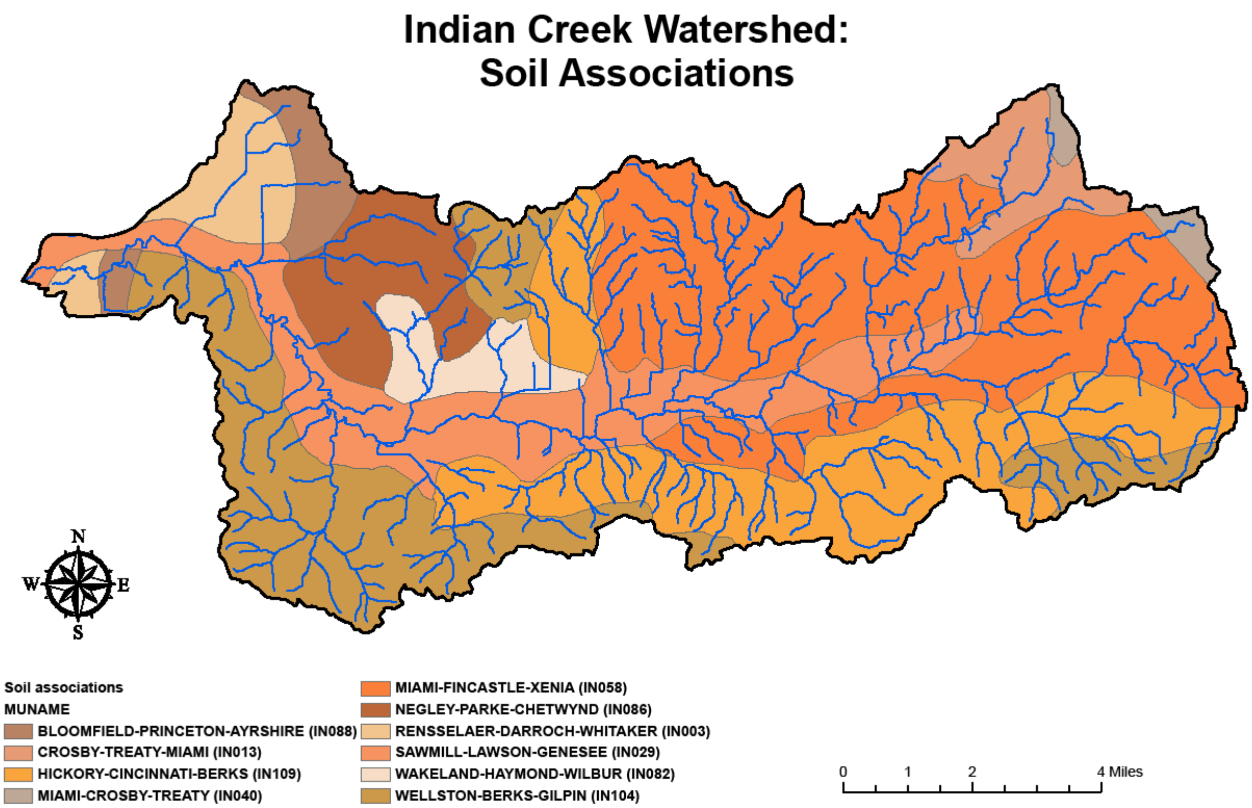

Figure 8. Indian Creek Watershed: Soil association distribution

There are 10 major soil associations in the Indian Creek Watershed:

(1) Bloomfield-Princeton-Ayrshire,

(2) Crosby-Treaty-Miami,

(3) Hickory-Cincinnati-Berks,

(4) Miami-Crosby-Treaty,

(5) Miami-Fincastle-Xenia,

(6) Negley-Parke-Chetwynd,

(7) Rensselaer-Darroch-Whitaker,

(8) Sawmill-Lawson-Genesee,

(9) Wakeland-Haymond-Wilbur,

(10) Wellston-Berks-Gilpin.

Table 5 lists the soil associations, the amount of watershed area classified in each, a brief description, and the degree and kind of limitations that affect the soils suitability for sanitary facilities (septic tank absorption fields, sewage lagoons, and sanitary landfills) (USDA - SCS, 1979).

Table 5. Soil associations, watershed area and description

Soil Association	% of watershed	Description	Degree and kind of limitation for septic tank absorption fields*
Bloomfield-Princeton-Ayrshire	2.69%	Deep, poorly drained to excessively drained soils that formed in deposits of silt and find sand; found on stream terraces and dunes	Severe; wetness, slow absorption
Crosby-Treaty-Miami	3.38%	Well drained to poorly drained soils, nearly level and gently sloping soils on terraces and uplands	Severe; wetness, slow absorption
Hickory-Cincinnati-Berks	17.83%	Deep, gently sloping to very steep, well drained and moderately well drained soils that formed in loamy glacial till or in loess and the underlying glacial till; on uplands	Severe; wetness, slope, slow absorption
Miami-Crosby-Treaty	1.06%	Deep, well drained to poorly drained, formed in loess and underlying loamy till; on uplands and till plains	Severe; wetness, slow absorption
Miami-Fincastle-Xenia	29.41%	Deep, nearly level to very steep, well drained to somewhat poorly drained soils that formed in loess and the underlying glacial till; on uplands	Moderate to severe; slow absorption, wetness
Negley-Parke-Chetwynd	6.15%	Deep, nearly level to very steep, well drained soils that formed in loess and the underlying loamy glacial drift or in outwash sediment; on moraines, outwash plains and terraces, kames and eskers	Slight to severe; slope
Rensselaer-Darroch-Whitaker	3.85%	Deep, nearly level and gently sloping, somewhat to very poorly drained soils that formed in silty and	Severe to slight; ponding, wetness, slow absorption

		loamy sediments; on terraces, lake beds and outwash plains	
Sawmill-Lawson-Genesee	14.52%	Very deep, poorly drained soils formed in loamy and silty alluvium; on flood plains and bottom lands	Severe; floods, wetness
Wakeland-Haymond-Wilbur	2.93%	Deep, well drained to somewhat poorly drained soils formed in silty alluvium; on bottom lands, flood plains and flood-plain steps	Severe; floods, wetness
Wellston-Berks-Gilpin	18.16%	Moderately deep and deep, gently sloping to very steep, well drained soils that formed in residuum of sandstone and shale or silt over sandstone, siltstone or shale	Severe to moderate; slope, depth to bedrock, wetness, slow absorption

*Limitations for sanitary facility use are considered: 1) slight if soil properties are favorable; 2) moderate if soil properties are less than favorable but can be overcome by special planning, design or maintenance; and 3) severe if soil properties or site features are unfavorable and difficult to overcome without significant planning, design, construction costs and maintenance.

Factors that adversely affect the performance of septic tank absorption fields include slow absorption, a high water table, depth to bedrock and flooding or wetness. Such factors can result in health threats from surfacing of effluent, hillside seepage or contamination of ground water. Depth to bedrock can limit absorption and interfere with installation.

Soil types are also major factors in the agricultural use of land, including suitability for particular crops, the ability to retain nutrients, and moisture retention. Other land uses influenced by soil characteristics include buildings (bearing capacity, shrink-swell and wetness), recreation (slope, erosion, and wetness), roads (wetness and strength), and constructed waterbodies (slope, seepage, depth to water, and erosion potential). The USDA Soil Surveys for each county provide tables and narrative descriptions for each county's soils, characteristics and suitability for a variety of uses.

F. Septic Systems

The Johnson County Health Department is responsible for septic systems within the county jurisdiction. The County does not have an accurate count of the number of active septic

systems due to the number of older systems installed without proper documentation. Per the Johnson County Health Department, all residences within the Indian Creek Watershed area of the county are on septic systems, however, there is no existing map of all active septic systems. The Johnson County GIS Department has mapped 465 homesites with septics in the Indian Creek Watershed. After examination of that map, however, the Indian Creek Steering Committee agreed that the actual number is grossly underestimated. Residents of the County are required to apply for a permit prior to installation of new systems and to report repairs. The County also keeps a record of all complaints reported. The County Health Department indicated that they had not received any complaints of failed septics or other septic-related problems in at least the past five years. The County does not currently require routine inspection or maintenance of septic systems, but does maintain a website containing information on septic system maintenance and other information for residents at
http://www.co.johnson.in.us/civil/healthdepartment/onsite_faq.htm.

The Morgan County Health Department is responsible for septic systems within their county jurisdiction. Sanitary sewers within the Morgan County area of the watershed are located in Martinsville and Morgantown. Per the Morgan County Health Department, sanitary sewers in Martinsville extend to approximately two miles outside of town. Per the Town of Morgantown, sanitary sewers in Morgantown extend to approximately one mile outside of town. Everyone outside those areas is on septic systems. The County maintains permit records for new septic systems, repair permits and complaints for existing systems. The County Health Department indicated that they had not received any complaints of failed septics or other septic-related problems in at least the past several years. The Morgan County residents can access a link to the Indiana State Department of Health Rule 401 IAC 6-8.1 Residential Sewage Disposal Systems from the Morgan County Health Department web site at
http://scican3.net/MCHD/environmental_health_services.htm.

Except for along State Road 135 in Brown County, residential land uses, and therefore septic systems, in the Monroe and Brown County areas of the watershed are sparse, with limited or no access to watershed waters. None of the streams in Monroe or Brown County located within the watershed were listed as impaired for *Escherichia coli* (*E. coli*) in the *Total Maximum Daily Load for Escherichia coli (E. coli) for the IDEM Indian Creek Watershed, Morgan and Johnson County, (TMDL)* dated December 22, 2004. The TMDL is discussed further under the Impaired Waterbodies section of this Plan and is attached as Appendix D.

As further detailed under Demographic History and Future Changes below, population growth lead by residential development within the Watershed is expected to remain below a 1% increase of the current population. The inadequacies of area soils for septic system usage has and will continue to limit residential development in the area.

G. NPDES Permitted Facilities

According to the Indiana Department of Environmental Management (IDEM) Total Maximum Daily Load for *Escherichia coli* (*E. coli*) for the Indian Creek Watershed, Morgan and Johnson County Report (TMDL), dated December 22, 2004, there are two Clean Water Act National Pollutant Discharge Elimination System (NPDES) permitted facilities within the Indian Creek Watershed: the Brown County Water Utility and the Morgantown Wastewater Treatment Plant (WWTP). NPDES permits are required of point sources that discharge pollutants into waters of the U.S. The U.S. EPA defines point sources as discrete conveyances such as pipes or man-made ditches and generally include industries, municipalities and other facilities with direct discharges to surface waters. According to the report, the Brown County Water Utility does not have a sanitary component to their discharge and is therefore not considered a source of *E. coli* pollution in the Watershed.

The Morgantown WWTP, however, had an *E. coli* reporting requirement added to its permit in February 2003. Prior to that time, it was believed that a natural attrition of *E. coli* was provided by an extended retention time of sanitary wastewater. Recent studies have indicated that *E. coli* may actually survive longer than previously thought, thus initiating a need for monitoring its concentrations in wastewater treatment discharges.

There were no permitted Confined Feeding Operations (CFOs) or Concentrated Animal Feeding Operations (CAFOs) located in the watershed according to the TMDL report.

H. Water Supply

Drinking water is provided through both private wells and municipal water systems in the watershed. Most of the water use in Johnson County is supplied by underground wells. The amount of water yielded by wells is dependent on the type of geologic formation in the area. Wells in the western one-third of the County are the least productive and are primarily “seep wells" (USDA, 1979). Some residents in the southwestern area of the County receive their water from the Brown County Water Utility, which receives its supply from purchased surface water.

Most of the drinking water supply for Morgan County is from groundwater wells. In many areas of the county, ground water is scarce because wells terminate in bedrock. Groundwater supplies are most abundant in the valleys of the White River and its major tributaries (USDA, 1981). Glacial sand and gravel deposits in these valleys provide the most abundant groundwater sources in this area. Figure 9 shows the potential yield of groundwater distribution. The Monroe County portion of the watershed also obtains its water supply from underground wells, although bedrock geology limits the abundance of this water source.

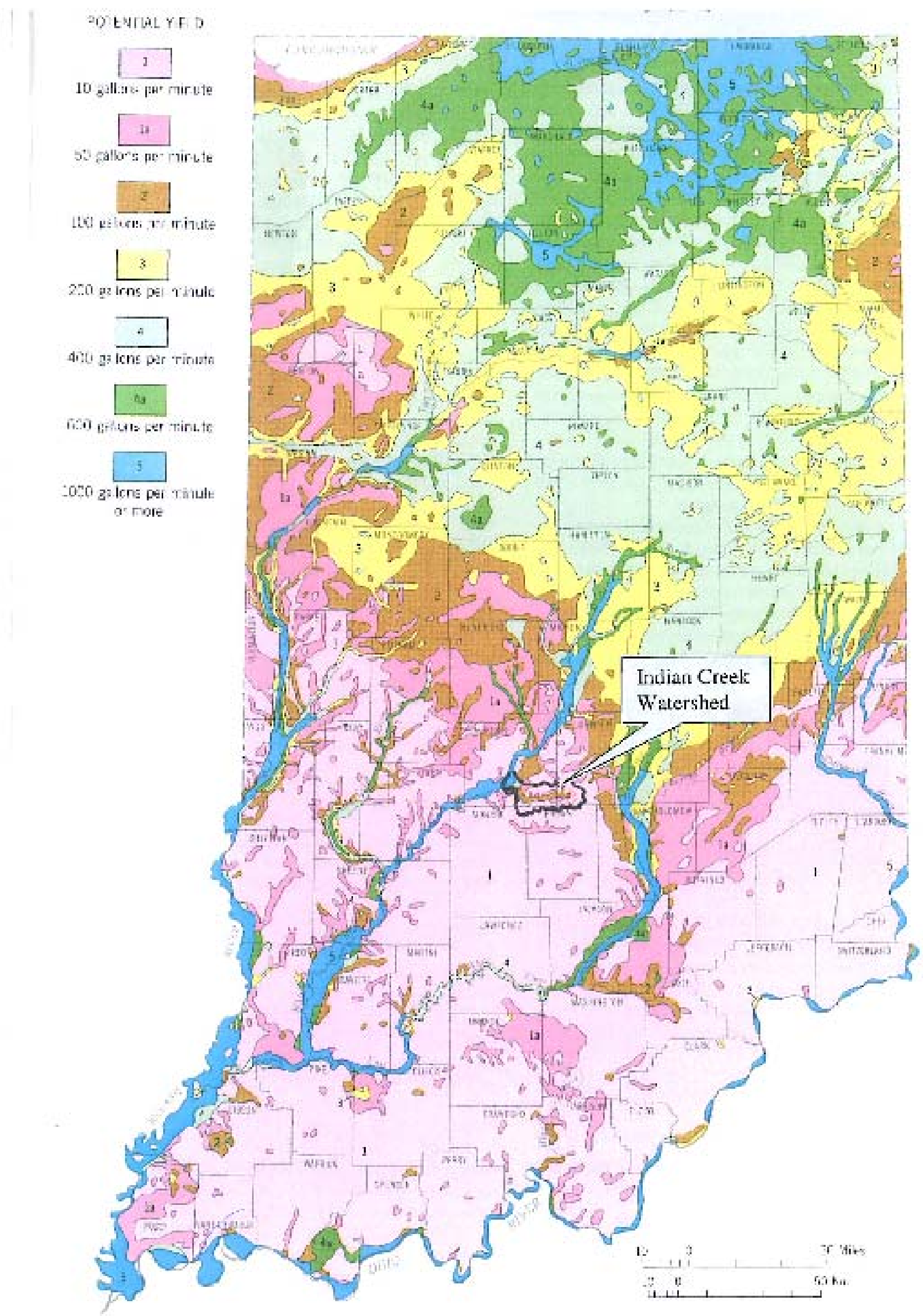

Figure 9. Potential yield of ground water (from properly constructed large diameter wells). (Clark 1980)

I. Hydrologic Features

The Indian Creek is approximately 27 miles in length and flows west from the southwest corner of Johnson County at Lamb Lake to south central Morgan County, south of Martinsville, where it empties into the West Fork of the White River. The Indian Creek receives waters from the following named tributaries as well as unnamed tributaries and legal ditches or drains (Figure 10):

(1) Lick Creek,
(2) Goose Creek,
(3) Barnes Creek,
(4) Bear Creek,
(5) Long Run,
(6) Crooked Creek,
(7) Long Run Creek,
(8) Pike Creek,
(9) Oliver Creek,
(10) Indian Trace Creek,
(11) Camp Creek,
(12) Robertson Creek, and
(13) Sand Creek.
(14) Sedwick Ditch
(15) Hilldale Cemetery Ditch
(16) Sator Ditch

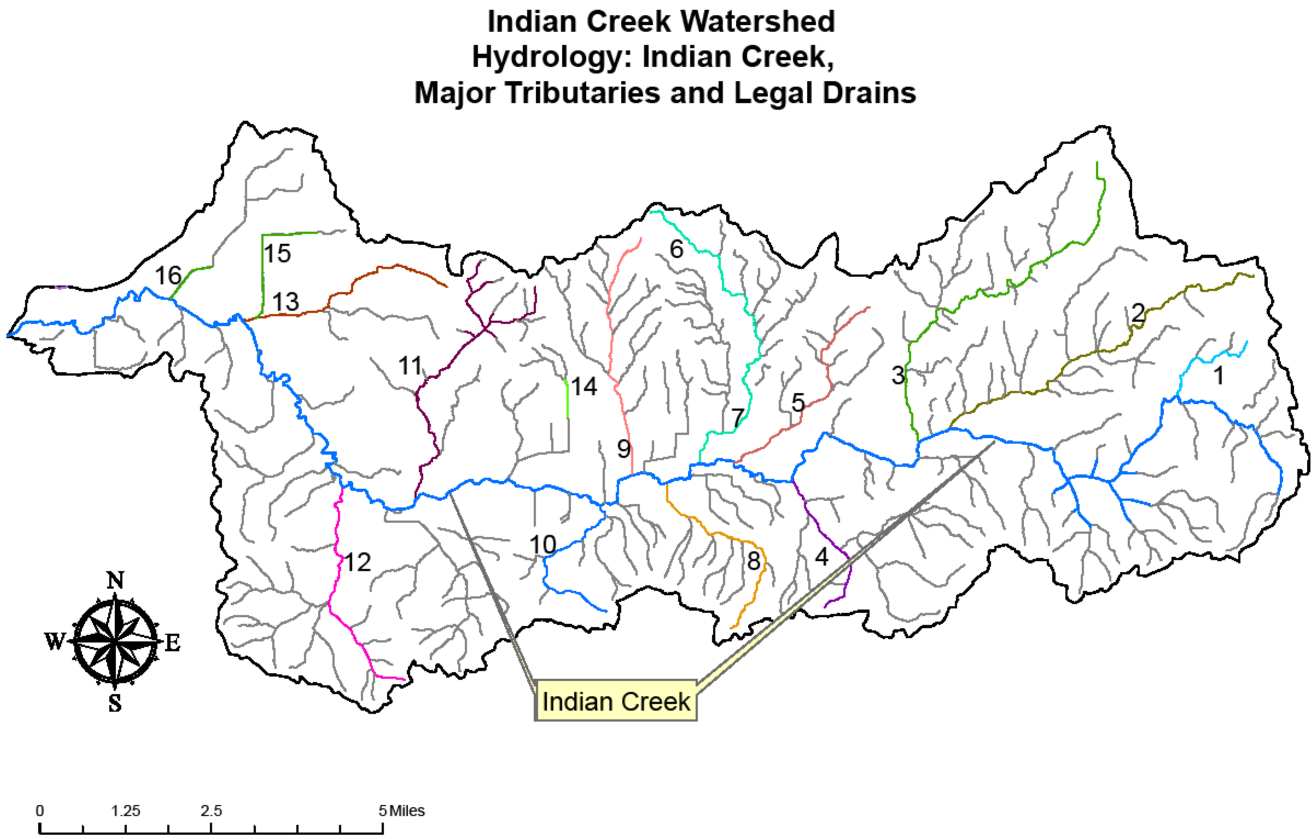

Figure 10. Indian Creek Watershed hydrology: Indian Creek and major tributaries

The Watershed is comprised of seven (7) sub-watersheds (14-digit HUC), shown in Figure 11, ranging in size from 10,297.2 acres to 7,299.1 acres. Each sub-watershed is named for the major waterbody(s) that drains the land area into the Indian Creek. The last two digits of the HUC codes identify the sub-watersheds. Examining land use on a sub-watershed level helps isolate potential contributing non-point sources of pollutants and thus address water quality issues.

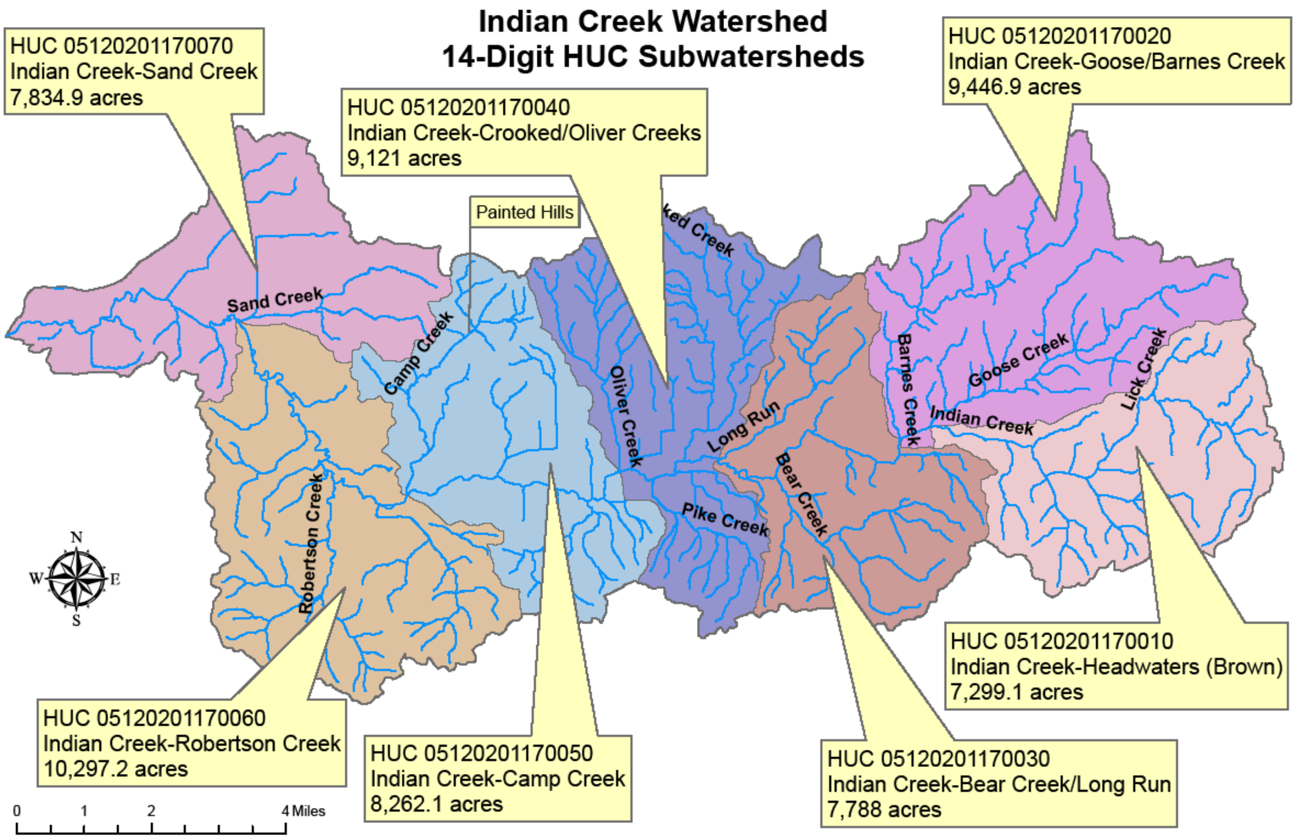

Figure 11. Indian Creek Watershed: Sub-watersheds

I.1.County Legal Drain Systems

A legal drain system is a segment or collection of segments of streams that drain water from agricultural land. According to the Surveyor of Johnson County, no legal drains in Johnson County are located within the Indian Creek Watershed. According to the Morgan County Surveyor, three legal drains are located within the Watershed: Sedwick Ditch, Hilldale Cemetery Ditch and Sator Ditch. Two of the legal drains (or ditches) are in the Sand Creek sub-watershed, and one is in the Camp Creek sub-watershed, as sown in Figure 10 above.

I.2. Wetlands

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service provides information about the extent, character and status of wetlands in the U.S. The NWI-produced digital map of wetlands in the Indian Creek Watershed area is based on remotely sensed satellite data.

According to the NWI database, 2% of the Indian Creek Watershed is classified as wetland. Most of the existing wetlands are located along Indian Creek, especially in the western quarter at the base of the Morgan-Monroe State Forest hills as the creek slopes toward the White River basin. Also included as wetlands in the NWI are Lamb Lake(s), the Lakes of Painted Hills and the fish hatcheries located southeast of Martinsville. Figure 12 shows the NWI identified wetlands in the Indian Creek Watershed.

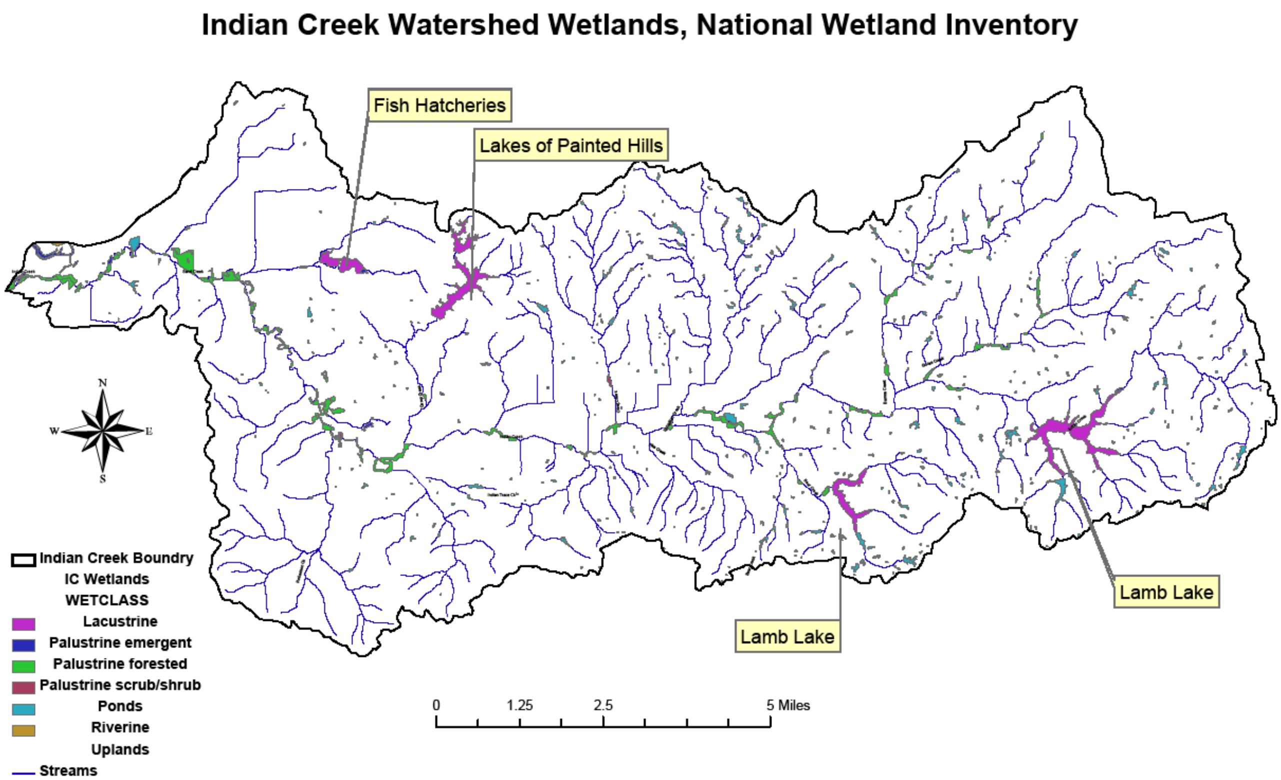

Figure 12. Indian Creek Watershed: wetlands (NWI)

I.3. Floodplains

The 100-year floodplain of the Indian Creek is shown in Figure 13. This area, consisting of more than 10,072 acres, contains the lowest and flattest land in the watershed, especially in the area within Morgan County. Figure 13 also shows that land uses in the watershed within the floodplain are primarily agricultural, either as cropland or pasture. Also of note is the inclusion of the areas around the two Lamb Lakes. Effective August 2, 2007, the Federal Emergency Management Agency (FEMA) issued updated Flood Insurance Rate Maps (FIRM) for Johnson County. Updated maps for Morgan County have not been released since June 1981. In November 1965, the Morgan, Monroe, Johnson and Brown County Soil and Water Conservation Districts released their Watershed Work Plan (for) Indian Creek Watershed for Watershed Protection and Flood Prevention to address flooding problems in the watershed. This report will be discussed in detail under Section IV: Investigation of Water Quality Issues and Benchmarks below.

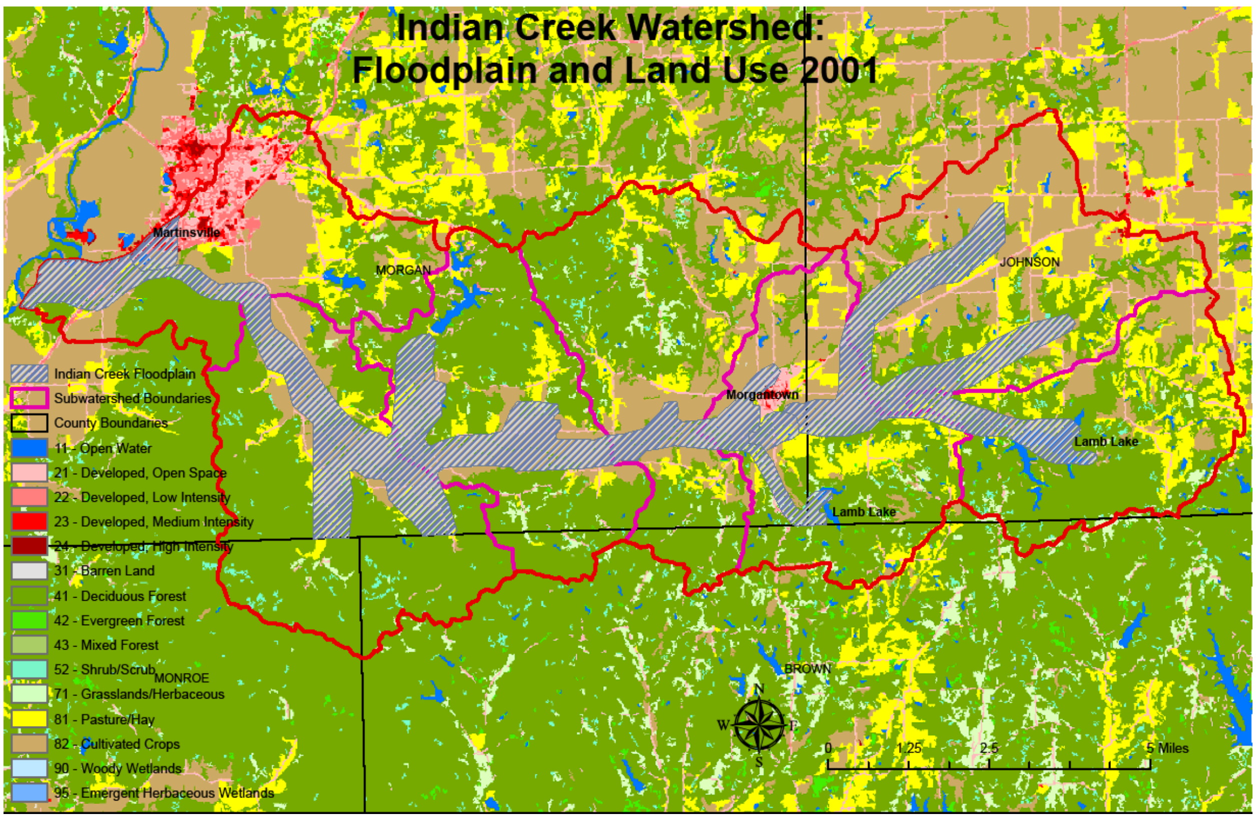

Figure 13. Indian Creek Watershed: Floodplain and Land Use 2001

(This map is for illustrative purposes only, is an approximation of the 100-year floodplain derived from historic floodplain maps and is not an official Federal Emergency Management Agency (FEMA) issued map.)

J. Ecoregions & Climate

Ecoregions, or ecological regions, are defined as areas within which ecosystems and environmental resources are similar. From a framework developed by James Omernik (Omernik 1987), the U.S. EPA has mapped the ecoregions of the U.S. based on the analysis of patterns and compositions of biotic and abiotic phenomena, such as geology, physiography, vegetation, climate, soils, and land use (Wiken 1986, Omernik 1987, 1995). According to the EPA, the Indian Creek Watershed is located within the Eastern Corn Belt Plains ecoregion. This ecoregion is characterized by rolling till plains of loamy, rich, well-drained soils from Wisconsinan-age glacial deposits. Originally, beech-maple forests were dominate, with a significant amount of white, black and northern red oak, yellow popular, hickory, white ash, and black walnut, eventually giving way to the present-day extensive production of corn, soybean, and livestock.

The climate, temperatures, and precipitation data for the Indian Creek Watershed are very similar to those of the Indianapolis area. The climate is continental, humid, and temperate, with warm humid summers and moderately cold winters. The median growing season in the region lasts 182 days, from the last spring frost in mid-April to the first fall frost in mid-October (MRCC, 2002). Monthly mean temperatures and precipitation values are shown in Figure 14.

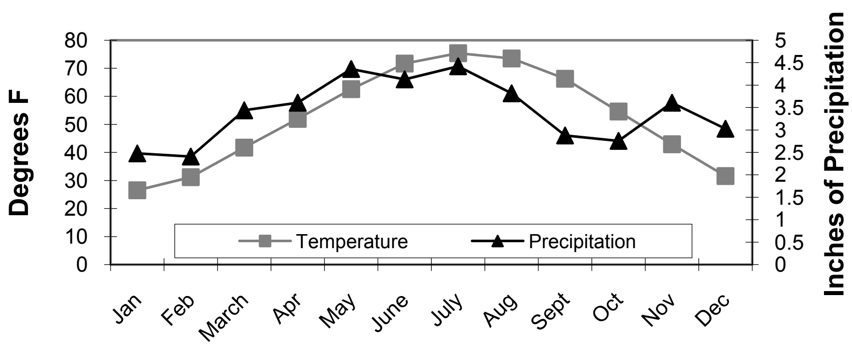

Figure 14. Indianapolis area monthly mean temperature and precipitation values

(Source, Midwestern Regional Climate Center)

Section III: Land Use Description of the Watershed

This section provides an overview of the watershed's land use from settlement history to recent land use changes, population changes, particular areas of interest in the watershed, point-source discharge facilities and unique recreational areas.

A. Land Use History

A.1. Johnson County

Once inhabited by Delaware Indians of the Miami tribe, Johnson County was formed in December 1822 and named in memory of John Johnson, the first judge of Indiana's Supreme Court. The population was 550. Most of the land at that time was wet, swampy, and covered with vegetation. Judge Franklin Harden described in D.D. Banta's *A Historical Sketch of Johnson County* (1881) a landscape dense with tall trees, laden with wide-spreading branches met by the dense shrubbery below.

With the clearing of forests and the installation of drainage tiles and ditches during the early settlement, much of the land use in the county became primarily agricultural. Since 1900, in Johnson County overall, land use devoted to farming has declined by 30% with individual farms declining in numbers from 2,053 in 1900 to 526 in 1997. Farmed land in the county still accounted for 66% of its land use in 1997, the most recently available data. Figure 15 illustrates these trends in land use.

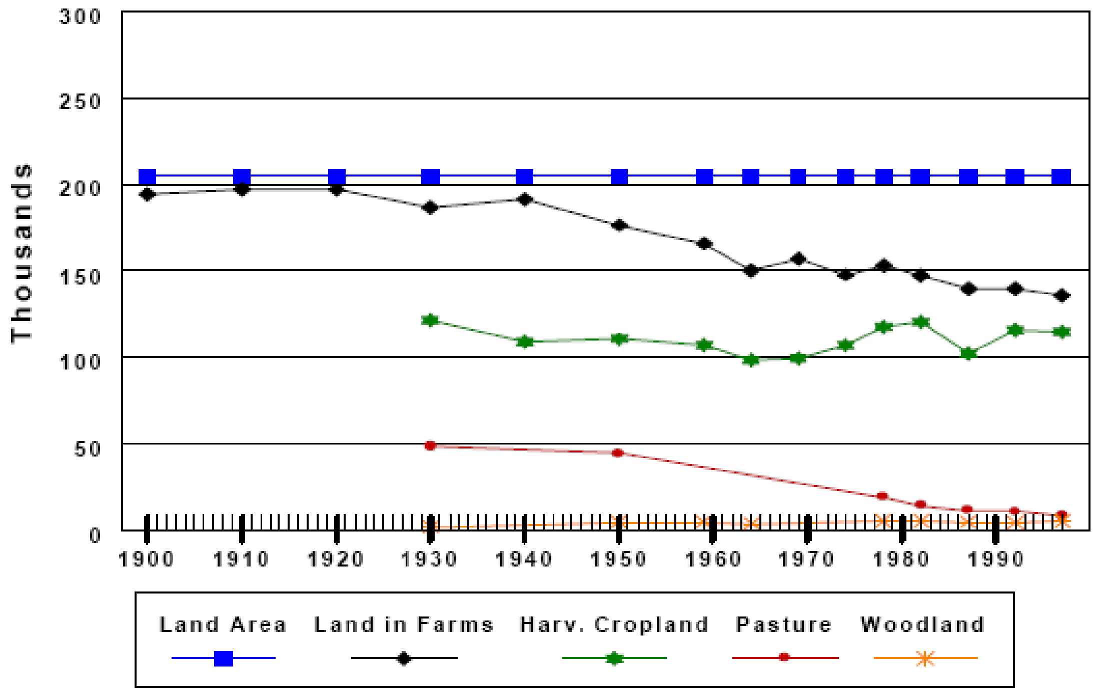

Figure 15. 1900-1997 Agricultural land use for Johnson County, IN

(Source: Indiana Agricultural Statistics Service, 1999)

Much of the farmland has been converted to residential, commercial and industrial development along the major roadways of US 31, I-65 and State Road 135, primarily around the cities of Greenwood, Whiteland, New Whiteland and Franklin, outside the boundaries of the Indian Creek Watershed. To a much lesser extent, farmland in Johnson County located within the Watershed has remained agricultural, with scattered residential developments and limited commercial development around the town of Trafalgar.

<u>A.2. Morgan County</u>

Named after Revolutionary War General Daniel Morgan, Morgan County was formed in 1822, with the city of Martinsville, named after founding father John Martin, designated as the county seat. Following its establishment, the 409-square mile county became populated by immigrants from the southern states looking for freedom from religious persecution and slavery.

The City of Martinsville, the county seat and largest city in the county, lies in the southeast quarter of the county. A search for natural gas in the area instead uncovered mineral springs, then believed to posses healing powers. Health spas sprang up and the city was dubbed as the 'Artesian City" after the wells located there. With the discovery of antibiotics, the draw of the spas declined and the focus of the county moved to its northern boundary, closer in proximity to the flourishing city of Indianapolis in Marion County.

Agricultural settlement in Morgan County developed along with its neighboring counties, with widespread clearing of forests and filling of swamps and wetlands for crops. In the northern and central parts of the county, agriculture remains a primary land use. In the southern quarter however, thin soils and steep terrain discouraged continued agricultural use after timber extraction and farming cause the loss of fertile topsoil through erosion by the 1930's. The ensuing purchase of those lands by federal and state government conservation agencies allowed reforestation of the hills, which are now part of the 24,000-acre Morgan-Monroe State Forest. Forestry property includes land from south of Martinsville well into northern Monroe County. Figure 16 shows that although the acreage of farmland has declined, woodlands have remained steady, and a decline in pasture has given way to an increase in harvested cropland.

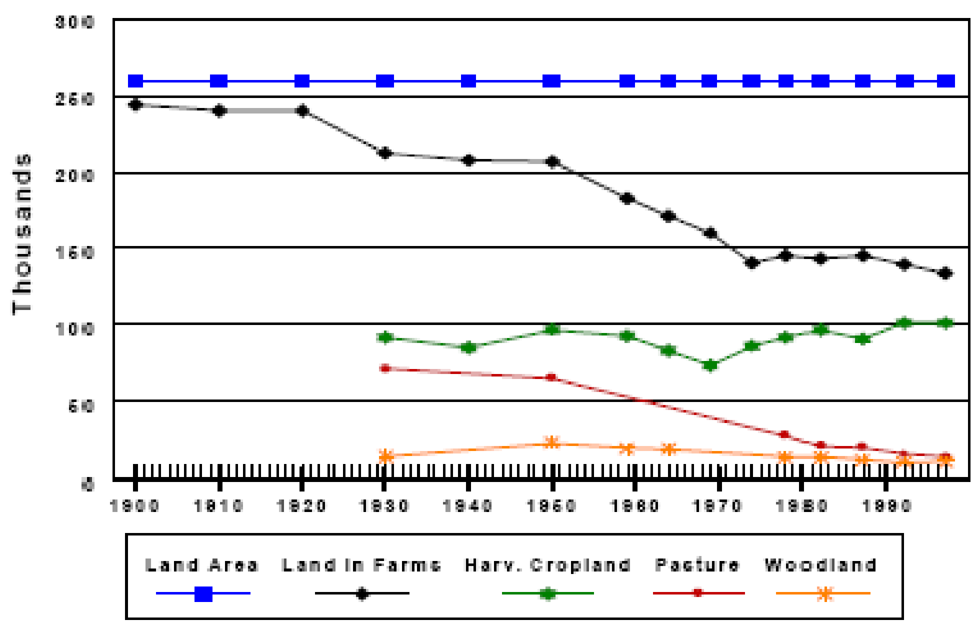

Figure 16. 1900-1997 Agricultural land use for Morgan County, IN

(Source: Indiana Agricultural Statistics Service, 1999)

Other large tracts of forested land to the northwest of Martinsville, namely Bradford Woods (2,500 acres) and Ravinia Woods (1,500 acres), as well as the State Forest have been included as an area The Nature Conservancy has named the "Big Woods." The Big Woods is the largest block of contiguous forest land remaining in Indiana.

Urban growth in Martinsville has remained slow but steady since its early settlement, primarily along the main corridors of State Road 39 on the west and State Road 37 on the east. Most of the urban development in the county has occurred to the north, between Mooresville and the Marion County line, well north of the Indian Creek Watershed.

Morgantown is the only other Morgan County municipality within the watershed. Founded in 1836 by Colonel John Vawter, Morgantown encompasses 0.4 miles of land in the southeastern one-quarter of the county near the Johnson County line. This small, historic rural community has grown slowly and little over the past several decades.

B. Land Use History: GAP Analysis Project

The USGS – Biological Resources Division and the U.S. Fish and Wildlife Service oversee the National Gap Analysis Program (GAP). The purpose of GAP is to identify the extent of habitats for animal and plant species so land managers, planners, scientists, and policy makers have the information they need to identify priority areas for conservation (USGS, 2002). Indiana's Gap Analysis Project began in 1994 and involved the analysis of vegetation from satellite imagery. From this analysis, a 30 x 30 meter resolution land cover map for the state was developed at Indiana State University (ISU, 1999), depicting land cover conditions in Indiana in 1992. Land use in the Indian Creek Watershed was inferred from this land cover layer (Figure 17).

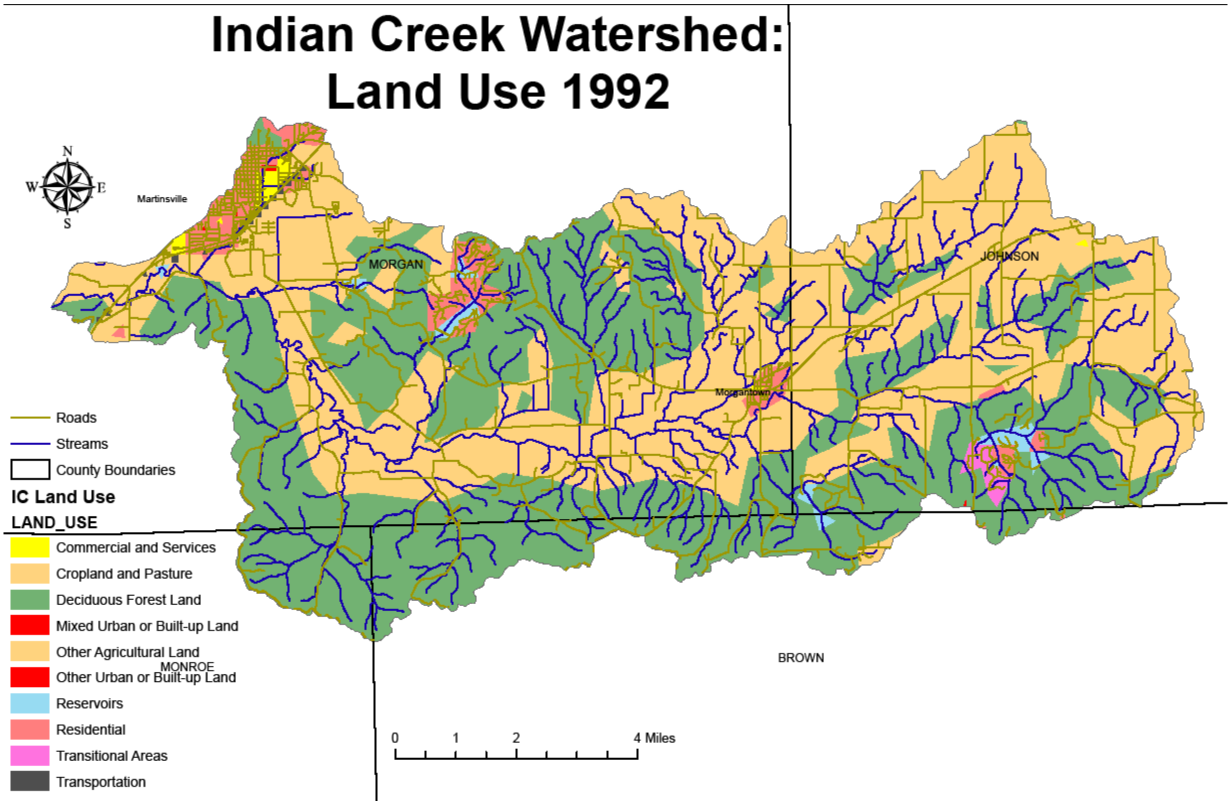

Figure 17. Indian Creek Watershed: Lane Use in 1992

C. Demographic History

Johnson County's population has grown steadily over the last century with the most dramatic increase of over 80,000 residents since 1950. According to census statistics, the largest percentage of increase has been experienced in the urbanized areas of Greenwood, Franklin, Whiteland, and Bargersville, all outside the boundaries of the Indian Creek Watershed. Trafalgar, located just outside the eastern boundary of the Watershed, has increased in population, although to a much lesser degree. The growth of the urban areas has been attributed to their proximity or easy access via major roads and highways to Indianapolis. Likewise in Morgan County, population increases have been experienced more in the Mooresville area in the northern portion of the county, closest to Indianapolis. Table 6 shows population trends in both counties and key cities/towns within both.

Table 6. Population trends in Johnson and Morgan Counties: 1980, 1990, 2000, 2005

Johnson County total population				
Area	**1980**	**1990**	**2000**	**2005**
Johnson County	77,240	88,109	115,209	133,316
Greenwood	20,220	26,265	36,037	44,767
Franklin	11,967	12,907	19,463	22,356
Whiteland	1,956	2,446	3,958	4,322
Bargersville	1,647	1,681	2,120	2,576
Trafalgar	NA	NA	798	1,041
Morgan County total population				
Area	**1980**	**1990**	**2000**	**2005**
Morgan County	51,999	55,920	66,689	69,778
Martinsville	N/A	N/A	11,698	11,657
Mooresville	N/A	N/A	9,273	11,111
Morgantown	N/A	N/A	964	966

D. Future Changes

Johnson County's population is projected to increase by 20,000 people over the next 20 years. Reports since 2002 indicate that more than 7,000 new homes were being planed for development in Johnson County around Franklin, Whiteland, New Whiteland and Greenwood, none of which is located in the Watershed (Holtkamp, 2002). For the Indian Creek Watershed, that projection may only impact areas near Trafalgar but not necessarily within the Watershed.

Morgan County's population is projected by the U.S. Census Bureau to increase from 69,778 in 2005 to almost 72,000 by 2010, a 3% increase. Most of this growth is projected to take place in the northern part of the county around Mooresville, as suburban areas around Indianapolis and Marion County continue to spread into surrounding counties. Mooresville experienced nearly a 20% population increase between 2000 and 2005, with Martinsville experiencing a 0.35% increase over the same time period. If these populations continue to grow at the same rate, the population of Mooresville is projected to exceed that of Martinsville by the year 2010. The *Indiana Economic Digest* (IBJ 2007) reported in October 2007 that Martinsville has struggled for years to improve its economic growth and attract new business and work force, citing a lack of racial diversity in the city's population as a hindrance to its growth. City officials and political leaders are divided on how to address the issue, creating a climate where dramatic changes or increases in the city's future growth will likely not occur in the foreseeable future.

The population of Morgantown, the only other urbanized area in the watershed, increased from 964 in 2000 to 966 in 2006, a 0.2% increase. The U.S. Census Bureau reports that only six new homes were built in the area between 1998 and 2000, continuing a decline in new housing starts in the area since 1960. Population growth for Morgantown is expected to remain steady, if not decline in the future.

Most of the soils within the watershed are inadequate for septic field absorption, as noted above under Soils. This limitation also reduces the attraction of the area for future growth as extending existing sanitary sewer systems is not economically feasible, therefore requiring the use of septic systems for development. Local authorities have become more diligently adhering to-site treatment or septic system regulations as awareness of failure in those systems increases.

E. Point Source Discharges

The Clean Water Act authorizes that all point source discharges into U.S. waters be regulated by the National pollution Discharge Elimination System (NPDES). Point source discharges are discrete channels such as pipes or man-made ditches that flow directly into surface water.

The Permit Compliance System (PCS) is a national information system designed to support the NPDES program. Permits established by the NPDES program and managed by each indicidual state provide pollution limits and specify monitoring requirements for these point sources. The Indiana Department of Environmental Management (IDEM) has two PCS facilities in the Indian Creek Watershed as of January 2007. (Figure 18).

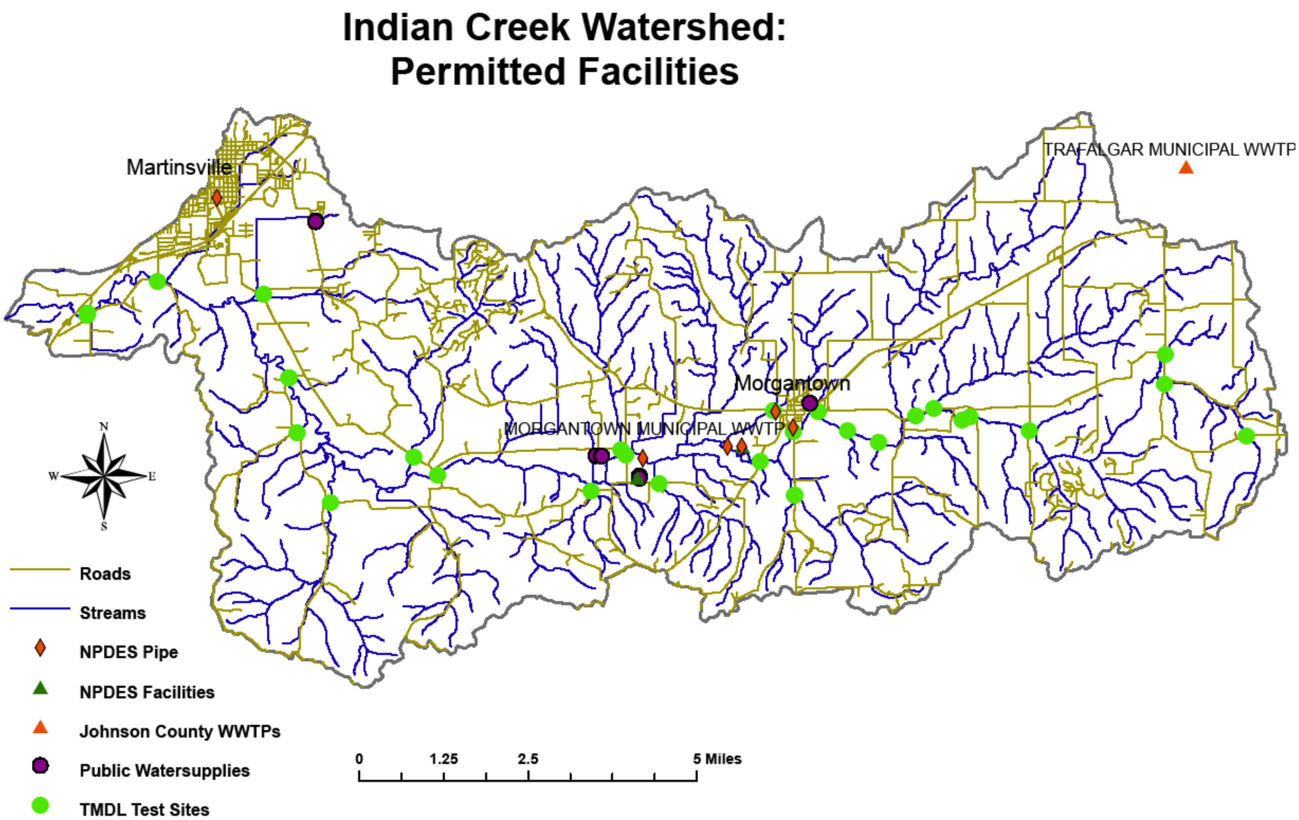

Figure 18. Indian Creek Watershed: PCS facilities

According to the TMDL report of December 22, 2004, one of the facilities, the Brown County Water Utility facility, does not have a sanitary component to their discharge and is not considered a source of *E. coli* or other pollutant of concern according to the TMDL report. The other facility, the Morgantown Municipal Sewage Treatment Plant (MSTP), has however, had a discharge component for *E. coli* since February 2003. Reported end-of-pipe *E. coli* limits for the facility in its quarterly reports show values of *E. coli* to range from 0 cfu/100ml to 50 cfu/100ml, well below the state water quality standard of 125 cfu/100ml.

The Indiana Department of Environmental Management (IDEM), Wastewater Compliance Evaluation, maintains reports of Sanitary Sewer Overflows (SSOs) reported by wastewater collection system facilities. SSOs occur when a collection system's capacity is exceeded because of wet weather, mechanical failure or other reason. SSOs may result in the release of untreated wastewater into surface waters. Reports of overflow discharges from the Morgantown MSTP exceeding allowable limits were made to IDEM on 6 occasions in 2005, 6 in 2006, and once in 2007. The 2006 bypasses were documented in January, October and December and sampling data for E. coli for the TMDL were taken in May and June, 2006. A likely conclusion can be drawn that the bypasses contributed to the E. coli but there is not data to support by how much.

F. Recreational Areas

The Morgan-Monroe State Forest and the Yellowwood State Forest encompass over 50,245 acres of forested land, campgrounds and lakes in Johnson, Morgan, Brown and Monroe Counties, 4,338 acres of which lie within the Indian Creek Watershed boundary. These publicly-owned properties are managed by the Indiana Department of Natural Resources. Figure 19 shows the publicly owned state forest land in and adjacent to the Indian Creek Watershed.

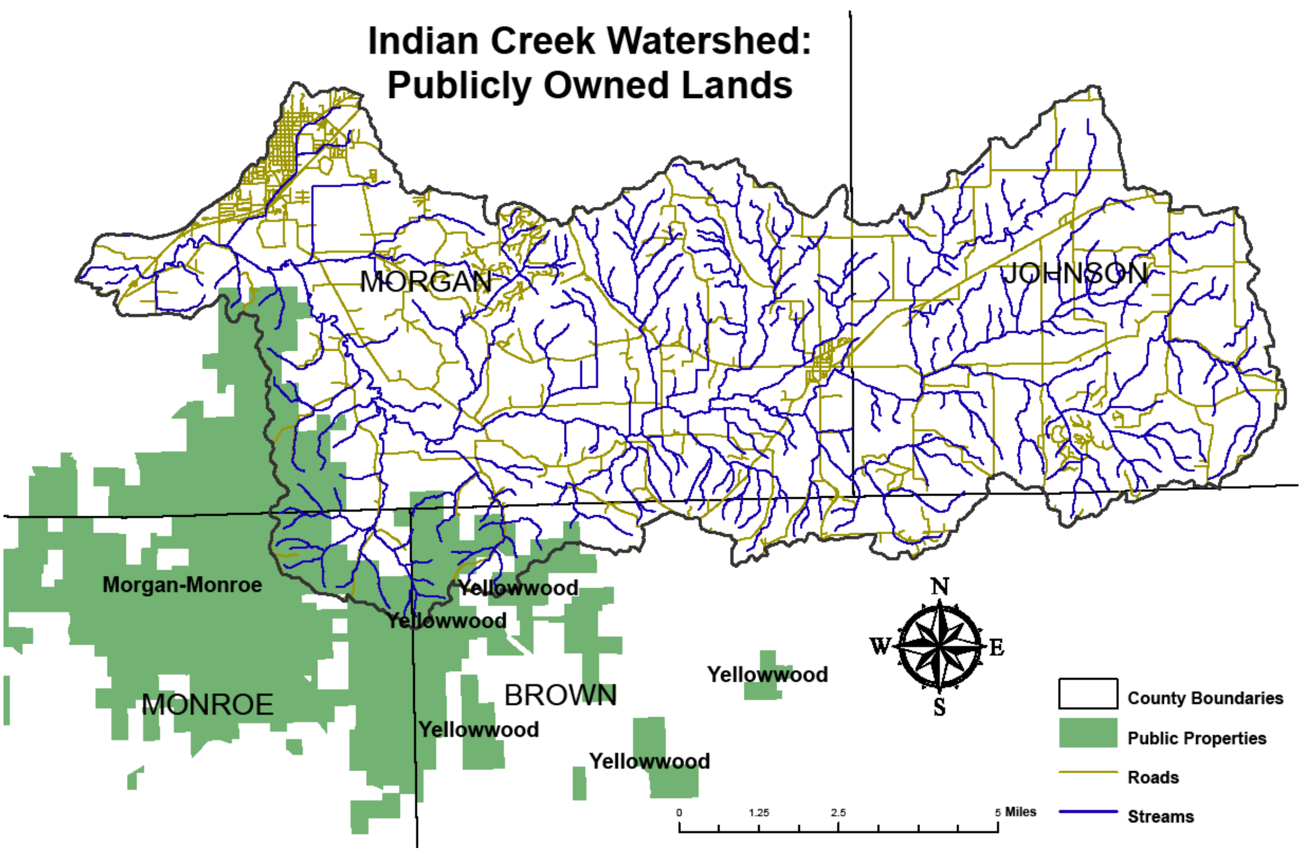

Figure 19. Publicly Owned Property in and adjacent to Indian Creek Watershed

Infill areas of privately owned forest land help make this a large contiguous forest area (see Figure 17) which provides habitat to many threatened and endangered species of flora and fauna, as well as an abundance of more common species. Rare and beautiful bird species include the Louisiana water rushes, red-eyed vireos, Acadian flycathchers, and cerulean warblers, all of which depend on large, expansive forests for nesting and breeding. The state-endangered timber rattlesnake is also found here and less often elsewhere as its numbers dwindle due to widespread habitat destruction. Rare and threatened flora also persist here, such as the Yellowwood trees which grows wild no where else in the state. The 15-acre Scout Ridge Nature Preserve, located in the Morgan-Monroe State Forest just inside the southwestern boundary of the Watershed as shown in Figure 20, provides special protection under state law (Indiana Code 14-31-1) for natural communities of flora and fauna, including pawpaws, red elm and many different ferns and wildflowers.

Recreational opportunities within the state forests include hiking, wildlife viewing, picnicking, camping, horseback riding, boating, fishing, and hunting throughout designated areas of the forests. To help preserve its habitats, recreation within the Scouts Ridge Nature Preserve is restricted to limited hiking trails, nature study and scientific research. Organized recreational opportunities include seasonal hikes for viewing spring-blooming wildflowers and colorful fall leaves.

Members of the Steering Committee felt it was important to include an assessment of the Morgan-Monroe State Forest in the Watershed Management Plan since there are several residents who live in close proximity to the Forest and logging is a concern to them.

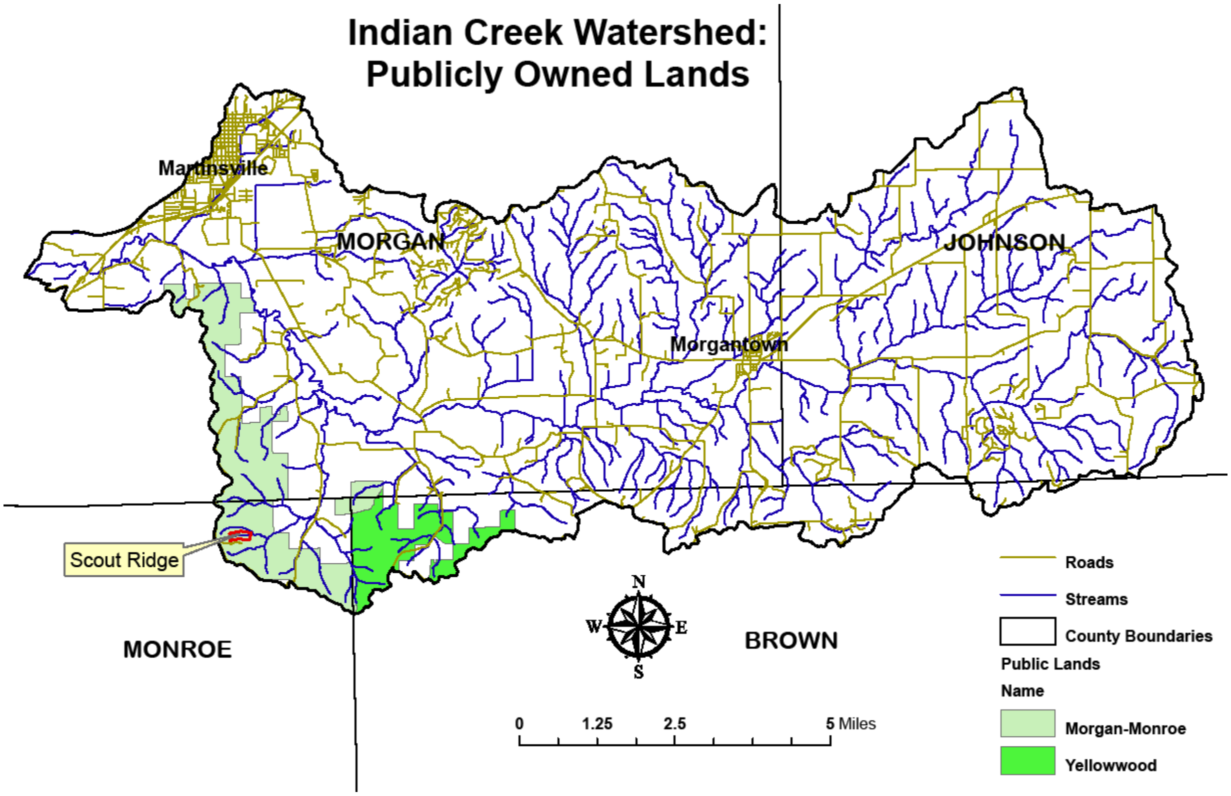

Figure 20. Indian Creek Watershed: Publicly Owned Properties within the watershed

G. Timber Production

In addition to providing recreational opportunities, the state forests provide timber harvests for one of the state's most abundant natural resources. Through its forest management and research programs, the Indiana Department of Natural Resources (IDNR) supervises timber harvest on state-owned properties and assists landowners with sustainable forestry practices on privately owned property.

A recent Hardwood Ecosystem Experiment researched and reported the impact of harvest practices on wildlife habitats at selected sites in the Morgan-Monroe State Forest, adjacent to the Indian Creek Watershed boundary. The information gained from this project will provide educational opportunities for students at Indiana colleges and universities and additional information for the development of the IDNR forestry management program. This program assists landowners in managing their privately owned forestland to increase timber revenues, improve timber quality, employ best management practices, and minimize the impact on the forest ecosystem.

H. Classified Forests

Classified forests and conservation easements provide private landowners an opportunity to preserve the integrity of the natural resources on their land, provide wildlife habitats and watershed protection, and reap financial benefits. The Classified Forest Program is administered by the IDNR. A classified forest is a tract of land 10 acres or greater in size set aside to remain in forest, supporting a growth of native or planted trees. In exchange for following the guidelines of the program, which include restriction from development, livestock access, and following standards of good timber management, the landowner is eligible for a reduced tax assessment of $1.00 per acre. By 2006, 64 sites totaling more than 3,355 acres in classified forests were located either partially or totally within the Indian Creek Watershed, as shown in Figure 21. Landowners are assisted in this program by IDNR District Foresters, who provide information and guidance to the owners and make annual inspections and reports of forest conditions.

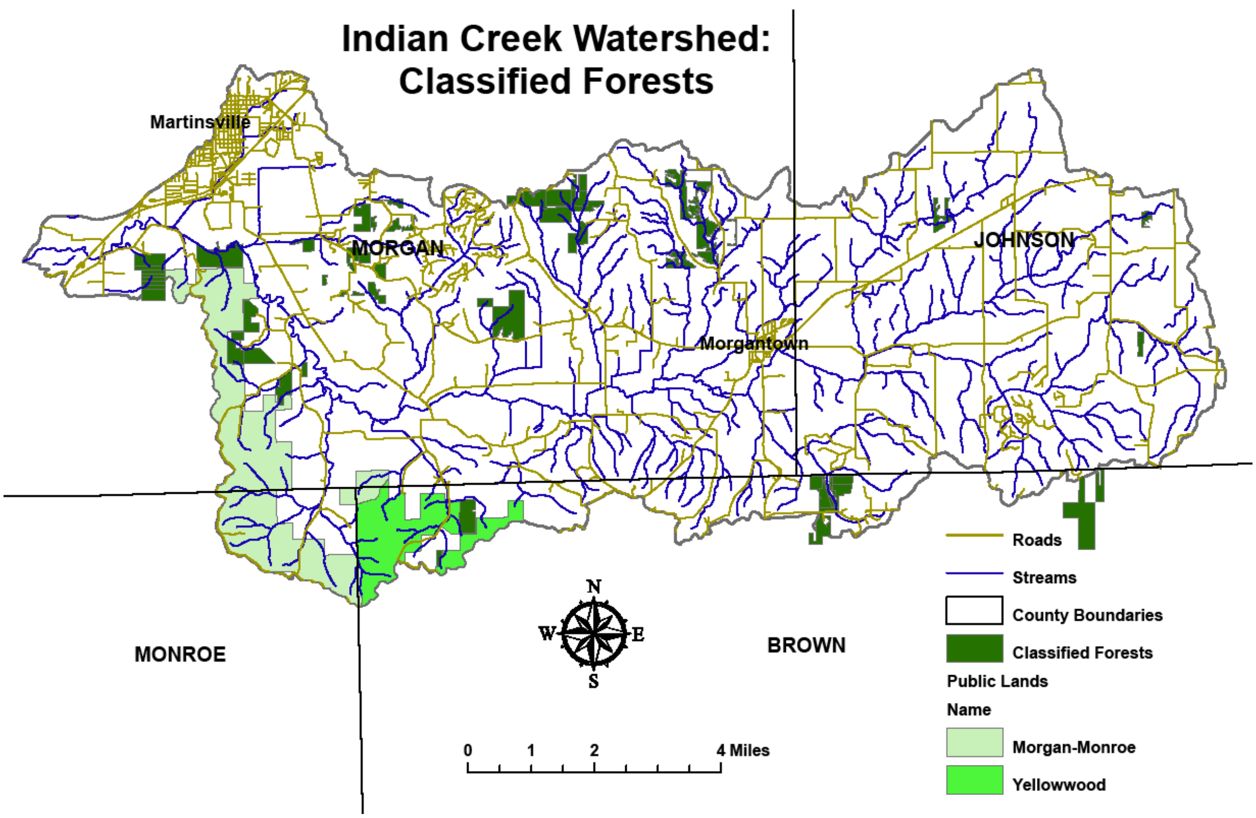

Figure 21. Indian Creek Watershed: Classified Forests

Section IV: Investigation of Water Quality Issues and Benchmarks

This section provides an overview of existing water quality data for the Indian Creek Watershed. Following the discussion of designated uses and impaired waterbodies, this section summarizes water quality studies that have been conducted in relation to the watershed, examines county tillage transect data, and contains the results of habitat and visual assessments conducted during this project.

A. Designated Uses

Under the provisions of the Clean Water Act, the Indiana Water Pollution Control Board, part of the Indiana Legislative Services Agency (1997) has designated state waters, except waters within the Great Lakes system (327 IAC 2-1.5), for the following uses (327 IAC 2-1-3): Full-body contact recreation (April – October); capable of supporting a well-balanced, warm water aquatic community and where temperatures permit, capable of supporting put-and-take trout fishing. There are no exceptions to this designation within the Indian Creek Watershed.

B. Impaired Waterbodies

Every two years, under Section 303(d) of the Federal Clean Water Act, states are required to identify waterbodies that do not meet water quality standards for designated uses. Impaired waterbodies may be impacted by both point and non-point sources of pollution. From the 303(d) list, states must establish priority rankings to develop Total Maximum Daily Loads (TMDL). A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

According to the TMDL for the Indian Creek Watershed, Morgan and Johnson County, dated December 22, 2004, in 1998, 2002, and 2004, Indiana's Section 303(d) list cited Indian Creek as being impaired for *E. coli* in Morgan and Johnson Counties. In 2004, in addition to Indian Creek, Bear Creek, Robertson Creek, Sand Creek, Camp Creek, and other tributaries were added to the Indiana Section 303(d) list. The TMDL addresses recreational uses impaired by elevated levels of *E. coli* during the recreational season of the Indian Creek and its tributaries in Morgan and Johnson Counties. Figure 22 shows the streams listed as impaired on the Indiana Section 303(d) list and the TMDL monitoring sites.

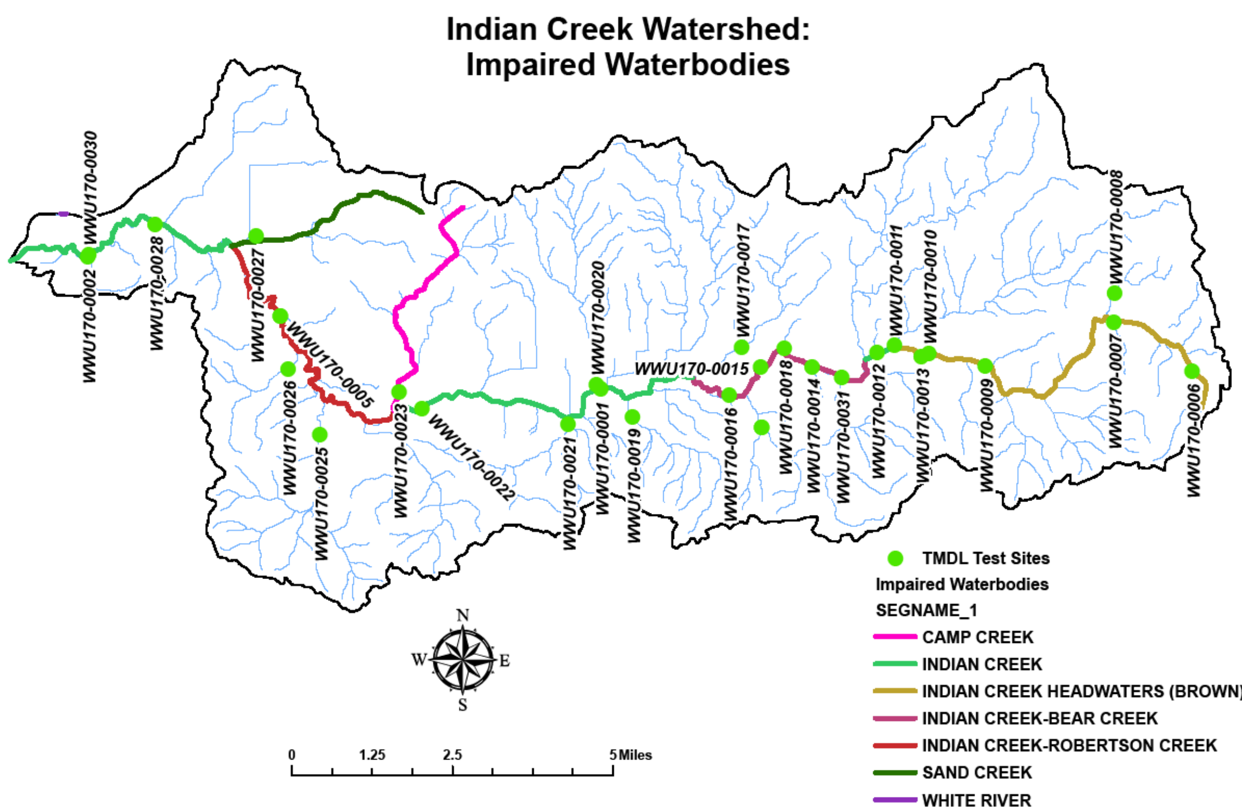

Figure 22. Indian Creek Watershed: Impaired Waterbodies

Escherichia coli (*E. coli*) is a bacterium commonly found in the intestinal tract of warm bodied animals, including humans, and used as an indicator for the potential presence of fecal contamination, pathogenic bacteria and waterborne disease. Indiana Water Quality Standards under 327 IAC 2-1-6(d) establish that for total body contact recreational use for all waters in the non-Great Lakes system:

> The *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

The TMDL states that:

"For the Indian Creek watershed during the recreational season (April 1st through October 31st) the target level is set at the *E. coli* WQS of 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period. "

Table 7, below, shows the data collected and geometric mean derived for the required five sampling dates. The corresponding numbered TMDL sites are shown in Figure 22, above. The complete data set, including sampling dates and results for each sample, can be found in Appendix X as an attachment to the TMDL. According to the TMDL, all twenty-six sites exceeded the single-sample maximum at least once during the monitoring cycle. The geometric mean for two sites was not calculated since the required five samples were either not collected or not usable.

Table 7. Indian Creek Watershed *E. coli* Data

Site #	L-Site #	Stream Name	Geometric Mean for Five Sample Data Sets (cfu/100mL)
1.00	WWU170-0002	1996 Synoptic - Indian Creek @ Jordan Rd	599.47
1.00	WWU170-0002	2001 Indian Cr @ Jordan Rd	435.85
2.00	WWU170-0030	2001 Indian Cr @SR 37	>814.36
3.00	WWU170-0028	2001 Indian Cr @ Burton Ln	259.02
4.00	WWU170-0027	2001 Sand Cr @ Mahalasville Rd	765.23
5.00	WWU170-0005	2001 Indian Cr @ Low Gap Rd/Taggart Crossing	578.57
6.00	WWU170-0026	2001 Unnamed Trib @ Downey Rd	N/A
7.00	WWU170-0025	2001 Robertson Cr @ Doeney Rd	>1545.29
8.00	WWU170-0023	2001 Camp Cr @ Mahalasville Rd	872.07
9.00	WWU170-0022	2001 Indian Cr @ Mahalasville Rd	466.02
10.00	WWU170-0021	2001 Indian Trace Cr @ Mahalasville Rd	>1092.91
11.00	WWU170-0020	2001 Oliver Cr @ Old Railroad Rd	222.97
12.00	WWU170-0001	1996 Indian Cr @CR 650 E	448.21

12.00	WWU170-0001	2001 Indian Cr @ CR 650 E	582.13
13.00	WWU170-0019	2001 Pike Cr @ Mahalasville Rd	515.87
14.00	WWU170-0016	2001 Indian Cr @Lick Creek Rd	402.68
15.00	WWU170-0004	2001 Bear Cr @SR 135	365.01
16.00	WWU170-0018	2001 Crooked Cr @ CR 700 S	N/A
17.00	WWU170-0015	2001 Indian Cr @ SR 135	315.51
18.00	WWU170-0017	2001 Long Run Cr @ CR 700 S	478.61
19.00	WW170-0014	2001 Indian Cr @ Co Line Rd	257.76
20.00	WWU170-0031	1996 Indian Cr @ CR 700 W	N/A
21.00	WWU170-0011	2001 Goose Cr @CR 700 S	N/A
22.00	WWU170-0013	2001 Barns Cr @ CR 700 S	197.27
23.00	WWU170-0012	2001 Indian Cr @ CR 700 S	241.23
24.00	WWU170-0010	2001 Indian Cr @ CR 575 W	453.39
25.00	WWU170-0009	2001 Indian Cr @CR 500 W	>405.28
26.00	WWU170-0008	2001 Lick Cr @ CR 300 W	>1053.81
27.00	WWU170-0007	2001 Indian Cr @ CR 300 W	500.09
28.00	WWU170-0006	2001 Indian Cr @ CR 750 S	221.71

The TMDL discusses the Watershed Characterization, which identifies potential non-point source and point sources of pollutants, Linkage Analysis and *E. coli* Load Duration Curves, TMDL Development, Allocations, and Potential Future Activities or 'best management practices" (BMPS) to reduce the *E. coli* loads.

C. TMDL Reasonable Assurance Activities

Reasonable assurance activities are programs developed by the TMDL that are in place or recommended to assist in meeting the watershed's TMDL allocations and the *E. coli* Water Quality Standard (WQS). Programs that are in place include the Morgantown Wastewater Treatment Plant NPDES permit and compliance with its E. coli WQS and the Lamb Lake Homeowners Association septic system inspection program. Recommendations include the initiation of a watershed group and watershed planning project to address the TMDL. BMPs recommended by the TMDL include riparian area management to protect streambanks with vegetated buffer zones, manure collection and storage to prevent runoff into surface waters, contour row crops and no-till farming to reduce soil erosion and nutrients in runoff, manure nutrient testing, drift fences, pet clean-up/education and septic system management and public education.

D. Upper White River Watershed Restoration Action Strategy

In January 2001, IDEM released the *Upper White River Watershed Restoration Action Strategy*. The West Fork of the White River is the primary waterbody in the Upper White River Watershed basin. The basin receives rainfall from sixteen counties, originating from the West Fork of the White River in Randolph County, flowing southwest through eleven counties until it flows into the Lower White River Watershed and joins the East Fork of the White River near Petersburg in Pike County. Figure 23 shows the Upper White River Watershed Basin and the location of the Indian Creek Watershed within it.

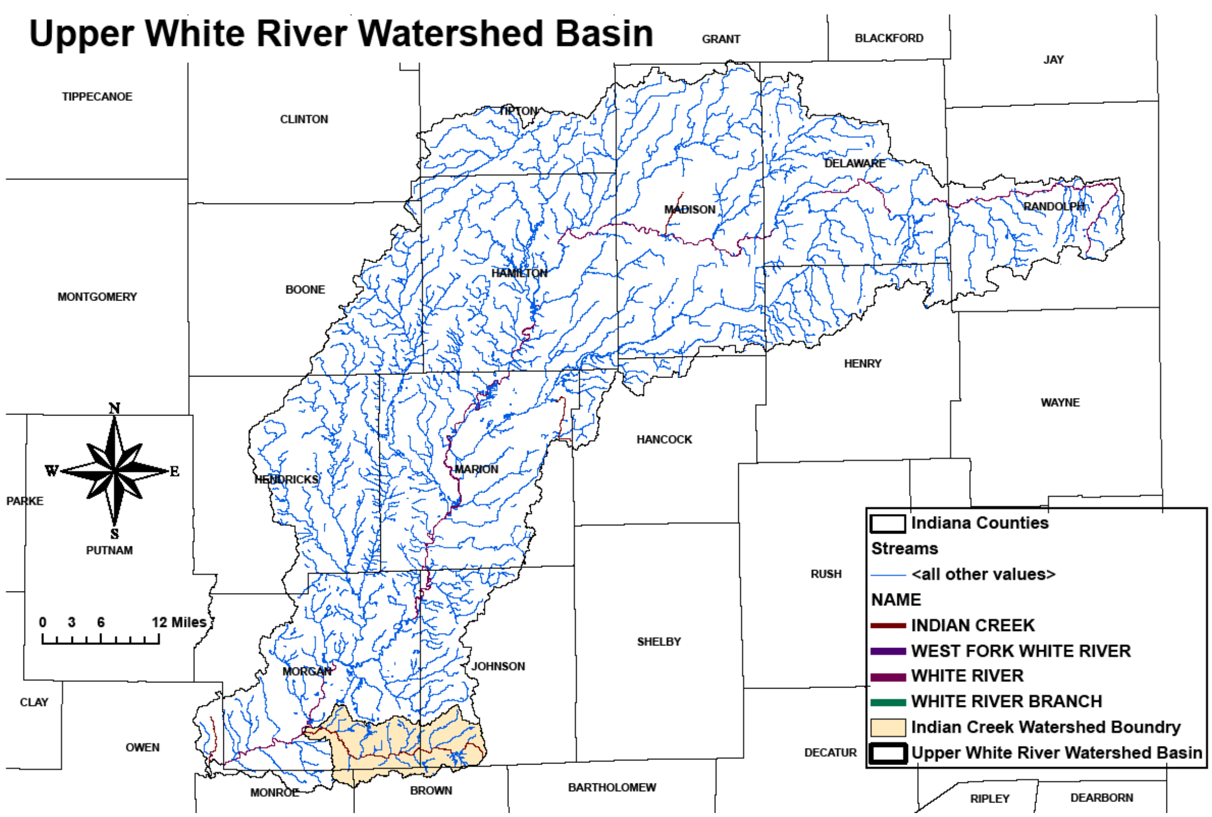

Figure 23. Upper White River Watershed Basin area

This strategy is a plan for the Upper White River Watershed that provides characterization, recommendations and reference materials to assist local watershed groups in their efforts. Although the strategy refers to the entire watershed, some 11-digit HUC specific information is provided, such as the Seasonal Kendall Analysis. New developments under this Action Strategy will be monitored as more data becomes available. Also, data gathered for Indian Creek Watershed can be incorporated into the WRAS to help provide a more complete characterization of the watershed basin.

E. Unified Watershed Assessment

A Unified Watershed Assessment (UWA) is one of 111 action items identified by President Clinton in 1997 through the Clean Water Action Plan. In September 1998, a workgroup consisting of staff from the USDA Natural Resources Conservation Service (NRCS) and IDEM developed a first version of the UWA, which ranked each 8-digit hydrologic unit watershed in Indiana according to the condition of the water. The resulting data layers provided information regarding the water column, ability to support aquatic ecosystems, and aquatic life. Each layer was divided by percentiles into five scores, with a score of one (1) representing good water quality, and five (5) representing impacted or degraded water quality. These scores indicated a watershed's ability to meet designated uses or act as a natural resource. The initial assessment targeted eleven 8-digit watersheds within Indiana for priority funding. In the summer of 1999, the workgroup used additional layers to evaluate each of the 361 11-digit hydrologic unit watersheds in Indiana for resource concerns and stressors. This assessment provided information at the local level in order to prioritize needs and allocate resources to address water quality issues. Table 8 provides the results of the 2000-2001 UWA for the Indian Creek Watershed. The parameters of greatest concern within the Indian Creek Watershed include aquifer vulnerability, surface drinking water intakes, and septic system density.

Table 8. Indian Creek Watershed Unified Watershed Assessment results (2000-2001)

Data Layer	What it tells us	Score
Recreational Use Attainment (Body Contact)	Whether the waters meet designated recreational uses for full-body contact; based on *E. coli* and other measures. The 303(d) listed waters that did not support recreation were included in this assessment.	3

Data Layer	What it tells us	Score
Aquifer Vulnerability	Level of concern regarding protection of groundwater for drinking and other uses.	4
Residential Septic System Density	The density of private septic systems; may indicate potential surface water and groundwater quality problems.	4
Critical Biodiversity Resources	Level of concern for reported endangered and threatened species and critical biological communities.	2
% Cropland	Reflects the potential for crop production impacts on a watershed.	2
Surface Drinking Water Intakes	Level of concern regarding drinking water protection in regards to surface water.	4
Urbanization	Reflects the potential for impacts on a watershed due to run-off from developed areas.	2
Livestock Production	Reflects the potential for livestock production impacts on a watershed.	2
Mussel Diversity	Incidence of fresh water mussel beds, with consideration given to the rarity and diversity of the species found. In this case no data may have meant no record, or may have meant that there were no mussels found.	ND
Aquatic Life Use Support	The livability of the water column for aquatic life; whether the waterbody meets designated use for aquatic life; made up of many metrics related to physical, chemical, and biological characteristics of the water. The 303(d) listed waters that did not support aquatic life were included in this assessment.	3
Stream Fishery	Measure of the small mouth bass community in streams. Score indicates recreational stream fishery resource.	ND
Mineral Resource Extraction	Reflects the potential for mineral resource extraction impacts on a watershed.	1
Lake Fishery	Large mouth bass harvest information for lakes only; a measure of fish diversity and fish community health. Score indicates quality of recreational fishery resource.	2
Eurasian Milfoil	Lakes affected with Eurasian Water Milfoil, an invasive exotic; this	ND

Data Layer	What it tells us	Score
	is an indicator of the impact of recreational use by boats.	
Lake Trophic Scores	Lake condition based on trophic scores, containing several metrics; an indicator for the rate at which a lake is aging due to inputs of nutrients and other factors.	2
Score: 1 = good water quality; 5 = severe impairment; ND = no data		

Aquifer vulnerability indicates the concern level regarding protection of groundwater used for drinking or other uses. Indian Creek's score of 4 was based upon a subjective ranking of the sensitivity of the aquifer in question and the connectivity of aquifers and surface waters.

Surface drinking water intakes indicates the concern level of protecting surface waters with regard to drinking water use. Indian Creek scored a 4 on this parameter, which indicates a concern for drinking water resources from both surface and groundwater.

Septic system density indicates the potential for water quality problems due to the density of private septic systems. Scores were based upon an EPA standard that considers more than 40 septics per square mile to be a water quality threat. Based upon this standard, an 11-digit watershed with a septic density of 40 septics per square mile scored a 5. Indian Creek scored a 4 for this parameter.

F. Johnson County Board of Health: Groundwater Study

In late spring of 1991 and 2000, the Johnson County Board of Health conducted a voluntary groundwater study of private wells throughout the county. Water samples were collected and tested for nitrate, alachlor, and atrazine. Nitrate is naturally occurring in soils but is also applied to farm fields to encourage crop growth. Alachlor and atrazine are major chemicals found in pesticides. The results indicated that these major farm chemicals did not turn up in large amounts in the county's groundwater supply. In 1991 (n=211), 4% of the wells tested over the Indiana water quality standard for nitrate, set at 10 milligrams per liter. In 2000 (n=139), only 1% of the wells tested over the nitrate standard. In 2000, only 6% of the wells tested did not meet the Indiana standard set for pesticides, a maximum contaminant level of two parts per billion.

In addition, the Health Department completed bacteriological analyses of 17 wells throughout the county in May 2000. Coliforms, a group of microscopic bacteria, are present in the digestive tracts and feces of humans and warm-blooded animals (cats, dogs, livestock). The results showed that eight of the 17 wells tested unsatisfactory for the total coliforms present. The Health Department followed up with unsatisfactory cases to ensure the water was disinfected.

G. 2007 Cropland Transect Survey

In the spring of 2007, the Johnson County SWCD and NRCS employees conducted a cropland transect survey throughout Johnson County. Also in the spring of 2007, the Morgan County SWCD and NRCS employees conducted a cropland transect survey throughout Morgan County. This roadside survey is designed to collect information about tillage practices within the county on an annual basis, if possible. Based upon crop residues, employees classified approximately 315 fields in Johnson County and 284 fields in Morgan County into one of the following tillage methods: no-till, strip-till, ridge-till, mulch-till, reduced-till, or conventional till. The following set of standardized conservation tillage system definitions were taken from the National Crop Residue Management Survey (CTIC, 1994).

Conservation tillage includes any tillage and planting system that covers 30% or more of the soil surface with crop residue, after planting, to reduce soil erosion by water. Where soil erosion by wind is the primary concern, a conservation tillage system is any system that maintains at least 1,000 pounds per acre of flat, small grain residue equivalent on the surface throughout the critical wind erosion period. Conservation tillage practices include no-till, ridge-till, and mulch-till systems. In a no-till system, the soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width. Planting or drilling is accomplished using disc openers, coulter(s), row cleaners, in-row chisels, or rototillers. Weed control is accomplished primarily with crop protection products. Cultivation may be used for emergency weed control.

In a ridge-till system, the soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width. Planting is completed on the ridge and usually involves the removal of the top of the ridge. Planting is completed with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with crop protection products (frequently banded) and/or cultivation. Ridges are rebuilt during row cultivation.

Mulch-till systems use full-width tillage that involves one or more tillage trips, disturbs the entire soil surface, and is done prior to and/or during planting. Tillage tools such as chisels, field cultivators, disks, sweeps, or blades are used. Weed control is accomplished with crop protection products and/or cultivation.

Tillage systems that cannot be classified as conservation tillage include reduced-till and conventional till. A reduced-till system uses full-width tillage that involves one or more tillage trips, disturbs the entire soil surface, and is performed prior to and/or during planting. There is 15-30 percent residue cover after planting or 500 to 1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with crop protection products and/or row cultivation.

Conventional or intensive till systems also use full-width tillage that involves one or more tillage trips, disturbs the entire soil surface, and is performed prior to and/or during planting. There is less than 15 percent residue cover after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with crop protection products and/or row cultivation.

The data collected during the transect survey provides accurate records on the adoption of conservation tillage methods. It also provides information to SWCD's and other agencies in establishing priorities for improvement. Further, it evaluates the progress in reaching county or state goals for tolerable soil loss.

Conservation tillage systems can help mitigate the impact of soil erosion and reduce run-off. At the field level, erosion causes the loss of productive land and reduces infiltration rates. Productive soil is important because it covers seedlings and provides support as they grow. Soil particles also hold on to nutrients, either applied or found naturally, and gradually deliver them to growing plants (Daily et al., 1997). As soil particles wash into a waterway, water quality is reduced. Aquatic communities may be impacted as increased sediment levels may smother spawning beds, reduce sunlight available for photosynthesis, or increase water temperatures. Further, sedimentation may increase flooding potential due to barriers in water flow and increase costs for maintenance (e.g. dredging).

H. 2007 Tillage Data

According to the Indiana 2007 tillage data, Johnson County ranks 70 out of the 90 counties (two counties not surveyed) for the percent of corn acres in no-till and 67 out of 90 counties for the percent of soybean acres in no-till. This shows a 15% improvement from 2002 for corn and no change for soybeans. Morgan County ranks 46 out of the 90 counties for the percent of corn acres in no-till and 33 out of 90 counties for the percent of soybean acres in no-till. This is a 20-40% increase for no-till corn and a 40-80% increase for no-till soybeans from 1990 transect data. Figures 24 and 25 show the distribution of acres in corn and soybeans for no-till, mulch till and conventional in Johnson County and Morgan County, respectively. For both counties, a much larger percent of acres in soybeans employs no-till methods over acres in corn. According to Purdue University (November 2000), management skills for no-till corn are more demanding, thus possibly contributing to a slower implementation than for soybeans. Also, farmers may see more positive trends in yields and lower costs with no-till beans than with corn, and no-till beans are also better able to deal with weather-related stress than no-till corn.

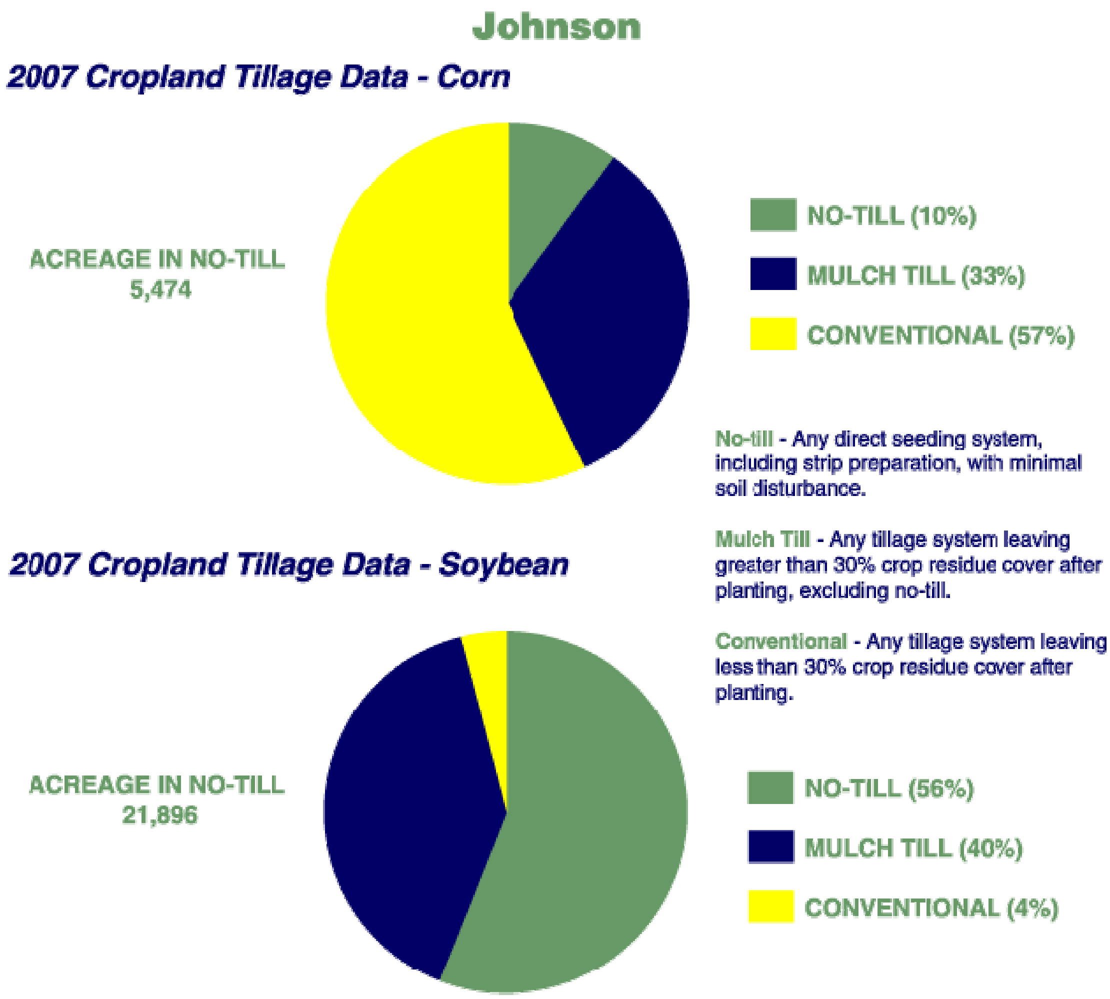

Figure 24. Johnson County 2007 tillage Data (ISDA, 2008)

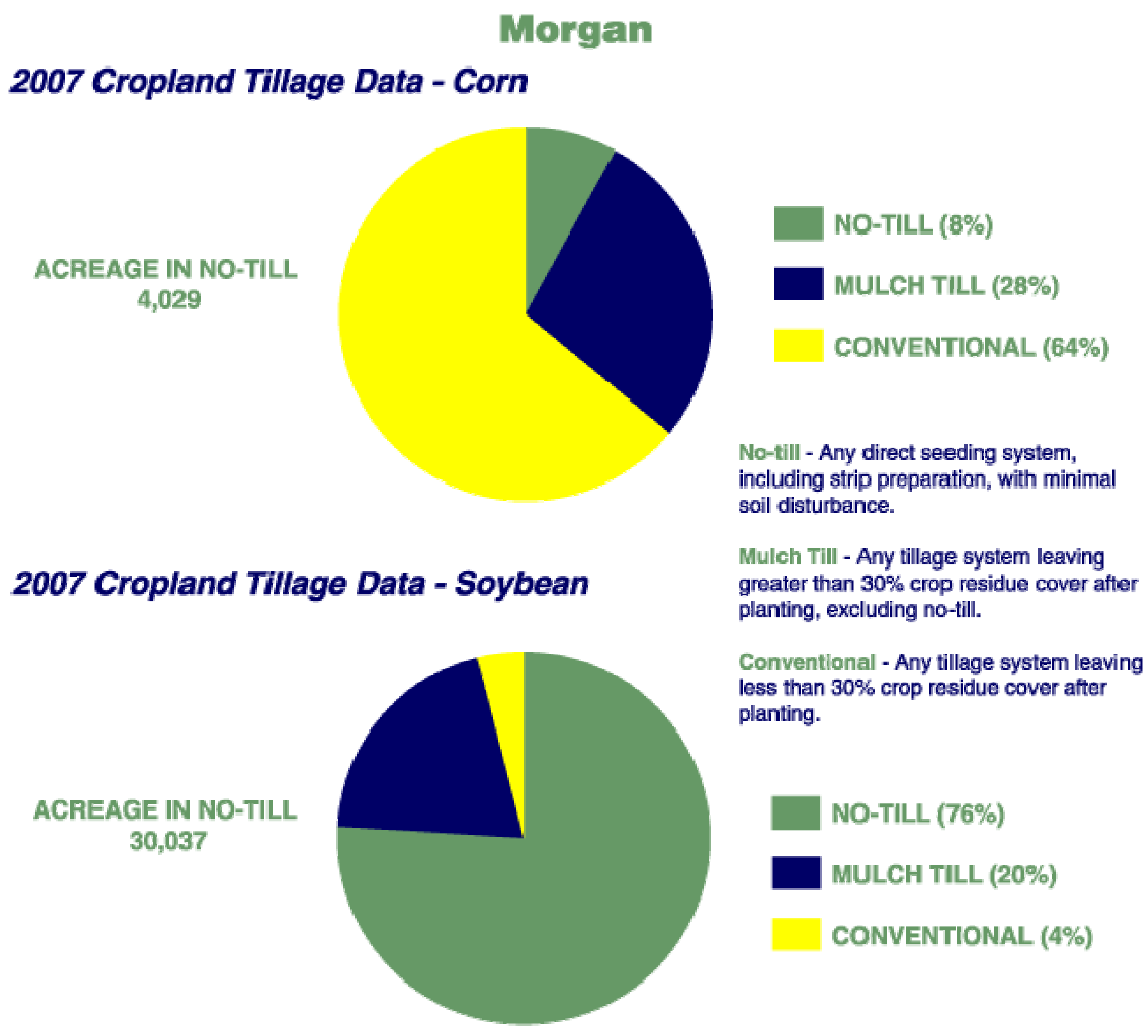

Figure 25. Morgan County 2007 Tillage Data (ISDA, 2008)

I. Indian Creek Watershed: Work Plan for Watershed Protection and Flood Prevention, November 1965

The *Indian Creek Watershed: Work Plan for Watershed Protection and Flood Prevention* report, dated November 1965, was the joint effort of the Morgan, Monroe, Johnson and Brown County Soil and Water Conservation Districts to address issues of "damage to crop and pasture from flooding, land damages in the flood plain, and a lack of recreational facilities" in the Indian Creek Watershed. The plan proposed the creation of an Indian Creek Conservancy District to serve as sponsor of the installation of "conservation measures having hydrologic, erosion, and sediment control significance in reducing floodwater damage, and those which contribute to achieving agricultural water management benefits" for an estimated $3,208,500, including funds for forestry measures. The conservation measures included both land treatments and structural facilities, including man-made lakes and flood-control structures.

Rapidly moving overland flows from heavy downpours moving down steep terrain onto flat bottomland resulted in flood damage to crops and pasture, inundation of roads, and deposition of sediment in the form of sand and fine gravel on cropland and in stream channels. Such damage created a negative economic impact on agricultural production, roadways and bridges, and decreased stream channel capacity for future flood waters. The report also identifies the lack of recreational facilities in the watershed for an anticipated growing population in the area as further justification. The remedies proposed by the report included conservation rotations, contouring and contour strip cropping, cover crops, open ditches, tile drains, grass waterways and diversions and erosion control structures. Woodland treatment and management was recommended on 7,550 acres to include exclusion of livestock, tree planting, wildlife habitat development, ditch bank seeding and critical area seeding. Structural measures included eight floodwater retarding structures and two man-made lakes as recreational facilities and floodwater storage. The floodwater retarding structures would be capable of storing floodwaters with controlled release. Appendix B shows the locations of the proposed structures and floodplain benefiting from this project. Based on the information contained in the report and facilities currently in place, the intentions of this plan were never realized. Since the report was released, roadways have been improved and elevated above damaging overland flows, and bridges have been reinforced or rebuilt, some of the cropland may have been given over to pasture or reforestation, and farmers may have installed measures at their own expense or abandoned farming the flood-prone land altogether.

Erosion remains an issue in the watershed. It is one of the primary concerns identified by the Steering Committee and physical evidence found by the visual assessments confirmed its persistence.

J. Visual Assessment Results

As part of the watershed assessment, a windshield survey was conducted to obtain direct visual observations of streams and the surrounding land. In order to efficiently observe as many streams and creeks as possible while respecting private property, observations were made from bridges. Observations were made both upstream and downstream at 65 sites throughout the watershed. The TMDL sites were included in this visual assessment, however, three were inaccessible by public road and therefore not assessed. Of note, a high percentage of streams in the watershed are inaccessible by public roads and therefore not subject to first-hand assessment. Examination of aerial photographs and first-hand knowledge of local residents will play an important role in developing a more conclusive assessment.

Observation sites were photographed with a digital camera, and survey observations were recorded on data sheets. The original data sheets and climate data for the observation periods are on file in the Johnson County SWCD office. Parameters recorded for each observation include basic stream characteristics, water appearance (clarity), adjacent land use, riparian buffer width, percent summer canopy cover, and potential sources of pollution such as the presence of trash, livestock access to the stream, and streambank erosion.

The survey was conducted during the summer of 2007 to observe streams and surrounding land uses. Climatic conditions were also observed as temperature and precipitation effect many characteristics of the stream habitat. Any combination of high or low temperatures and high or low precipitation amounts can effect stream character from depth and flow velocity to clarity and algal growth. Survey results were compiled in a Microsoft Excel spreadsheet and exported to ArcView GIS. This section provides an overview of the survey results.

J.1. Water Clarity

The clarity of the water can indicate a number of things about water quality. Water becomes turbid or cloudy when suspended particles obscure sunlight from reaching the stream bottom. These particles can consist of clay, silt, and organic materials that are often washed into the stream from streambanks or surrounding land. Too much suspended sediment can threaten the health and habitat of aquatic plants, fish, and macroinvertebrates. These soil particulates can also carry bacteria, chemicals, and nutrients into streams that encourage the growth of algae and other unwanted organisms.

Due to the scope of the project, specific measurements of turbidity and transparency were not conducted. Instead, a visual observation of water clarity was made. Water was classified as clear (stream bottom visible, no algae or other material on surface) or turbid (cloudy water, stream bottom obscured).

Water clarity can be influenced by several factors, particularly precipitation. Rain events can stir up existing creek sediment and introduce new silt through run-off. Since sediment is a non-point source pollutant, the specific source of sediment in the streams is difficult to determine. (Figure 27). Since climate records show a record low for precipitation during the assessment period of the summer 2007, causes for turbid waters are even more difficult to ascertain.

Figure 27. Turbid water from unidentifiable sources, Summer 2007

Discolored water was also noted, often seen in association with trash in the stream. Algae, foam or oily sheens were also seen in some waters with discoloration, such as Figure 27 above and Figure 28 below. Discoloration can result from trash deposited in the stream or a chemical or biological pollutant introduced from another source. Pollutants that discolor waters in a stream may be toxic to aquatic life, interfere with their reproduction or maturation, or disrupt feeding habits and to human health.

Figure 28. Discolored water from unknown sources, Summer 2007

The presence of algae was also noted during the visual assessment of water clarity (Figure 29). Most of the sites with algae present were adjacent to or in close proximity to residential or agricultural areas. Algae are microscopic plant organisms that can reproduce rapidly and form large visible clumps known as blooms. High nutrient levels, particularly phosphorus, are key to algal growth. High nutrient levels occur when streams receive run-off or leaching from nutrient-rich sources such as fertilized fields, lawns, manure, storm drains, septic systems, or sediment. Algae usually does not produce toxic substances, but can deplete oxygen supplies when large amounts of algae decay in streams. The decomposing algae can deprive aquatic organisms of their oxygen, and the decay can also produce an unpleasant smell.

The absence of water or extremely low flows was also noted at many sites, including TMDL sites, as a result of the persistently above-average high temperatures and below-average precipitation during the summer of 2007. The Indiana State Climate Office Monthly Weather Reports show drought conditions during this period progressed from abnormally dry to moderate in June to severe by mid-August.

Figure 29. Summer 2007 observations of algal growth near residential and agricultural uses

Algae are most productive and noticeable when streams are warm, clear, and calm. The growth of most algal species is limited in cool water temperatures, and turbid water prohibits growth by blocking sunlight from algal organisms. Calm water allows individual algal organisms to rise to the surface and absorb the maximum amount of sunlight. When on the surface, microscopic algal organisms often join together to form a visible scum, which was noted during the visual assessment.

Algal growth was observed during the summer 2007 survey, most often in smaller headwater streams (Figure 30). These headwater stream sites where algae were observed possessed many beneficial characteristics for algal growth. Temperatures during July and August of 2007 often exceeded 90 degrees F and water was mostly clear and calm. In addition, most sites provided plenty of exposure to sunlight; of sites where algal growth was observed, 63% were observed to have very little (less than 20%) stream surface shading. Also, the flow in these smaller streams decreased during the late spring and summer months of 2007, so the water surface was usually very calm. The results also indicate that nutrients were readily available in July and August to support algal growth in the streams.

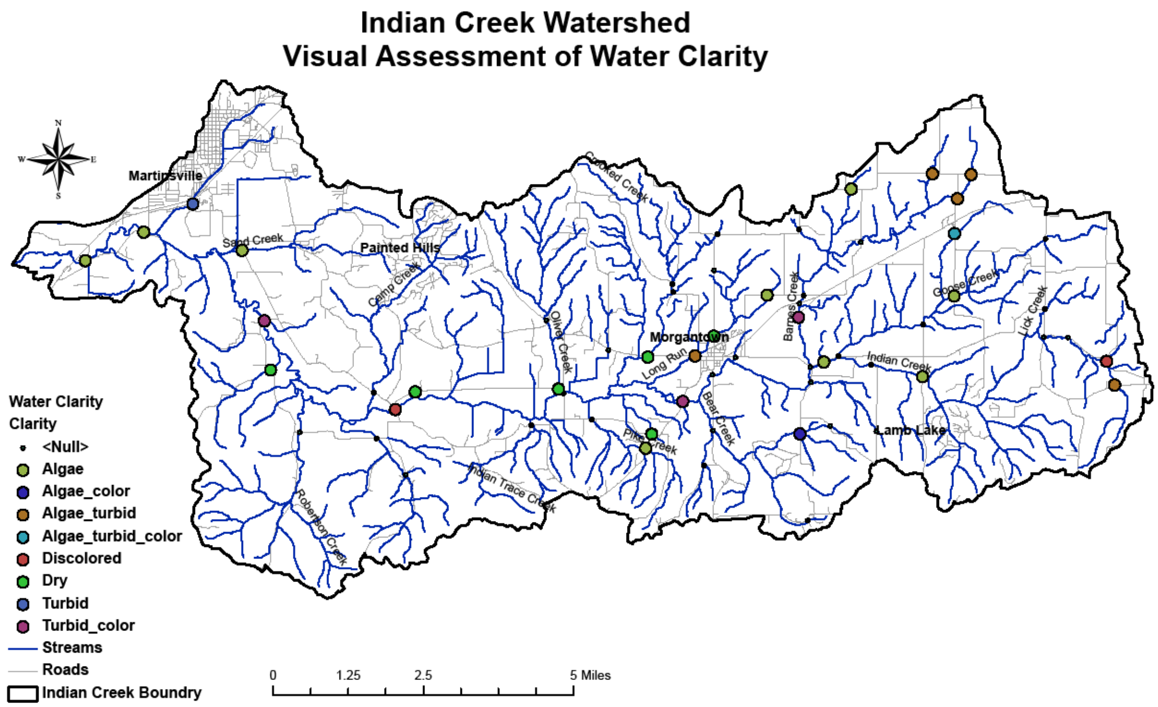

Figure 30. Water appearance, Summer 2007

J.2. Riparian Buffer Width and Percent Summer Canopy

Riparian buffer refers to the zone of land directly adjacent to stream channels. When left undisturbed and maintained at an optimum width of 30 to 50 feet, this buffer zone helps maintain stream water quality and healthy aquatic life. Tall grass or woody vegetation along this riparian buffer provides important water quality benefits. Vegetation filters sediment, nutrients, and other pollutants from stormwater run-off, and it reduces erosion potential by stabilizing streambanks. In addition to direct water quality benefits, vegetated buffers provide habitat for wildlife, help shade the surface water and reduce the stream temperature, and help slow and store floodwater.

A visual survey of the riparian buffers within the watershed provided a rough estimate of the watershed's capacity to provide these benefits. Results in Figure 31 show that almost 85% of the streams within the watershed provide a vegetated riparian buffer, with 24% of that number providing buffers from 15 to 30 feet wide and 43% in excess of the optimum 30 feet or greater. Figure 32 shows examples of sites with wide riparian buffers and good summer canopy. Sites that lacked riparian buffers were located in residential areas (Figure 33), adjacent to major thoroughfare highways or straddled by pasture land (Figure 34).

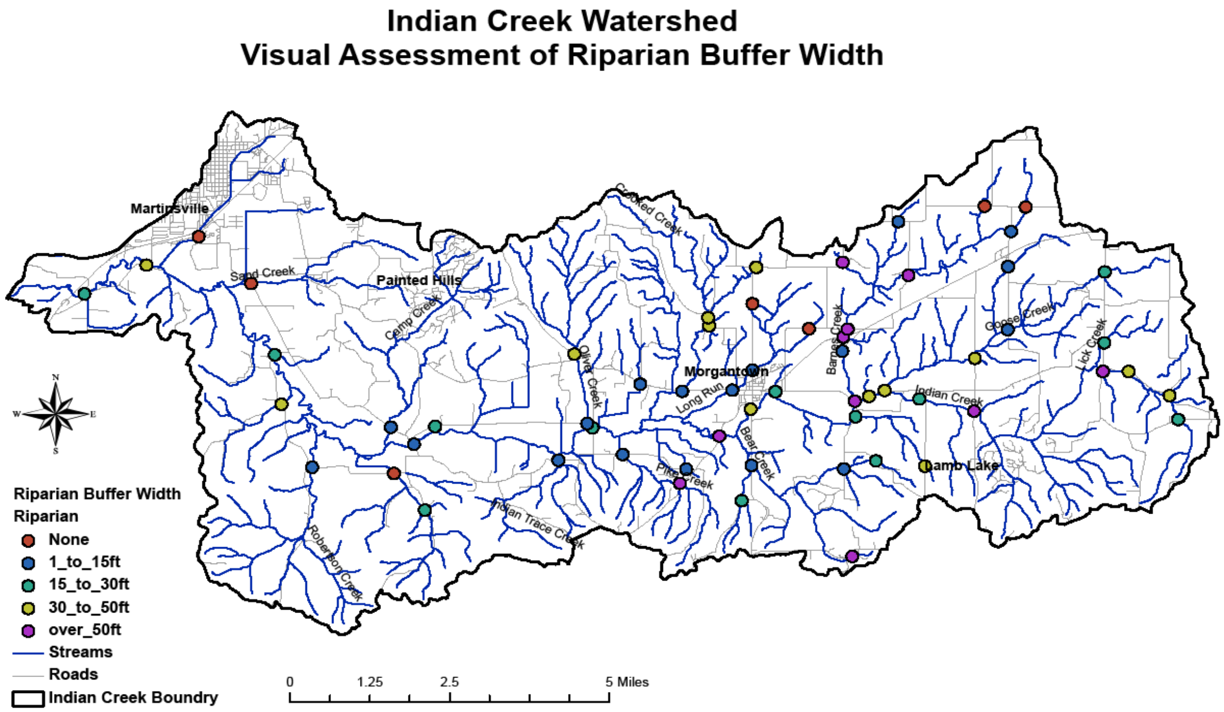

Figure 31. Map of vegetated riparian buffer widths

Figure 32. Stream segments with wide riparian buffer and good summer canopy

Figure 33. Stream segments through residential areas with no riparian buffer or summer canopy

Figure 34. Stream segment straddled by pasture with no riparian buffer or summer canopy

Within the city limits of Martinsville, including the developing area east and southeast of State Road 37, streams lacked riparian buffer and adequate summer canopy due to residential lawns and commercial development up to the streambanks. These streams were also often lined with riprap and served as roadside ditches. The length of streams in this area however is relatively small compared to the extensive multi-tiered stream systems spawned by the rolling and forested hills found throughout the majority of the watershed. The largest concentration of agricultural and more densely populated areas are found along the Indian Creek through the central part of the watershed and either side of the Johnson-Morgan County line where less dramatic changes in elevation are found. In the hillier areas of the watershed, forests are more abundant and wider riparian buffers are maintained. Agricultural land is often cited as a major contributor of nutrients into streams via stormwater runoff. A lack of adequate riparian buffers between streams and agricultural land can result in stream contamination of nutrients from fertilizer and *E. coli* bacteria from land-applied manure used as fertilizer.

Canopy cover is related to woody riparian buffer vegetation. The percent summer canopy cover refers to the amount of stream that is shaded by surrounding vegetation. Figure 35 shows the distribution of percent canopy cover for sites assessed during the summer of 2007. Stream shading is important in preventing excessive water temperatures during the summer and providing fish habitat. Excessive water temperature can lead to depleted oxygen supply in streams, especially when stream flows are low. Extreme temperatures can adversely affect aquatic life reproduction and feeding habits.

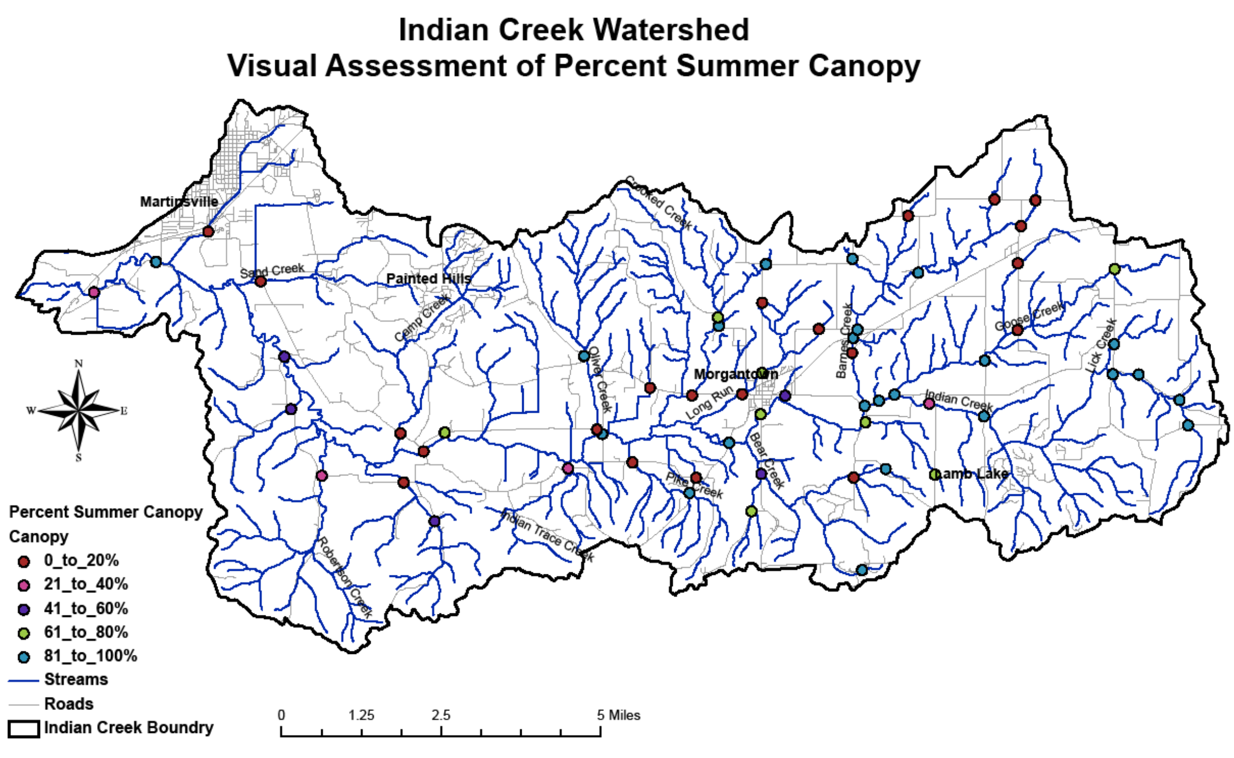

Figure 35. Percent Summer Canopy Cover, Summer 2007

Streams with well developed riparian buffers often provide abundant canopy cover. The percent of cover is dependent on the height and density of the trees along the streambank. Figure 32 above shows sites with 100% cover while Figures 33 and 34 show sites with no canopy cover due to a total lack of trees or shrubs.

Livestock with direct access to streams can cause water quality problems for humans and aquatic life and habitat destruction of both the stream channel and riparian buffer. Trampling in streambeds can result in destruction of streambed substrate and suspension of solids in the water. Although it is tempting to assume that livestock in streams means direct deposit of waste into streams, research conducted by the USDA Natural Resources Conservation Service (NRCS) determined that cattle access watercourses only for drinking or crossing and seldom defecate or urinate while in the stream. Their conclusion was that cattle may stir up bacteria in the stream water but may not necessarily be a direct source. Livestock travel routes to, around and across streams can cause trampling of riparian vegetation resulting in streambank erosion and an increased potential for livestock waste deposited on the land to be carried into streams by stormwater runoff.

During the visual assessment, the type of livestock was recorded and classified as direct access if livestock was observed in streams or nearby with unobstructed access to the stream. If no livestock was present but signs of livestock was evident, such as hoof tracks, feeding troughs, barns or waste, the site was recorded as potential access. Figure 36 shows the locations of such noted sites and type of livestock access. Of further note, woody vegetation riparian buffers were absent from sites where streams were accessible by cows. Those streambanks were also notably more eroded. Figure 37 shows two such sites with streams running through cow pastures. Figure 38 shows a stream site with visible hoof tracks on the stream bank and in the stream bed. Horse accessible sites, however, did support some woody vegetation riparian buffers and much less bank erosion.

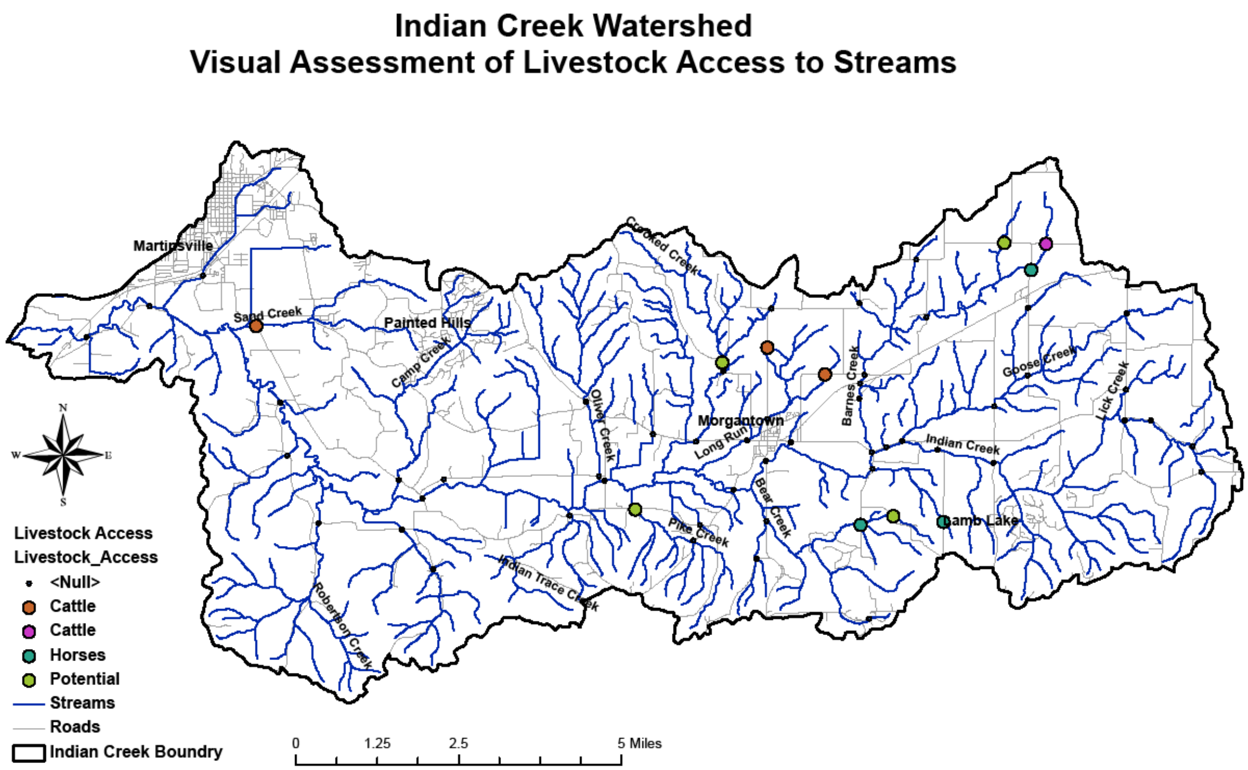

Figure 36. Livestock access to streams in watershed, summer 2007

Figure 37. Sites with cow access to streams, summer 2007

Figure 38. Site with hoof tracks on stream bank and in stream bed, summer 2007

J.4. Streambank Erosion

In addition to erosion from livestock access, stream banks are subject to erosion from flowing water and stormwater runoff. Fast-flowing streams can scour and undercut their banks, contributing to high sediment loads to the stream. As stream flows and velocity are returned to normal, sediments are deposited downstream, contributing to lower streambed capacity and higher bankfull conditions. Streambank erosion is a natural process that can be accelerated by insufficient riparian buffers and increased volume and velocity from urban development.

Excessive streambank erosion can lead to a number of water quality problems. Eroded streambanks can result in the loss of vegetation and habitats for aquatic organisms. Suspended sediments in streams can reduce water clarity which interferes with aquatic organisms feeding and reproduction habits. Sediment can also carry chemicals, nutrients and other pollutants into the streams, adversely affecting water quality.

Stream bank erosion was categorized for this assessment based on the degree of erosion observed. Figure 39 shows the occurrence of stream bank erosion ranging from none or rare to heavy or artificially reinforced. The most severely eroded banks were most often found where banks were steep or riparian buffers were insufficient or absent. Figure 40 shows examples of steep banks and lack of riparian buffer protection.

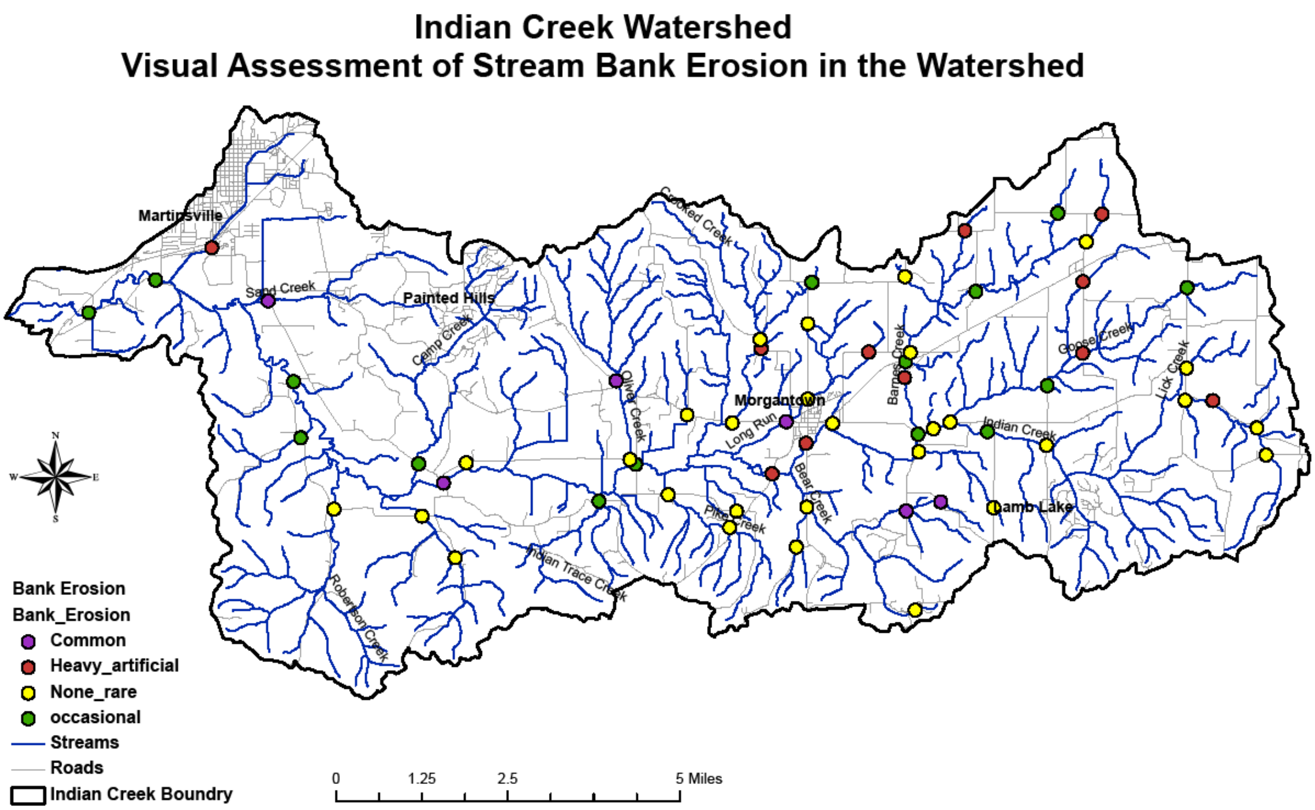

Figure 39. Map of Stream bank erosion, summer 2007

Figure 40. Stream bank erosion on steep banks, summer 2007

J.5. Trash

The presence of trash was noted during the visual stream assessments. Trash can be introduced into the stream directly, carried by run-off or wind-blown, or carried by the stream itself under flood conditions. Once in the water, trash can float along the surface or sink to the bottom. In either case, trash can interfere with aquatic habitats, impeded navigation, decompose, and harm wildlife. Trash can also contain substances or chemicals harmful to aquatic organisms and wildlife. In addition, trash degrades a stream's aesthetic benefits.

Although not in abundance at any one location, trash was observed throughout the watershed. Figure 41 shows those locations where trash was observed in streams or near enough to pose a threat to stream waters via run-off.

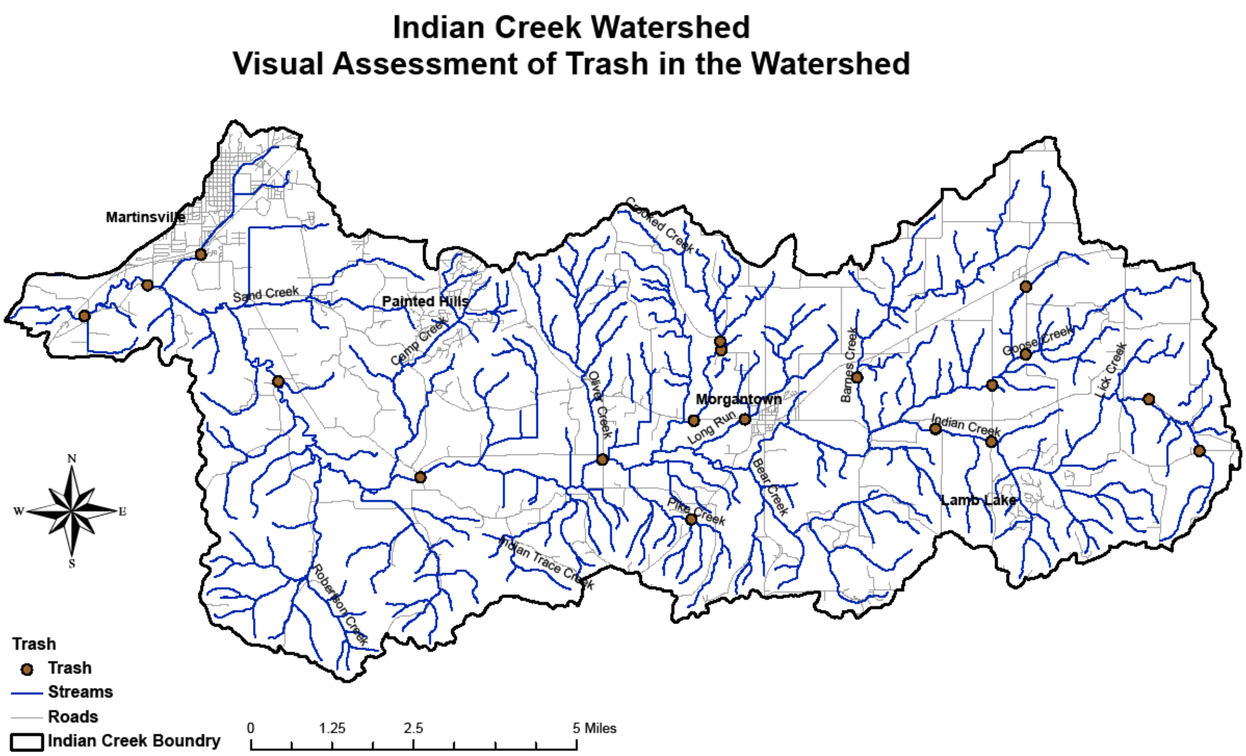

Figure 41. Trash located in the watershed

Trash was most often noted near bridges and roads, usually as beverage or food containers. This litter was probably thrown from vehicles on the roadway, either thrown directly into the streams or carried via wind or stormwater run-off from roadside areas. Figure 42 shows a site with typical roadside trash. Less typical but observed at least twice were larger objects, such as tires, appliances, steel drums, and a mattress. Given their size and proximity from the road, these objects were most likely dumped in the stream or on its banks. Figure 43 shows some of the larger objects observed in the watershed streams. These larger objects were most often observed in more secluded areas of the watershed where dumping was less likely to be witnessed. Discolored or turbid water near dumped objects was also frequently observed.

Figure 42. Roadside trash in the watershed, summer 2007

Figure 43. Large objects (tires, drums, appliances) dumped into and near watershed streams, summer 2007

Section V: Development of Problem Statements and Goals

The Indian Creek Steering Committee (ICSC) investigated the TMDL, benchmark data, and existing water quality information to determine the scope of each water quality concern and develop problem statements that adequately summarized the main concerns within the watershed. The following paragraphs and matrix summarize the discussions and decisions made by the Steering Committee.

A. Problem Statements

The TMDL for *E. coli* established the presence of high concentrations of *E. coli* in the watershed waters. Concerns about a history of sanitary sewer overflows into watershed waters from the Morgantown WWTP and the existence of septic systems throughout the watershed substantiated a need to address *E. coli* contamination. Based on this evidence and the effect s of *E. coli* contamination, the ICSC adopted the following problem statement:

- High concentrations of *E. coli* can result in unhealthy conditions for consumption and recreational uses in the Indian Creek Watershed.

Additional concerns identified by the ICSC arose from first-hand knowledge of problems in watershed waters and professional knowledge of current environmental issues. The group identified soil erosion into streams as one such primary concern. Many causes of erosion were identified and the effects of erosion on both the water and the land resulted in the development of the following multiple problem statements:

- The loss of excess soil and nutrients to the streams reduces both water and soil quality.
- Sedimentation in streams reduces channel capacity and increases the potential for flooding.
- Increased turbidity impairs aquatic life habitats and may interfere with feeding and reproduction.

Although the group initially identified nutrients in the waters as a concern, a lack of monitoring data redirected the concern to the presence of excessive aquatic plant growth as an indicator of nutrients in watershed waters. Visual observation of algae on water surfaces and coating rocks in streambeds and other aquatic plants substantiated the concern and the following problem statement was developed:

- Excessive aquatic plant growth, an indicator of excess nutrient load, has been observed in the Indian Creek Watershed.

Visual observation also confirmed the presence of trash and illegal dumping of other objects into watershed waters and along stream banks. The following problem statements reflect the effects of trash on watershed waters:

- Illegal dumping and litter raises concerns regarding water quality, safety, quality of life and property values.
- Trash in waters can contain harmful chemicals detrimental to recreational uses and aquatic life.

The fifth concern, exotic or invasive species, was included primarily as a preventative measure. Although the benchmark data did not identify any specific exotic or invasive species, the introduction of such species via the lakes in the watershed does present a very real possibility for future problems. The group chose to use the opportunities of this Watershed Management Plan to implement preventative measures now rather than face corrective measures later. The group felt that by addressing exotic or invasive species here, preventative measures could be introduced now and would more likely be included in any future funding or management plans for the watershed. The problem statement addressing exotic or invasive species is as follows:

Exotic and/or invasive aquatic and terrestrial species have been found or have the potential to be introduced throughout the Indian Creek Watershed and have been linked to ecosystem disruption, economic loss, loss of aesthetics and possible harm to human health.

B. Identifying Causes, Sources and Critical Areas

The first step toward developing goals was to identify potential causes or sources of each concern. Table 9 shows the potential causes or sources identified by the ICSC.

Table 9. Water Quality Concerns, Stressors and Problem Statements

Water Quality CONCERN	***Stressor***	***Problem Statement***
E. coli	Livestock access to streams Failing septic systems Or straight pipes WWTP bypass Pet waste left on lawns	High concentrations of E. coli can result in unhealthy conditions for consumption and recreation uses.
Sediment in streams	Lacking or inadequate riparian buffers	Increased turbidity impairs aquatic life habitats and may interfere with feeding and reproduction.
	Livestock access to streams	Sedimentation in streams reduces channel capacity and increases potential for flooding.
	Natural stream bank erosion	The loss of excess soil and nutrients to the streams reduces both soil and water quality.
	Erosion from adjacent farm land	Sedimentation in streams reduces channel capacity and increases potential for flooding.
Excessive aquatic plant growth	Nutrient-laden soil eroding from farmland	Excessive aquatic plant growth is an indicator of excess nutrients in water.
	Livestock access to streams	Excessive aquatic plant growth can degrade the health of the water.
	Runoff from lawns	
Illegal dumping and littering	Roadside littering, landowner dumping	Illegal dumping and litter raises concerns regarding water quality, safety, quality of life, and property values.
	Illegal dumping	Trash in the waters can contain harmful chemicals detrimental to recreational uses and aquatic life.
Exotic and/or invasive aquatic and terrestrial species	Transported on recreational vehicles	Exotic invasive aquatic species can cause ecosystem disruption, economic loss, loss of aesthetics, and possible harm to human health.
	Residential water gardens	
	Dumped bait or aquariums	

B.1. E. coli Sources

B.1a. Livestock Access to streams

The visual stream assessments conducted by watershed staff confirmed 11 sites where livestock had direct access or potential access to streams and animal waste could enter the streams either directly or as a result of storm water runoff from land adjacent to the streams. Additional visual assessments by members of the Steering Committee confirmed widespread occurrence of free-roaming livestock, including cattle, horses, llamas, sheep and elk. There were also at least five horse boarding facilities observed throughout the watershed. It was not determined how these operations dispose of animal waste collected from stalls or fenced areas. Agricultural land used for pasture or grassland was identified as the critical for E. coli from livestock or boarding facilities. Figure 44 below shows the location of those areas. As shown on Figure 44, the Goose/Barnes Creek sub-watershed contains the highest percentage of land use devoted to pasture/grassland and Bear Creek/Long Run has the second highest. The IDNR Prioritization Study of Riparian Buffers, detailed below, also identified these sub-watersheds as the first and second highest potential sources for non-point source pollutants. Based on this information, these sub-watersheds will be the highest priority areas for targeting of this concern, specifically addressing pastures adjacent to streams.

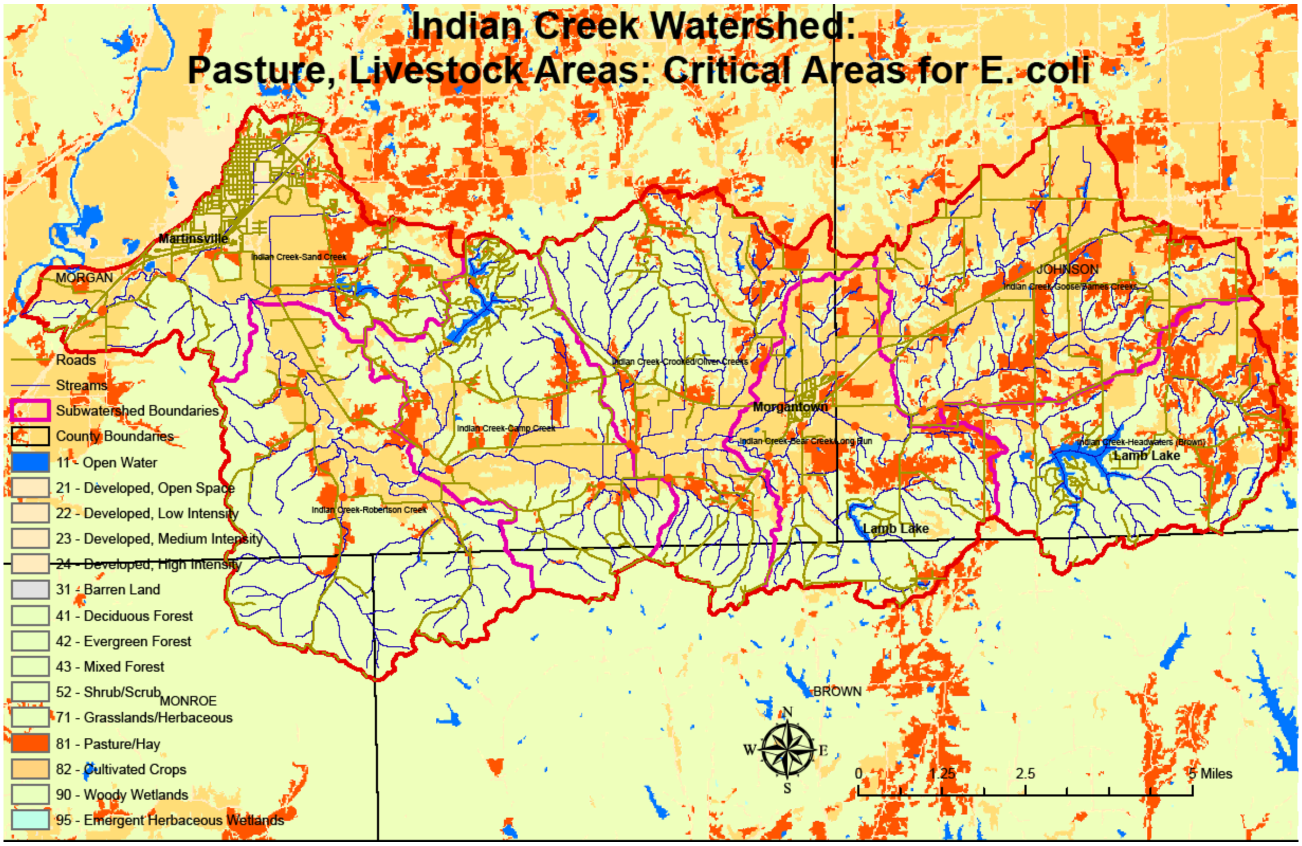

Figure 44. Indian Creek Watershed: Pasture, livestock critical areas for E. coli (areas highlighted in orange)

B.1b. Septic Systems failures in the watershed

Johnson and Morgan County health departments were unable to confirm any septic system failures in the watershed. Painted Hills stated casual incidents of septic system failures, while the Lamb Lake community has implemented a very proactive program of septic system maintenance and inspection requirements. Since only Morgantown and Martinsville are connected to sanitary sewers, septic systems are located throughout the entire watershed and include residential, agricultural, recreation, and transportation related land uses. Johnson County is the only county within the watershed that has mapped septic systems in a GIS format. Figure 45 below shows the approximate locations of septic systems in the Johnson County area of the watershed. Points indicating the presence of a septic system only mark the property on which the system is located and not the exact location of the system in the ground. As shown on the map, septic systems are located on properties associated with all different land uses. Similar demographics throughout the watershed would indicate that locations of septic systems and land use associations would be similar to those found in Johnson County.

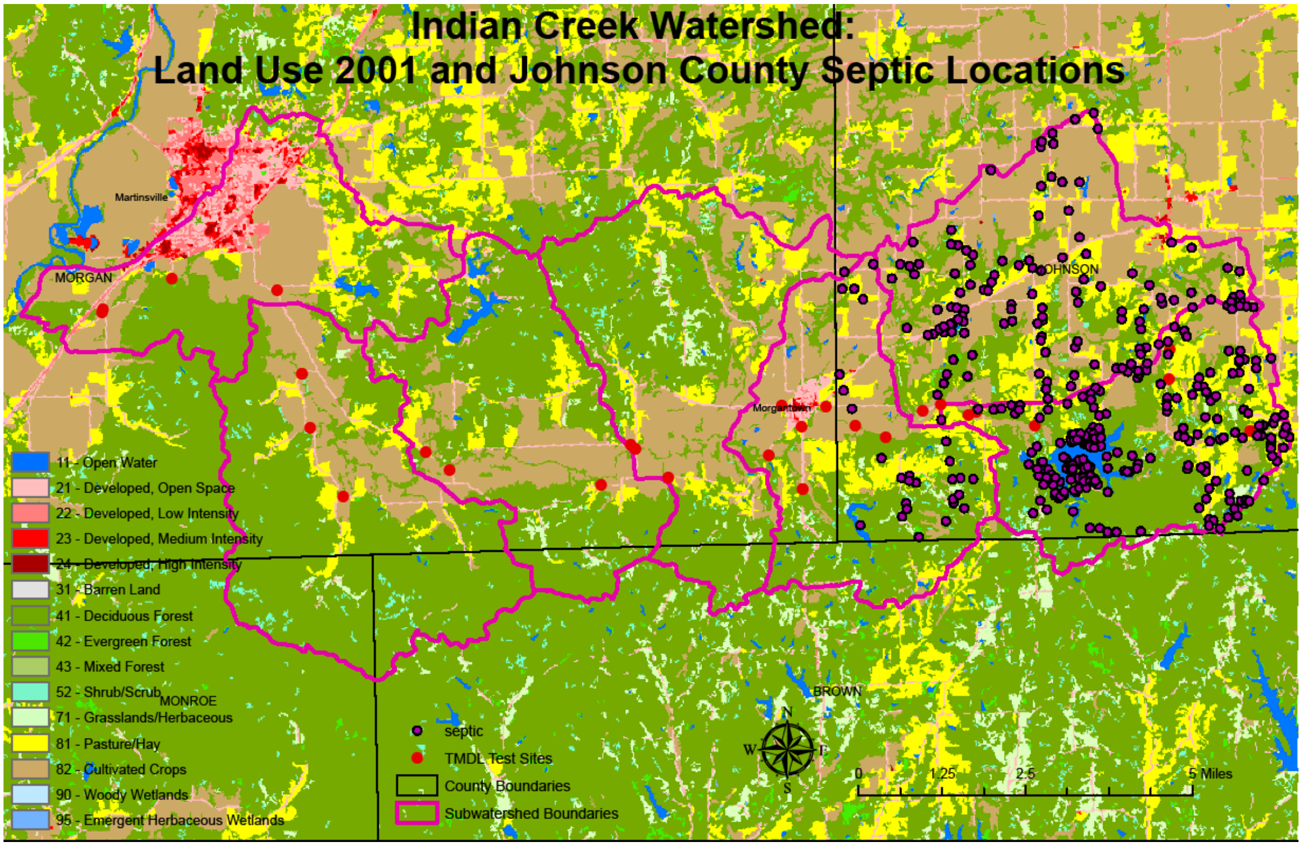

Figure 45. Indian Creek Watershed: Johnson County septic locations

Older septic systems would be at the highest risk for failure due to age and are typically located at older homes associated with farm properties since the area was initially settled by farmers. Denser residential areas such as subdivisions, including the lake communities, are newer and less likely to fail due to system age but may fail because, as shown in Table 5 above, many of the soils in the watershed have severe limitations for use as septic drainfields. Based on the area's demographics as summarized under Section III, Demographic History and Future Changes above, the population growth of the area has been under 1% for some time and is not anticipated to exceed that percentage due to a lack of major roadway access to the area. The planned development of residential subdivisions, listed below under Sediment and Soil Erosion, will all utilize on-site septic systems. Recognition of the impact of septic system failures on water quality will hopefully assure prudence when the county health departments approve septic systems for these residential developments. Four of the five listed planned subdivisions are in close proximity to a watershed water and are considered critical areas for E. coli.

B.1c. Permitted Facilities bypass

The Morgantown WWTP reported bypass of untreated wastewater to IDEM on six occasions in 2005, seven occasions in 2006 and one occasion in 2007. (The WWTP is currently under enforcement action by IDEM for bypasses.) This history of bypasses confirms the WWTP contribution to E. coli in the streams.

B.1d. Pet waste

Private properties were not trespassed to confirm presence of pet waste on lawns, however the survey of residents from the Morgan County fair show that residents do admit to leaving pet waste on lawns and free-roaming dogs were witnessed during the visual assessments. Pet ownership was also witnessed in the more urban areas, especially around Martinsville. General surveys of pet owners indicate that a majority of pet owners do not pick up after their pets and no dog parks or program discouraging that behavior exists within the watershed. Priority critical areas for this source of E. coli will concentrate on more densely populated areas closest to streams or open ditches, specifically the lake communities, subdivisions and urban areas of Martinsville.

B.2. Sediment and Soil Erosion Sources

B.2a. Soil Erosion and Construction Sites

During the visual stream assessments, five major construction sites were observed. Table 10 below lists those sites by sub-watershed, location of the site and proximity to watershed waters. As the table shows, only one site is not physically adjacent to a watershed water.

Sub-watershed	Project Name	Location	Proximity to stream
Goose/Barnes Creek	Lakes of Avallon residential development	North of 700 South, east of Morgantown	Goose Creek flows through site
Bear Creek/Long Run	St. John's Commons residential development	Morgantown Road just north of Morgantown	Tributary to Long Run flows through site
	Unknown name	North side of 700 South, east of	Not located near any waterway

		Morgantown	
Crooked/Oliver Creeks	Pine Ridge residential development	East of 700 East, west of Hickey Road, northwest of Morgantown	Tributary to Crooked Creek
Sand Creek	Commercial development	East of S.R. 37, south of S.R. 252	North side of tributary/channel to Sand Creek

Table 10. Construction sites in the watershed as of Fall 2007

A primary road through the Lakes of Avallon allowed the observation of Goose Creek flowing through that project. None of the other projects allowed access to observe how the projects interacted with the streams they involved and whether or not erosion control measures were in use. Due to a lack of precipitation during the visual assessments, no soil erosion from these sites was observed in the streams. However, the lack of precipitation may have prevented soil erosion that may have otherwise occurred. Therefore, no visual observations can establish that soil erosion actually results from the existing construction sites due to lack of controls but can only be inferred by their proximity to the streams. Since construction on individual residential development sites is short-term (generally three to six months in duration), and commercial sites are subject to closer and more frequent scrutiny by governing Municipal Separate Storm Sewer System (MS4) entities, efforts to address soil erosion from construction sites should be addressed under general terms directed at all future forms of construction in accordance with Indiana Administrative Code IAC 327 (Rule 5), enforceable by the authorized Municipal Separate Storm Sewer System (MS4) entity.

B.2b. Stream Bank Erosion and Livestock Access

Livestock grazing and feeding areas along or near streams was identified as a potential source of sediment in streams. Of the eleven sites identified by the visual assessment as exhibiting heavy erosion or artificial stream bank stabilization, cattle were observed at two. These two sites also exhibited algal growth, lacked riparian buffers and summer canopy were less than 20%. Of the six sites exhibiting a common occurrence of erosion, one site had cattle present, one has horses present and one displayed the potential for livestock access. Of the fifteen sites exhibiting occasional bank erosion, only one with the potential for livestock access was observed.

Therefore, access to stream banks by livestock does pose the threat of increased stream bank erosion, although other factors such as slope and vegetative cover of adjacent land may also be important contributing factors. Critical areas are those pastures adjacent to streams.

B.2c. Soil Erosion and Riparian Buffers

The record-setting low precipitation amounts experienced during 2007 resulted in a lack of evidence during visual stream assessments that soil erosion in the watershed is due to a lack of riparian buffers. Research suggests that under normal rainfall totals conditions, a lack of riparian buffers results in a great loss of soil to erosion from agricultural land. In lieu of actual visual evidence of erosion from adjacent land, the presence of algae in streams near agricultural fields could indicate that nutrient-laden soils had entered the water, resulting in the algal growth. The L-THIA model and the *Riparian Conservation Prioritization* model results described below both point to areas of agricultural land as the primary sources of nutrients and sediment into watershed streams. The stream reach model of the *Riparian Conservation Prioritization* specifically identifies stream reaches lacking riparian buffers adjacent to agricultural land as the highest priority for non-point source pollutants. The visual stream assessments confirmed a lack of riparian buffers and the presence of algae in those streams identified by the models. Of the 64 visual stream assessment sites, sixteen sites exhibited algal growth, ten of which lacked riparian buffers of more than 15 feet. Those ten sites also provided less than a 20 percent summer canopy, exposing the streams to the summer sun and increased water temperature, also a factor in algal growth.

Of the 39 visual assessment sites with riparian buffers of 30 feet or less, 31 are located adjacent to agricultural land and four are located in urbanized areas. Of those sites, seven exhibited heavy erosion or artificial bank stabilization and thirteen exhibited at least occasional stream bank erosion. The absence of at least a 30-foot riparian buffer between land uses and streams can result in soil erosion from the land into the streams, especially when that land is being used for agricultural crop purposes and a greater percentage of soils are void of vegetation, such as between row crops. Results of the models confirm the increased potential of non-point source pollutants from these areas. Runoff increases velocity when unimpeded by vegetation, which can not only result in greater soil loss from the land, but also increase stream bank erosion, increase volume and velocity in stream channels, and increase stream channel scour and bank undercutting.

The Steering Committee also cited logging on private land as a contributor to the soil erosion problem. Steering Committee members who reside near forested areas cited frequent incidents of clear-cut logging by independent companies hired by adjacent landowners. These members expressed great concern that this issue be included in the concerns of the Committee and addressed by the Watershed Management Plan with a plan to reduce clear-cut logging and introduce educational programs for forest land owners regarding forest management and stewardship. Clear-cut logging exposes forest soils to erosion from runoff. The removal of canopy trees also exposes vulnerable understory vegetation not otherwise destroyed by the logging process, further removing important layers of vegetation necessary for protection of soils from erosion by runoff.

B.2d. Soil Erosion and Agricultural Land Use

Agricultural land use has long been identified as a culprit of soil erosion as notably documented in Dr. Walter Clay Loudermilk's report "Conquest of the Land through 7,000 Years" (1939). The 1930's United States saw massive amounts of soil carried from the land by wind and water as a result of indiscrete agricultural practices. The development of the Soil Conservation Service, predecessor to the Natural Resources Conservation Service, and state soil and water conservation entities established the need for more conservative agricultural practices relative to soil loss. Yet soil loss from agricultural lands continues as fields are tilled, riparian buffers are removed to extend crop production, and aging field tile fail to prevent overland flows.

Agricultural land use in the floodplain of the Indian Creek Watershed has also been of concern, as noted by the above-referenced *Indian Creek Watershed: Work Plan for Watershed Protection and Flood Prevention* report. The report discusses erosion damage from upland sheet flow causing floodplain scour, gully erosion, and channel bank erosion. The report states that scour occurs to some extent throughout the entire floodplain, most extensively in the middle and lower reaches. The report also refers to an infertile deposition of soils, mostly sand and fine gravel, carried by storm water from the uplands into and upon agricultural land in the middle and lower main flood plain reaches. The report estimates that in excess of 5,555 acres, 75% of which is cropland, is inundated from one to three times a year as a result of 50-year flood events.

As previously addressed under 2007 Cropland Transect Survey above, the state-compiled 2004 Cropland Tillage Data for corn acreage shows farmers still utilize conventional tillage methods in 51% of acres in Johnson County and 67% in Morgan County.

Most susceptible to soil loss by overland flows are agricultural land in floodplains. These lands are more frequently inundated and lie at the foothills where overland flows reach a maximum velocity when unimpeded by dense vegetation. Where riparian buffers are lacking or insufficient in width, soil is carried into streams from adjacent fields where bare soil is exposed between rows of crops. Of the 60,049 acres of land within the Indian Creek Watershed, the Gap Analysis Program (GAP) showed that in 1992, land use in the watershed was approximately 44% agriculture, 51% forested and 5% developed, water or other. That means 26,420 acres are highly subject to soil erosion. The 2001 land use analysis shows little change, with a slight increase in forested land over agriculture. As noted above under Floodplains, 10,073 acres of land within the watershed are located in the 100-year floodplain. As shown by Figure 48, agriculture dominates most of that floodplain.

B.2e. Soil Erosion and Lake Communities

There are three lake communities located in the watershed: two separate Lamb Lake communities and Lakes of the Painted Hills. Indian Creek flows through the larger Lamb Lake at its headwaters. Bear Creek flows from the smaller Lamb Lake and into Indian Creek further west. The Camp Creek headwaters originate at the Lakes of the Painted Hills and flow into Indian Creek just southeast of Martinsville. All three are residential communities with recreational usage, including motorized boating, of the lakes. Wave action created by motorized boats however, can be a leading cause of shoreline erosion. All three communities are experiencing moderate to severe shoreline erosion. Additionally, nutrients attached to soils can be carried by stormwater runoff from residential properties into the lakes, further contributing to both the issue of sediment and nutrients in the water.

B.3. Excessive Aquatic Plant Growth Sources

Excessive aquatic plant growth, such as algae, is often associated with excessive nutrients in waters. Monitoring data for nutrients in the Indian Creek Watershed is lacking however, so the responsibility of nutrients for the aquatic plant growth in watershed waters can only be assumed. Primary sources for excessive nutrients are generally identified as agricultural, from both crops and livestock, and residential or urban areas, such as commercial properties and golf courses, where fertilizers are used on lawns.

Riparian buffers are one defense against nutrients being carried via storm water runoff into streams. As noted above under **Section B.2d. Soil Erosion and Riparian Buffers**, inadequate riparian buffers are found throughout the watershed, primarily adjacent to agricultural and urban land uses. Unimpeded runoff from livestock grazing areas were noted at 11 of the 62 sites with algae present at six of the 11. Grazing areas contribute nutrients from animal waste deposited on the ground and carried into streams with storm water runoff. This waste can be especially high in nitrogen. Several small livestock areas and horse boarding facilities are located throughout the watershed. Since none of these operations are classified as an IDEM regulated confined feeding operation (CFO), the method of disposal of animal waste from these sites is up to the owner's or operator's discretion. Members of the Steering Committee reported that these owners/operators do not always use reasonable discretion in protecting streams and other bodies of water in their waste disposal methods.

Algae was noted at 16 sites adjacent to other agricultural uses. Chemicals applied to fields of row crops are carried into streams via eroded soils. As noted above, the majority of land in the floodplain of the watershed is occupied by agricultural uses and thus very likely to contribute to excessive nutrients in streams, especially during rainy periods. Additionally important, the 2004 Cropland Tillage Data shows that farmers continue to utilize traditional tillage methods known to contribute dramatically to soil erosion and the transport of nutrients via soil into streams.

Algae was also noted in the denser populated areas of Martinsville and Morgantown where mixed uses of residential, commercial and institutional are all potential contributors to excessive nutrients from lawn chemicals. Massive amounts of algae were observed at a golf course east of Morgantown where riparian buffers were absent and frequent application of lawn nutrients would be needed for maintenance of course fairways and greens. Improper application of lawn fertilizers by homeowners has been identified by the U.S. Environmental Protection Agency (EPA) as a major contributor of nutrients to the nation's waters. Commercial and institutional properties, such as the hospital and schools, may also be lawn chemical contributors, especially since riparian buffers on these properties were lacking. Properties along the lake shores are also heavy potential contributors to nutrients in the water. Lawns directly adjacent to the lakes contribute nutrients washed from lawns by stormwater and attached to soils washed from the shoreline.

B.4. Illegal Dumping and Litter Sources

Litter thrown from moving vehicles can be found along almost every highway, large or small, across the nation. Prior to the Earth Day revolution of the 1970's, throwing trash from a car window was an acceptable means of disposal. Awareness has brought about large-scale clean-ups of highways and, although the problem has not completely disappeared, it has greatly diminished. That awareness not only alerted us to the unsightliness of the litter but the dangers as well of materials not belonging in the environment being introduced via litter and illegal dumping. Most prevalent have been the cases where barrels of toxic chemicals have been buried or otherwise disposed of in manners where chemicals were allowed to escape. The use of water as a source for waste disposal also has a long history, and with it hard lessons learned about the problems associated with it.

Roadside litter has decreased but not ceased over the past three decades. Its presence is unsightly, it can cause road flooding where debris blocks storm drains, and it can be harmful to aquatic life when it enters streams, Of perhaps greater impact to aquatic life though, is the illegal dumping done away from major highways, objects not tossed from passing car windows. The visual stream assessment observed at least five sites where large objects such as barrels, appliances, tires, fencing, even a mattress, were discarded in or near streams. Fluids from appliance motors and unknown contents of barrels leak into streams, threatening aquatic life and human health through contact with those waters. The sites where these items were dumped were in more secluded areas of the watershed, off the main roads, where dumping activities would be less likely to be witnessed. The disposal of these items could also have been done by the inhabitants of those properties.

B.5. Exotic Invasive Aquatic Species Sources

Invasive species in the Great Lakes have had a profound environmental impact, displacing native species and changing the balance of the Lakes' ecosystem. They have also had an enormous economic impact. The U. S. Environmental Protection Agency report, *The Great Lakes Water Quality Agreement*, states that municipalities and larger industries in the region pay an average $360,000 per year to control zebra mussels, with a basin-wide cost of $120 million from 1989 to 1994. The report further states that the zebra mussels are being accidentally transported by recreational boaters to inland waters in all eight Great Lakes States. Inland waters such as those at Lamb Lake and the Lakes of the Painted Hills are prime examples of lakes with the potential for infestations from recreational boaters. Exotic invasive aquatic species are transported via boats, trailers, equipment, boots, clothing, even dogs from an infested waterbody to another and include exotic mussels and other mollusks, crustaceans, plants, fish, and parasites. Nearly one half of the residents questioned at the Painted Hills Home Owners Association annual meeting in December of 2007 said they used their boats on other lakes in the state. When questioned about cleaning, all admitted that hosing down the hull was the extent of their clean-up, if any. This falls short of the methods recommended by the U.S. Fish & Wildlife Service as necessary for the prevention of transporting exotic species. Once established, exotic species cannot be eradicated, only controlled. No thorough inspection of the lakes for exotic species has been conducted to eliminate the presence of exotic species. The potential is great for exotic species to be spread throughout the watershed should they be introduced into any of the lakes since the lakes flow into tributary streams of Indian Creek.

Live bait dumped into the water is also a source of introduction of an exotic species. The likelihood of introduction through this source is great given the popularity of recreational fishing at all three lake communities. Dumping aquariums into waters also introduces exotic species. Although more difficult to gauge, the likelihood of this activity is greater where residences are close to a source of water, such as at the lake communities.

A source of exotic plant species is water gardens. Exotic plant species such as water hyacinth, sold by retail nurseries for use in residential water gardens, can thrive out of control when escaping into the wild. Whether intentionally discarded, released from a water garden into a network of streams, or carried by wildlife, most exotic species sold for use in residential water gardens have no natural predators to keep them in check, growing out of control and chocking out native species that provide food and protection to aquatic organisms and wildlife. The number of water gardens located in the watershed is unknown, however, local nurseries and retailers do offer exotic aquatic plants for sale. Such availability suggests a market for water gardens exists in the watershed.

C. Estimated Existing Pollutant Loads and Recommended Reductions

C.1. E. coli: Estimated Loads and Recommended Reductions

Using data collected from the TMDL sampling data, the IDEM developed Load Duration Curves for the 1996-2001 data for sites WWU170-001 and WU170-002, Figures 46 and 47, respectively. The USGS flow data used for the TMDL was also utilized in the development of these Load Duration Curves. Both curves show a decrease in the E. coli counts as flows decreased, with counts exceeding target amounts more often than not. Only three of eleven datasets for site WWU170-001 fell below the target, and only four of eleven data sets for site WWU170-002 fell below the target. Table 11, below, lists all sites, the Geometric Mean for each site's data and the recommended percent reduction needed to meet the state water quality standard target of 125 colonies per one hundred milliliters as a 30-day geometric mean. The TMDL lists recommended BMPs for reduction of E. coli.

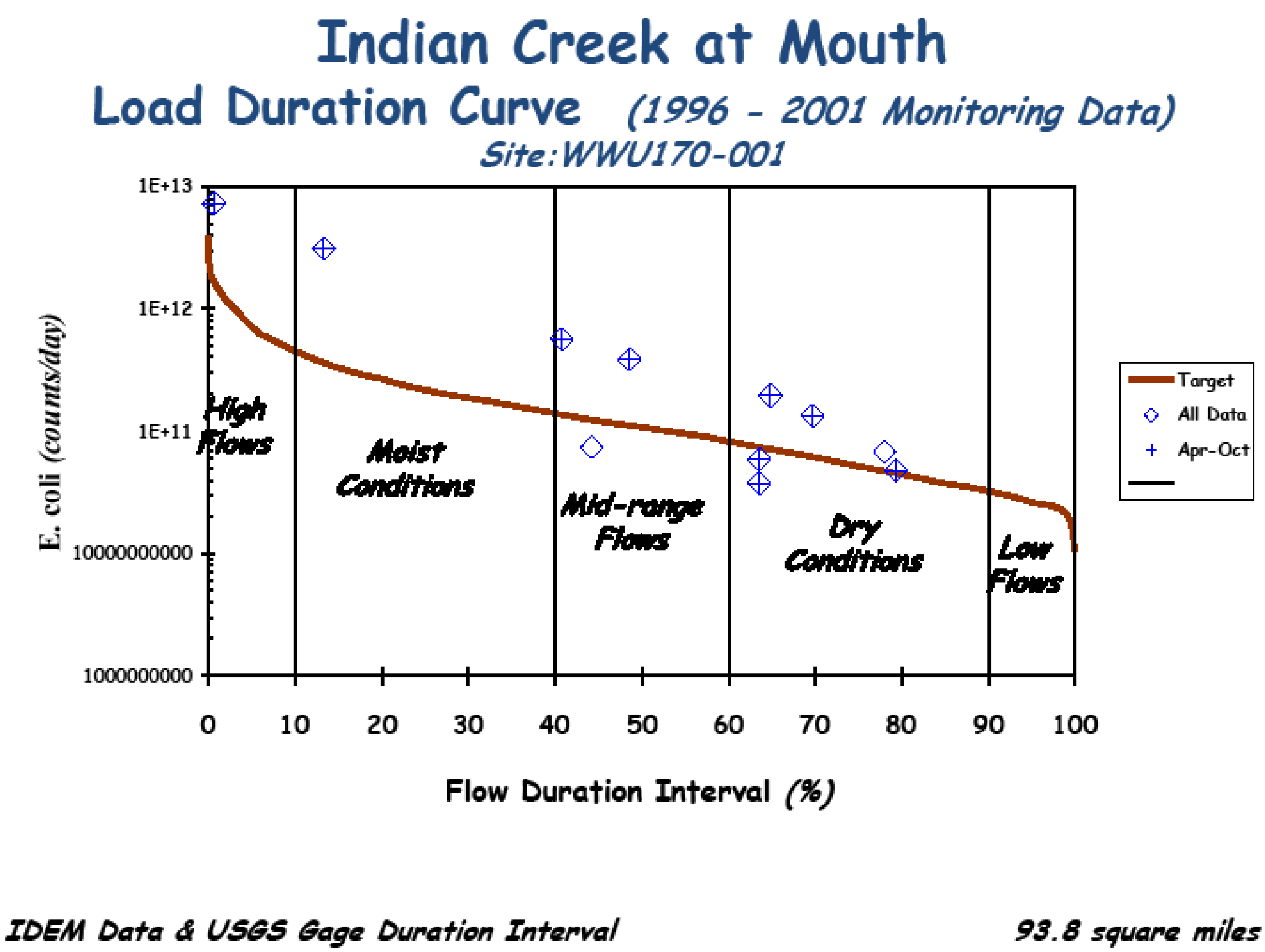

Figure 46. E. coli Load Duration Curve: Site WWU1170-001

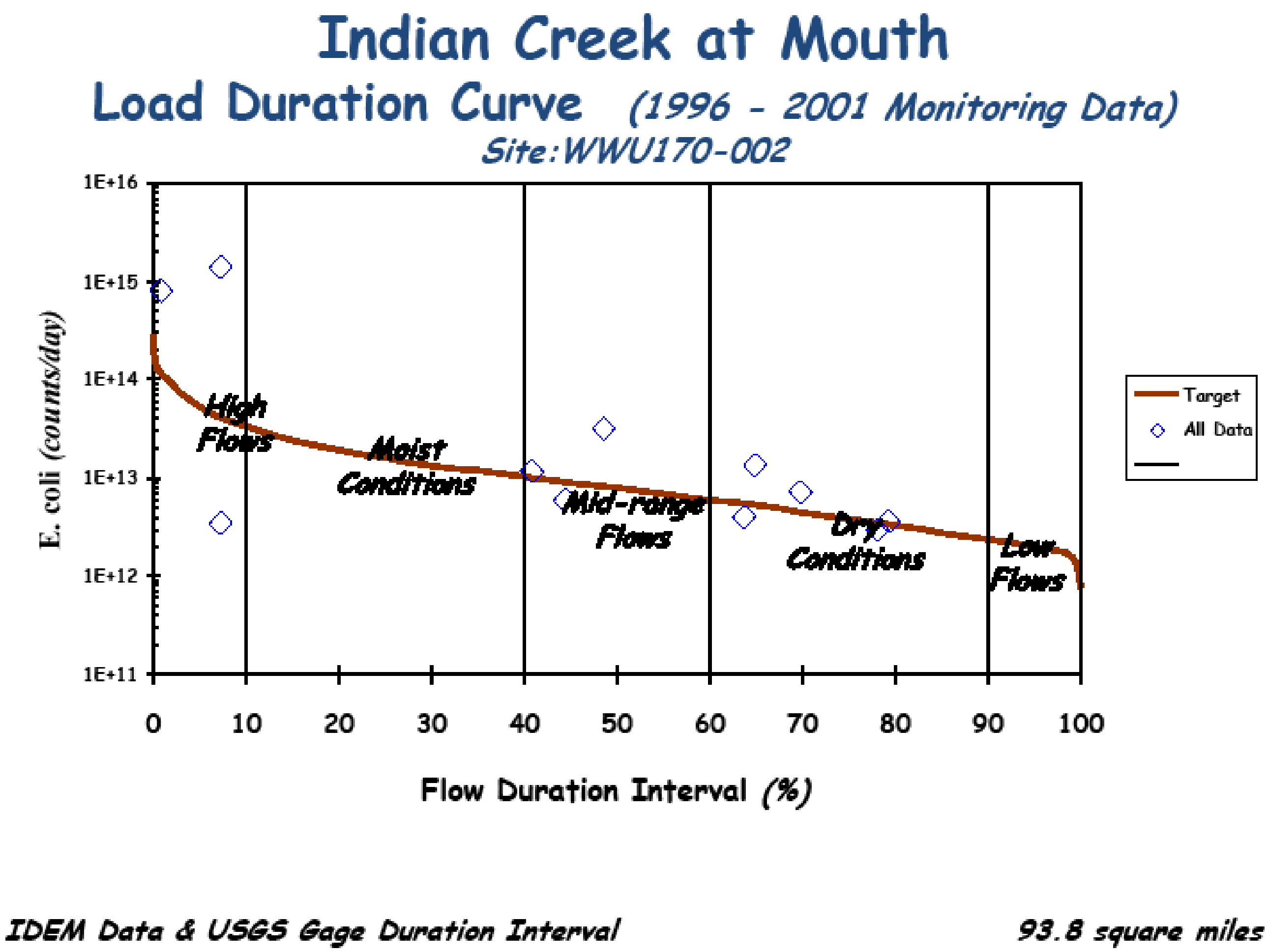

Figure 47. E. coli Load Duration Curve: Site WWU1170-002

Table 11, below, includes the Geometric Mean for the above referenced sites, with Site WWU1170-001 listed as Site #12 and WWU1170-002 listed at Site #1. The recommended Load Reductions are the percent reductions needed to bring watershed waters into compliance with the Indiana Water Quality Standard (WQS) for E. coli of 125 colony forming units (cfu) per 100 milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st. Priority Ranking is based on 2001 sampling data geometric mean with 1 as the highest priority with the greatest reduction requirement on down.

Site #	L-Site #	Stream Name	Geometric Mean for 5 sample data sets (cfu/100mL)	Reductions to meet WQS of 125 cfu/100mL	Priority Ranking
1.00	WWU170-0002	1996 Synoptic - Indian Creek @ Jordan Rd	599.47	79%	NR
1.00	WWU170-0002	2001 Indian Cr @ Jordan Rd	435.85	71%	15
2.00	WWU170-0030	2001 Indian Cr @SR 37	>814.36	84%	5
3.00	WWU170-0028	2001 Indian Cr @ Burton Ln	259.02	51%	20
4.00	WWU170-0027	2001 Sand Cr @ Mahalasville Rd	765.23	83%	6
5.00	WWU170-0005	2001 Indian Cr @ Low Gap Rd/Taggart	578.57	78%	8
6.00	WWU170-0026	2001 Unnamed Trib @ Downey Rd	N/A	N/A	N/A
7.00	WWU170-0025	2001 Robertson Cr @ Doeney Rd	>1545.29	91%	1
8.00	WWU170-0023	2001 Camp Cr @ Mahalasville Rd	872.07	85%	4
9.00	WWU170-0022	2001 Indian Cr @ Mahalasville Rd	466.02	73%	12
10.00	WWU170-0021	2001 Indian Trace Cr @ Mahalasville Rd	>1092.91	88%	2
11.00	WWU170-0020	2001 Oliver Cr @ Old Railroad Rd	222.97	43%	23
12.00	WWU170-0001	1996 Indian Cr @CR 650 E	448.21	72%	NR
12.00	WWU170-0001	2001 Indian Cr @ CR 650 E	582.13	78.5%	7
13.00	WWU170-0019	2001 Pike Cr @ Mahalasville Rd	515.87	75%	9
14.00	WWU170-0016	2001 Indian Cr @Lick Creek Rd	402.68	68%	17
15.00	WWU170-0004	2001 Bear Cr @SR 135	365.01	65%	18
16.00	WWU170-0018	2001 Crooked Cr @ CR 700 S	N/A	N/A	N/A
17.00	WWU170-0015	2001 Indian Cr @ SR 135	315.51	60%	19
18.00	WWU170-0017	2001 Long Run Cr @ CR 700 S	478.61	73%	11
19.00	WW170-0014	2001 Indian Cr @ Co Line Rd	257.76	51%	21
20.00	WWU170-0031	1996 Indian Cr @ CR 700 W	N/A	N/A	N/A
21.00	WWU170-0011	2001 Goose Cr @CR 700 S	N/A	N/A	N/A
22.00	WWU170-0013	2001 Barns Cr @ CR 700 S	197.27	36%	25
23.00	WWU170-0012	2001 Indian Cr @ CR 700 S	241.23	48%	22
24.00	WWU170-0010	2001 Indian Cr @ CR 575 W	453.39	72%	13
25.00	WWU170-0009	2001 Indian Cr @CR 500 W	>405.28	69%	16
26.00	WWU170-0008	2001 Lick Cr @ CR 300 W	>1053.81	88%	3
27.00	WWU170-0007	2001 Indian Cr @ CR 300 W	500.09	75%	10
28.00	WWU170-0006	2001 Indian Cr @ CR 750 S	221.71	43%	24

Table 11. TMDL Data Sets

To simplify the process of prioritizing the TMDL sites, Table 12 lists only the 2001 data (the most current data) for which a geometric mean is given. The sites are also listed in order of priority ranking from 1, the highest reduction needed, to the lowest.

Site #	L-Site # *	Stream Name **	Sub-watershed	Reductions to meet WQS of 125 cfu/100mL	Priority Ranking
7	0025	Robertson Cr @ Downey Rd	Robertson Creek	91%	1
10	0021	Indian Trace Cr @ Mahalasville Rd	Camp Creek	88%	2
26	0008	Lick Cr @ CR 300 W	Headwaters (Brown)	88%	3
8	0023	Camp Cr @ Mahalasville Rd	Camp Creek	85%	4
2	0030	Indian Cr @ SR 37	Sand Creek	84%	5
4	0027	Sand Cr @ Mahalasville Rd	Sand Creek	83%	6
12	0001	Indian Cr @ CR 650 E	Crooked/Oliver Creeks	78.5%	7
5	0005	Indian Cr @ Low Gap Rd/Taggart	Robertson Creek	78%	8
13	0019	Pike Cr @ Mahalasville Rd	Crooked/Oliver Creeks	75%	9
27	0007	Indian Cr @ CR 300 W	Headwaters (Brown)	75%	10

Table 12. Top Ten Critical Sites for E. coli based on TMDL data

*All L-Site #'s preceeded by WWU170-

**All data from 2001 monitoring cycle

As shown by Table 12, the ten highest ranked sites are located in five of the seven sub-watersheds, with Camp Creek and Sand Creek having both sites ranked in the top six. This would indicate that the most critical areas for E. coli are the Camp Creek and Sand Creek sub-watersheds. Figure 48, below, shows the location of the top ten ranked sites and the land uses potentially responsible for the high concentrations of E. coli. These ten sites are the most critical areas for addressing E. coli load reductions.

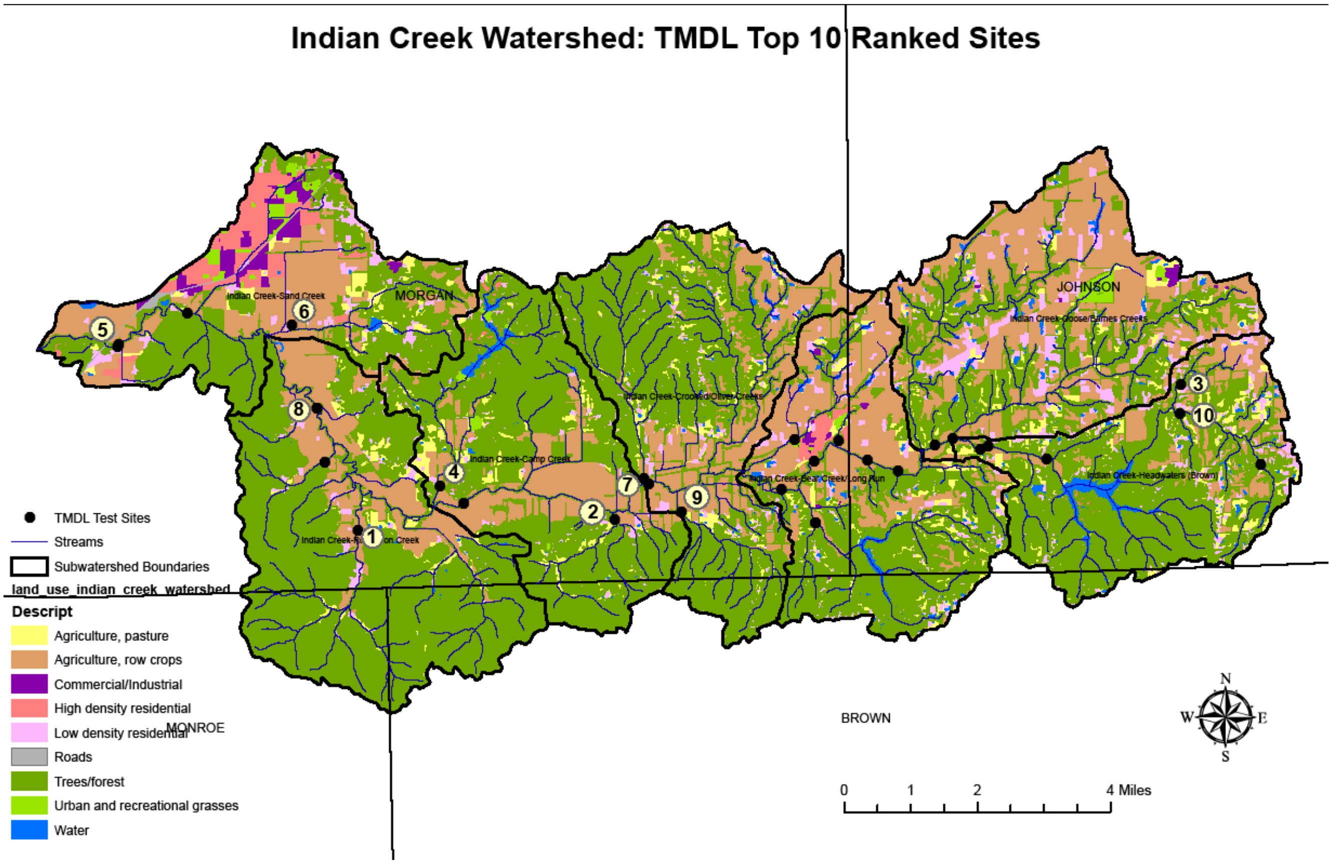

Figure 48. Top Ten TMDL Sample Sites

In addition to land uses, the TMDL identifies on-site wastewater treatment systems or septic systems as potential sources of E. coli. Areas within a two-mile radius of Martinsville and a one-mile radius of Morgantown are serviced by permitted facilities, with all other areas serviced by on-site systems, making this a watershed-wide issue. Older systems and systems installed in inadequate soils provide the highest potential for failure, however, outdated and incomplete records by both Johnson and Morgan County Health Departments make it difficult to properly identify specific locations of older systems. A watershed-wide outreach and education program and partnership with county health departments and MS4 stormwater departments to introduce maintenance requirement ordinances may be one effective approach in addressing this issue.

C.2. Long Term Hydrologic Impact Analysis (L-THIIA) Model: Pollutant Loads

To help determine estimated pollutant loads and help identify critical areas, the *Long Term Hydrologic Impact Analysis* (L-THIA) Model was used to calculate estimated loads based on runoff estimates of different land uses. L-THIA was developed by the Purdue Research Foundation as an "analysis tool to provide estimates of changes in runoff, recharge and nonpoint source pollution resulting from past or proposed land use changes." (Engel) The model uses climate data collected over the past 30 years along with current land use maps, soil data and curve number (CN) values to determine the average impact of runoff, recharge and non-point source pollution resulting from various land use scenarios. Limitations of the model, intended to minimize its complexity, include neglecting the inclusion of snowfall as precipitation, the effect of frozen ground that could increase stormwater runoff, and variations in antecedent moisture conditions. The IDEM ran the model for the Indian Creek Watershed.

The L-THIA model uses a distributed approach in calculating runoff, that is, runoff is calculated for each unique area in a watershed, then summed. This approach results in a more accurate runoff estimation as opposed to other methods which average CN values prior to calculating runoff. The result is a more accurate estimation of pollutant loads from particular land uses and specific areas.

The L-THIA model was run on each of the 14-digit sub-watersheds of the 11-digit Indian Creek Watershed. Below is a summary of the findings from the model. Figure 49 below is the key for the 14-digit sub-watershed identification used by the L-THIA Model maps. Figure 50 is the land use map utilized by the L-THIA model.

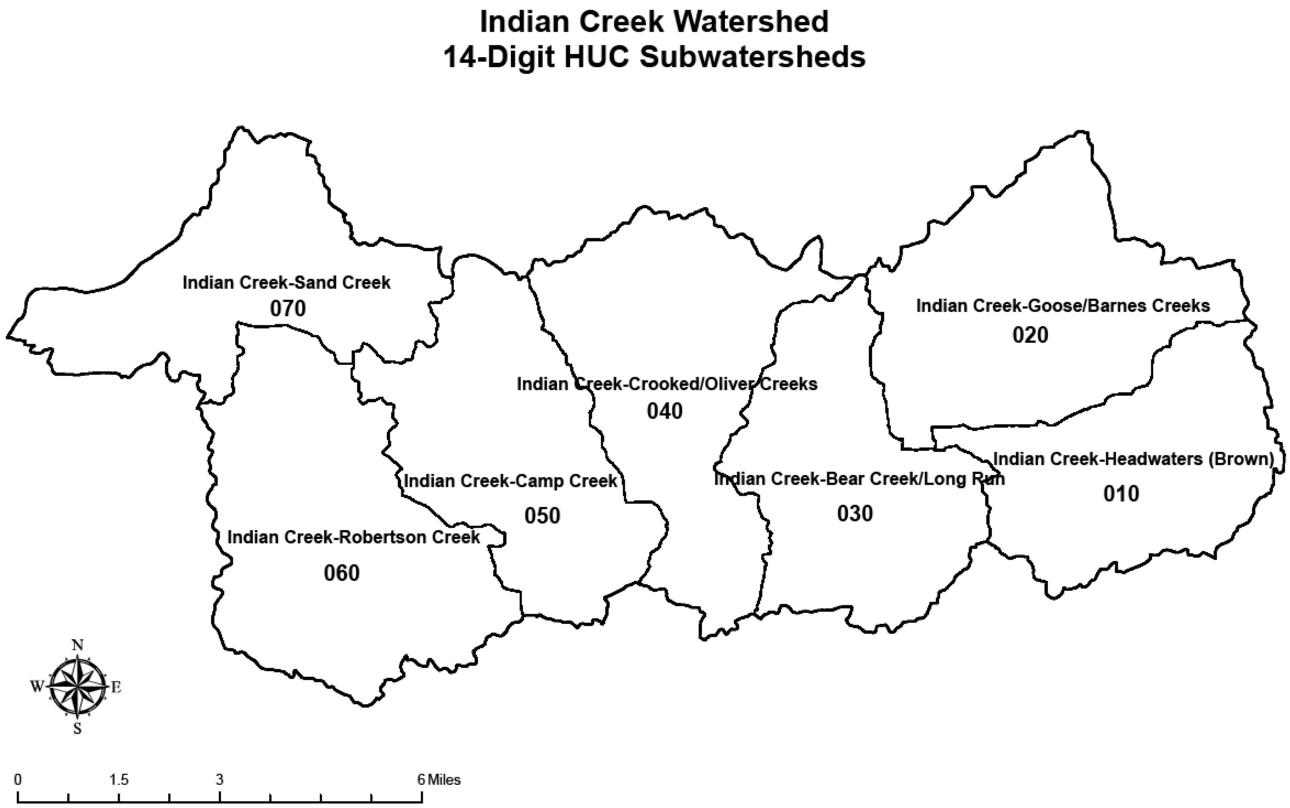

Figure 49. L-THIA Model map key to sub-watershed identification

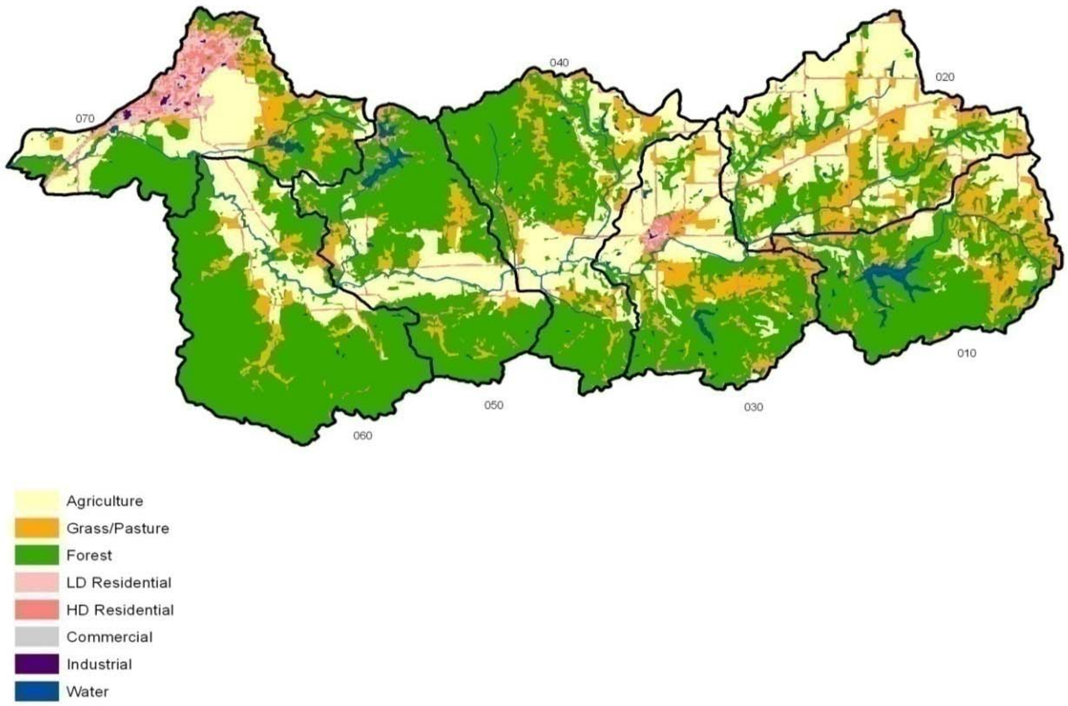

Figure 50. Indian Creek Watershed Land Uses map utilized for L-THIA Model

C.2a. Pollutant Load Contribution by Land Use: (entire) Indian Creek Watershed

The L-THIA-generated data in Table 13, below, shows the total number of acres for each type of land use for the entire Indian Creek Watershed, with contributions of Average Annual Runoff Volume, Nitrogen, Phosphorus, Suspended Solids, and Fecal coliform broken down for each land use. According to the data, 26.2% (15,741 acres) of the land use in the watershed is agricultural. That 26.2% however, is responsible for 75-85% of the runoff, nutrients, suspended solids and fecal coliform contributions into watershed waters. Such high contributions would indicate the greatest need for BMPs on agricultural land. Agricultural land is indicated in yellow and orange (grass/pasture) on the land use map in Figure 50. Forests cover 53% (31,801.3 acres) of the watershed and contribute 30% of the runoff, 9% of the nitrogen, and 1% or less of phosphorus, suspended solids and fecal coliform. This data confirms the effectiveness of forest cover in reducing pollutant contributions. It should be noted that the high contribution of runoff is most likely the result of the steep slopes on which much of the forests are located, especially in the Morgan-Monroe State Forest area. Forests are the best land use/land cover to prevent erosion from steep areas such as this, as confirmed by the extremely low contributions of nutrients and suspended solids in relation to the high percentage of runoff at 30%, which is considerably less than the 42% from agricultural land that covers almost 27% less of the total watershed area. Forest areas are shown in green on the land use map Figure 50.

High density residential land use was identified as the second highest contributor of nitrogen (11%), phosphorus (13%), suspended solids (11%) and fecal coliform (20%) while only occupying 4.4% (2,671.4 acres) of the land area. Low density residential contributed 1% to 2% of all pollutants while occupying 1.1% (657.4 acres) of the land area of the watershed. The estimate of contributions for residential land may be low based on the land use map utilized to run the L-THIA model for this plan. A more current land use map, developed through a cooperative effort with Indiana University, used in Figure 45 provides more detailed locations of residential areas. The development of this current land use map was not complete at the time the L-THIA model was run.

Industrial and commercial land uses within the watershed comprise a total of less than 1% of the land use in the watershed and are confined to the City of Martinsville and Town of Morgantown, shown in purple and grey, respectively, in Figure 50. The Figure 50 land use map also identifies the Indian Creek School properties as industrial/commercial, as seen on the northeast boundary of the Goose/Barnes Creek sub-watershed. As shown by the pie charts in Figures 51, 52, 53 and 54, pollutant contributions by these land uses are 1% or less, except for suspended solids, with commercial uses contributing 2% of the total for that pollutant.

Land Use	**Area (acres)**	**Average Annual Runoff Vol. (acre-ft)**	**Nitrogen (lbs)**	**Phosphorus (lbs)**	**Suspended solids (lbs)**	**Fecal coliform (millions of coliform**	**% of Total Area**
Agriculture	15741	6650.81	80713	23842	1,962,935	47,697,638	26.2
Commercial	220.5	325.94	1201	285	49,898	620,399	0.4
Forest	31,801.3	4710.3	9090	124	12,986	259,846	53
Grass/pasture	8060.4	1316.12	2534.83	30.901	3626	72,603	13.4
Hi Density Residential	2671.4	2293.01	11,506	3600	259,320	12,649,975	4.4
Industrial	69.6	73.69	255	55.485	12,299	197,231	0.1
Low Density Residential	657.4	185.09	925.962	289.665	20,931	1,021,329	1.1
Water/ Wetlands	828	0	0	0	0	0	1.4
Totals	60,049.6	15,554.96	106,225.8	28,227.051	2,321,995	62,519,021	100

Table 13. L-THIA-generated data for Pollutant Contribution by land Use; Indian Creek Watershed

Figures 51,52,53 and 54 present the pollutant load information in pie charts for Nitrogen, Phosphorus, Suspended Solids and Fecal Coliform Loads. The charts give a better visual comparison of land uses and pollutant contributions. As shown by the charts, agricultural land uses contribute 76% or more of each of the listed pollutants while covering only 26% (15,741 acres) of the total land area of 60,049.6 acres.

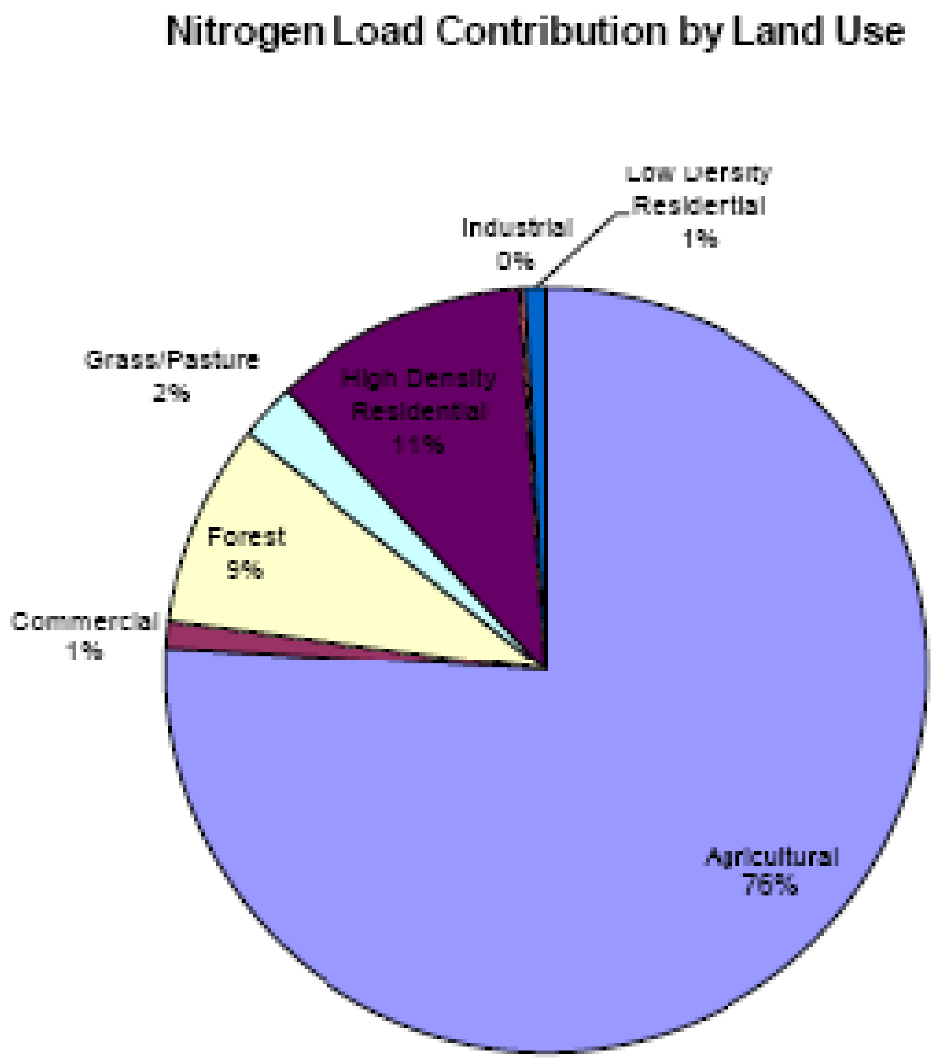

Figure 51. L-THIA Model Nitrogen Load Contribution by Land Use: Indian Creek Watershed

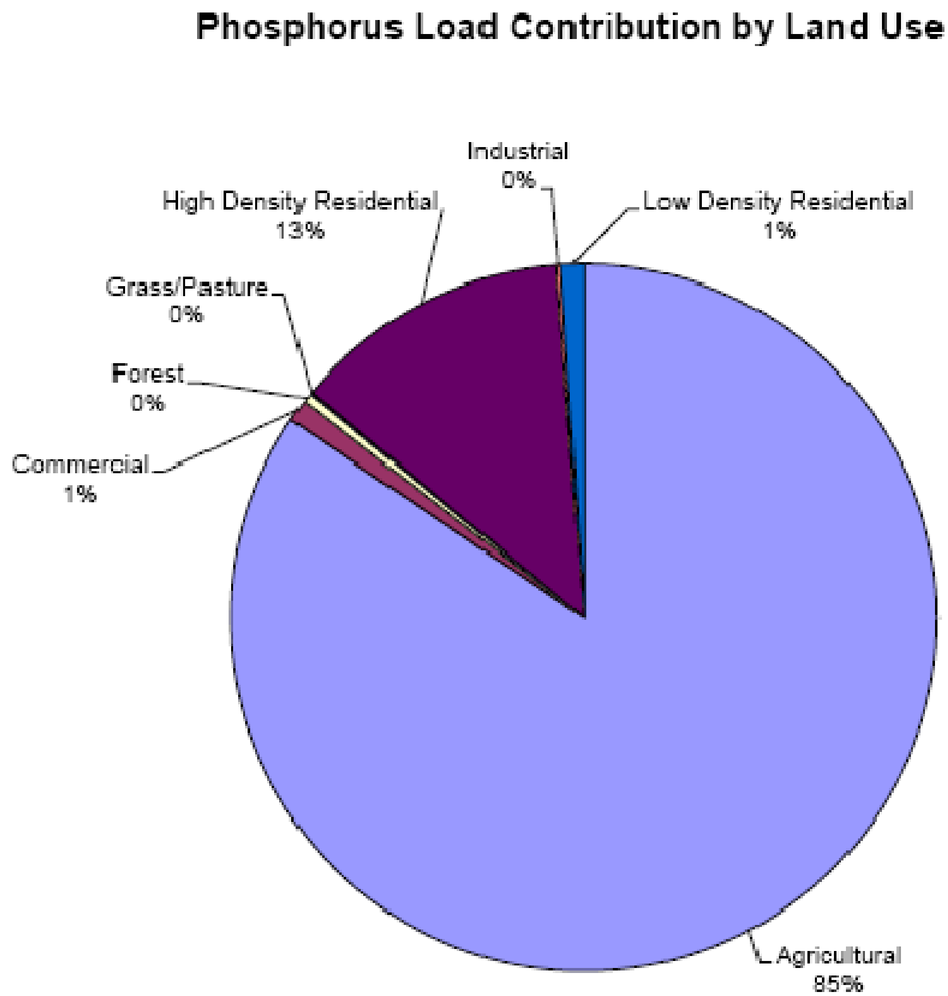

Figure 52. L-THIA Model Phosphorus Load Contribution by Land Use: Indian Creek Watershed

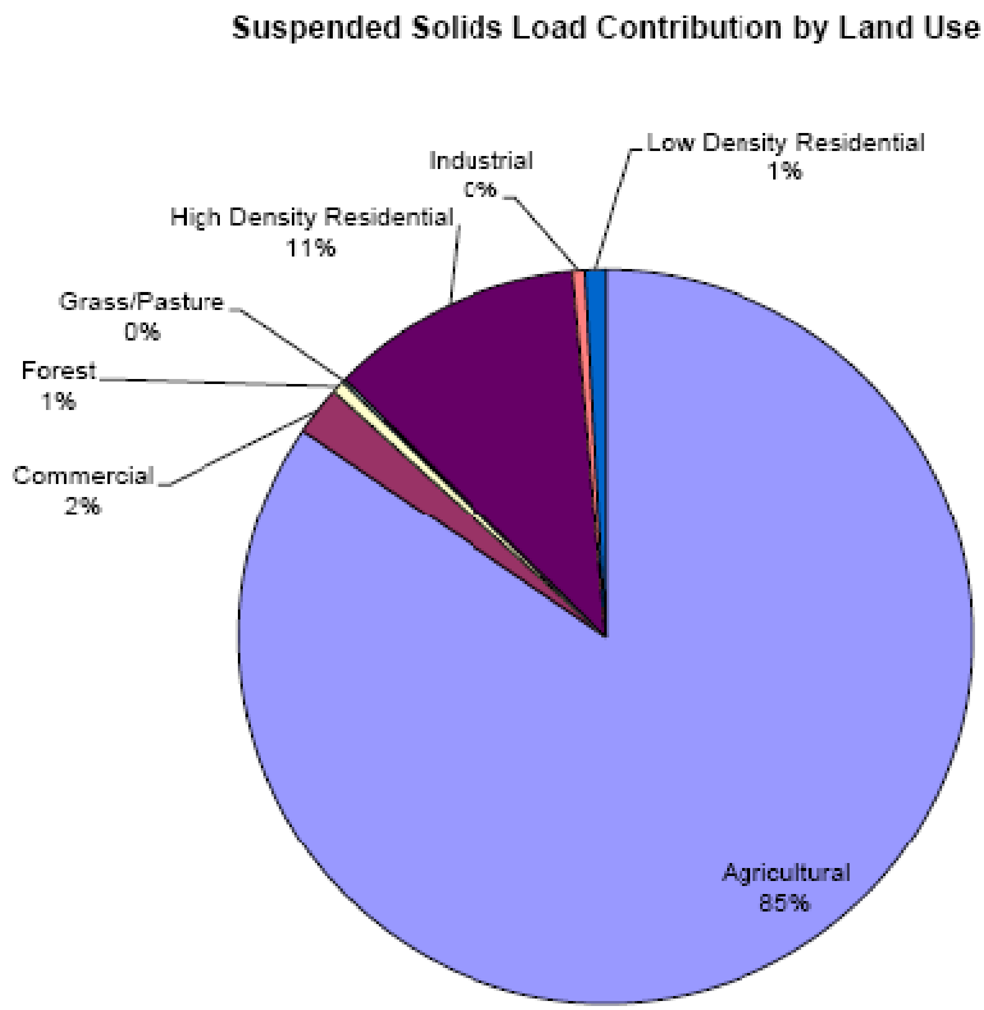

Figure 53. L-THIA Model: Suspended Solids Load Contribution by Land Use: Indian Creek Watershed

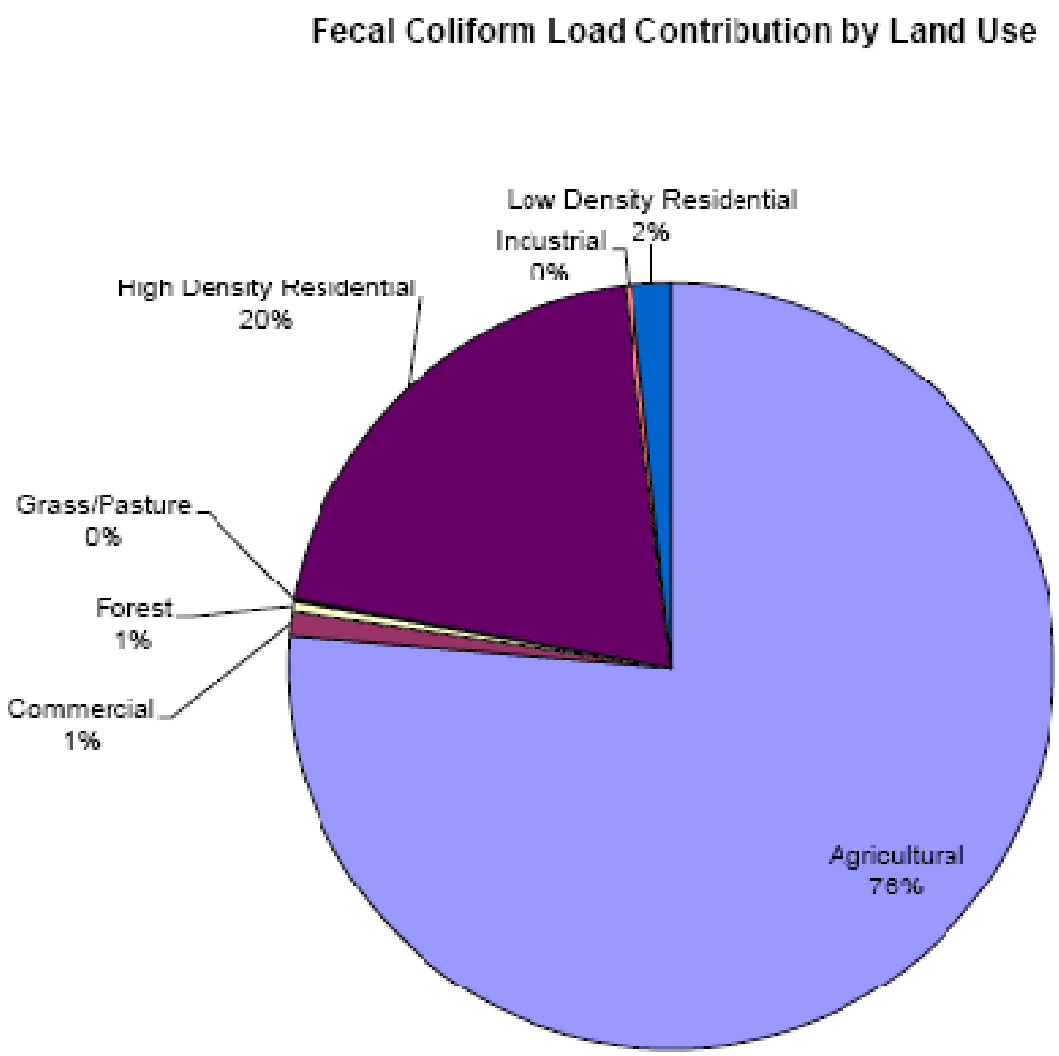

Figure 54. L-THIA Model Fecal Coliform Load Contribution by Land Use: Indian Creek Watershed

C. 2b. L-THIA Model: Pollutant Load by HUC 14-Digit Sub-watershed

The L-THIA Model was used to prioritize the HUC 14-digit sub-watersheds based on pollutant loads. This prioritization helps in identifying critical areas for these pollutants of concern. The graphs for each sub-watershed's pollutant loads can be found in Appendix C, below. The information contained in the table provided the basis for comparison among the seven sub-watersheds to determine priority based on the greatest pollutant load contributions. Table 14, below, shows the total pollutant load by sub-watershed and each sub-watersheds ranking based on the total load contributions.

HUC*	Acres	Nitrogen (ppm)	N Rank	Phosphorus (ppm)	P Rank	Susp. Solids (ppm)	SS Rank	Fecal coliform**	FC Rank
*010	7301	1.931	7	0.455	7	36.924	7	3740711	7
*020	9448	3.476`	1	0.996	1	81.427	1	18047501	1
*030	7788	2.977	3	0.832	3	68.326	3	8801551	3
*040	9122	2.527	5	0.661	4	53.869	4	7626656	4
*050	8263	2.305	6	0.587	6	47.694	6	6545428	5
*060	10298	1.78	4	0.39	5	31.954	5	6407000	6
*070	7835	2.463	2	0.683	2	58.459	2	11350174	2
Total Avg.	60055	2.5		0.67		54.9		62519021	

*complete HUC is 5120201170 followed by three-digit code in HUC column (i.e. 5120201170010)
**millions of coliform

Table 14. L-THIA Model Total Pollutant Load by Sub-watershed

Appendix C contains bar charts showing the distribution of pollutant loads among the seven sub-watersheds. L-THIA data shown graphically using maps of the watershed, Figures 55, 56, and 57, below, illustrate the distribution of pollutant loads throughout the watershed. Comparison of these maps to the Figure 50 land use map show that the areas identified as the greatest contributors to non-point source pollutant loads are primarily agricultural land uses, especially in the Goose/Barnes Creek (020), Bear Creek/Long Run(030), and Sand Creek (070) sub-watersheds. The highest contributing areas in the Crooked/Oliver Creeks (040), Camp Creek (050), and Robertson Creek (060) sub-watersheds are located in the Indian Creek floodplain, which is also primarily agricultural land uses. Forest areas in all sub-watersheds contribute the least amount of pollutants, with forests on steeper slopes contributing slightly higher loads of nitrogen than those on more gradual slopes.

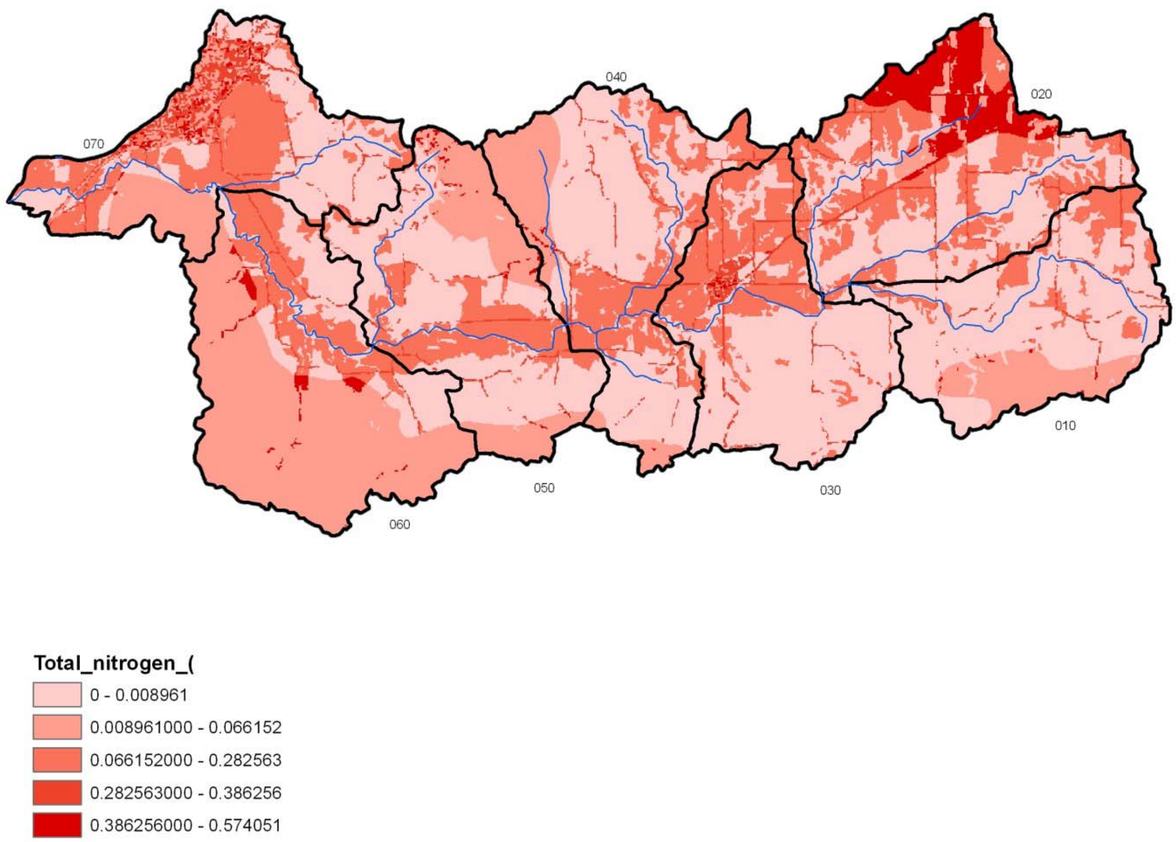

Figure 55. L-THIA: Total Nitrogen Load in Indian Creek Watershed

The mapped L-THIA Model data shows that the estimated total nitrogen load is greatest in the Goose/Barnes Creek sub-watershed (020). As shown on the land use map, this area is primarily agricultural. Field observation and aerial photos of the area also show mostly field crops as land use, with little or no riparian buffers, as confirmed by the visual assessment detailed above. The northern one half of the Bear Creek/Long Run sub-watershed (030), the midsection and urbanized area (Martinsville) of the Sand Creek sub-watershed (070), and the Indian Creek floodplain are also high in estimated total nitrogen loads. These areas, except for the urbanized area of Martinsville, are also agricultural land uses for either row crops or livestock, as indicated by the visual assessment described above. Although not shown on the Figures 50, 55, 56, 57, and 58, the Hilldale Cemetery Ditch and Sator Ditch (see Figure 10), both legal drains in Morgan County, are included in the area of the Sand Creek sub-watershed indicated as high in estimated loads for nitrogen, phosphorus and suspended solids. County legal drain regulations have prevented the growth of riparian buffers associated with those ditches, thus facilitating the introduction of pollutants into the waters of the ditches and the watershed.

Also of note on these maps is that the areas within the Indian Creek floodplain (see Figure 13) are substantial contributors to all pollutant loads. As indicated by the 1965 Work Plan for Watershed Protection and Flood Prevention, summarized above in Section IV, the floodplains have long been of concern for their contributions of sediment and nutrients and should be recognized as a whole as a critical area.

The greatest total estimated phosphorus loads, shown in Figure 56, are from the same areas as the nitrogen loads, with much lesser loads contributed by forested areas. Again, the greatest contributing areas are the Goose/Barnes Creek, northern half of Bear Creek/Long Run and middle and urban areas of Sand Creek sub-watersheds and the Indian Creek floodplain.

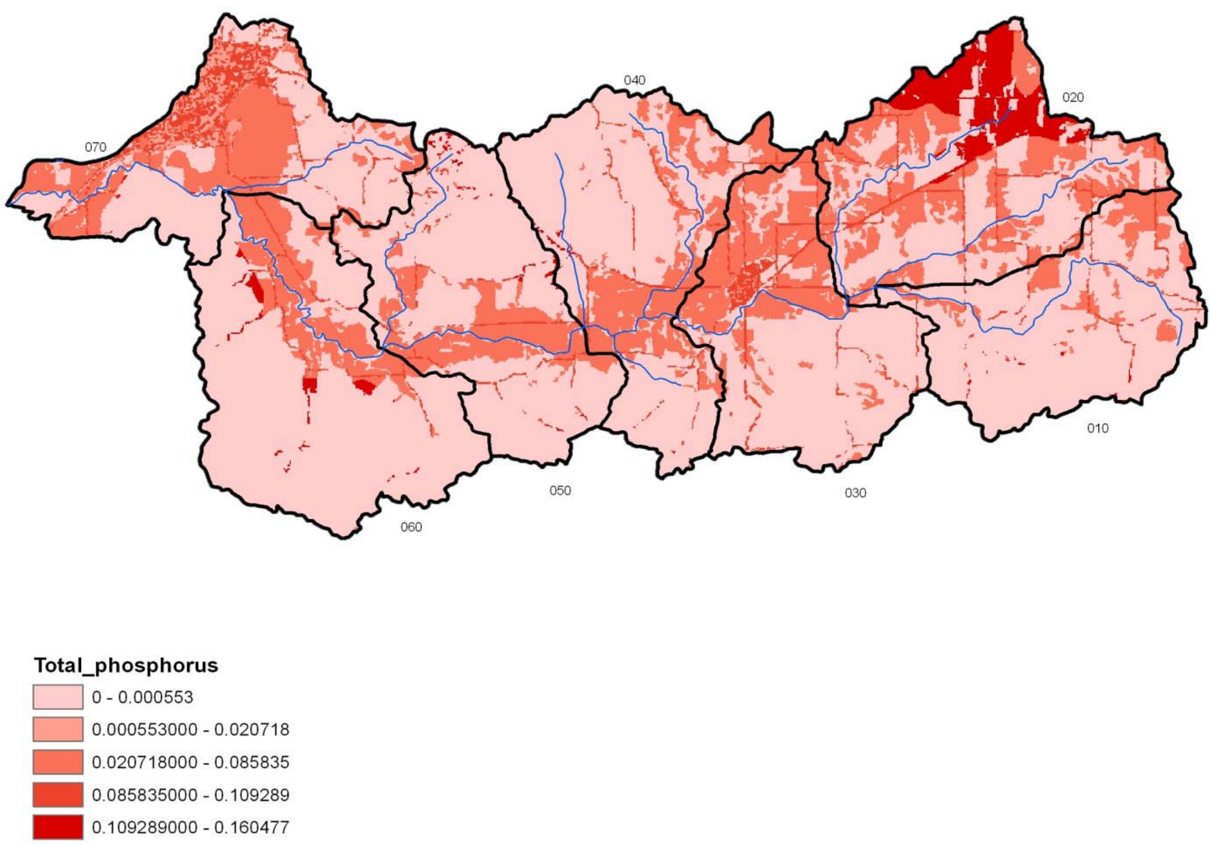

Figure 56. L-THIA: Total Phosphorus Load in Indian Creek Watershed

Almost a carbon copy of the Total Phosphorus Loads, the estimated Suspended Solids loads originate from the same areas of the watershed. As expected, agricultural uses on sloped land and along the Indian Creek floodplain and urban areas are the greatest contributors to suspended solids.

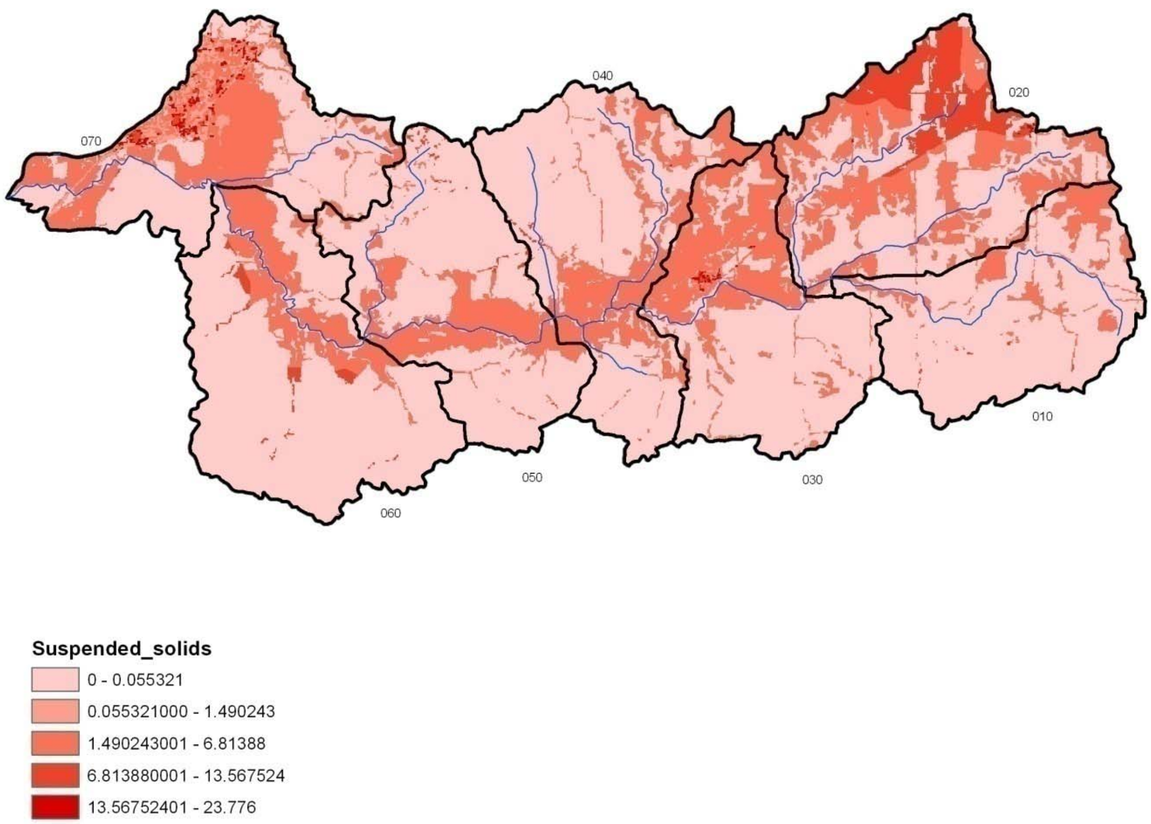

Figure 57. L-THIA: Total Suspended Solids Load in Indian Creek Watershed

Figure 58 illustrates the run-off values of the sub-watersheds, which is a factor of land use and slope. Compared with the land use map (Figure 50), runoff values are highest for agricultural land in the Goose/Barnes Creeks sub-watershed and the urban areas of the Sand Creek and Bear Creek/Long Run sub-watersheds. Values then decrease in the Indian Creek floodplain, steep forested areas and flatter forested areas respectively.

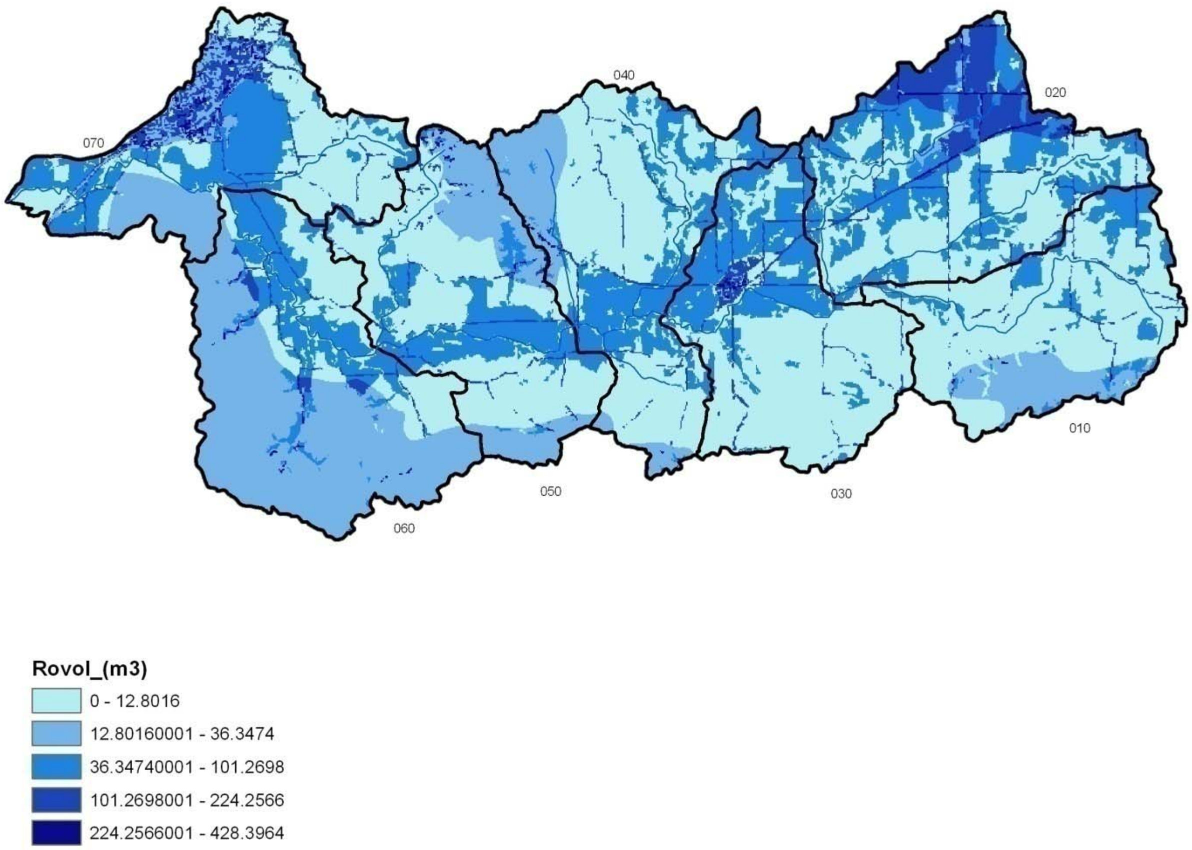

Figure 58. L-THIA: Runoff Values in Indian Creek Watershed

D. Identifying Critical Areas: Prioritization Model

Riparian buffers play an important role in reducing and filtering runoff from land adjacent to streams in the watershed. The Watershed Conservation through Forestry Project developed by Jennifer Sobecki, Indiana Department of Natural Resources, Division of Forestry, uses land use/land cover (LULC), elevation and soils data to identify areas in the watershed where riparian buffers could be critical in reducing pollutant loads to streams. The model developed through this project prioritizes the sub-watersheds and stream reaches to identify critical areas where BMPs would be most effective. Results of this model are confirmed by the visual stream assessments and the L-THIA model results. This model also helps identify additional areas of interest not included in the initial visual assessment.

D.1a. Summary of Methods

The model utilizes a two-stage prioritization framework to target the sub-watershed and stream reach scales. The prioritization utilizes four indicators to score and rank the sub-watersheds on their percent of riparian lands and potential for non-point source pollutant contribution based on LULC and average annual soil loss as determined by the Revised Universal Soil Loss Equation (RUSLE). Maps illustrating the results of the percent riparian land, erosion, riparian land use and land/land use scores and final scores are found below in Figures 59 through 64.

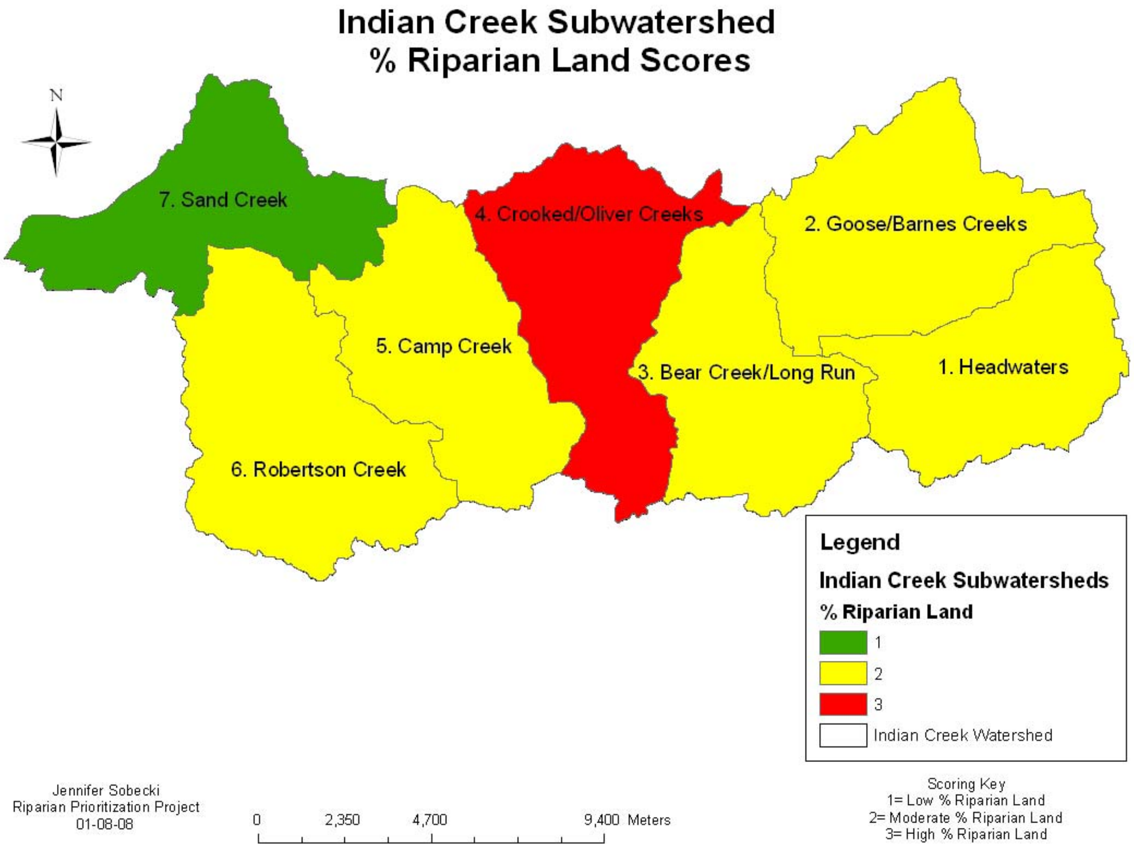

Figure 59. Prioritization Project: % Riparian Land Scores

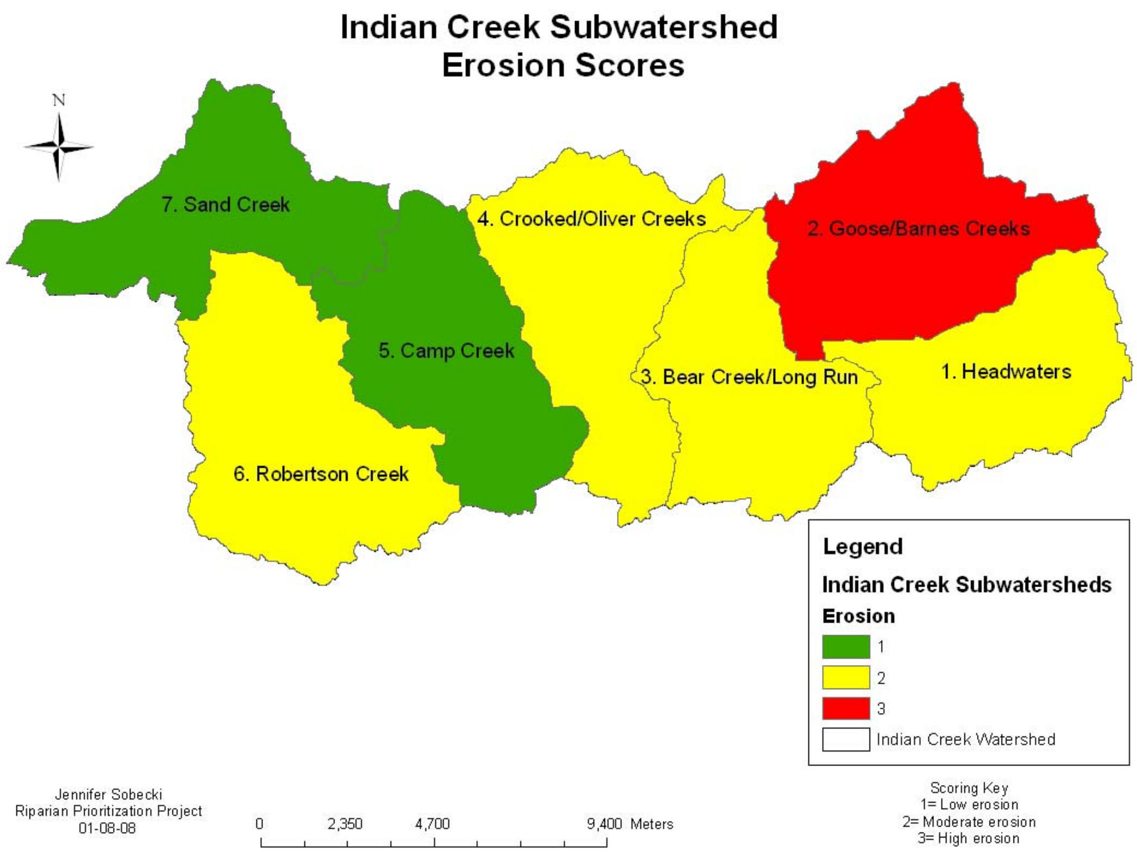

Figure 60. Prioritization Project: Erosion Scores

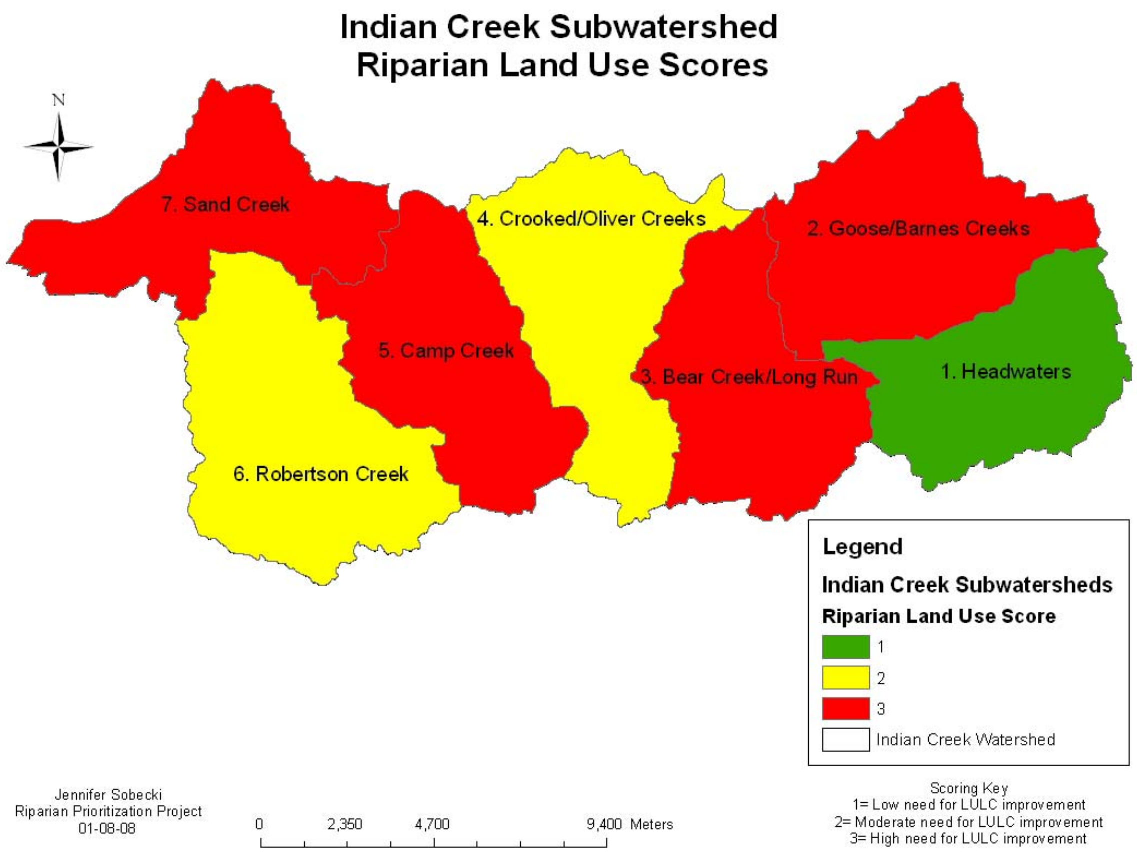

Figure 61. Prioritization Project: Riparian Land Use Scores

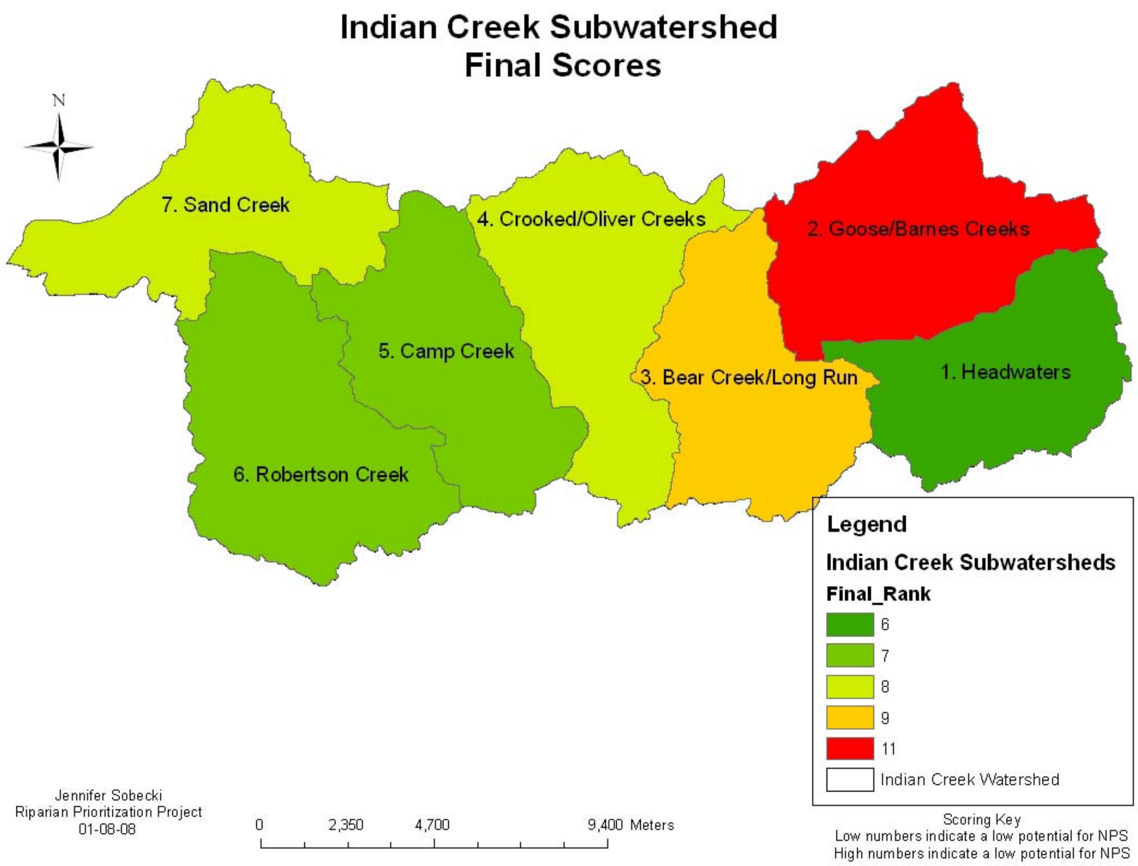

Figure 62. Prioritization Project: Final Scores

D.1b. Watershed Conservation through Forestry Project Prioritization Results

When compared to the L-THIA model, the results are very similar, with most of the same areas highlighted as most critical for contributing to non-point source pollutants, as seen when comparing Figure 62, above, to the L-THIA results shown in Figures 55 through 57. The prioritization model found that the Goose/Barnes Creeks sub-watershed scored the highest potential for non-point source pollutants, with Bear Creek/Long Run second. The L-THIA model identified the Goose/Barnes Creeks sub-watershed as the highest contributor of total suspended solids, phosphorus, nitrogen and runoff, with Sand Creek second and Bear Creek/Long Run third. When ranked on pounds per acre however, Sand Creek became first and Goose/Barnes Creeks second, with contributing factors being total acres of each sub-watershed, topography, and total linear feet of receiving waters. These results focus on the broad areas of the sub-watersheds and fail to show that not all areas of each sub-watershed contribute equally to non-point source pollutants.

The stream reach scoring and ranking of the prioritization model provides an even more detailed look at each sub-watershed, further refining the identification of critical areas at the stream reach scale. The prioritization model analyzed only the riparian areas of the sub-watersheds for the stream reach analysis, setting a riparian zone at 30 meters wide on each side of a stream with reaches approximately ½ mile long. The two parameters used were percent of contributing LULC and average annual soil loss within the reach. Higher scores indicated a greater potential for pollutant contributions and need for riparian forest buffers. Figures 63 and 64, below show the results for each sub-watershed overlaid on the L-THIA model runoff results. This comparison shows mostly agreement on areas of greatest concern. In general, the higher ranked stream reaches (in red and orange) correspond with the L-THIA model darker shades indicating where greater runoff occurs.

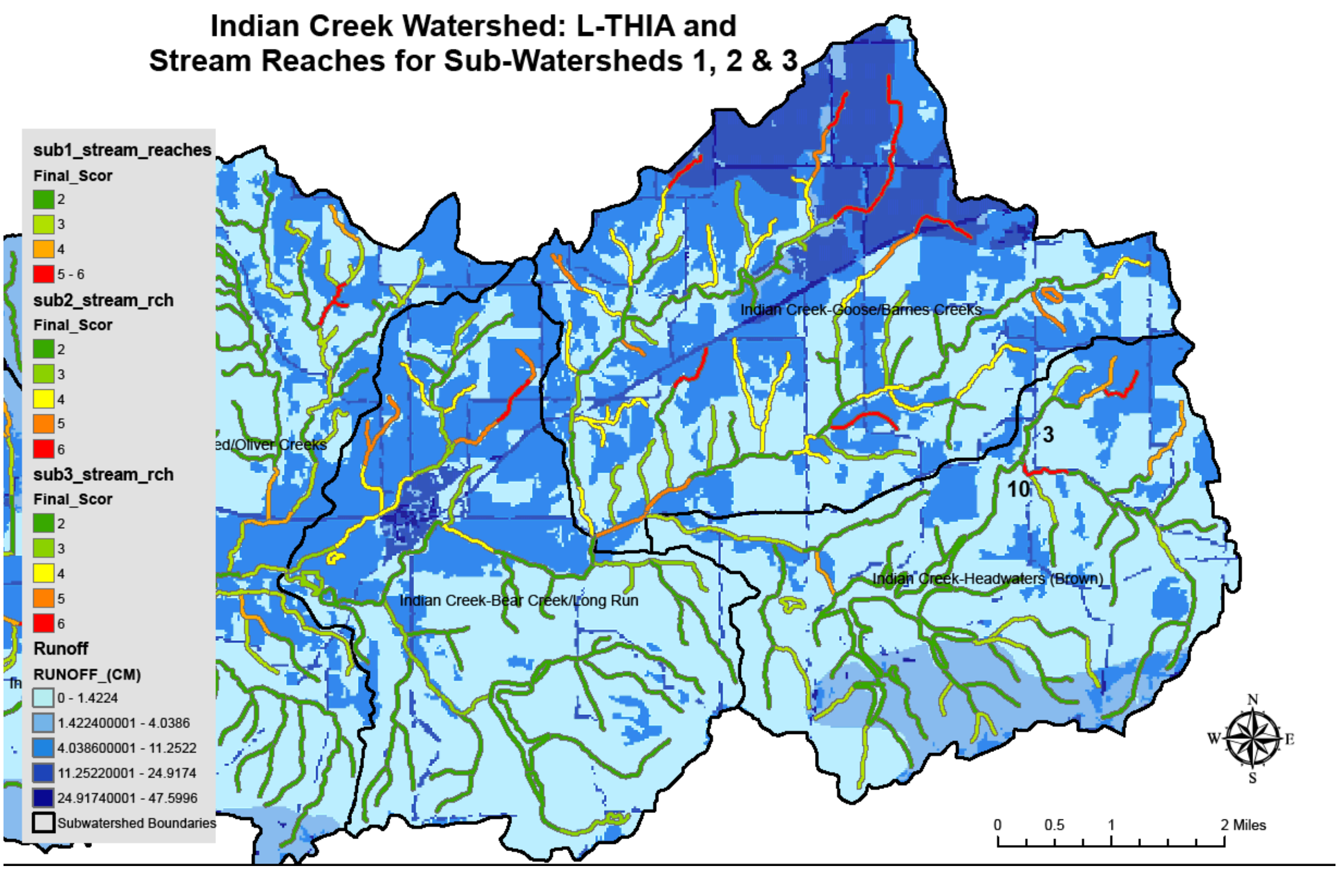

Figure 63. L-THIA and Stream Reach Prioritization for Sub-watersheds 1, 2 and 3

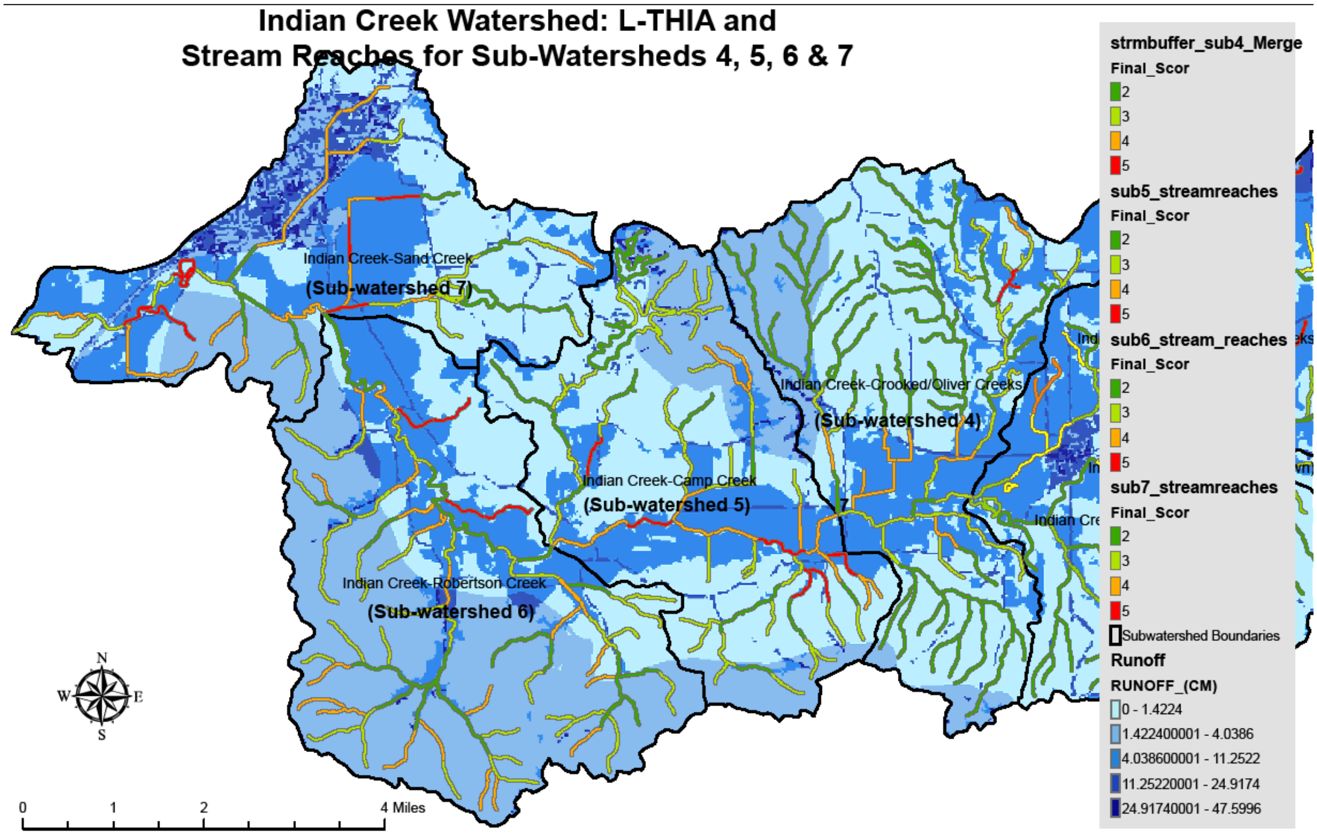

Figure 64. L-THIA and Stream Reach Prioritization for Sub-watersheds 4,5, 6 and 7

Compared with the Stream Reach and Land Use/Land Cover maps in Figures 65 and 66 below, these higher ranked areas also correspond to cultivated cropland or pasture land, and to a lesser degree, residential and urban areas. The conclusions that can be made by comparing these models are that BMPs are needed for agricultural , residential and urban lands draining to the higher ranked stream reaches, especially practices that would slow and filter runoff from that land before it reaches the streams.

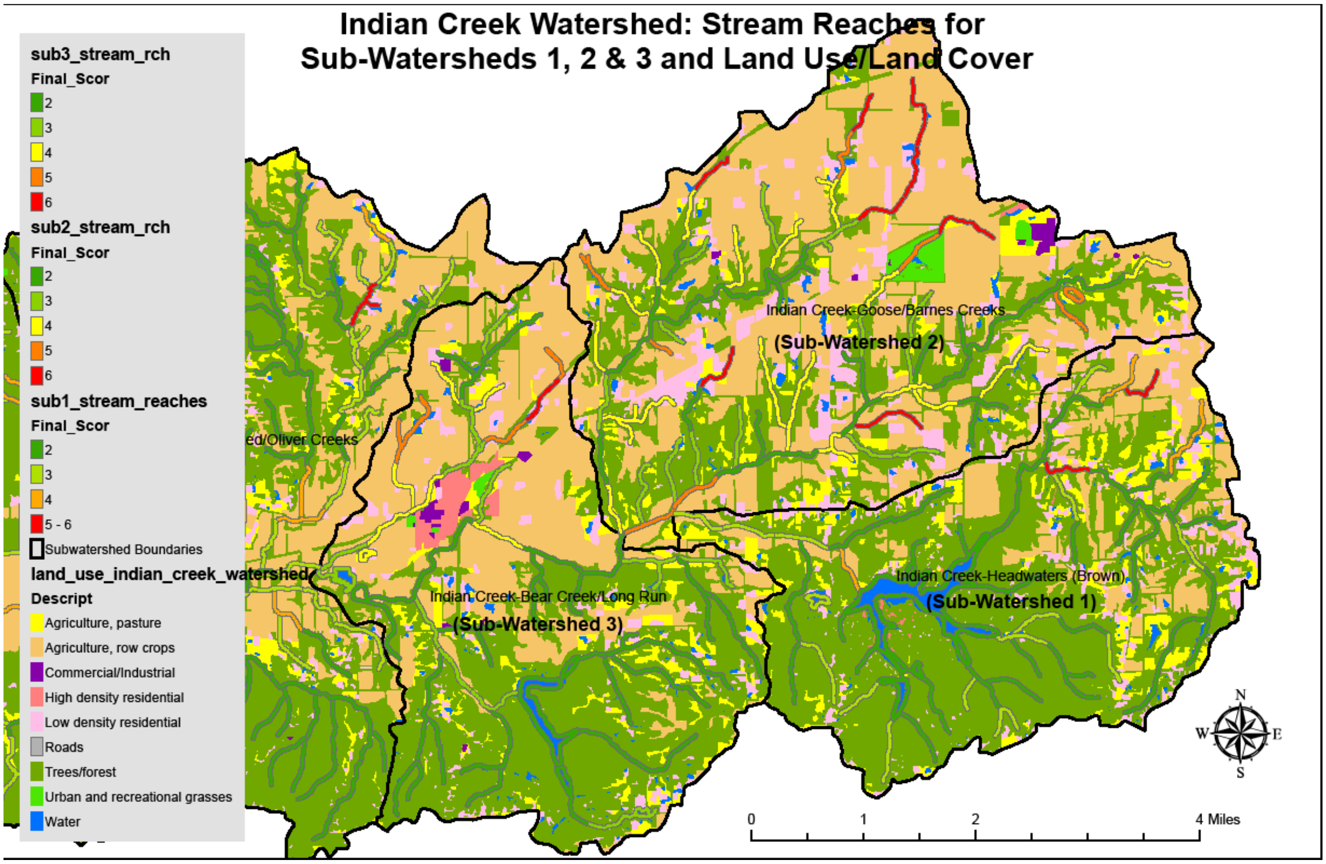

Figure 65. Stream Reaches for Sub-watersheds 1, 2 and 3 and Land Use/Land Cover

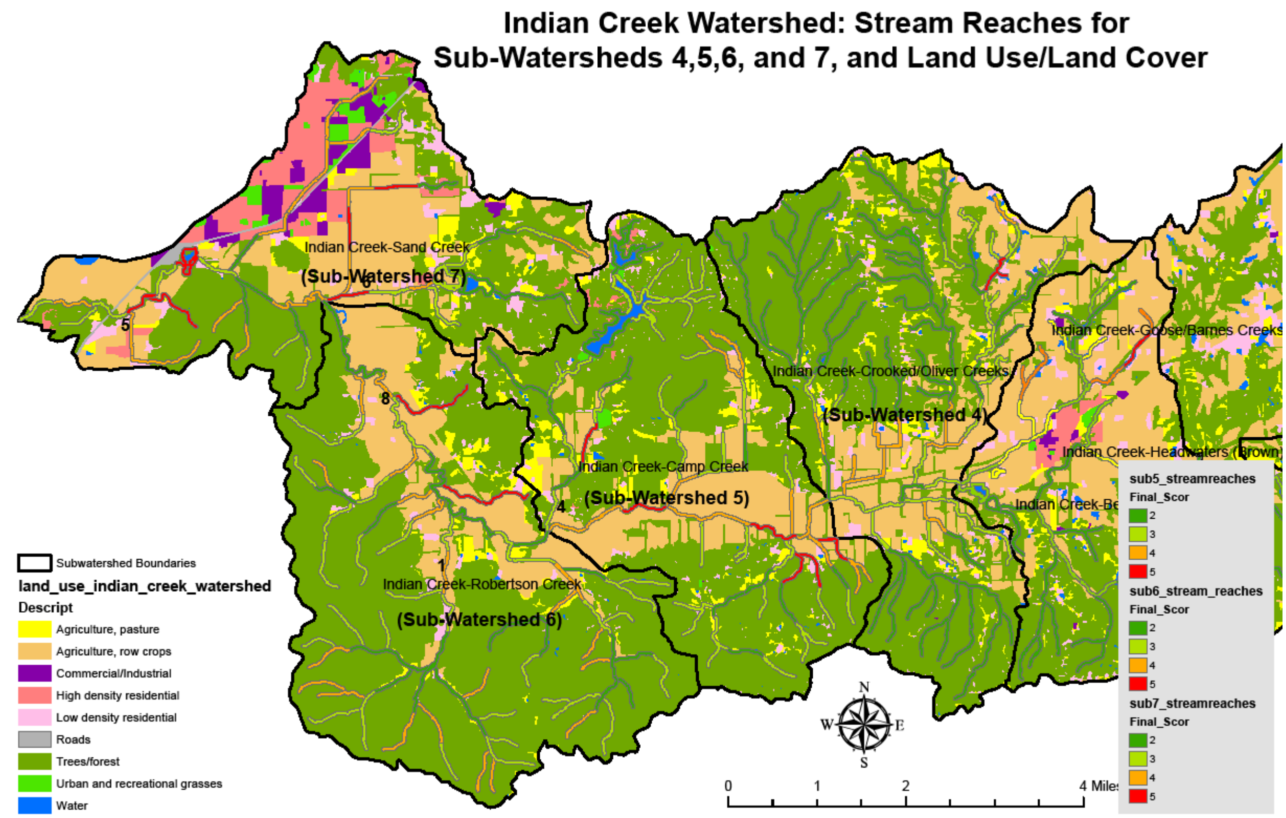

Figure 66. Stream Reaches for Sub-watersheds 4,5, 6 and 7 and Land Use/Land Cover

The following Figures 67 through 72 compare the results of the Stream Reach model and the visual stream assessments conducted by the watershed staff, which provides ground-truthing of the Prioritization model. Figures 67 and 68 show that the riparian buffer widths from the visual assessments closely match the results from the Prioritization model in identifying stream reaches in need of riparian buffers. Figures 69 and 70 show to what extent those reaches identified as higher priority have suffered stream bank erosion, as observed by the stream assessment. Figures 71 and 72 show the correlation between stream reaches needing riparian buffers and displaying signs of non-point source pollutants in the form of excessive algae growth, turbidity, discolored water or a combination of those conditions. These maps confirm the critical areas for excessive stream bank erosion and in-stream pollutants, as evidenced by algae and turbidity, as the same areas identified by the L-THIA model and the Prioritization model.

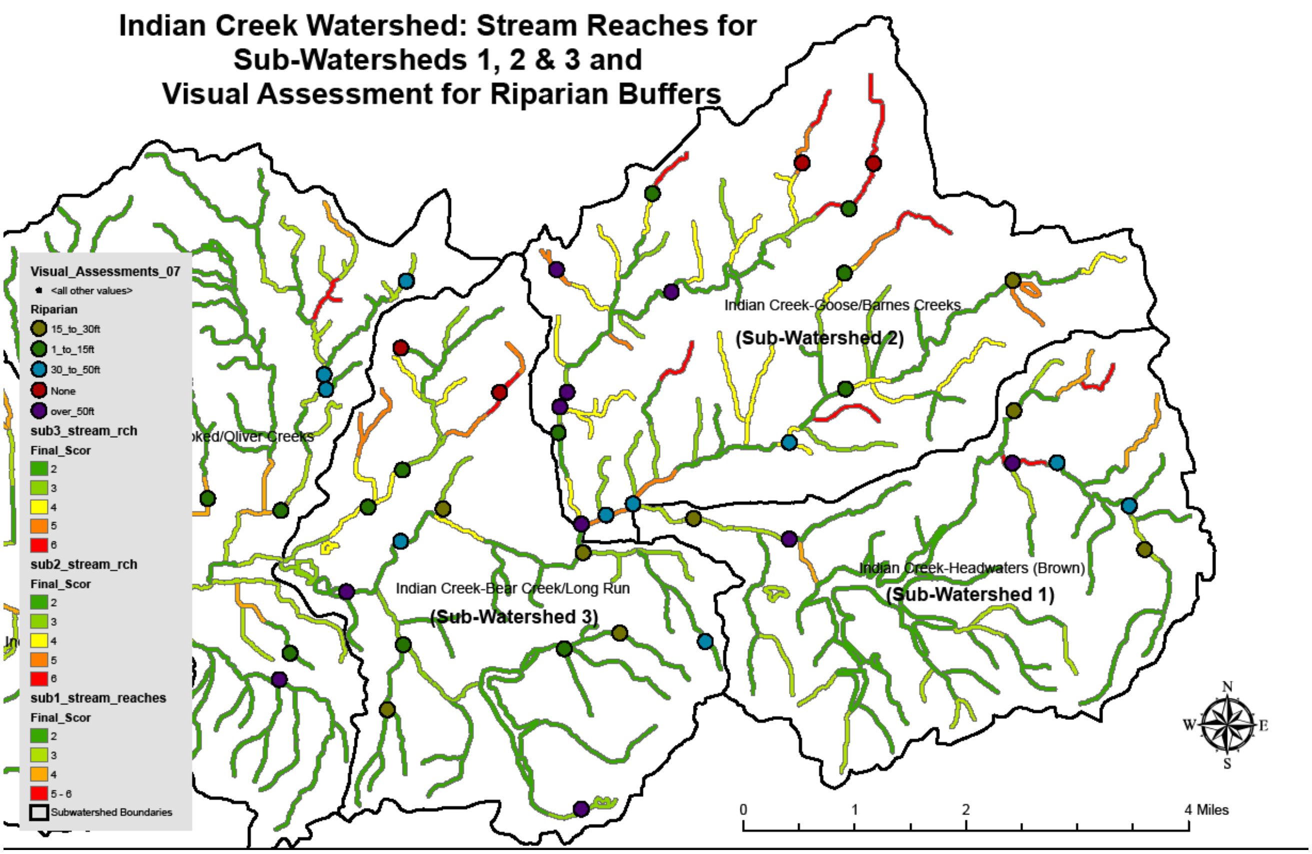

Figure 67. Stream Reach Prioritization with Visual Stream Assessment of Riparian Buffer Widths for Sub-watersheds 1, 2 and 3

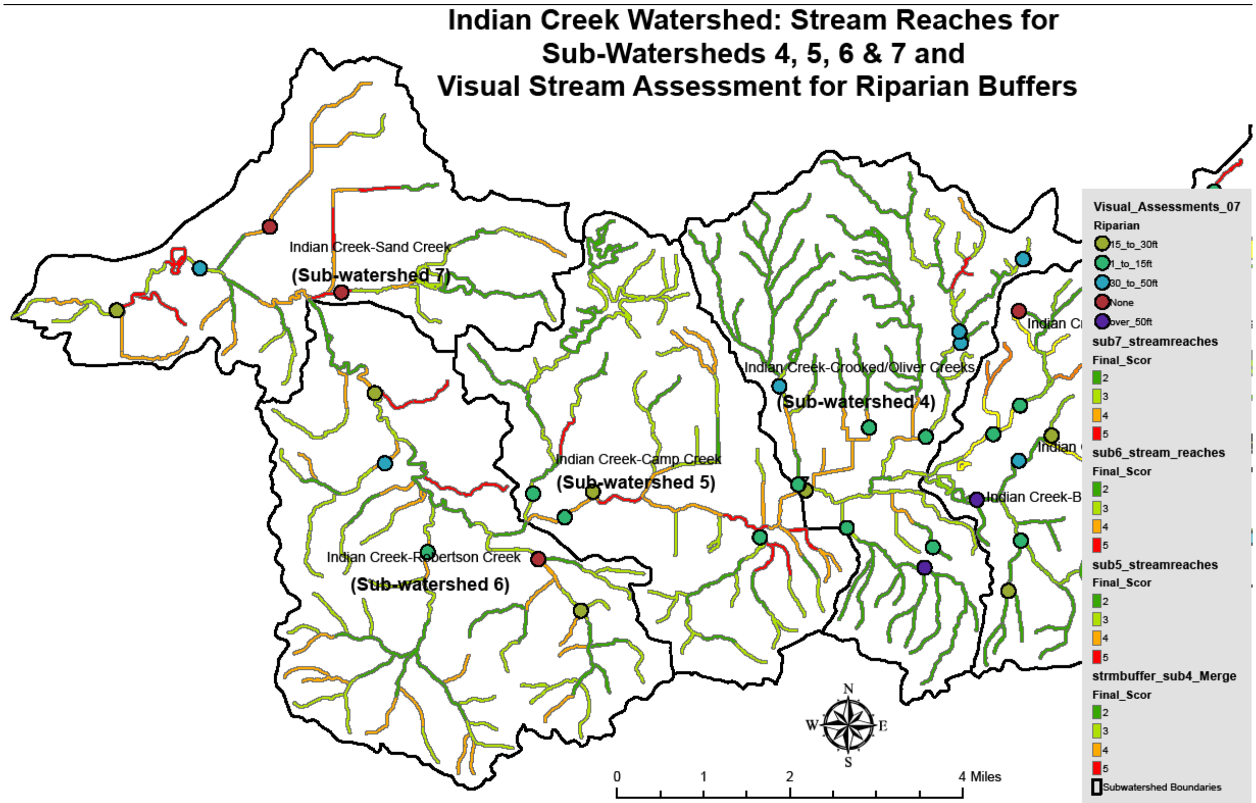

Figure 68. Stream Reach Prioritization with Visual Stream Assessment of Riparian Buffer Widths for Sub-watersheds 4, 5, 6 and 7

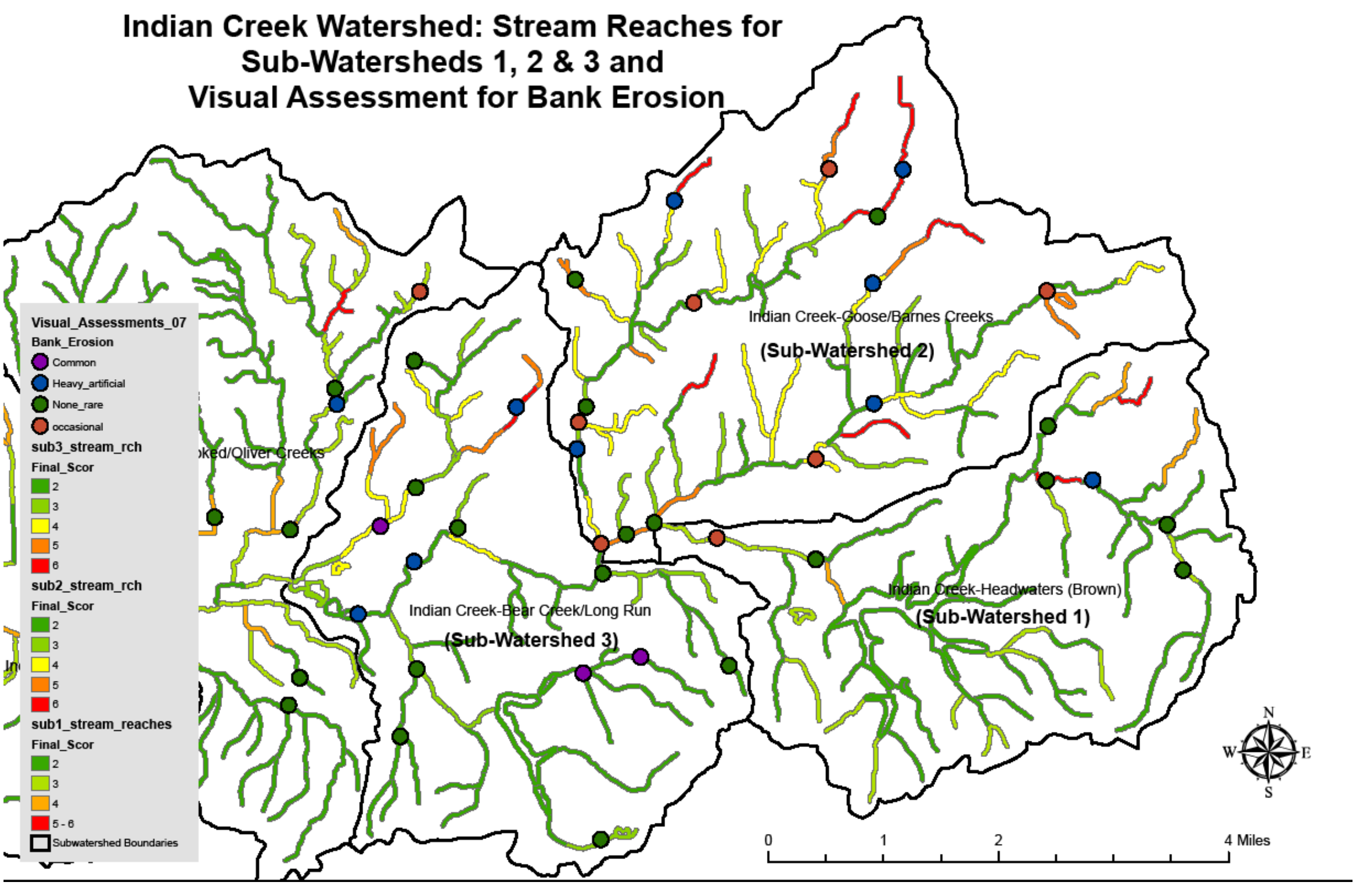

Figure 69. Stream Reach Prioritization with Visual Stream Assessment of Stream Bank Erosion for Sub-watersheds 1, 2 and 3

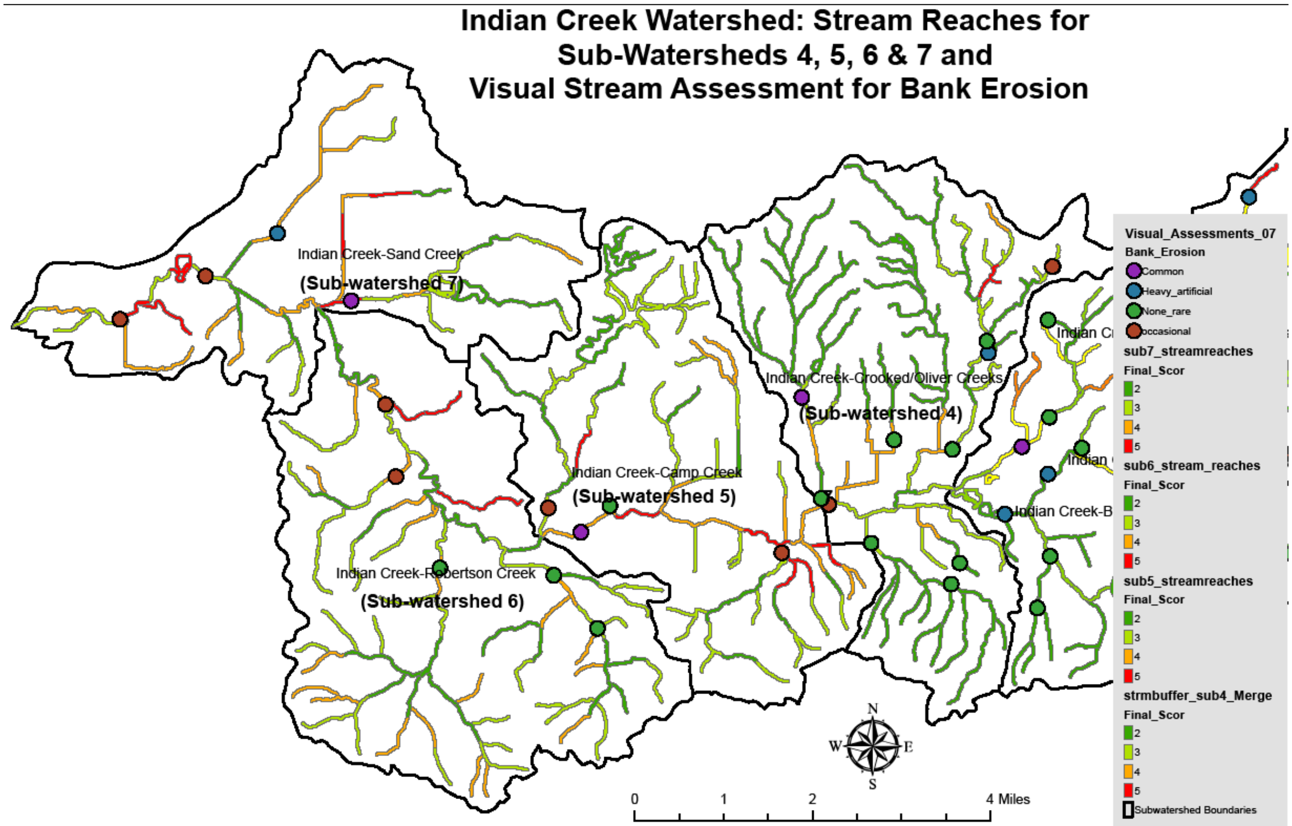

Figure 70. Stream Reach Prioritization with Visual Stream Assessment of Stream Bank Erosion for Sub-watersheds 4, 5, 6 and 7

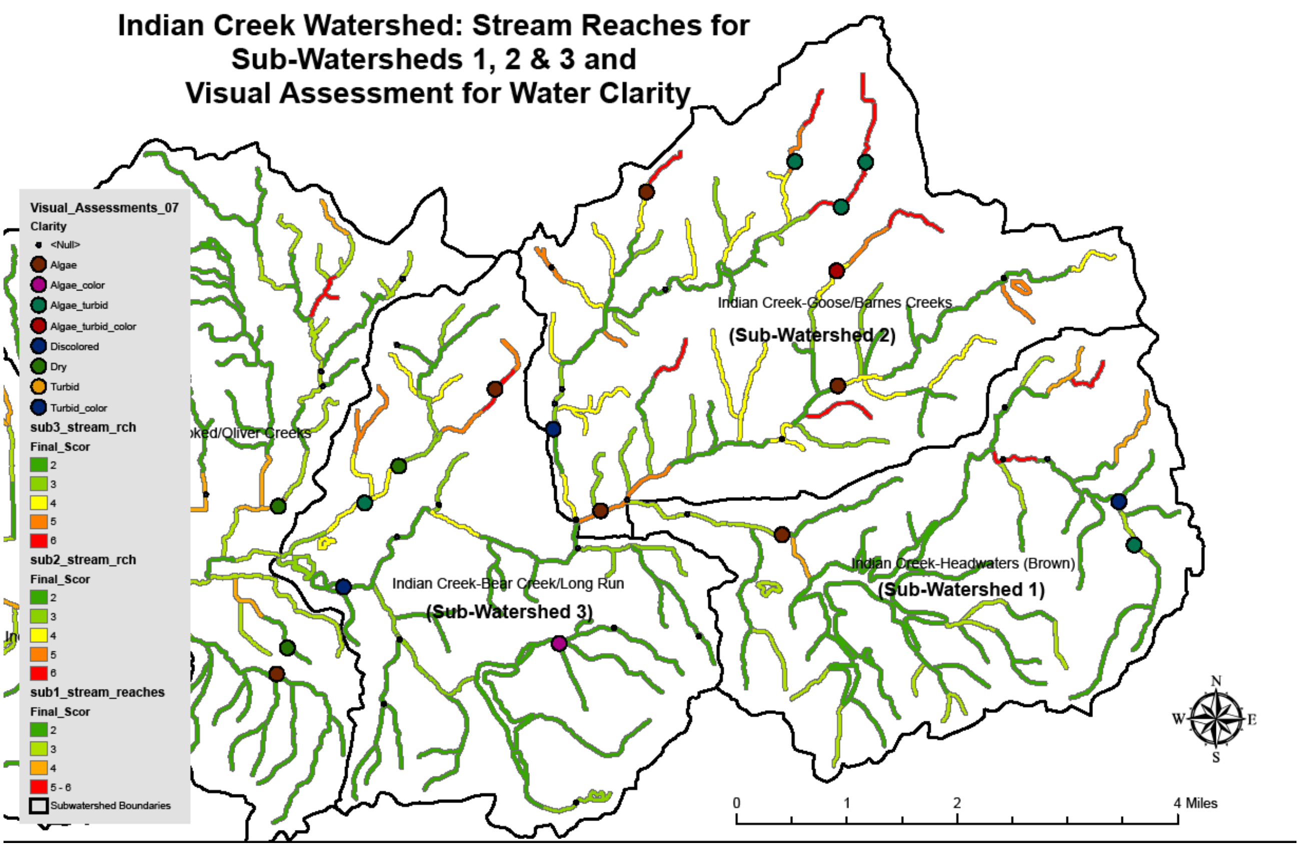

Figure 71. Stream Reach Prioritization with Visual Stream Assessment of Water Clarity for Sub-watersheds 1, 2 and 3

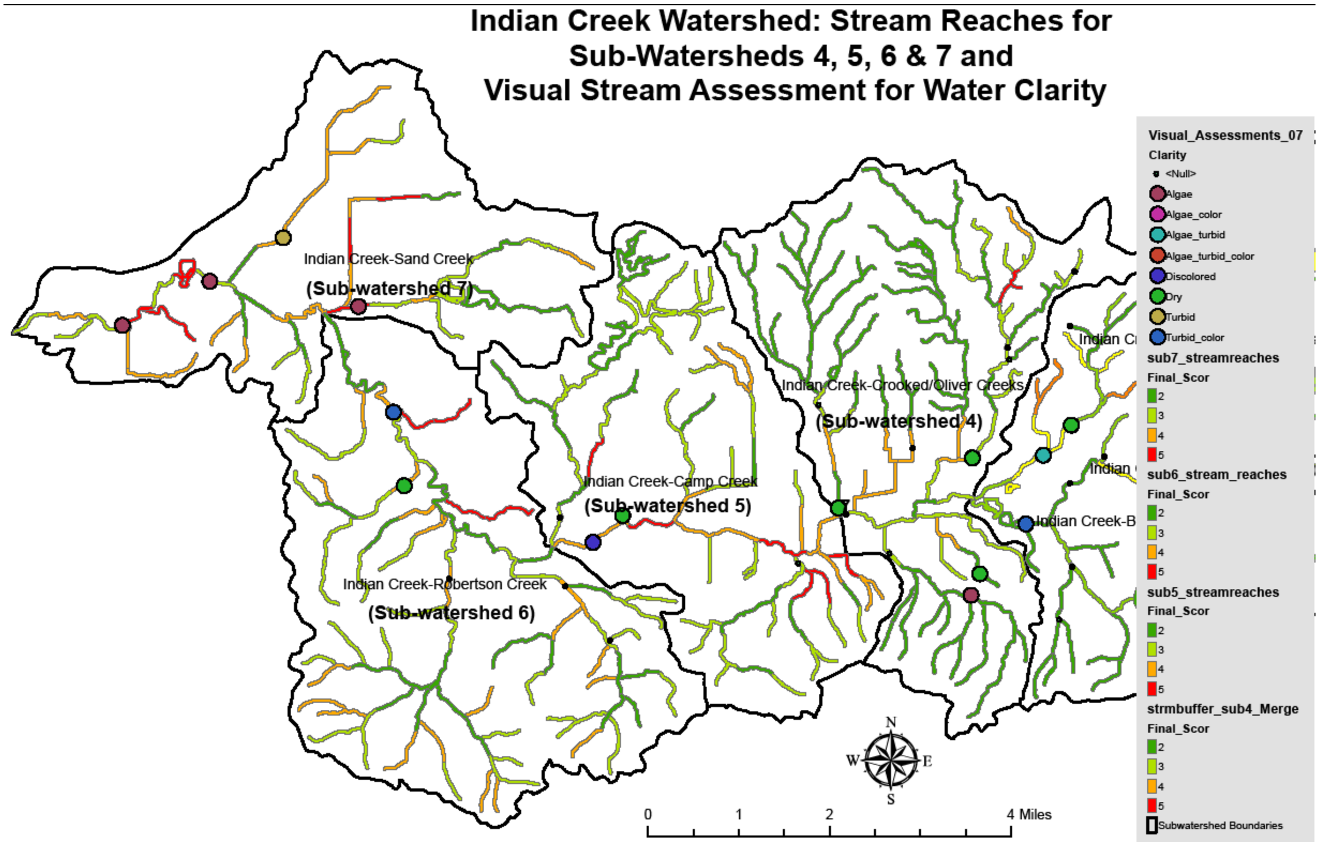

Figure 72. Stream Reach Prioritization with Visual Stream Assessment of Water Clarity for Sub-watersheds 4, 5, 6 and 7

Table 15, below, summarizes the critical areas as identified by comparing data from the TMDL report, L-THIA model, the Prioritization Report and the visual stream assessments. The quantity of acres of land needing BMPs is based on an estimate determined by the Youngs Creek Watershed Management Plant that ten (10) acres of land contributes runoff and non-point source pollutants to each ¼ mile of stream segment (Youngs Creek Watershed Management Plan). The miles of stream segment needing BMPs was determined by identifying all ½-mile segments with a priority ranking of 4 or higher by the Prioritization Model as in need of conservation. The total number of stream miles was then divided into ¼-mile segments and multiplied by 10 to determine approximately how many acres of land are contributing to the identified stream segments.

Additionally, the estimated number of home sites with septic systems, eroding shorelines at lake communities and boat docks requiring signage warning about invasive aquatic species are included since these where identified as concerns by the Steering Committee but not addressed by the models or visual stream assessments. The estimate of home sites with septics was determined from a count of the approximate septic system locations provided by the Johnson County GIS Department and the home site locations provided by the Morgan County GIS. The miles of shoreline needing stabilization and number of docks needing signage were provided by representatives from the Painted Hills and Lamb Lake Home Owners Associations.

Critical area	Quantity	Priority rating
Agricultural land in Sub-watersheds 02, 03 and 07	380 acres along either side of Barnes Creek and Goose Creek segments in red or orange on Figure 63; 100 acres along either side of Long Run segments in red or orange on Figure 63; 220 acres along either side of Sand Creek and legal drain segments in red or orange on Figure 64	Based on 10-acre contributing area for each ¼ mile of stream segment
Agricultural land in the Indian Creek floodplain in Sub-watersheds 02, 03 and 07	416 acres	Agricultural land highly susceptible to flooding and erosion
Stream banks needing stabilization or riparian buffers in Sub-watersheds 02,03 and 07	19 miles in Sub-watershed 02, 5 miles in Sub-watershed 03 and 11 miles in Sub-watershed 07	Segment priority rankings of 4 or higher from Prioritization Model
Home sites with on-site septic systems	1690	Approximate number of home sites with septic systems in watershed
Eroding Lake shoreline needing stabilization at Painted Hills and Lamb Lake	35 miles	Estimates from Painted Hills and Lamb Lake HOAs
Lake docks needing signage for invasive exotic species	40	Estimates from Painted Hills and Lamb lake HOAs

Table 15. Critical areas determined by TMDL, Models and Steering Committee

D.2a. Special Note about the Flood of June 2008

From June 6th through June 7, 2008, approximately 10.7 inches of rain fell on Johnson , 6.58 inches on central Morgan County, 6.37 inches on northern Morgan County and approximately 8.8 inches fell on southern Morgan County and the Indian Creek Watershed. Rainfall on northern and central Morgan County worked its way down the White River to the southern portion of the county, exacerbating flooding conditions there from localized heavy rains. Heavy rains earlier in the month and at the end of May, 2008, had saturated soils throughout both counties, causing waterways to swell far beyond their banks during the June 6-7 flood event. Already severely eroded stream banks were further cut away by runoff from torrential rains and surging streams. In addition to extensive bank damage, many large trees along narrow riparian zones were uprooted, further damaging banks. Assessment of the damage is an ongoing effort between landowners and government officials. Sites identified in the visual assessment as occasional or common for erosion may now be heavily eroded, especially in the Martinsville area where the Indiana Creek reached its highest peak flow, and could contribute to a greater number of stream miles requiring protection, stabilization or restoration.

E. Water Quality Criteria for Nutrients and Total Suspended Solids

Neither the U.S. EPA nor the State of Indiana have established numeric water quality standards for nutrients and total suspended solids in waters designated for full body contact recreational uses, but instead use what is referred to as "narrative criteria." All states have adopted the following EPA narrative in some variation but with the same basic stipulations. The EPA narrative states that:

"All waters, including those within mixing zones, shall be free from substances attributable to wastewater discharges or other pollutant sources that:

1. Settle to form objectional deposits;
2. Float as debris, scum, oil, or other matter forming nuisances;
3. Produce objectionable color, odor, taste, or turbidity;
4. Cause injury to, or are toxic to, or produce adverse physiological responses in humans, animals, or plants; or
5. Produce undesirable or nuisance aquatic life (54 F.R. 28627, July 6, 1989).

This criteria can be applied to algal growth, discolored water and sedimentation observed by the visual stream assessments, as noted above. To further assist this Management Plan in determining a means of assessing acceptable levels of pollutants in conjunction with the narrative criteria, the standards for NPDES permits of 0.3 mg/L for phosphorus and 10 mg/L for nitrogen and 30 mg/L of Total Suspended Solids (TSS) will be used.

As shown in Table 14, above, based on the results of the L-THIA model, none of the sub-watersheds exceeded the standards for Nitrogen but all exceeded the standard of 30 mg/L for TSS and the 0.3mg/L target for phosphorus. The Goose/Barnes Creeks sub-watershed (02) total contribution is estimated by the model as almost three times the standard at 81.427 ppm and the Bear Creek/Long Run sub-watershed (03) total contribution is estimated at 68.326, more than twice the standard. TSS can include soil particles with attached bacteria, nutrients, and pesticides which can help account for the exceedances of phosphorus. Turbid waters and sedimentation in the streams observed by the visual stream assessment confirms that soil particles are present in watershed waters and the presence of algae suggests that nutrients may also be in excess. As stated above in the summary of the L-THIA findings, patterns of land use pollutant contributions for nutrients and suspended solids are very similar. No actual sampling data is available to either confirm or dispute these assumptions. A monitoring program for nutrients and TSS would be necessary to more accurately determine the presence of these pollutants and gauge the effectiveness of any BMPs implemented to improve water quality. Table 16, below shows the pollutant loads as estimated by the L-THIA model, the load criteria, and the recommended percent load reductions for the entire Indian Creek Watershed.

Pollutant	Estimated Concentration (mg/L)	Estimated Load (lbs)	Target Concentration (mg/L)	Target Load (lbs)	Load Reduction (%)	Load Reduction (lbs)
Nitrogen	2.5	106,226	10	422,996	0	0
Phosphorus	0.67	28,227	0.3	12,690	55.2	15,537
TSS	54.9	2,321,995	30	1,268,987	45.4	1,053,008

Table 16. Recommended Pollutant Load Reductions for Nutrients and TSS

F. WATER QUALITY IMPROVEMENT AND PROTECTION GOALS

Based on the problem statements in the previous section, the Indian Creek Watershed Steering Committee reviewed existing data, considered alternatives, and developed goals to address water quality issues in the Indian Creek Watershed:

F.1. E. Coli Goals

Goal

Reduce E. coli concentrations to the State Standard of 125 cfu/100mL in critical areas by the year 2013.

Objectives

1. Implement and install BMPs that filter and reduce runoff from farmland in critical areas that may transport E. coli into streams, such as filter strips, grassed waterways, and riparian buffers and streamside fencing.
2. Increase awareness about how farmland practices may impact water quality through printed media, public meetings and workshops or field days. Encourage and promote the use of watering and manure management systems.
3. Increase awareness about septic system maintenance by partnering with local health agencies and homeowner associations, printed materials, mailings, and other media.
4. Work with local health departments and homeowner associations in developing a system or process for requiring or encouraging septic system owners to perform routine maintenance of their systems by the year 2013.
5. Increase awareness about pet waste impacts on water quality and promote proper disposal through educational and outreach programs by the year 2013.
6. Develop a monitoring program for E. coli to determine the effectiveness of these goals by the year 2013.

These efforts will be directed at the three primary sources identified by the stakeholder Steering Committee: livestock pastures and boarding facilities, failing septic systems, and pet waste on lawns. The Steering Committee examined maps showing land uses and discussed at length those land uses they felt contributed most to the E. coli problem, including discussing landowners they had witnessed with livestock or horses either in streams or grazing on lands adjacent to streams. Discussions were made at several of the stakeholder Steering Committee meetings regarding livestock in the waterways, how to keep them out, how to work with uncooperative landowners, and how the past season of dry weather would influence their perspective of using alternative watering for their livestock. The number of small boarding facilities located throughout the watershed was also discussed, with members stating their personal knowledge of existing operations too small to require operations permits through IDEM. Several of the discussions also involved how to deal with wildlife and how they also contribute to the E. coli problem but no solutions were found. The stakeholders also discussed how pet waste left on lawns could be a potential problem when lawns were located in close proximity to streams.

Stakeholders also suggested setting priority areas as those identified above in Table 12 and using the top ten TMDL Sample Sites, Figure 48, above, as starting point s and look upstream of those sites for land uses that would pose the greatest potential for E. coli contributions. The TMDL sites themselves are not considered to be the critical areas. Efforts will also be directed toward exiting agricultural land within the watershed that supports livestock, provides boarding for horses or land-applies manure and has access to streams. Additional measures, including education and outreach, will be directed toward landowners with septic systems and those with pets through a partnership with local health agencies and homeowner associations.

F.2 Sediment Delivery/Erosion Goals

Goal

Reduce total suspended solids delivery in critical areas within the watershed by 45.4% to meet the narrative water quality criteria and recommended target of 30mg/L.

Objectives

1. Install and implement BMPs that reduce the amount of sediment runoff from the land and total soil loss.
2. Promote timber harvest management and forestland protection practices for the purposes of erosion control.
3. Increase the awareness of consequences to the water quality from sedimentation and what practices can be implemented to reduce runoff through an education and outreach program that will include field days, pasture walks, educational seminars, and brochures.

While actual water quality data was not collected to determine total suspended solids, the L-THIA model indicates that there is high potential for sedimentation and predicts that over 2 million lbs of TSS is deposited in to waters located within the Indian Creek watershed annually (Table 16). The L-THIA model, therefore, indicates nearly a 46% decrease of TSS is required in the watershed to meet the target of 30mg/L. The goal for TSS will be accomplished by directing efforts toward sources identified by the steering committee; lack of riparian buffers, conventionally tilled land, livestock access to streams, shoreline erosion caused by recreational activity in the lakes, and construction sites. BMPs implemented for the purpose of reducing *E. coli* concentrations, such as livestock exclusion fencing and riparian buffers will consequentially reduce sediment delivery to streams. A stream monitoring and sample analysis program is recommended to establish actual water quality data on TSS to appropriately address this concern.

F.3 – Aquatic Plant Growth/Nutrient Goal

Goal

Reduce phosphorus levels by 55.2% to meet the target of 0.3mg/L and maintain acceptable levels of nitrogen to meet the target of 10mg/L in the watershed waters.

Objectives

1. Install and implement BMPs that reduce the amount of nutrient runoff from the land.
2. Increase awareness of consequences to the water quality from improper septic system maintenance through an education and outreach program that will include educational seminars and brochures.
3. Increase the awareness of consequences to the water quality from nutrient runoff and what practices can be implemented to reduce runoff through an education and outreach program that will include field days, pasture walks, educational seminars, and brochures.

Since the L-THIA model found phosphorus concentrations to be in excess by 55.2% of the target of 0.3 mg/L the primary goal for nutrients is to reduce phosphorus loadings into the watershed waters. However, it is also important to maintain acceptable levels of nitrogen in watershed waters which can be accomplished through the BMPs and education and outreach programs that will be implemented to address the phosphorus issue. Nutrients can be carried into waterways by eroded soils and thus share many of the same BMPs for the resolution of sediment delivery. Visual assessments of the watershed waters verified the presence of excess nutrients, likely deposited by sediment. BMPs such as riparian buffers, streamside fencing and nutrient management plans will be a main focus to reduce nutrient loads in the watershed. Educational programs directed toward landowners on septic systems and residential landowners, golf courses, and business owners focusing on the proper application of fertilizer will also improve nutrient loading into watershed waters.

F.4 – Trash/Waste Goals

Goal

Significantly reduce the amount of trash and debris found along roadsides and waterways within the watershed.

Objective

1. Educate watershed stakeholders on the water quality of debris and dumping in and near watershed waters by the year 2013.
2. Partner with local government agencies and non-profit groups to sponsor programs addressing littering and illegal dumping and stream clean-ups.

Visual observations were made of illegal dumping and littering along stream banks during the windshield survey conducted as part of writing this Plan. Debris in the watershed was identified as a major stakeholder concern during early stakeholder meetings and debris may contain various noxious chemicals which may have deleterious effect on aquatic, wildlife, and human health, as well as reduce aesthetic appeal, it is important to include a goal for trash and waste in this Plan. The main way of accomplishing the goal of reducing the amount of trash and debris in the watershed is implement an education and outreach program to educate the public on the effects of littering as well as alternatives to littering.

F.5 - Invasive Aquatic Species Goal

Goal

Protect watershed waters from invasive aquatic species through watershed stakeholder education and outreach.

Objectives

1. Assist lake community HOAs with finding partners to educate lake users on the concerns of invasive aquatic species.
2. Assist HOAs in finding partners to educate the public on potential dangers of decorative water garden plant species that may become invasive.
3. Assist HOAs in finding partners to establish a monitoring program for invasive aquatic species.

Stakeholders identified invasive species as a concern and the 2000 UWA determined invasive species to be a problem in the watershed. Although specific invasive species were not found in the watershed during a visual assessment, invasive species, if introduced into the watershed, can have detrimental effects on native aquatic species, as well as reduce aesthetics. Therefore; the goal to protect watershed waters from invasive species was added to the Plan as a preventative measure.

Section VI. Recommended BMPs and Measures

To achieve the water quality improvements needed to reduce pollutant concentrations as identified above and to protect those waters and areas identified as important for maintaining high water quality, the stakeholder Steering Committee selected BMPs , outreach and educational programs, and preventative measures from sources such as the U.S. EPA and the NRCS that have been determined to address the specific water quality concerns identified above. Several BMPs were selected because of their ability to address more than one concern. For example, riparian buffers address the concern of erosion and nutrients from agricultural fields as well as stream bank erosion. Some BMPs work best if implemented along with others, such as fencing livestock from stream access and providing alternate watering systems with heavy use area pads to eliminate the need for watering from streams. The fencing helps prevent stream bank erosion and the heavy use area pads prevent erosion from watering areas.

A. Summary of Concerns, Critical Areas, Estimated Loads and Load Reductions

The TMDL Report and the stakeholder Steering Committee identified water quality concerns in the watershed as: E. coli, erosion/TSS, nutrients, trash/debris and exotic invasive species.

The TMDL, L-THIA model, Prioritization Model and visual assessment identified areas or land uses most likely to contribute to pollutants in watershed waters. Agricultural land uses and under-protected stream reaches were identified as the primary sources of E. coli, and erosion/TSS, nutrients. Residents and users of the roads in the watershed were identified as the primary sources of the trash and debris. The lake communities were identified as the primary source of possible introduction of invasive aquatic species.

The TMDL identifies the concentration of E. coli at specific monitoring sites and IDEM provided data for the recommended percentage of reduction needed to meet state water quality standards.

The L-THIA model provides estimates for loads of nitrogen, phosphorus, TSS and fecal coliform from various land uses, however, actual data is not available. Therefore, conclusions are based solely on estimated data.

B. Estimated Load Reductions for Management Measures

Based on estimates determined from the L-THIA model, no reduction for nitrogen was needed but phosphorus exceeds the water quality target of 0.3mg/L by 55.2% which means that a load reduction of 15,537 lbs/yr must be accomplished to meet our target. The L-THIA model also predicted an exceedance in the TSS target for the watershed of 30mg/L, by 45.4% requiring a reduction of 527 tons/yr. To reach these targets it is first necessary to determine which BMPs will provide the most effective reductions. Table 17 provides a list of the pollutants of concern for which load calculations have been made and what measures have been identified to reduce those loads. The load reductions for TSS are an estimated average of calculations for practices installed in Johnson County under the Youngs Creek Watershed Management Plan and examples cited in the Michigan Department of Environmental Quality's *Pollutants Controlled Calculation and Documentation for Section 319 Watershed Training Manual.* Sediment delivery calculations were made using the RUSLE method to estimate the loss of soil from priority fields prior to the installation of BMPs. The RUSLE method is best utilized on sites with slope lengths of less than 1000 feet and based on the delineation of soil types within that area. Phosphorus reductions were estimated by using the EPA Region 5 Load Reduction Model. No reliable method currently exists for the calculation of *E. coli* reduction through the utilization of a BMP. However, a reasonable assumption can be made that through the utilization of BMPs for the reduction of other pollutants, *E. coli* will also be reduced. Additionally, BMPs specifically for the reduction of *E. coli,* such as livestock exclusion fencing and riparian buffers along streams, are known to reduce the loading of other pollutants. The recommendation of this Plan is to implement a water quality monitoring program to help determine if these BMPs will actually reduce *E. coli* after their implementation.

Table 17. Table w/load reductions per BMP

BMP	TSS Reduction	Phosphorus Reduction	Nitrogen Reduction
No-till	2.3 t/acre/yr	126 lbs/acre/yr	234 lbs/acre/yr
Mulch-till	1.4 t/acre/yr	126 lbs/acre/yr	234 lbs/acre/yr
Filter Strips	1.6 t/acre/yr	20 lbs/acre/yr	234 lbs/acre/yr
Residue Management	1.1 t/acre/yr	126 lbs/acre/yr	234 lbs/acre/yr
Riparian Buffers	2.5 t/acre/yr	28 lbs/acre/yr	57 lbs/acre/yr
Exclusion Fencing	1.0 t/acre/yr	42 lbs/acre/yr	85 lbs/acre/yr
Heavy Use Area Pads	0.2 t/acre/yr	42 lbs/acre/yr	85 lbs/acre/yr
Pasture/Hay Seeding	2.5 t/acre/yr	28 lbs/acre/yr	57 lbs/acre/yr
Grassed Waterway	1.6 t/acre/yr	28 lbs/acre/yr	57 lbs/acre/yr
Nutrient/Pest Mgnt.	0.4 t/acre/yr	126 lbs/acre/yr	234 lbs/acre/yr
Shoreline Protection	2.5 t/acre/yr	42 lbs/acre/yr	85 lbs/acre/yr
Shoreline Stabilization	2.5 t/acre/yr	42 lbs/acre/yr	85 lbs/acre/yr

C. MONITORING PROGRAM

C.1. Purpose of Monitoring Program

A monitoring program would be essential to determine the effectiveness of the BMPs proposed by this plan and provide a current, more accurate description of water quality conditions in the watershed. A monitoring program would provide actual data to supplement the generalized data generated by the L-THIA model at the commencement of the implementation phase of this plan and additional data to measure the success of BMPs as the plan is implemented. It would also provide data on E. coli concentrations as a result of BMP installation since calculations to estimate concentration reduction are not possible. Also, it would establish an ongoing program for the watershed to continue monitoring water quality well into the future.

Generalized data collected during this planning phase was through the use of the L-THIA model to help determine where water quality problems were expected to be better or worse and identify critical areas based on the parameters used by the L-THIA model. Actual data from on-site sampling and analysis will provide a basis to determine what actual pollutant levels exist prior to implementation of BMPs and any reductions in those pollutants as a direct result of BMPs through implementation of the plan. Monitoring will also provide more current data regarding E. coli concentrations since the most recent available data collected in 2001 is now more than seven years old.

C.2. Development and Submittal of a Quality Assurance Project Plan

A Quality Assurance Project Plan (QAPP) will be developed and submitted to the IDEM to assist in the development of a monitoring plan and prior to conducting any monitoring. A QAPP will provide guidance for the monitoring plan to achieve the project goals, provide focus, clearly outline the quality of the data to be collected, provide a plan to ensure data quality and consistency, and allow problems with data to be discovered early in the process. The QAPP and monitoring plan will describe how monitoring data will be used to assist the plan in meeting its water quality goals. It will identify where monitoring samples will be collected and the frequency of collection, the methods used to collect and analyze the samples, what parameters will be analyzed, and how the data will be interpreted.

C.3. Monitoring Goals

The first goal of the monitoring plan will be to fill in data gaps in water quality data available for the watershed. Although the TMDL provides data for E. coli concentrations, stream flow data is absent, which is an important component in determining the potential sources of the bacteria, and thus the BMPs necessary to address it. Habitat assessment is another gap in data that would provide a more comprehensive picture of the watershed water quality. Actual quantitative data for nutrients and TSS are also gaps in data that are vital for determining which and where BMPs would be most effective. As mentioned above, monitoring will also be essential in determining the effectiveness of the BMPs in reducing pollutants.

Another goal of the monitoring plan is to more accurately determine the sources of the named pollutants by diversifying the monitoring sites beyond the Indian Creek into the tributary streams, which were not monitored previously. Also, the monitoring plan would provide a database of parameters for future use in land use planning.

C.4. Monitoring Site Selection

Site selection will employ both synoptic and target approaches. There are twelve sites that would provide data for a synoptic approach. A synoptic approach will sample sites along all the major tributaries and the main stream of Indian Creek itself. This approach will provide information regarding the contributions from the major tributaries to the Indian Creek. Many of these sites are TMDL sites and thus provide data for comparison of the existing pre-implementation data from the TMDL and subsequent post-implementation data. The data from these sites will provide an overall summary of the watershed's water quality. An additional eight to ten sites would use the target approach. The target approach will involve the selection of sites identified by the Prioritization model as most critical in their contributions of pollutants along the major tributaries. These sites will provide data for pre- and post-implementation of specific BMPs and their effectiveness. A combination of site selection using these two approaches will allow capitalization of logistical efficiencies and provide flexibility in implementing the plan if issues not picked up by the model are identified.

C.5. Monitoring Frequency

For comparisons of data from the TMDL to data generated under this plan to be valid, monitoring conditions and locations must be consistent. The Indiana WQS sets the target for E. coli at 125 cfu per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1 through October 31. TMDL data came from samples taken five days apart between July 25, 2001 and August 21, 2001. Adherence as close to that time frame as possible would provide the best comparable data generated by this plan. To provide an accurate comparison of before and after BMP implementation data, the sampling would be conducted in the first year prior to BMP implementation and at least every other year thereafter to accurately detect anticipated reductions in the target parameters. Monitoring on a two- year cycle may be sufficient to provide adequate data since the recommended structural BMPs will be installed over a period of years and may not reduce targeted pollutants for a number of years.

C.6. Monitoring Methods

Methods for collecting samples and analyzing data will be conducted according to the IDEM's Consolidated Assessment and Listing Methodology so results can be evaluated for compliance with Indiana's WQS for E. coli and benchmarks for parameters such as TSS and nutrients that have no defined WQS. Watershed or SWCD staff and volunteers trained in the Indiana Department of Natural Resources (IDNR) Hoosier Riverwatch program will collect grab samples at sites determined by the monitoring plan. Water quality monitoring will be accomplished by two methods: 1) analysis by a professional laboratory; and 2) analysis by trained volunteers or project partners who have analytical capabilities to conduct the analyses for in-kind match.

This method can also yield a data set that can be used to calibrate modeled results obtained using the L-THIA model and subsequent future data collected by Hoosier Riverwatch volunteers.

C.7. Monitoring Parameters

Monitoring parameters will be for pollutants of concern as identified by the TMDL and the watershed stakeholders. The first parameter is E. coli, which has been identified in the TMDL as a pollutant of concern in concentrations above the State Water Quality Standard for that pollutant. The stakeholder Steering Committee identified nutrients, specifically nitrogen and phosphorus, as potential causes of excessive aquatic plant growth such as algae. The Steering Committee and the L-THIA model both identified sediment or Total Suspended Solids as pollutants resulting from soil erosion.

Hoosier Riverwatch volunteers will collect grab samples from designated sites and perform analysis of E. coli, turbidity and nutrients while submitting additional samples to a professional laboratory for analysis for E. coli and TSS. The analysis of samples for E. coli by the Hoosier Riverwatch group is recommended for comparison to the results from the laboratory to calibrate results for future reference when funds for professional analysis may no longer be available and monitoring will be conducted only by Hoosier Riverwatch volunteers or a partnering agency with laboratory analysis availability.

Since E. coli concentrations have been established through the TMDL and if data is potentially to be used by IDEM for CWA section 303(d) listing decisions, an accurate gauge of progress would necessitate a continuation of the use of EPA or Standard Methods to collect and analyze data. Also, since State Water Quality Standards are established for E. coli, it is important that sample analysis be consistent with State criteria. Monitoring for E. coli will help determine the effectiveness of BMPs such as streamside fencing to limit livestock access, filter strips and riparian buffers. It will also help determine if awareness of septic system maintenance through outreach and education programs has resulted in a reduction of E. coli from those sources.

Nutrients and sediment as TSS are also identified in this plan as other parameters needing monitored. Hard data for these parameters is needed to determine if BMPs such as filter strips, riparian buffers and cover crops are effective in reducing these pollutants. Also, as noted above, this data will be used to calibrate modeled results obtained using the L-THIA model. The use of trained Hoosier Riverwatch volunteers for obtaining and analyzing samples will allow the monitoring program to continue beyond any subsequently 319- funded phases of this plan and also allow more flexibility in adding additional monitoring sites if necessary. Continued monitoring for TSS using Hoosier Riverwatch methods would require the purchase of special equipment, such as a drying oven, laboratory scale, filters, etc, which are not part of the typical Hoosier Riverwatch toolkit. Partnering with a laboratory for in-kind services is also an alternative. Identifying such a laboratory would be accomplished in the initial stages of the next phase of this project.

C.8. Data Quality

The monitoring plan will identify Data Quality Objectives (DQOs) for all the parameters to be analyzed. The DQOs will assure the quality of the data for purposes of serving the WMP and comparability to other data sources. The quality of data is vital because the sensitivity or precision of data will affect the study goals by determining if goals are being met or not. This part of the monitoring plan will also identify control measures built into the study to identify accuracy checks and who will perform them.

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Section VII. Measures and BMPs to Apply

A. Determining Measures and BMPs

The stakeholder Steering Committee and SWCD staff reviewed the NRCS Field Office Technical Guides (FOTGs), EPA's *National Management Measures for the Control of Nonpoint Pollution from Agriculture*, USDA programs, and the Youngs Creek Watershed Management Plan for BMPs suitable to address land uses in the watershed and the resultant pollutants. BMPs were selected for their effectiveness in reducing contributions of multiple pollutants, ease of installation, projected costs and likelihood of adoption. The following Implementation Schedule Action Register tables address the problem statements, goals and objectives framed by the Steering Committee and outline a path to achieving those goals and objectives.

IMPLEMENTATION SCHEDULE ACTION REGISTER

Table 18. Problem Statement: High concentrations of E. coli result in unhealthy conditions for consumption and recreational uses in the Indian Creek Watershed.

Goal 1: Reduce E. coli concentrations to 125 cfi/100ml in critical areas by 2013.

Objective 1: Implement and install BMPs on farmland in critical areas that filter and reduce runoff that may transport E. coli into streams.

Action Items	RESPONSIBLE PARTY	Total Costs	Funding Mechanism	Indicators	Milestones		
					Short < 1 yr	Med < 3 yr	Long < 5 yr
Task 1 Install BMPs on agricultural lands to protect streams	SWCD Indian Creek Project, USDA programs, EQIP, CREP	$306,400	USDA programs, EQIP, CREP, 319 grant funds	# acres with BMPs installed # streamside fencing installed	50	150	250
I/E Activities for Task 1 Host informational workshops and meetings with farmers and landowners Distribute brochures informing farmers and landowners about management practices that reduce E. coli introduction into streams Inform farmers about USDA programs through mailings.	SWCD Indian Creek Project, ISDA, USDA		319 grant funds, USDA programs,	# workshops held # participants # requests for assistance # brochures distributed # mailings distributed	2 40 6 400 400	4 80 12 800 800	6 120 18 1200 1200

Objective 2: Increase awareness of landowners about the impact of septic systems on water quality and E. coli contributions.

Task 2 Work with local officials on septic system failure reporting	SWCD Indian Creek Project, Johnson & Morgan County Health Departments	$20,000		# failed septic systems reported	10	20	30
I/E Activities for Task 2 Distribute brochures on septic system maintenance Hold workshops on septic system maintenance Provide web-based resource site about programs Distribute quarterly newsletter to keep stakeholders informed	SWCD Indian Creek Project, Johnson & Morgan County Health Departments	$5,000	SWCD funds	# brochures distributed # workshops held # participants # hits on web site # newsletters distributed	1,000 1 200 20 1000	2,000 2 400 40 2000	3,000 3 600 80 3000
Monitoring Activities for Task 1/2 Develop monitoring program for E. coli	SWCD Indian Creek Project	$16,000/yr	LARE grants, 319 grant funds	E. coli concentrations (cfu/100 ml)	1	2	3

IMPLEMENTATION SCHEDULE ACTION REGISTER

Table 19. Problem Statement: Excessive soil and nutrients into streams reduces both water and soil quality.

Goal 2: Reduce TSS delivery in critical areas within the watershed by 45.4% to meet the narrative water quality standard of 30mg/L and phosphorus delivery by 55.2% to meet the target of 0.3mg/L.

Objective 1: Install BMPs on agricultural lands to prevent soil erosion and phosphorus delivery into streams.

Action Items	RESPONSIBLE PARTY	Total Costs	Funding Mechanism	Indicators	Milestones		
					Short <1 yr	Med <3 yr	Long <5 yr
Task 1 Promote and implement BMPs such as riparian buffers, no-till equipment modifications and exclusion fencing	SWCD Indian Creek Project, USDA programs, EQIP, CREP	$806,400	LARE grants, 319 grant funds, USDA programs, EQIP, CREP	# acres with BMPs installed	50	100	150
I/E Activities for Task 1 Host informational workshops and meetings with farmers and landowners Distribute brochures on erosion prevention from farmland, streambanks, and lake shorelines Inform farmers about USDA programs through mailings	SWCD Indian Creek Project, USDA, IDNR, local land conservancy groups	$20,000	SWCD funds, local land conservancy funds, 319 grant funds	# brochures distributed # workshops held # participants # mailings distributed	200 1 50 200	400 2 100 400	600 3 150 600

Objective 2. Promote timber harvest management and forestland protection practices for the purposes of erosion control.

Action Items	RESPONSIBLE PARTY	Total Costs	Funding Mechanism	Indicators	Milestones <1 yr	<3 yr	<5 yr
Task 2 Install BMPs on logged forested land to reduce soil erosion	SWCD Indian Creek Project	$ 50,000	LARE grants	# acres with BMPs installed # stream miles protected	10 5	20 10	30 15
Task 3 Work with state agencies and local groups to promote forest management to reduce erosion from logged forests	SWCD Indian Creek Project, IDNR, local land conservancy groups	$20,000	SWCD funds	# requests for assistance	2	4	6
I/E Activities for Task 2 &3 Host informational workshops and meetings with forest land owners on timber harvest and forest land management Distribute brochures on harvest management and forest management and protection	SWCD Indian Creek Project, USDA, IDNR, local land conservancy groups	$20,000	SWCD funds	# workshops held # participants # brochures distributed	1 50 100	2 100 200	3 150 300
Monitoring Activities for Task 1 and Task 2 Develop monitoring program for TSS	SWCD Indian Creek Project	$16,000/yr	LARE grants, 319 grants	% TSS loads	30	60	100

IMPLEMENTATION SCHEDULE ACTION REGISTER

Table 20. Implementation Schedule for Illegal dumping and trash

Goal 3: Significantly reduce the amount of trash and debris found along roadside and waterways within the watershed.

Objective 1: Educate the residents of the watershed on the water quality impacts of illegal dumping and litter.

Action Items	RESPONSIBLE PARTY	Total Costs	Funding Mechanism	Indicators	Milestones		
					Short < 1 yr	Med < 3 yr	Long < 5 yr
Task 1 Disseminate informational literature on impacts caused by trash and debris and newsletters on watershed related activities.	SWCD Indian Creek Project, HOAs	$20,000	SWCD, Solid Waste programs	# workshops held # participants # requests for assistance	1 40 2	2 80 4	3 120 6
I/E Activities for Task 1							
Develop web-based resource site				# hits on web site	20	40	60
Publish quarterly newsletter to keep stakeholders informed				# newsletters distributed	500	1000	1500
Hold stream clean-up events				# participants in stream clean-up events	1	2	3

IMPLEMENTATION SCHEDULE ACTION REGISTER

Table 21. Implementation Schedule for Invasive aquatic species

Goal 4: Protect watershed waters from invasive aquatic species through education and outreach.

Objective 1: Educate lake residents and users on the water quality and habitat degradation of invasive aquatic species and how to identify them.

Action Items	RESPONSIBLE PARTY	Total Costs	Funding Mechanism	Indicators	Milestones		
					Short < 1 yr	Med < 3 yr	Long < 5 yr
Task 1 **Develop an education and outreach program regarding invasive species in the watershed.**							
I/E Activities for Task 1 Disseminate informational literature to residents on water quality impacts of invasive aquatic species. Install signage at lake communities' boat docks	SWCD Indian Creek Project, HOAs, US FWS, IDNR HOAs, US FWS, IDNR	$20,000 $0	US FWS, LARE grants N/A	# events held # participants # newsletters distributed	1 300 600 20	2 600 1200 40	3 900 1800 40
Develop program to asses presence or absence of invasive species in watershed waters	HOAs, US FWS, IDNR, SWCD Indian Creek Project	$0	N/A	# invasive species identified through reported sightings	2	4	6

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Section VIII: Monitoring Effectiveness

The success of this plan can be determined by tracking the indicators identified above under Section VI to evaluate the effectiveness of the implementation effort. Four primary tasks will address each concern, goal and objective and provide measurable indicators to determine the effectiveness of the proposed BMPs. The four primary tasks and how they will measure effectiveness are:

1. BMP installation or implementation:
    a. How each indicator can be measured – the number of BMPs installed, the number of acres protected;
    b. Result evaluation;
    c. How reported to the group.
2. Monitoring by sample analysis for E. coli, TSS and nutrients:
    a. How each indicator can be measured – numeric for concentration, load;
    b. Party responsible for gathering information, taking samples;
    c. Equipment needed;
    d. Sample locations and frequency;
    e. Beginning and ending dates;
    f. Who will evaluate results;
    g. How they will be reported to the group.
3. Outreach and education:
    a. How indicators can be measured – number events held, # participants, # materials distributed;
    b. Result evaluation;
    c. How reported to the group.
4. Measuring Success:
    a. Have goals been met;
    b. Have BMPs met expectations;
    c. When will watershed plan will be re-evaluated;
    d. Who will do it;
    e. Who is responsible for revisions or adaptations.

A. BMP Installation or Implementation

A key component for reducing E. coli and TSS is the installation and implementation of the BMPs identified above in Table 17. As previously stated, no readily available calculations can predict the reduction in E. coli concentrations as a result of BMP installations, however, a reasonable conclusion indicates that the elimination of known sources of E. coli will automatically result in the reduction of E. coli concentrations. Similarly, the installation of BMPs targeting the sources of TSS can be calculated and proven effective. To monitor the effectiveness of this Plan, BMPs installed or implemented for the intent of reducing the identified pollutants and the number of acres they are intended to protect will be tracked and monitored for sustainability.

The number of BMPs installed will be reported to IDEM and the Steering Committee on a quarterly basis, detailing the number and type of BMPs installed, the number of acres intended to protect and the projected reduction in pollutants. As site sample monitoring is conducted, these results will be compared with the projected reductions and analysis made regarding advancement toward goal achievement.

B. Monitoring by Sample Analysis

The best means by which to determine the effectiveness of the BMPs is to directly measure the targeted pollutants in the streams they are intended to protect. The intention of this Plan is to initiate a Sample Analysis Monitoring Plan to provide a numeric starting place of watershed water quality and monitor the targeted pollutants for changes in concentrations or loads as a result of BMP installation and implementation. This Monitoring Plan will provide feedback for BMP effectiveness and give the watershed water quality data it has thus far lacked. The Monitoring Plan will identify initial sites deem critical in gauging the watershed's water quality but remain flexible in adding sites if the results determine more are needed. The Plan also establishes a program for implementing a volunteer monitoring program. Through a coordinated effort between laboratory analysis and Hoosier Riverwatch-trained volunteers, results from volunteer analysis could be calibrated to reflect the laboratory analysis for the same pollutants so that future volunteer analysis would provide credible data. This data would also provide much needed feedback on the actual effectiveness of BMPs in reducing E. coli concentrations and keep stakeholders engaged in the watershed efforts.

The results of this measure will be reported to the Steering Committee and the SWCD as monitoring activities are conducted. Comparisons with existing data will be reported on at least an annual basis.

C. Outreach and Education

Outreach and education are as equally important as installing BMPs to improve water quality in the watershed. Through outreach and education programs, behaviors detrimental to water quality can be changed and positive, responsible behaviors can be reinforced. There is no direct means for measuring the impact of outreach and education on reductions in pollutant loads and concentrations so measurable indicators will be through tracking the number of participants in events such as workshops and field days, school programs and community programs and the number of materials distributed through mailings or at county fairs or other community events. The intent of the outreach and education component of this Plan is to change behaviors associated with the targeted pollutants. Programs targeting specific behaviors such as lawn chemical applications, hazardous waste and pet waste disposal and littering are anticipated to have a direct impact on nutrient loads, E. coli concentrations and trash in waterways.

An especially important outreach and education program will be directed at landowners who log their forested land through the encouragement of adopting forest management strategies. The intent of forest management is to reduce sedimentation and TSS in waterways through sustainable and selective logging methods, discourage clear cutting, replanting of logged areas, and selective thinning of forests to encourage stronger tree growth. The number of landowners attending forest management workshops and participating in forest management programs will provide indicators for the success of this program. Monitoring for TSS in streams associated with logged forested areas will provide quantitative indicators as to the program's success.

The watershed staff will track indicators for the outreach and education programs throughout the implementation of this Plan and report to IDEM and the Steering Committee at least quarterly.

D. Measuring Success

The success of this Plan will be measured by the determination of how well the identified goals have been met. Meeting goals for E. coli, TSS and nutrient reductions will be accomplished by BMP installation and verified by sample analysis. Sample analysis is expected to help determine the effectiveness of the installed BMPs. Outreach and education programs are also expected to help reach those goals and will be measured by tracking the number of participants in programs directed at reducing specific pollutants such as nutrients from lawn chemical applications and sediment from logging practices. The sample analysis is expected to provide valuable information in re-evaluating the success of the Watershed Management Plan and if the goals outlined in the Plan were accomplished or are achievable. The watershed staff and the Indian Creek Watershed Steering Committee would be responsible for making such a determination and recommendations for revisions or adaptations.

E. Monitoring Plan for Goal Indicators

The following tables outline how the effectiveness of the Plan will be determined by outlining six primary goals of the next phase needed to properly address the concerns identified by the TMDL and the stakeholder Steering Committee.

Table 23. Monitoring Plan for Goal Indicators

Progress Reports	**Indicator Description and Responsible Party**	**Estimated load reduction (where applicable)**
Goal 1: By 2013, install BMPs to protect 10,080 acres of contributing land to reduce E. coli and TSS		
Annually	The SWCD will work with land owners in critical areas to install BMPs to protect 10,080 acres of land that contribute runoff to watershed waters.	Through installation of BMPs, TSS loads will be reduced by 1570 tons/yr,
Annually	The SWCD will conduct E. coli, TSS and nutrient sampling to help refine identification of pollutant sources and the effectiveness of installed BMPs.	
Quarterly	The SWCD will track participation in programs to enroll landowners in watershed projects, USDA projects, EQIP and CREP	
Goal 2: By 2013 install BMPs to protect at least 63 (25%) of the 252 miles of watershed stream banks needing protection		
Annually	The SWCD, in cooperation with the ISDA and USDA-NRCS, will work with land owners to install fencing or riparian buffers to restrict livestock access to streams or buffer streams from farmed land.	Riparian buffer installation estimated to reduce sediment loads by 15,372 tons/yr,
Annually	The SWCD will conduct E. coli, TSS and nutrient sampling to determine the effectiveness of the installed BMPs.	
Quarterly	The SWCD will track the length of streamside fencing or acres of riparian buffers installed.	
Goal 3: Encourage and promote the use of alternative watering, heavy use pads and manure management systems.		

Annually	The USDA-NRCS will report the number of manure management plans developed for farmers in the watershed.	
Annually	The SWCD will conduct sampling for E. coli concentrations, TSS and nutrient to determine the effectiveness of the installed BMPs.	
Quarterly	The SWCD will track participation in outreach activities and enrollment in cost-share projects that focus on alternative watering and manure management.	
Every two years	The SWCD will conduct visual observations of watershed streams for livestock access to streams	
Goal 4: Protect 35 miles of lake shorelines at the lake communities through the installation of stabilization or restoration BMPs.		
Annually	The SWCD will work in cooperation with the lake communities and the IDNR to provide stabilization or restoration to 35 miles of eroding lake shorelines.	
Quarterly	The SWCD will tract the number of miles of lake shoreline being stabilized or restored through the installation of BMPs	
Goal 5: Work with the IDNR to promote forest management and sustainable logging practices to landowners of forested land.		
Quarterly	The SWCD will track the number of participants in outreach activities promoting forest management and sustainable logging practices.	
Goal 6: Promote water-friendly behaviors among residents of the watershed, especially septic system maintenance and lawn chemical applications.		
Annually	The SWCD will conduct sampling for E. coli concentrations, TSS and nutrients to determine the effectiveness of outreach and educational programs.	

Quarterly	The SWCD will track the number of participants in outreach and educational programs on septic system maintenance and lawn chemical applications, as well as pet waste disposal, littering and dumping in streams, and transportation of invasive aquatic species.	
Goal 7: Develop and maintain a monitoring plan for sampling and analyzing water quality for E. coli concentrations, TSS and nutrient loads and aquatic habitat assessment. The monitoring plan will include the use of Hoosier Riverwatch volunteers who can continue the monitoring plan beyond any Section 319 funding for subsequent phases of the Indian Creek Watershed Management Plan.		
Annually	The SWCD will develop a QAPP and a monitoring plan at the commencement of the implementation phase of the Indian Creek Watershed Management Plan and maintain the monitoring plan thereafter.	
Annually	The SWCD, with assistance from Hoosier Riverwatch volunteers and professional laboratories, will collect and analyze samples from the watershed waters for determination of E. coli concentrations, TSS and nutrient loads.	
Annually	The SWCD, with assistance from Hoosier Riverwatch volunteers, will conduct aquatic habitat assessments annually for a period of not less than three years to determine the health of aquatic habitats in the watershed.	

*Calculations based on estimates concerning conservation tillage using the IDEM Loading Workbook (US EPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) and Region 5 Load Estimation Model) by the Youngs Creek Watershed Management Plan. Calculations based on implementation of conservation tillage on a 40-acre field, resulting in estimates of sediment reduction by 314 tons/year, phosphorus reductions of 332 lbs/year, and nitrogen reductions of 664 lbs/year. Based on a two-year adoption of conservation tillage for five 40-acre fields, the total sediment load would be reduced by 1570 tons/year, phosphorus reduced by 1660 lbs/year and nitrogen reduced by 3320 lbs/year.

**Estimated load reductions for riparian buffers also used the IDEM Loading Workbook (STEPL). Calculations are based on 10-acre contributing areas for each ¼ mile of stream segment. Total amounts given are based on estimated reductions per one (1) mile of riparian buffer over two years of sediment reduction at 244/tons/year, phosphorus reduction of 288 lbs/year, and nitrogen reduction of 536 lbs/year.

Section IX: References and Appendices

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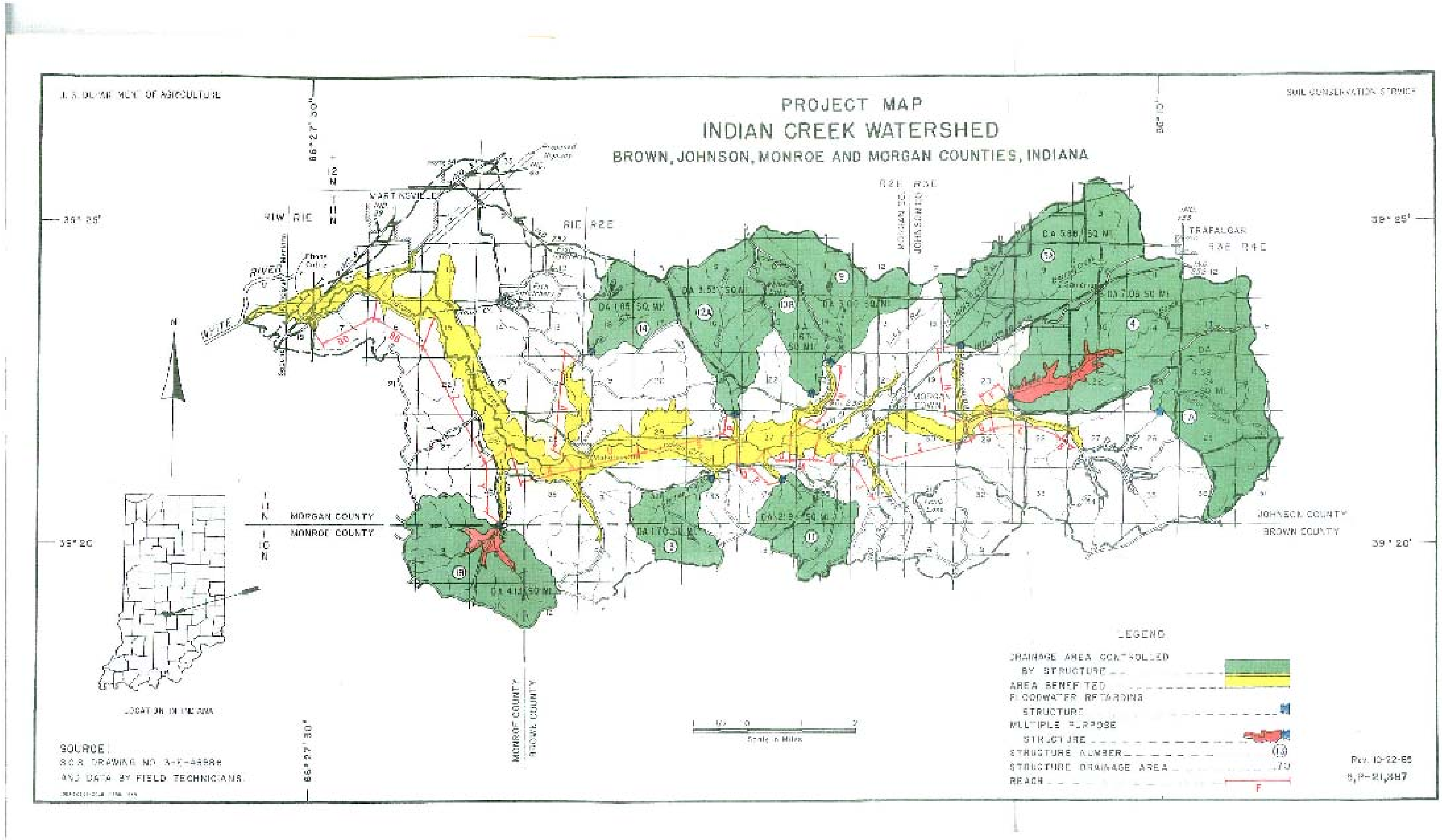
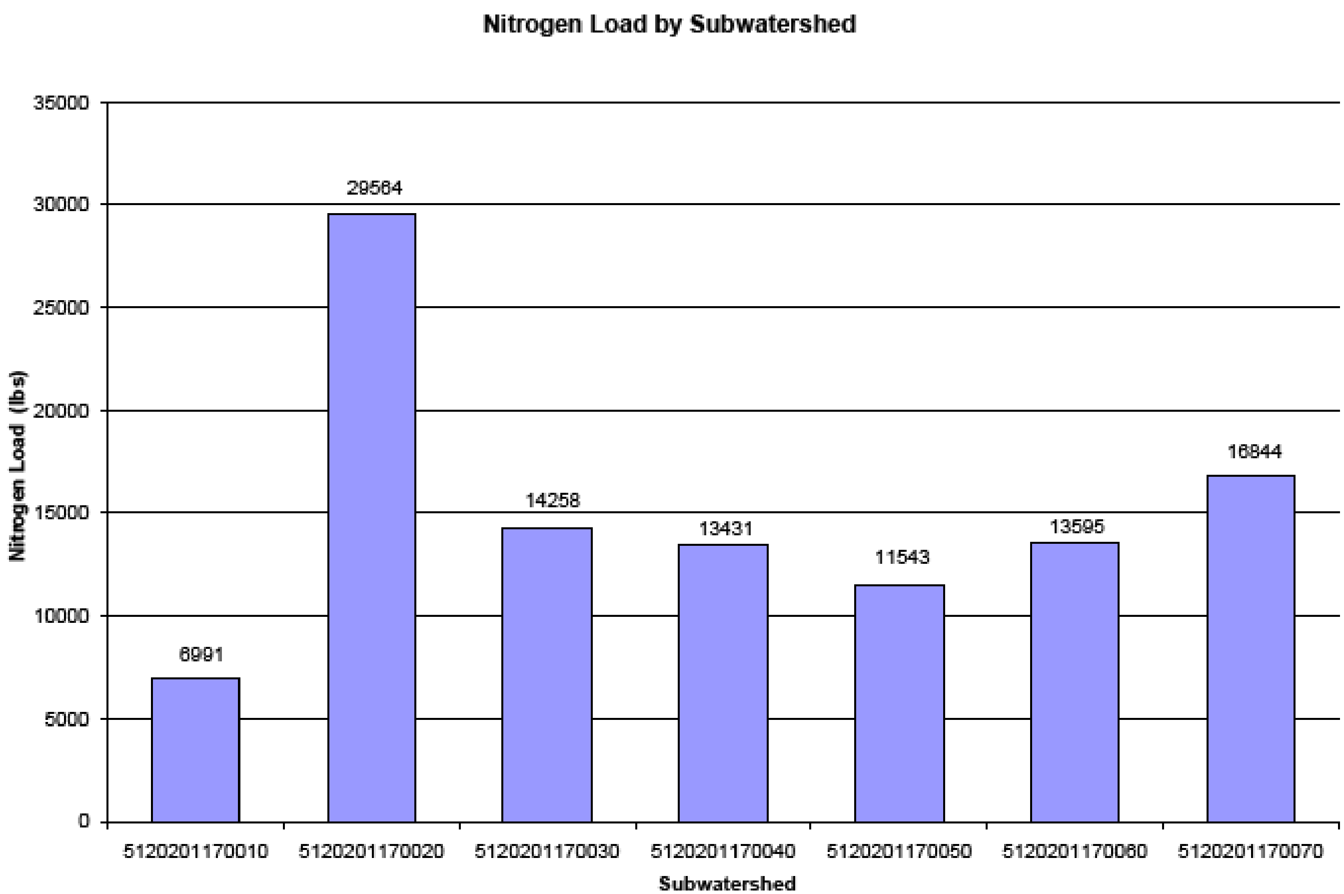
Appendix A. Steering Committee participants

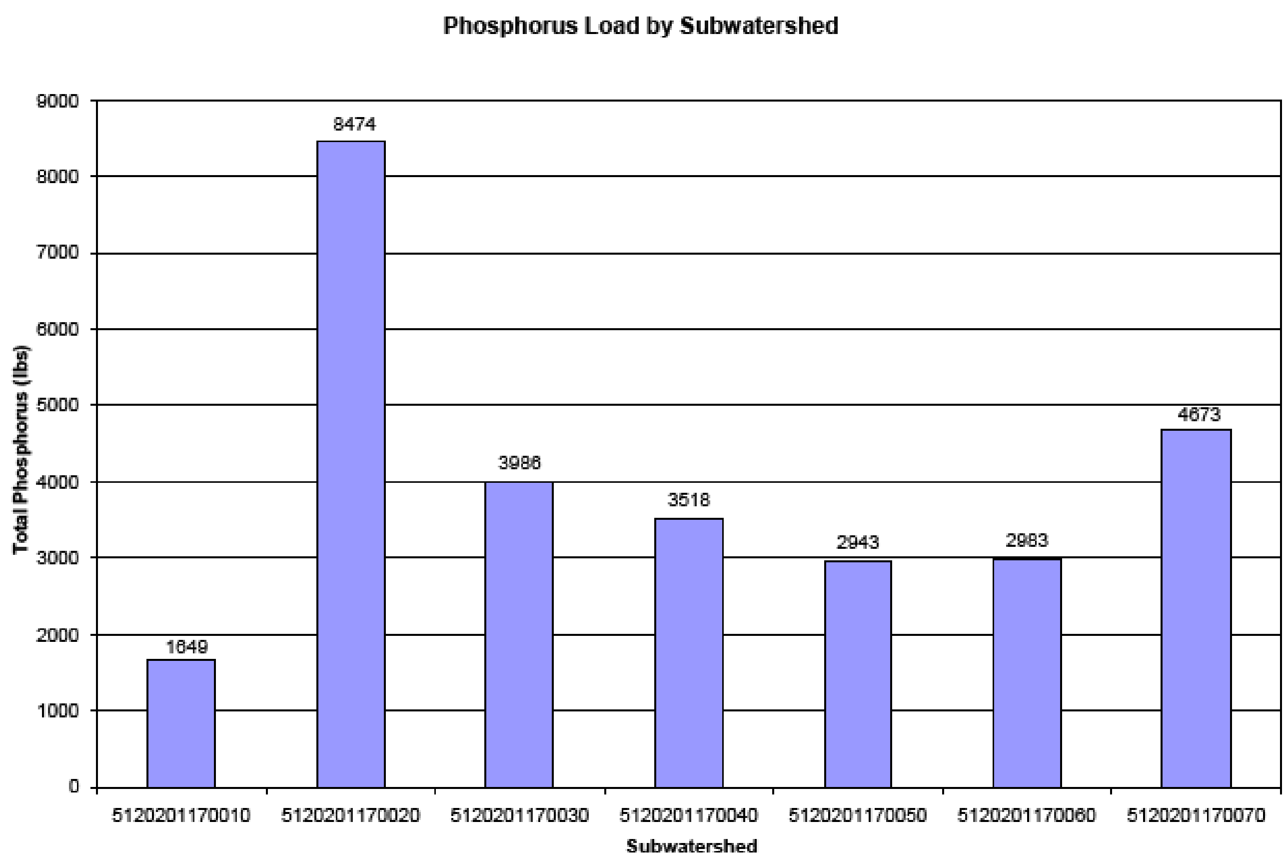
Bob Atnip	Painted Hills resident and GIS specialist
Pat Clark	Morgan County resident and professor of ecology, IUPUI
Steve Cravens	Painted Hills resident
Bonny Elifritz	IDEM
Terry Fenimore	Lamb Lake resident
Donald Fox	Resident
Jacob Hougham	Morgan County resident, IDNR, Division of Forestry
Brett Lackey	Morgan County resident, environmental scientist
James Leonard	Resident, farmer
Jennifer Sobecki	IDNR, Division of Forestry
Norman Voyles	Morgan County resident, Morgan County Commissioner

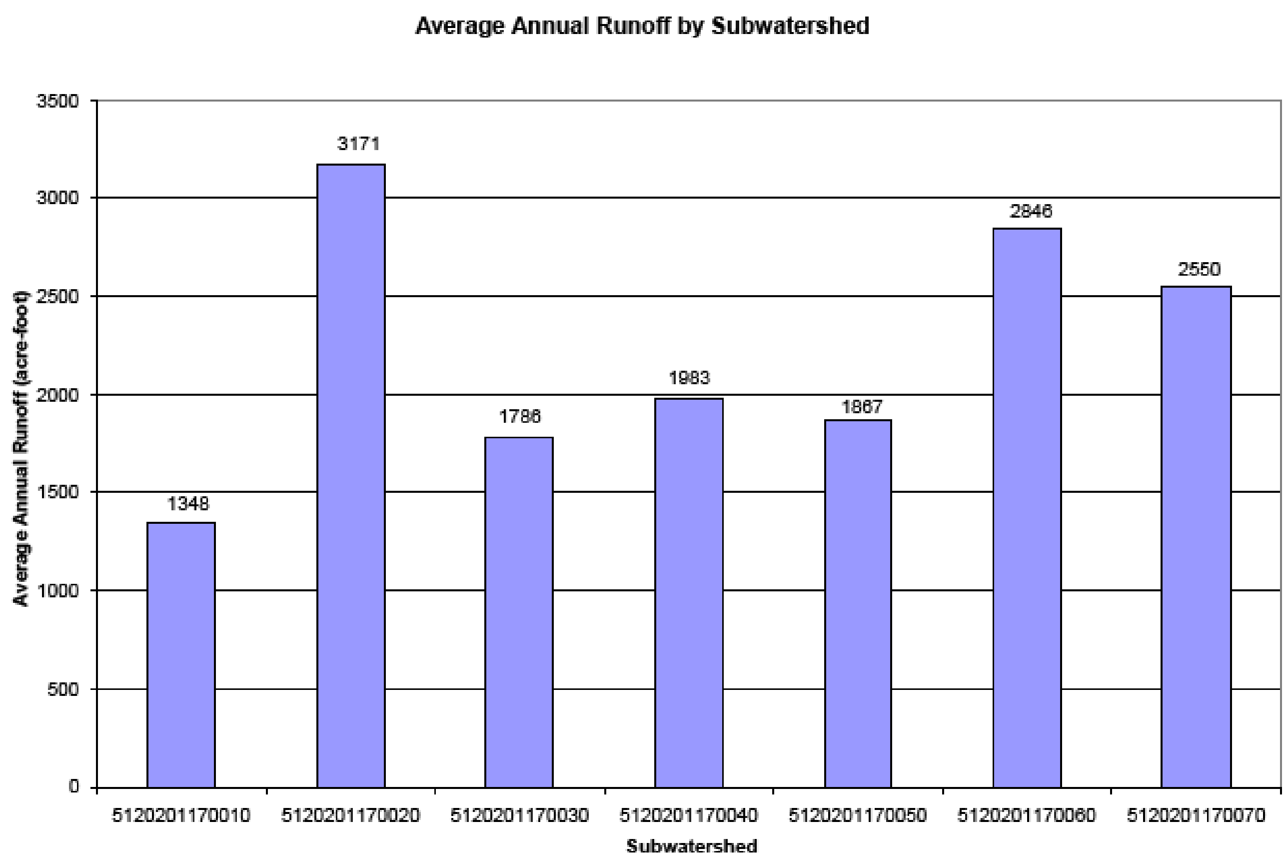
Appendix B. Figure 26: Historic map of flood project, November 1965

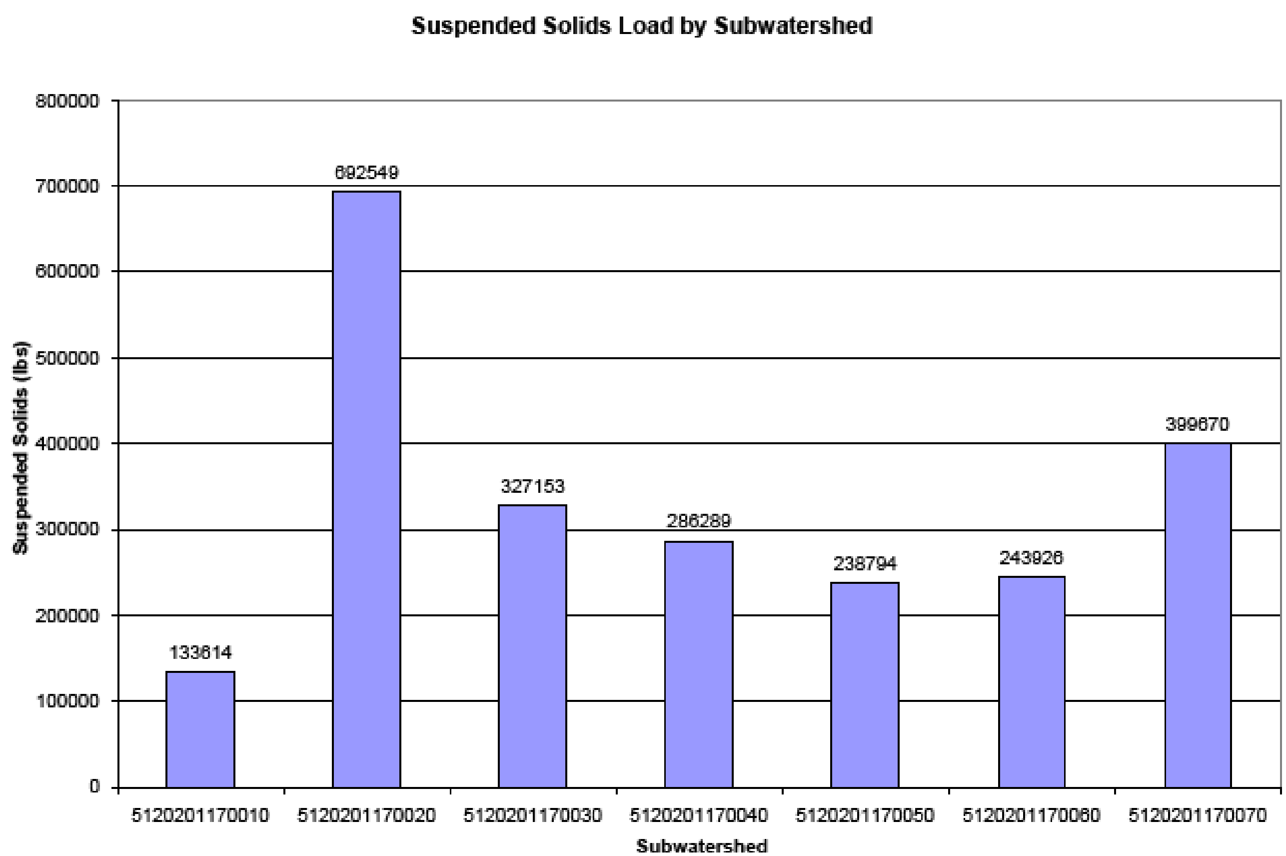

PROJECT MAP
INDIAN CREEK WATERSHED
BROWN, JOHNSON, MONROE AND MORGAN COUNTIES, INDIANA
SOIL CONSERVATION SERVICE
MARTINSVILLE
WHITE RIVER
TRAFALGAR
MORGAN COUNTY
MONROE COUNTY
JOHNSON COUNTY
BROWN COUNTY
LEGEND
DRAINAGE AREA CONTROLLED BY STRUCTURE
AREA BENEFITED
FLOODWATER RETARDING STRUCTURE
MULTIPLE PURPOSE STRUCTURE
STRUCTURE NUMBER
STRUCTURE DRAINAGE AREA
REACH
SOURCE:
AND DATA BY FIELD TECHNICIANS
LOCATION IN INDIANA

Appendix C. L-THIA Model Results


Nitrogen Load by Subwatershed
35000
30000
25000
20000
15000
10000
5000
0
Nitrogen Load (lbs)
29564
6991
14258
13431
11543
13595
16844
5120201170010
5120201170020
5120201170030
5120201170040
5120201170050
5120201170060
5120201170070
Subwatershed


Phosphorus Load by Subwatershed
Total Phosphorus (lbs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1649
8474
3986
3518
2943
2983
4673
5120201170010
5120201170020
5120201170030
5120201170040
5120201170050
5120201170060
5120201170070
Subwatershed


Average Annual Runoff by Subwatershed
Average Annual Runoff (acre-foot)
3500
3000
2500
2000
1500
1000
500
0
1348
3171
1786
1983
1867
2846
2550
5120201170010
5120201170020
5120201170030
5120201170040
5120201170050
5120201170060
5120201170070
Subwatershed


Suspended Solids Load by Subwatershed
Suspended Solids (lbs)
800000
700000
600000
500000
400000
300000
200000
100000
0
133614
692549
327153
286289
238794
243926
399670
5120201170010
5120201170020
5120201170030
5120201170040
5120201170050
5120201170060
5120201170070
Subwatershed

Appendix D. Total Maximum Daily Load for Escherichia coli (E. coli) for the Indian Creek Watershed, Morgan and Johnson County

Office of Water Quality
Total Maximum Daily Load Program

Total Maximum Daily Load for *Escherichia coli* (*E. coli*) For the Indian Creek Watershed, Morgan and Johnson County

Prepared by:

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Indiana Department of Environmental Management
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December 22, 2004

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Attachments

A. **Indian Creek Watershed *E. coli* Data**
B. **Water Quality Duration Curves for Indian Creek Watershed TMDL**

C. Load Duration Curves for Indian Creek Watershed TMDL

Indiana Department of Environmental Management
Total Maximum Daily Load Program
December 22, 2004

Total Maximum Daily Load (TMDL) for *Escherichia coli* (*E. coli*) in Indian Creek Watershed, Morgan and Johnson Counties in Indiana

Introduction

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources and determine the allowable levels of *E. coli* bacteria that will result in the attainment of the applicable WQS in the Indian Creek watershed in Morgan and Johnson Counties, Indiana.

Background

In 1998, 2002, and 2004 Indiana's section 303(d) list cites Indian Creek as being impaired for *E. coli* in Morgan and Johnson Counties. In 2004, Indiana's section 303(d) list cites, in addition to Indian Creek, Bear Creek, Robertson Creek, Sand Creek, Camp Creek, and other tributaries. The majority of Indian Creek watershed is impaired for *E. coli*. This TMDL addresses approximately 178.11 miles of the Indian Creek watershed in Morgan and Johnson Counties, located in central Indiana, where recreational uses are impaired by elevated levels of *E. coli* during the recreational season (Figure 1). All of the twenty-five (25) segments of the listed streams for this TMDL are located in the West Fork White River Basin in hydrologic unit code 05120201170. The description of the study area, its topography, and other particulars are as follows:

Waterbody Name	303(d) List ID	Segment ID Number(s)	Length (miles)	Impairment
Indian Creek	120	INW01H1_T1097, INW01H2_T1098, INW01H3_T1099, INW01H4_T1100, INW01H5_T1101, INW01H6_T1102, INW01H7_T1103, INW01H1_1099	26.69	*E. coli*
Bear Creek	120	INW01H3_T1098	3.82	*E. coli*
Robertson Creek	120	INW01H6_T1101	10.51	*E. coli*
Camp Creek	120	INW01H5_00	7.06	*E. coli*
Sand Creek	120	INW01H7_00	6.60	*E. coli*
Oliver Creek, Crooked Creek, Pike Creek	120	INW01H4_00, INW04H4_T1101, INW01H4_1102	32.10	*E. coli*

Barnes Creek, Goose Creek	120	INW01H2_00	33.88	*E. coli*
Lick Creek and Unnamed Tributaries	120	INW01H1_T1096	3.60	*E. coli*
Long Run Creek	120	INW01H3_T1097	7.29	*E. coli*
Indian Trace Creek	120	INW01H5_T1102,	10.79	*E. coli*
Sartor Ditch	120	INW01H7_00	3.40	*E. coli*
Sedwick Ditch	120	INW01H5_T1103	6.03	*E. coli*
Unnamed Tributaries	120	INW01H6_T1103, INW01H1_T1098, INW01H3_T1096, INW01H7_1101	15.61	*E. coli*

Historical data collected by IDEM documented elevated levels of *E. coli* in Indian Creek in 1996. This data was the basis for the listing of the Indian Creek on the 1998 303(d) list. IDEM completed an intensive survey of the watershed for the Indian Creek watershed in 2001. IDEM sampled twenty-six sites five times, with the samples evenly spaced over a 30-day period from July 25, 2001 to August 21, 2001. This period falls within Indiana's recreational season (April 1st through October 31st) (Figure 2). All twenty-six sites violated the single sample maximum standard at least once during this sampling event. The geometric mean could not be calculated for two of the sampling sites, since five samples were not collected or were not usable. Of the remaining twenty-four sites where a geometric mean value could be calculated, four sites, Site 1, 8, 9, and 15, did not violated the geometric mean standard. Based on this intensive study in 2001, IDEM determined that an *E. coli* TMDL would need to be completed on the Indian Creek watershed (Attachment A).

The TMDL development schedule corresponds with IDEM's basin-rotation water quality monitoring schedule. To take advantage of all available resources for TMDL development, impaired waters are scheduled for TMDL development according to the basin-rotation schedule unless there is a significant reason to deviate from this schedule. Waterbodies could be scheduled based on the following:

1) Waterbodies may be given a high or low priority for TMDL development depending on the specific designated uses that are not being met, or in relation to the magnitude of the impairment.

2) TMDL development of waterbodies where other interested parties, such as local watershed groups, are working on alleviating the water quality problem may be delayed to give these other actions time to have a positive impact on the waterbody. If water quality standards still are not met, then the TMDL process will be initiated.

3) TMDLs that are required due to water quality violations relating to pollutant parameters where no EPA guidance is available, may be delayed to give EPA time to develop guidance.

This TMDL was scheduled based on the data available from the basin-rotation schedule, which represents the most accurate and current information on water quality within waterbodies covered by this TMDL.

Water quality *E. coli* load duration curves were created by using IDEM's data. A flow duration interval is described as a percentage. Zero percent corresponds to the highest stream discharge (flood condition) and one hundred (100) percent corresponds to the lowest discharge (drought condition). The *E. coli* values at two of the sampling sites were plotted with the corresponding flow duration interval to show the *E. coli* violations of the single-sample maximum standard and geometric mean standard during both the recreational and non-recreational seasons. These two sampling sites have *E. coli* data that was collected in 1996 and 2002. These two sites are representative of the hydrodynamics of the Indian Creek watershed (Attachment B).

Numeric Targets

The impaired designated use for the waterbodies in the Indian Creek watershed is for total body contact recreational use during the recreational season, April 1st through October 31st.

327 IAC 2-1-6(d) establishes the total body contact recreational use *E. coli* Water Quality Standard (WQS[1]) for all waters in the non-Great Lakes system as follows:

> *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

[1] *E. coli* WQS = 125 cfu/100ml or 235 cfu/100ml; 1 cfu (colony forming units)= 1 mpn (most probable number)

The sanitary wastewater *E. coli* effluent limits from point sources in the non-Great Lakes system during the recreational season, April 1st through October 31st, are also covered under 327 IAC 2-1-6(d).

For the Indian Creek watershed during the recreational season (April 1st through October 31st) the target level is set at the *E. coli* WQS of 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period.

Source Assessment

Watershed Characterization

The Indian Creek watershed starts in the southwest corner of Johnson County and flows west through Morgan County, where it then discharges into the West Fork of the White River. The major tributaries of this waterbody include Lick Creek, Goose Creek, Barnes Creek, Bear Creek, Long Run Creek, Crooked Creek, Oliver Creek, Pike Creek, Indian Trace Creek, Camp Creek, Robertson Creek, Sand Creek and an unnamed tributary.

The tributaries of Bear Creek, Camp Creek, Robertson Creek, and Sand Creek were added to the 2004 303(d) list for *E. coli*. Based on sampling completed in 2001, each of these tributaries is also contributing to the impairment of Indian Creek. Goose Creek, Barnes Creek, Crooked Creek, Oliver Creek, and Pike Creek are not listed on the 2004 303(d) list for *E. coli* but the sampling completed in 2001 confirms that they are impaired for *E. coli* and contributing to the impairment on Indian Creek. These segments will be listed in the 2006 303(d) list based on the sampling completed in 2001, however as these segments are part of this TMDL, the segments will be listed in Category 4 as part of a completed TMDL.

Lick Creek, Long Run Creek, Indiana Trace Creek, Sartor Ditch, Sedwick Ditch, and numerous unnamed tributaries were not on the 2004 303(d) list and also do not have stream segment ID numbers. None the less, the sampling in 2001 shows these streams to be impaired. Segment ID numbers are based in the Reach Index for the State of Indiana.
Indiana's Reach Index was created using the National Hydrography Database (NHD) at a map resolution of 1:100K. At this scale, many of the state's first and second order streams do not appear on the NHD and, as a result, do not appear on Indiana's Reach Index. The fact that a given stream does not appear on the Reach Index does not preclude assessments of its water quality and subsequent inclusion in a TMDL if it is found to be impaired. IDEM's Assessment Database (ADB) allows for the addition of waterbodies and assessments of their water quality regardless of whether they have been reach indexed. IDEM's approach

for impaired waterbodies that are not included in the Reach Index is to assign a segment ID to them for the purposes of assessment and add them to the Reach Index once a NHD is available at higher resolution for that basin.

The landuse information, which was gathered from the mid-1970s for the Indian Creek watershed, consisted of approximately 45% agriculture, 50% forested, 4% developed, and 1% water. Landuse information was also assembled in 1992 using the Gap Analysis Program (GAP). In 1992, the landuse in Indian Creek consisted of approximately 44% agriculture, 51% forested, 3% developed, 1% water, and 1% unknown. (Figure 3). When comparing the mid-1970s landuse with the 1992 landuse information, no substantial changes to the Indian Creek watershed were found.

Wildlife is a known source of *E. coli* impairments in waterbodies. Many animals spend time in or around waterbodies. Deer, geese, ducks, raccoons, turkeys, and other animals all create potential sources of *E. coli*. Wildlife contributes to the potential impact of contaminated runoff from animal habitats, such as urban park areas, forest, and cropland.

Most of the homes within the Indian Creek watershed are on septics. Failing septic tanks are known sources of *E. coli* impairment in waterbodies. Conversations with Morgan and Johnson County Health Department staff indicate that septic system failure does occur. No tangible septic failure rate has been established by either local Health Department at this time. (Morgan and Johnson County Health Departments 2004)

National Pollutant Discharge Elimination System (NPDES) Permitted Dischargers

There are two NPDES permitted facilities in the Indian Creek watershed (Table 1). Permit IN0044971 is for Brown County Water Utility. This facility does not have a sanitary component to their discharge and is not considered a source of *E. coli*

Permit IN0036820 is for the Morgantown Wastewater Treatment Plant. Prior to February 2003, the Morgantown Wastewater Treatment Plant permit did not contain *E. coli* limits because it was believed that an extended retention time of sanitary wastewater was sufficient to provide a natural attrition of *E. coli* that would be in compliance with Indiana's *E. coli* WQS. However, recent studies completed by Ron Turco from Purdue University have indicated that *E. coli* may live longer in this environment than originally believed. Therefore, *E. coli* reporting requirements were added to this permit in February of 2003.

Since the addition of the *E. coli* reporting requirement, the Morgantown Wastewater Treatment Plant has reported end-of-pipe *E. coli* limits for April, May, July and October of 2003 and April, May, June, and July of 2004. The *E. coli* values have ranged from 0 cfu/100mL to 36 cfu/100mL daily maximum for 2003 and 15 cfu/100mL to 50 cfu/100mL daily maximum for 2004. Based on these reported *E. coli* values, it may be determined that the Morgantown Wastewater Treatment Plant is not a source of *E. coli*.

Confined Feeding Operations and Confined Animal Feeding Operations

The removal and disposal of the manure, litter, or processed wastewater that is generated as the result of confined feeding operations falls under the regulations for confined feeding operation (CFOs) and confined animal feeding operations (CAFOs). There were three (3) CFOs in the watershed. These permits were voided in 2000 and there are no active enforcement actions. Therefore, CFOs and CAFOs not considered a source of *E. coli* for the Indian Creek TMDL.

There are many smaller livestock operations in the watershed. These operations, due to their small size, are not regulated under the CFO or CAFO regulations. These operations may still have an impact on the water quality and the *E. coli* impairment. No specific information on these smaller livestock operations is currently available, however, it is believed that these smaller livestock operations could be a source of *E. coli* impairment.

Linkage Analysis and *E. coli* Load Duration Curves

The linkage between the *E. coli* concentrations in the Indian Creek watershed and the potential sources provides the basis for the development of this TMDL. The linkage is defined as the cause and effect relationship between the selected indicators and the sources. Analysis of this relationship allows for estimating the total assimilative capacity of the stream and any needed load reductions. Analysis of the data for the Indian Creek watershed indicates that *E. coli* load enters the Indian Creek watershed through both wet (nonpoint) and dry (point) weather sources.

To investigate further the potential sources mentioned above, an *E. coli* load duration curve analysis, as outlined in an unpublished paper by Cleland (2002), was developed for each sampling site in the Indian Creek watershed. The load duration curve analysis is a relatively new method utilized in TMDL development. The method considers how stream flow conditions relate to a variety of pollutant loadings and their sources (point and non-point).

In order to develop a load duration curve, continuous flow data is required. The USGS gauge for the West Fork White River (03354000) located in Centerton, Indiana was used for the development of the *E. coli* load duration curve analysis for the Indian Creek watershed TMDL. USGS gauge 03354000 is located upstream from the mouth of Indian Creek on the West Fork of the White River, therefore the drainage area for the Indian Creek watershed is not accounted for in the drainage area for this gauge. In order to obtain an estimated flow for the Indian Creek watershed, the drainage area was calculated at the mouth of the Indian Creek watershed (93.8 square miles) and compared to the West Fork White River (WFWR) drainage area downstream of the Indian Creek watershed (2619 square miles). The flow for USGS gauge 03354000 was then multiplied by the percent of drainage area that is accounted for in the total drainage area at the WFWR location. The calculated flow number and the drainage area for Indian Creek watershed were then used to create the load duration curves for the Indian Creek watershed.

The USGS gauge (03354000) located in Centerton, Indiana was used for the development of the *E. coli* load duration curve analysis for the Indian Creek watershed TMDL. USGS gauge (03354000) is located upstream from the mouth of Indian Creek on the West Fork of the White River; however it is the closest gauge to the Indian Creek watershed. To determine if the closer gauge was acceptable IDEM compared the USGS gauge in Centerton, Indiana with the USGS gauge (03360500) in Newberry, Indiana, which is located downstream of Indian Creek watershed. This comparison uses a coefficient of determination value, R2, to indicate the "fit" of the data. The comparison found the coefficient of determination, R2, to be 0.7. Values near 1 for R2 indicate a good fit of the data, whereas values near 0 indicate a poor fit of the data. Therefore the USGS gauge (03354000) in Centerton was used for the load duration curves for the Indian Creek watershed. The flow from this gauge and the *E. coli* data from the Indian Creek watershed were then used to create the load duration curves for the Indian Creek watershed.

The flow data is used to create flow duration curves that display the cumulative frequency of distribution of the daily flow for the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time that those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100 percent of the time, to extremely high flows, which are rarely exceeded. Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for *E. coli* and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves, in that the x-axis represents the flow recurrence interval and the y-axis represents the allowable load of the water quality parameter. The curve representing the allowable load of *E. coli* was calculated using the daily and geometric mean standards of 235 *E. coli* per 100 ml and 125 *E. coli* per 100 ml, respectively. The final step in the development of a load duration curve is to add the water quality pollutant data to the curves. Pollutant loads are estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality pollutant monitoring data are plotted on the same graph as the load duration curve that provides a graphical display of the water quality conditions in the waterbody. The pollutant monitoring data points that are above the target line exceed the Water Quality Standards (WQS); those that fall below the target line meet the WQS (Mississippi DEQ, 2002).

Load duration curves were created for two sampling sites in the Indian Creek watershed. The sampling site on CR 650 E and the sampling site on the Jordan Road crossing of Indian Creek provide the best description of the sources of *E. coli* to the Indian Creek watershed (Figure 2, Attachment C). This is because these two sites have monitoring data from 1996 and 2001. The data indicate that the largest exceedances of the *E. coli* WQS are prevalent during wet weather events (noted by diamonds above the curve on the far left side of the figure in Attachment C). Dry weather contributions are also a source of *E. coli* to the Indian Creek watershed (noted by the diamonds above the curve on far right side of the figure in Attachment C).

While there are point source contributions, compliance with the numeric *E. coli* WQS in the Indian Creek watershed most critically depends on controlling of nonpoint sources using best management plans (BMPs). If the *E. coli* inputs can be controlled as outlined above, then the total body contact recreation use in the Indian Creek watershed will be protected.

TMDL Development

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving Water Quality Standards (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of critical conditions that, when addressed by appropriate controls, will ensure attainment of WQS for the pollutants. For example, the critical conditions for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to Indian Creek watershed arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Indian Creek watershed and the contributing sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). For *E. coli* indicators, however, mass is not an appropriate measure, because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). The geometric mean *E. coli* WQS allows for the best characterization of the watershed. Therefore, this *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the *E. coli* WQS for a geometric mean for each month of the recreational season (April 1 through October 31).

Allocations

TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. This *E. coli* TMDL is concentration-based consistent with USEPA regulations at 40 CFR, Section 130.2(i).

Wasteload Allocations

As mentioned previously, there are two NPDES permits located in the Indian Creek watershed. The Morgantown WWTP (IN0036820) is the only permit that has a sanitary component to its discharge. Since February of 2003, it has been required to monitor for *E. coli*. The current *E. coli* values that have been reported from the Morgantown WWTP do not violate WQS. However, to guarantee continued compliance with the *E. coli* WQS, IDEM's TMDL program recommends that requirements for monitoring for *E. coli* continue in Morgantown's NDPES permit during their next permit renewal.

The WLA is set at the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st.

Load Allocations

The LA is equal to the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1st through October 31st. The assumption used in this load allocation strategy is that there are equal bacterial loads per unit area for all lands within the watershed. Therefore, the relative responsibility for achieving the necessary reductions of bacteria and maintaining acceptable conditions is determined by the amount of land under the jurisdiction of the various local units of government within the watershed. This gives a clear indication of the relative amount of effort that will be required by each entity to restore and maintain the total body contact designated uses to the Indian Creek watershed.

The government entities and land area in the Indian Creek watershed are divided as follows; in Morgan County , Jackson Township (30.49%), Washington Township (21.76%) and the City of Martinsville (2.74%), in Johnson County, Hensley Township (31.94%), Nineveh Township (1.77%), and Union Township (0.09%). The remaining government entities are in Brown County, Jackson Township (6.95%) and Hamblen (1.15%) and Monroe County, Benton Township (3.11%) (ESRI, 2004). (Table 2 and Figure 4.)

Load allocations may be affected by subsequent work in the watershed. There are currently no watershed project or plans in the Indian Creek watershed. However, there are several in the surrounding areas. IDEM plans to work with the watershed coordinators in the surrounding areas along with local government agencies to encourage interest in watershed projects. It is anticipated that watershed projects will be useful in defining and addressing the nonpoint sources of the *E. coli* in the Indian Creek watershed.

Margin of Safety

A Margin of Safety (MOS) was incorporated into this TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into TMDL analysis thorough conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS by applying a couple of conservative assumptions. First, no rate of decay for *E. coli* was applied. *E. coli* bacteria have a limited capability of surviving outside of their hosts and therefore, a rate of decay normally would be applied. However, applying a rate of decay could result in a discharge limit that would be greater than the *E. coli* WQS, thus no rate of decay was applied. Second, the *E. coli* WQS was applied to all flow conditions. This adds to the MOS for this TMDL. IDEM determined that applying the *E. coli* WQS of 125 per one hundred milliliters to all flow conditions and with no rate of decay for *E. coli* is a conservative approach that provides for greater protection of the water quality.

Seasonality

Seasonality in the TMDL is addressed by expressing the TMDL in terms of the *E. coli* WQS for total body contact during the recreational season (April 1^{st} through October 31^{st}) as defined by 327 IAC 2-1-6(d). There is no applicable total body contact *E. coli* WQS during the remainder of the year in Indiana. Because this is a concentration-based TMDL, *E. coli* WQS will be met regardless of flow conditions in the applicable season.

Monitoring

Future monitoring of the Indian Creek watershed will take place during IDEM's five-year rotating basin schedule and/or once TMDL implementation methods are in place. During the five-year rotating basin schedule, IDEM will monitor the Indian Creek watershed for *E. coli*. Monitoring will be adjusted as needed to assist in continued source identification and elimination. When these results indicate that the waterbody is meeting the *E. coli* WQS, IDEM will conduct monitoring at an appropriate frequency to determine if Indiana's 30-day geometric mean value of 125 *E. coli* per one hundred milliliters is being met.

Reasonable Assurance Activities

Reasonable assurance activities are programs that are in place or will be in place that assist in meeting the Indian Creek watershed TMDL allocations and the *E. coli* Water Quality Standards (WQS).

National Pollutant Discharge Elimination Systems

327 IAC 5-2-11.1(h) requires effluent limits to be included in NPDES permits for pollutants discharged at levels that have the reasonable potential to cause an exceedance above water quality standards. Even though the Morgantown Wastewater Treatment Plant (IN0034932) has reported *E. coli* values below the *E .coli* WQS, it is recommended that they continue monitoring to assure continued compliance with Indiana's *E. coli* Water Quality Standards.

Watershed Projects

There are watershed projects in the surrounding areas of the Indian Creek watershed. IDEM plans to work with the watershed coordinators in the surrounding areas along with local government agencies to encourage interest in watershed projects. It is anticipated that watershed projects will be useful in defining and addressing the nonpoint sources of the *E. coli* in the Indian Creek watershed.

The Lamb Lake Homeowners Association has instituted a septic system inspection program. This program will insure that the systems surrounding the lake remain in good working order. The inspection program evaluates all aspects of homeowner septics and requires repairs and regular maintenance to insure proper operation. This program will help assure that septics in this part of the watershed are not contributing to the *E. coli* impairment.

In addition, IDEM has recently hired a Watershed Specialist for this area of the state. The Watershed Specialist will be available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the Indian Creek watershed.

Potential Future Activities:

Nonpoint source pollution, which is the primary cause of E. coli impairment in this watershed, can be reduced by the implementation of “best management practices" (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Livestock owners, farmers, and urban planners, can implement BMPs outside of a watershed management plan, but the success of BMPs would be enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be used to reduce *E. coli* runoff:

Riparian Area Management - Management of riparian areas protects streambanks and riverbanks with a buffer zone of vegetation, either grasses, legumes, or trees.

Manure Collection and Storage - Collecting, storing, and handling manure in such a way that nutrients or bacteria do not run off into surface waters or leach down into ground water.

Contour Row Crops - Farming with row patterns and field operations aligned at or nearly perpendicular to the slope of the land.

No-Till Farming - No-till is a year-round conservation farming system. In its pure form, no-till does not include any tillage operations either before or after planting. The practice reduces wind and water erosion, catches snow, conserves soil and water, protects water quality, and provides wildlife habitat. No-till helps control soil erosion and improve water quality by maintaining maximum residue plant levels on the soil surface. These plant residues: 1) protect soil particles and applied nutrients and pesticides from detachment by wind and water; 2) increase infiltration; and 3) reduce the speed at which wind and water move over the soil surface.

Manure Nutrient Testing - If manure application is desired, sampling, and chemical analysis of manure should be performed to determine nutrient content for establishing the proper manure application rate in order to avoid over application and run-off.

Drift Fences - Drift fences (short fences or barriers) can be installed to direct livestock movement. A drift fence parallel to a stream keep animals out and prevents direct input of E. coli to the stream.

Pet Clean-up / Education - Education programs for pet owners can improve water quality of runoff from urban areas.

Septic Management/Public Education - Programs for management of septic systems can provide a systematic approach to reducing septic system pollution. Education on proper maintenance of septic systems as well as the need to remove illicit discharges could alleviate some anthropogenic sources of E. coli.

Conclusion

The sources of *E. coli* to the Indian Creek watershed include both point and nonpoint sources. In order for the Indian Creek watershed to achieve Indiana's *E. coli* WQS, the wasteload and load allocations for the Indian Creek watershed in Indiana have been set to the *E. coli* WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty day from April 1st through October 31st. Achieving the wasteload and load allocations for the Indian Creek watershed depends on:

1) continued compliance with Water Quality Standards for the Morgantown Wastewater Treatment Plant NPDES Permit; and

2) controlling nonpoint sources of *E. coli* by implementing best management practices in the watershed.

The next phase of this TMDL is to identify and support the implementation of activities that will bring the Indian Creek watershed in compliance with the *E. coli* WQS. IDEM will continue to work with its existing programs on implementation. In the event that designated uses and associated water quality criteria applicable to the Indian Creek watershed are revised in accordance with applicable requirements of state and federal law, the TMDL implementation activities may be revised to be consistent with such revisions. Additionally, IDEM will work with local stakeholder groups to pursue best management practices that will result in improvement of the water quality in the Indian Creek watershed.

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Mississippi Department of Environmental Quality. 2002. Fecal Coliform TMDL for the Big Sunflower River, Yazoo River Basin.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. United States Environmental Protection Agency, 841-R-00-002.

Table 1: NPDES Permits in the Indian Creek Watershed

Permit No.	Facility Name	Receiving Waters
IN0036820	Morgantown WWTP	Indian Creek
IN0044971	Brown County Water (Drinking Water Filter)	Indian Creek

Table 2: Land Area Distribution for the Indian Creek Watershed

Municipality	Square Mile	Percent
Morgan County		
Jackson Township	1700.84	30.49
Washington Township	1214.22	21.76
City of Martinsville	152.58	2.74
Johnson County		
Hensley Township	1782.07	31.94
Nineveh Township	98.83	1.77
Union Township	4.46	0.09
Brown County		
Jackson Township	387.87	6.95
Hamblin Township	64.28	1.15
Monroe County		
Benton Township	173.58	3.11

Attachment A

Indian Creek Watershed *E. coli* Data

Attachment A: Indian Creek Watershed E.coli Data

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
1.00	1996 Synoptic	WWU170-0002	DI20099	Indian Cr	Jordan Rd	02/27/96	160.00	599.47
1.00			DI20910			04/30/96	1600.00	
1.00			DI21299			06/07/96	8000.00	
1.00			DI21675			07/17/96	180.00	
1.00			DI22149			10/09/96	210.00	
1.00	2001 Indian Creek Assessment	WWU170-0002	AA06458	Indian Cr	Jordan Rd	07/25/01	275.50	435.85
1.00			AA06653			07/30/01	920.80	
1.00			AA06865			08/07/01	387.00	
1.00			AA06981			08/14/01	261.30	
1.00			AA07318			08/21/01	613.10	
2.00	2001 WF White River White Lick to Buckhall Bridges	WWU170-0030	AA08400	Indian Cr	Off SR 37, first left 1/3 mile	09/11/01	1700.00	>814.36
2.00			AA08503			09/20/01	>2419.2	
2.00			AA08656			09/25/01	>2419.2	
2.00			AA08828			10/02/01	200.00	
2.00			AA08839			10/10/01	180.00	
3.00	2001 Indian Creek Assessment	WWU170-0028	AA06460	Indian Cr	CR 50 W Before it turns into Burton Lane	07/25/01	285.10	259.02
3.00			AA06656			07/30/01	770.10	
3.00			AA06868			08/07/01	148.30	
3.00			AA06984			08/14/01	110.00	
3.00			AA07321			08/21/01	325.50	
3.00								
4.00	2001 Indian Creek Assessment	WWU170-0027	AA06461	Sand Cr	Mahalasville Rd	07/25/01	2419.17	765.23
4.00			AA06657			07/30/01	1553.07	
4.00			AA06869			08/07/01	1119.85	
4.00			AA06985			08/14/01	191.60	
4.00			AA07322			08/21/01	325.50	

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
5.00	2001 Indian Creek Assessment	WWU170-0005	AA06462	Indian Cr	Low Gap Rd Taggart Crossing	07/25/01	517.20	578.57
5.00			AA06658			07/30/01	980.40	
5.00			AA06870			08/07/01	488.40	
5.00			AA06986			08/14/01	601.50	
5.00			AA07323			08/21/01	435.20	
6.00	2001 Indian Creek Assessment	WWU170-0026	AA06463	Unnamed Trib	Downey Rd	07/25/01	261.30	N/A
6.00			AA06659			07/30/01	686.70	
7.00	2001 Indian Creek Assessment	WWU170-0025	AA06464	Robertson Cr	Doeney Rd	07/25/01	2419.17	>1545.29
7.00			AA06660			07/30/01	>2419.2	
7.00			AA06872			08/07/01	1203.31	
7.00			AA06987			08/14/01	517.20	
7.00			AA07325			08/21/01	>2419.2	
8.00	2001 Indian Creek Assessment	WWU170-0023	AA06466	Camp Cr	Mahalasville Rd	07/25/01	1732.87	872.07
8.00			AA06661			07/30/01	1986.28	
8.00			AA06874			08/07/01	770.10	
8.00			AA06988			08/14/01	95.80	
8.00			AA07326			08/21/01	1986.28	

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
9.00	2001 Indian Creek Assessment	WWU170-0022	AA06467	Indian Cr	Mahalasville Rd	07/25/01	157.60	466.02
9.00			AA06662			07/30/01	313.00	
9.00			AA06875			08/07/01	686.70	
9.00			AA06989			08/14/01	579.40	
9.00			AA07328			08/21/01	1119.85	
10.00	2001 Indian Creek Assessment	WWU170-0021	AA06469	Indian Trace Cr	Mahalasville Rd	07/25/01	>2419.2	>1092.91
10.00			AA06669			07/30/01	1986.28	
10.00			AA06876			08/07/01	>2419.2	
10.00			AA06990			08/14/01	461.10	
10.00			AA07329			08/21/01	290.90	
11.00	2001 Indian Creek Assessment	WWU170-0020	AA06472	Oliver Cr	Old Railroad Rd	07/25/01	248.90	222.97
11.00			AA06666			07/30/01	419.80	
11.00			AA06879			08/07/01	101.20	
11.00			AA06993			08/14/01	85.00	
11.00			AA07332			08/21/01	613.10	
12.00	1996 Synoptic	WWU170-0001	DI20098	Indian Cr	CR 650 E	02/27/96	140.00	448.21
12.00			DI20909			04/29/96	1000.00	
12.00			DI21290			06/06/96	2000.00	
12.00			DI21674			07/17/96	190.00	
12.00			DI22148			10/09/96	340.00	
12.00	2001 Indian Creek Assessment	WWU170-0001	AA06471	Indian Cr	CR 650 E	07/25/01	980.40	582.13
12.00			AA06665			07/30/01	816.40	
12.00			AA06878			08/07/01	517.20	
12.00			AA06992			08/14/01	248.90	
12.00			AA07331			08/21/01	648.80	

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
13.00	2001 Indian Creek Assessment	WWU170-0019	AA06470	Pike Cr	Mahalasville Rd	07/25/01	547.50	515.87
13.00			AA06664			07/30/01	2419.17	
13.00			AA06877			08/07/01	307.60	
13.00			AA06991			08/14/01	325.50	
13.00			AA07330			08/21/01	275.50	
14.00	2001 Indian Creek Assessment	WWU170-0016	AA06490	Indian Cr	Lick Creek RD	07/25/01	285.10	402.68
14.00			AA06715			07/30/01	686.70	
14.00			AA06895			08/07/01	191.80	
14.00			AA06977			08/14/01	410.60	
14.00			AA07349			08/21/01	686.70	
15.00	2001 Indian Creek Assessment	WWU170-0004	AA06489	Bear Cr	SR 135	07/25/01	107.10	365.01
15.00			AA06713			07/30/01	1732.87	
15.00			AA06893			08/07/01	90.60	
15.00			AA06975			08/14/01	248.10	
15.00			AA07346			08/21/01	1553.07	
16.00	2001 Indian Creek Assessment	WWU170-0018	AA06533	Crooked Cr	CR 700 S	07/25/01	>2419.2	N/A
16.00			AA06667			07/30/01	816.40	
16.00			AA06880			08/07/01	1413.60	
17.00	2001 Indian Creek Assessment	WWU170-0015	AA06488	Indian Cr	SR 135	07/25/01	365.40	315.51
17.00			AA06714			07/30/01	410.60	
17.00			AA06894			08/07/01	172.50	
17.00			AA06976			08/14/01	166.40	
17.00			AA07348			08/21/01	726.00	
18.00	2001 Indian Creek Assessment	WWU170-0017	AA06532	Long Run Cr	CR 700 S	07/25/01	1203.31	478.61
18.00			AA06668			07/30/01	1119.85	
18.00			AA06881			08/07/01	357.80	
18.00			AA06979			08/14/01	63.80	
18.00			AA07334			08/21/01	816.40	

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
19.00	2001 Indian Creek Assessment	WWU170-0014	AA06486	Indian Cr	Co line RD	07/25/01	167.40	257.76
19.00			AA06716			07/30/01	547.50	
19.00			AA06892			08/07/01	238.20	
19.00			AA06974			08/14/01	75.90	
19.00			AA07345			08/21/01	686.70	
20.00	1996 Watershed	WWU170-0031	DI21806	Indian Cr	CR 700 W	08/13/96	70.00	N/A
22.00	2001 Indian Creek Assessment	WWU170-0013	AA06487	Barns Cr	CR 700 S	07/25/01	259.50	197.27
22.00			AA06711			07/30/01	360.90	
22.00			AA06891			08/07/01	69.70	
22.00			AA06973			08/14/01	83.60	
22.00			AA07344			08/21/01	547.50	
23.00	2001 Indian Creek Assessment	WWU170-0012	AA06484	Indian Cr	CR 700 S	07/25/01	143.90	241.23
23.00			AA06710			07/30/01	613.10	
23.00			AA06896			08/07/01	185.00	
23.00			AA06972			08/14/01	61.30	
23.00			AA07343			08/21/01	816.40	
24.00	2001 Indian Creek Assessment	WWU170-0010	AA06482	Indian Cr	CR 575 W	07/25/01	298.70	453.39
24.00			AA06708			07/30/01	579.40	
24.00			AA06888			08/07/01	1046.24	
24.00			AA06970			08/14/01	129.60	
24.00			AA07341			08/21/01	816.40	
25.00	2001 Indian Creek Assessment	WWU170-0009	AA06481	Indian Cr	CR 500 W	07/25/01	158.50	>405.28
25.00			AA06707			07/30/01	920.80	
25.00			AA06887			08/07/01	112.40	
25.00			AA06980			08/14/01	275.50	
25.00			AA07340			08/21/01	>2419.2	

Site #	Project ID	L-Site #	Sample #	Stream Name	Description	Sample Date	E.coli (MPN/100 mL)	Geometric Mean
26.00	2001 Indian Creek Assessment	WWU170-0008	AA06480	Lick Cr	CR 300 W	07/25/01	1732.87	>1053.81
26.00			AA06706			07/30/01	>2419.2	
26.00			AA06886			08/07/01	770.10	
26.00			AA06968			08/14/01	166.40	
26.00			AA07339			08/21/01	>2419.2	
27.00	2001 Indian Creek Assessment	WWU170-0007	AA06479	Indian Cr	CR 300 W	07/25/01	410.60	500.09
27.00			AA06705			07/30/01	726.00	
27.00			AA06885			08/07/01	816.40	
27.00			AA06967			08/14/01	313.00	
27.00			AA07338			08/21/01	410.60	
28.00	2001 Indian Creek Assessment	WWU170-0006	AA06477	Indian Cr	CR 750 S	07/25/01	387.30	221.71
28.00			AA06702			07/30/01	488.40	
28.00			AA06883			08/07/01	69.70	
28.00			AA06964			08/14/01	111.20	
28.00			AA07335			08/21/01	365.40	

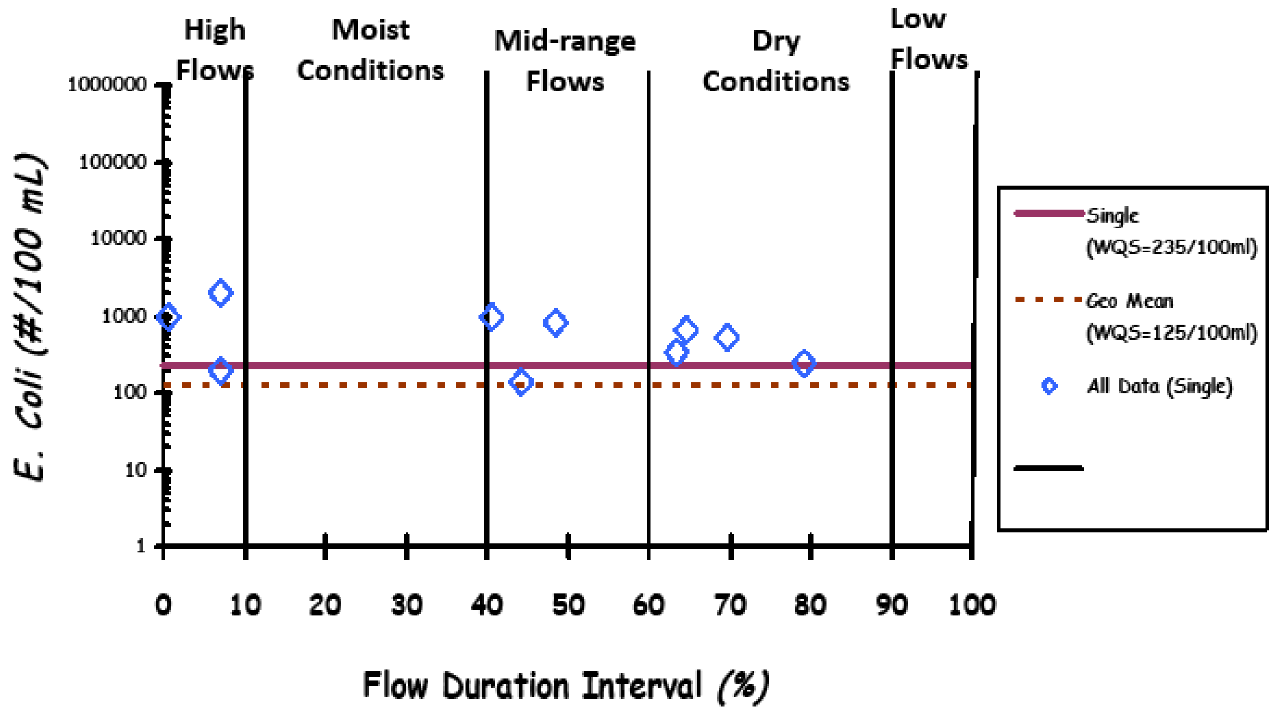
Attachment B

Water Quality Duration Curves for Indian Creek Watershed TMDL

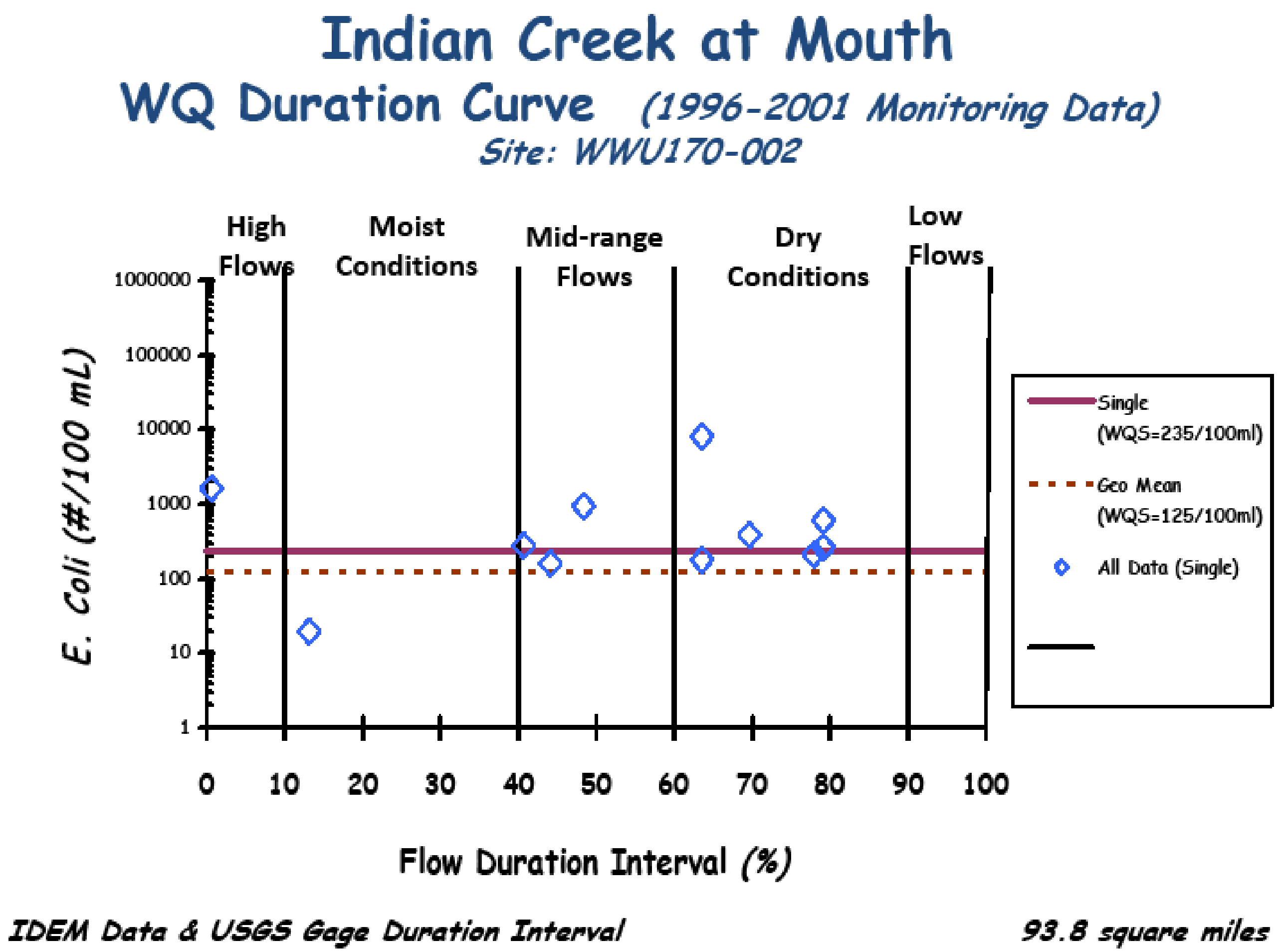
Indian Creek at Mouth

WQ Duration Curve *(1996-2001 Monitoring Data)*

Site: WWU170-001



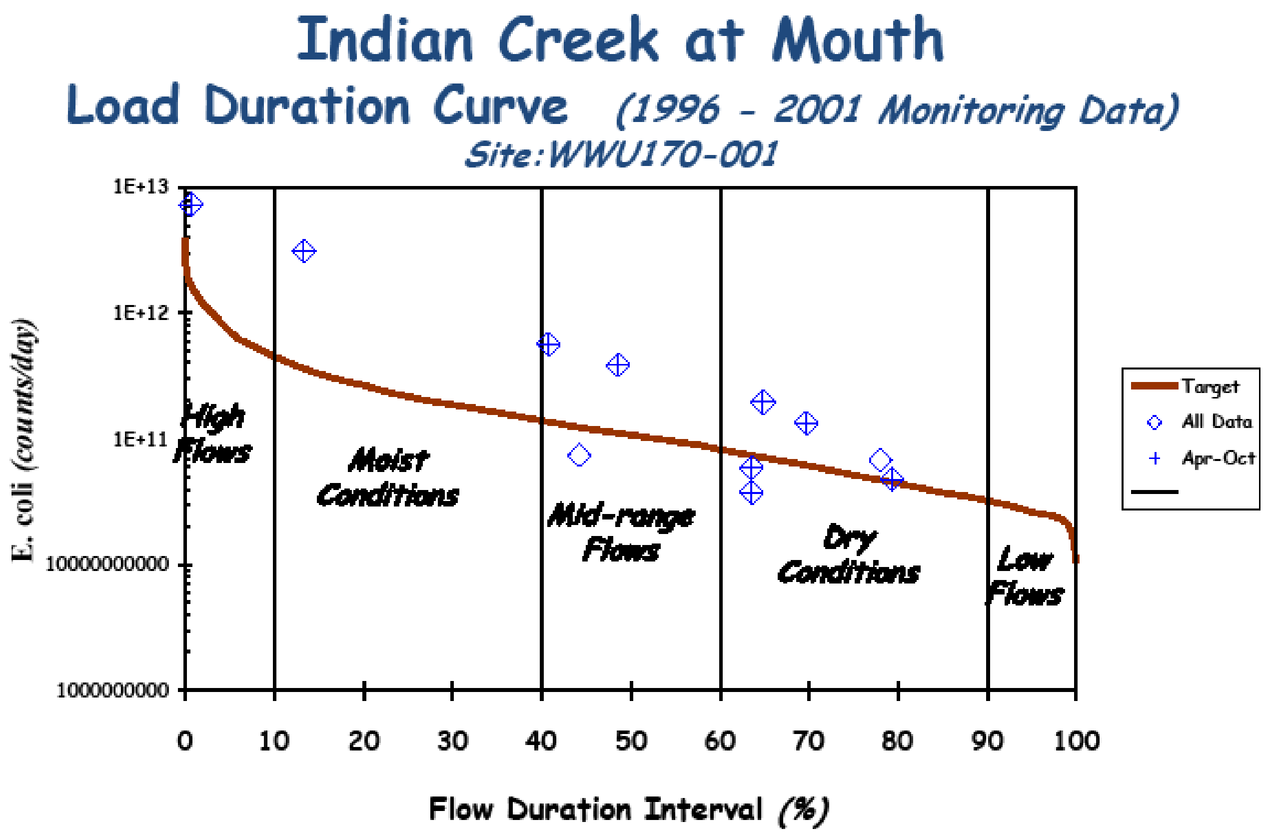
IDEM Data & USGS Gage Duration Interval *93.8 square miles*



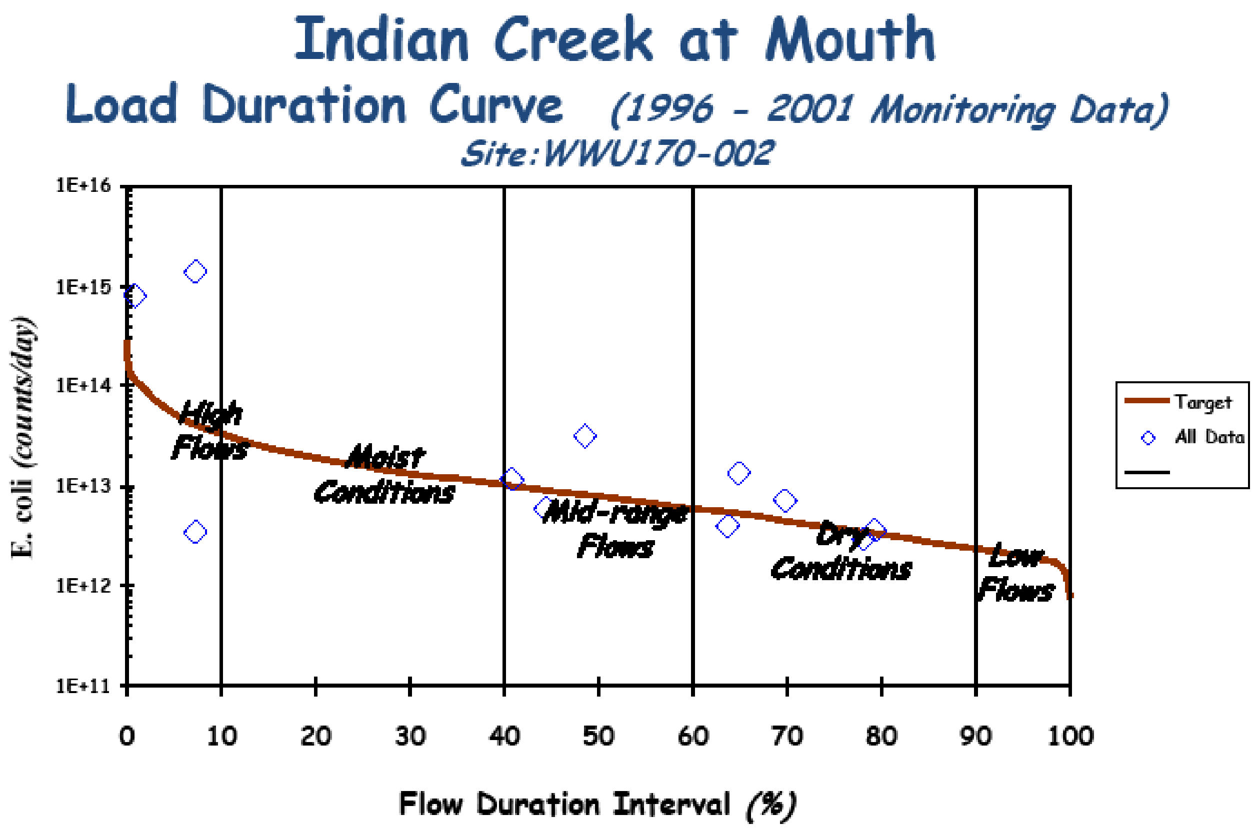
Indian Creek at Mouth
WQ Duration Curve (1996-2001 Monitoring Data)
Site: WWU170-002
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
E. Coli (#/100 mL)
1000000
100000
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Single (WQS=235/100ml)
Geo Mean (WQS=125/100ml)
All Data (Single)
Flow Duration Interval (%)
IDEM Data & USGS Gage Duration Interval
93.8 square miles

Attachment C

Load Duration Curves for Indian Creek Watershed



IDEM Data & USGS Gage Duration Interval *93.8 square miles*



IDEM Data & USGS Gage Duration Interval *93.8 square miles*