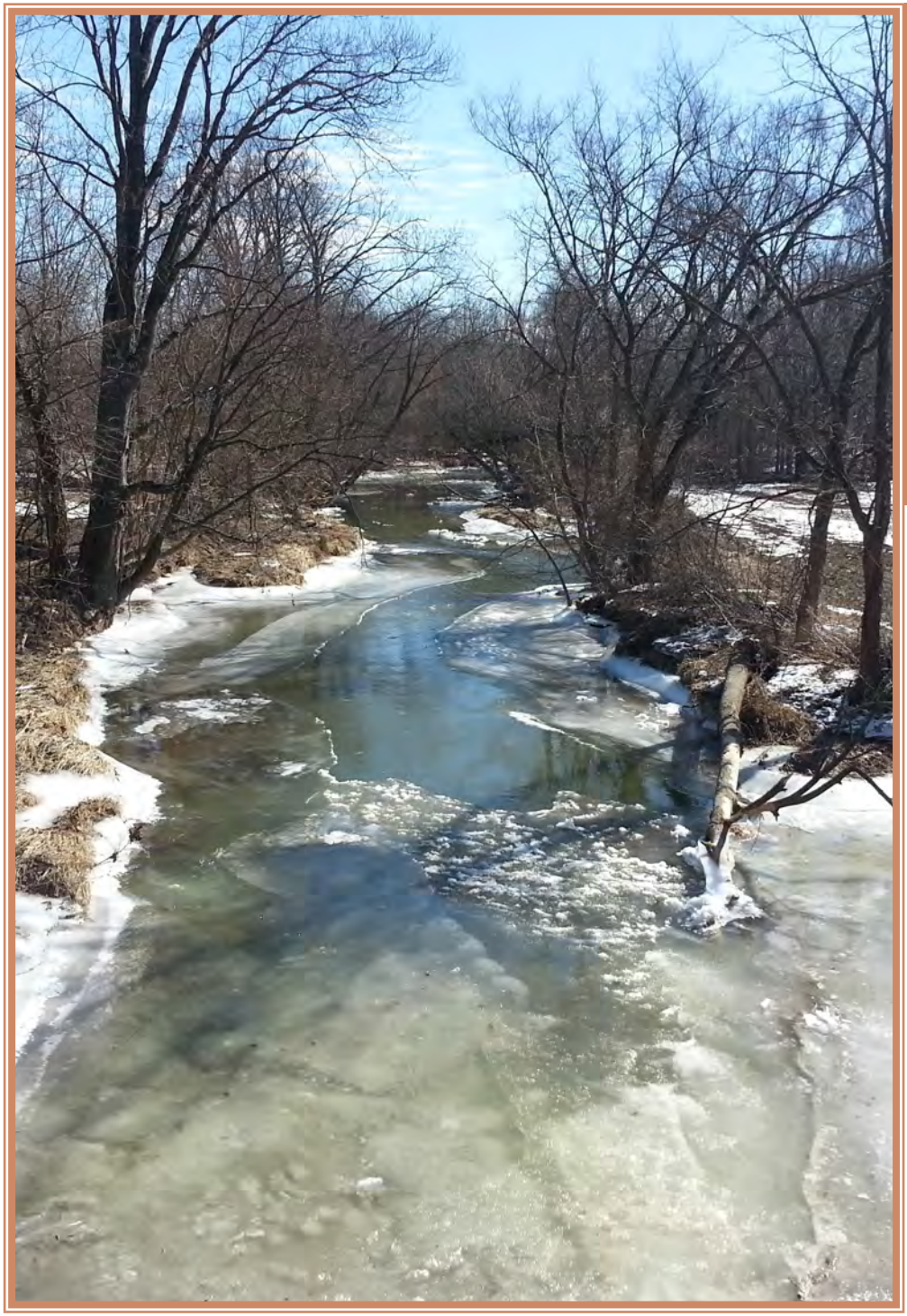

Watershed Management Plan for the Deer Creek-Sugar Creek Watershed

Carroll, Cass, Howard, Miami, & Tippecanoe Counties

December 2015

Project Contributors:

Carroll County Soil and Water Conservation District
The Wabash River Enhancement Corporation

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ACRONYM LIST

APC	Area Planning Commission
BFE	Base Flood Elevation
BMP	Best Management Practice
CFO	Confined Feeding Operation
CQHEI	Citizen Qualitative Habitat Evaluation Index
CR	County Road
CWP	Center for Watershed Protection
E. coli	*Escherichia coli*
FCA	Fish Consumption Advisory
GIS	Geographic Information Systems
HES	Highly Erodible Soils
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IBC	Impaired Biotic Community
IDDE	Illicit Discharge Detection and Elimination
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
ISDA	Indiana State Department of Agriculture
IWMA	Integrated Water Monitoring Assessment
kg	Kilograms
L	Liters
lb	Pounds
LUST	Leaking Underground Storage Tank
MCM	Minimum Control Measure
mg	Milligrams
MGD	Million Gallons per Day
NASS	National Agricultural Statistics Service
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PCB	Polychlorinated Biphenyls
PHES	Potentially Highly Erodible Soils
ppm	Parts per million
QHEI	Qualitative Habitat Evaluation Index
RC&D	Resource Conservation and Development
STP	Sewage Treatment Plant
RM	River Mile
SWCD	Soil and Water Conservation District
µg	Micrograms
USGS	United States Geological Survey
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WMP	Watershed Management Plan
WQS	Water Quality Standard
WREC	Wabash River Enhancement Corporation

1.0 WATERSHED COMMUNITY INITIATIVE

A watershed is the land area that drains to a common point, such as a location on a river. All of the water that falls on a watershed will move across the landscape collecting in low spots and drainage ways until it moves into the waterbody of choice. All activities that take place in a watershed can impact the water quality of the river that drains it. What we do on the land, such as constructing new buildings, fertilizing lawns, or growing crops, affects the water and the ecosystem that lives in it. A healthy watershed is vital for a healthy river, and a healthy river can enhance the community and helps maintain a healthy local economy. Watershed planning is especially important in that it will help communities and individuals determine how best to preserve water functions, prevent water quality impairment, and produce long-term economic, environmental, and political health.

The Deer Creek–Sugar Creek watershed includes portions of Carroll, Cass, Howard, Miami, and Tippecanoe Counties. All of the tributaries eventually drain into the Wabash River. The watershed of interest includes the area that drains into the Wabash River from Deer Creek, Sugar Creek, and Buck Creek. The Deer Creek watershed drains into the Wabash River approximately a mile before entering Tippecanoe County (from Carroll County). Sugar and Buck creeks flow into the Wabash River within Tippecanoe County. This watershed totals 345 square miles.

By managing and improving the Deer Creek-Sugar Creek watershed, we can do our part to improve water quality in the Wabash River. The following section details the history of the projects including funding details, project purposes, and stakeholder involvement as part of the Deer Creek – Sugar Creek Watershed Management Plan.

1.1 Project History

E. coli, impaired biotic communities, nutrients, PCBs, and mercury have been persistent problems in the Deer Creek-Sugar Creek watershed. The 2010 and the draft 2012 IDEM 303(d) lists identified several streams within the watershed with impairments: Buck Creek, Bachelor Run-Kuns Ditch, Deer Creek, Guckien-Cohee Ditch, Hughes Ditch, Little Deer Creek, Little Sugar Creek, Paint Creek, Price Plank Ditch, Shirar Ditch, Sugar Creek, and unnamed tributaries for *E. coli*; Buck Creek Ditch, Buck Creek and its tributaries, and the Wabash River for impaired biotic communities; Deer Creek, Little Deer Creek, and the Wabash River for nutrients; Deer Creek and the Wabash River for PCBs and mercury in fish tissue. Because of these impairments, a water management plan is needed to get the levels of these four parameters within state suggested ranges.

In the fall of 2010, the Carroll County Soil and Water Conservation District submitted a Section 319 Non-point Source Program grant application to the Indiana Department of Environmental Management (IDEM) watershed planning section. Concurrent with grant submission, identification of watershed partners occurred. Many of these initial partners became part of the project steering committee. The grant was awarded in April 2011 and signed in April 2012.The grant's purpose was fivefold:

1. To produce a watershed management plan for the Deer Creek–Sugar Creek watershed (Figure 1);
2. To provide education and outreach to the watershed community;
3. To assess stakeholder opinions and provide educational opportunities;

4. To monitor water quality within Deer Creek, Sugar Creek, and their tributaries with hopes of showing a measurable improvement (change) in water quality during the implementation phase of the project; and
5. To develop and implement a cost-share program.

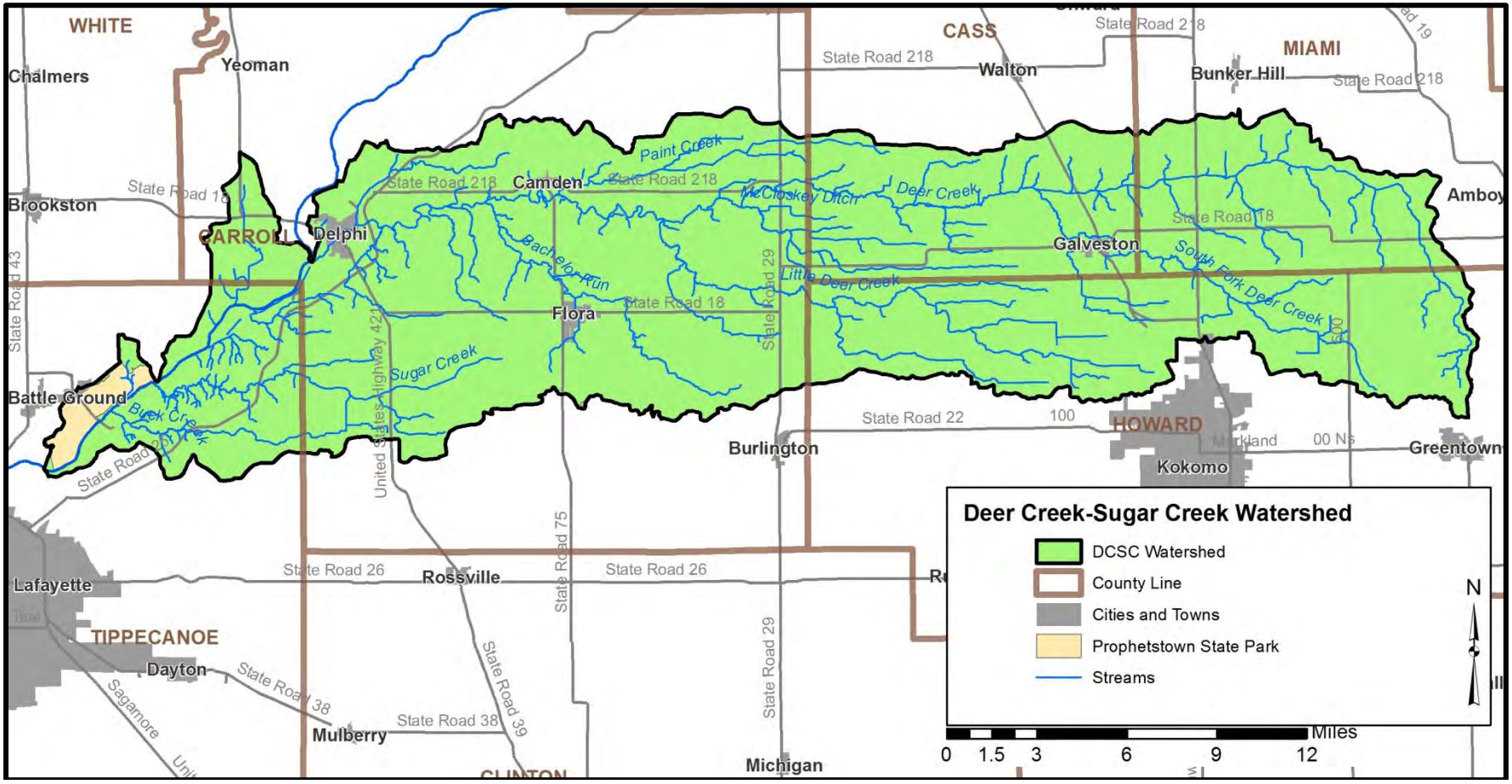

Figure 1. Deer Creek – Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

Once the contract was signed, the Carroll County Soil and Water Conservation District subcontracted with the Wabash River Enhancement Corporation to coordinate and complete all aspects of this grant. WREC staff was responsible for writing the watershed management plan with

input and insight from the watershed partners and steering committee members. Additionally, WREC staff was responsible for guiding plan development, coordinating and facilitating committee meetings, and planning and implementing water quality and watershed information gathering. Purdue University was responsible for current water quality data collection and data analysis and stakeholder surveys.

Development of the Deer Creek–Sugar Creek watershed management plan was a community driven process and involved a diverse group of local citizens, experts, organizations, and community leaders. The following sections detail the committees created as part of this project, the work these committees completed, and the outcomes developed by the committees. Additionally, input from watershed stakeholders and the mechanisms in which this input was generated are also included in the following sections. All of these efforts were guided by the following mission and vision developed by public participants and committee members:

Mission: Communities working together to develop a roadmap of solutions to become better stewards of land, water, and wildlife in the Deer Creek-Sugar Creek watershed.

Vision: An improved watershed with healthy streams, diverse wildlife, and sustainable agricultural practices.

1.2 Stakeholder Involvement

Development of a watershed management plan requires input from interested citizens, local government leaders, and water resource professionals. These individuals are required to not only buy into the project and the process but must also become an integral part of identifying the solution(s) which will result in improved water quality. WREC involved stakeholders in the watershed management planning process through public meetings and a steering committee.

1.2.1 Steering Committee

Individuals representing the cities, towns, and counties within the watershed; neighborhood associations; environmental groups; natural resource and engineering professionals; and industrial and educational entities comprised the steering committee. The steering committee met bimonthly starting in May 2012. Table 1 identifies the steering committee members and their affiliation.

Table 1. Deer Creek-Sugar Creek watershed steering committee members and affiliations.

Steering Committee Member	Organization(s) Represented
Megan Benage	Tippecanoe County SWCD
Andrea Brown	Purdue Cooperative Extension, Carroll County
Judy Buttice	Cass County SWCD
Lynn Corson	Carroll County Chamber of Commerce; RC&D
Rick Duff	USDA/NRCS – Miami County
Larry Falk	Carroll County Resident
Jessica Fulgoni	Wabash River Enhancement Corporation
Angie Garcia-Miller	Tippecanoe County SWCD
Calvin Hartman	Howard County SWCD
Rhonda Hicks	Carroll County SWCD
Skyler Hill	DNR – Prophetstown State Park
Jerry Holsapple	Greater Lafayette Commerce; Carroll County Resident
Sarah Lake	Indiana State Department of Agriculture
Mary Lou Musselman	Miami County SWCD
Kathy Mylet	Carroll County Area Planning Commission
Allen Nail	Tippecanoe County Park & Recreation Department
Gus Nyberg	NICHES Land Trust
Joe O'Donnell	NRCS – Carroll County
Rick Parsons	Tippecanoe County Soil Waste District and SWCD
Sara Peel	Wabash River Enhancement Corporation
Donnie Shockley	Carroll County Survey
Evan Smith	NRCS – Howard County
Dale Snipes	Tippecanoe County Surveyor, MS4
Randy Strasser	Mayor, City of Delphi
Talia Tittelfitz	Wabash River Enhancement Corporation
Leanne Whitesell	Indiana Department of Environmental Management

1.2.2 Public Meetings

Public participation is necessary for the long-term success of any watershed planning and subsequent implementation effort. One component of public participation for this project was public meetings. Three public meetings have been held in Flora and Delphi, Indiana. Each has been organized and facilitated by Purdue University graduate and undergraduate students taking Dr. Linda Prokopy's class, *Community Involvement in Natural Resource Planning.* The meetings met class requirements and have also assisted in the development of the Deer Creek-Sugar Creek Watershed Management Plan (WMP). Additional annual public meetings, most likely in the fall towards the end of harvest season, will continue to be held as part of this project.

October 19, 2011

The purpose of the public meetings was to provide information on the overall planning effort and its process; solicit stakeholder input, opinions, and participation; and build support for future phases of the project.

The public meeting was advertised to the residents within the watershed in several ways. A "Save the Date" announcement was advertised in the local newspapers and posters and fliers were distributed throughout the community. Personal letters were mailed to key stakeholders that had been identified within the watershed. Additionally, information was e-mailed to involved residents in the area. The meeting was held at the 4-H Building in Flora, Indiana. Approximately 27 individuals attended the meeting, which included a BBQ, a public input session and children's activities. Attendees represented citizens, environmental groups, city and county employees, and local government agencies. During this meeting, the Carroll County SWCD detailed the history of the project; WREC described opportunities for individuals to volunteer as part of the project; and Purdue University students provided attendees with the opportunity to identify their concerns about the Deer Creek, Sugar Creek, and Buck Creek, their tributaries, and the watershed.

October 30, 2012

The purpose of the public meeting was to build on a list of issues and concerns started at the 2011 meeting.

The evening meeting was held in the Flora Community 4-H Building, and a BBQ dinner was provided. The meeting was attended by over 30 people from throughout the watershed, many of whom had lived here for over ten years. Meeting participants heard information about the grant, the Wabash River Enhancement Corporation, progress on the watershed management plan, and possible best management practices. They then had the opportunity to vote on their top concerns which could be addressed by the watershed management plan including agricultural, aesthetic and recreational, and industrial issues. Students also facilitated discussions of the problem areas in the watershed.

October 23, 2013

The purpose of this public meeting was to update the watershed communities on the progress of the watershed management plan, alert them to the upcoming cost share program, and solicit their feedback on critical components of the WMP.

The meeting was held in the evening at the United Methodist Church in Delphi, Indiana. Participants were served a church dinner and provided with a brief update on the progress of the WMP. Participants then moved into smaller breakout groups facilitated by Purdue students for smaller and more in-depth discussions on the draft goals statements of the WMP, the best means of conducting outreach and education in the watershed, and the specific feasibility and potential of selected best management practices.

1.3 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public detailed concerns for the Wabash River, its tributaries, and its watershed. Public and committee meetings formed the primary mechanism for individual concerns to be recorded; however, concerns were also gathered at the county 4-H fairs and other education events. The committee and public's concerns voiced throughout the process are listed in Table 2. The order of concern listing does not reflect any prioritization by watershed stakeholders. Concerns have been consolidated and grouped in the right hand column for further analysis later in the plan.

Table 2. Stakeholder concerns identified during public input sessions and grouped for use in the planning process.

Stakeholder Concerns	Grouped Concerns
Agriculture run-off into Deer Creek	Agriculture run-off is contributing to the high nutrient concentrations and sedimentation (turbidity) within the Deer Creek Sugar Creek watershed.
Chemicals from farming	Pesticide concentrations in Deer Creek.
Loss of crops due to farms flooding	Flood prone ground is farmed causing additional sediment and nutrient loading to waterbodies in the Deer Creek-Sugar Creek watershed.
Too much till-farming of flood prone ground	
Use of cover crops to slow run off and erosion	Too few agricultural best management practices are located in the Deer Creek-Sugar Creek watershed.
Tree planting, shrubs, grasses to pressure stream banks, etc.	
Shallow wetland areas	
Implement filter strips	
Dead animals in Deer Creek (Hogs)	There are dead animals (hogs) in Deer Creek.
E. coli. from livestock	Waste from livestock is increasing the *E. coli* concentrations in watershed waterbodies.
Hog sewage in Little Deer Creek	Hog sewage (waste) is sitting/stagnate in Little Deer Creek.
Agriculture runoff sitting in Deer Creek because of low flow	
Livestock impact on water quality	Livestock is negatively impacting water quality.
	There are unregulated animal farms within the watershed.
	Livestock have access to the stream.
Decline in fish populations	Fish populations have been negatively affected by the water quality.
Decline in insect populations	Macroinvertebrate populations have been negatively affected by the water quality.
Wildlife areas encouraged and protected	Wildlife areas should be encouraged and protected within the watershed.
Decline in crawfish populations	There has been a decline in crawfish populations.

Stakeholder Concerns	Grouped Concerns
Want to see wetlands, water treatment systems, better systems, and rain barrels	Lack/decrease of wetlands within the watershed.
Lack of wetlands	
There are invasive species issues within the watershed.	There are invasive species issues within the watershed.
Safety of the consumption of fish caught within the watershed (Bass species)	Fish caught within the watershed are not safe for consumption.
The volume of manure produced in the Deer Creek-Sugar Creek watershed.	The volume of manure produced in the Deer Creek-Sugar Creek watershed.
There is a lack of manure management in areas of the watershed.	There is a lack of manure management in areas of the watershed.
Some CFO facilities are storing their manure too close to creeks.	Some CFO facilities are storing their manure too close to creeks.
There have been several manure spills/fish kills within the watershed.	There have been several manure spills/fish kills within the watershed.
Manure is being applied throughout the watershed.	Manure is being applied throughout the watershed.
Bio-solid issues	Bio-solid issues.
Nitrogen concentrations exceed suggested levels.	Nitrogen concentrations exceed suggested levels.
Phosphorus concentrations exceed suggested levels.	Phosphorus concentrations exceed suggested levels.
Turbidity/sediment exceeds recommended levels by USEPA.	Turbidity/sediment exceeds recommended levels by USEPA.
E. coli concentrations exceed the state of Indiana's suggested level.	*E. coli* concentrations exceed the state of Indiana's suggested level.
Monitoring stations on Deer Creek/Wabash River	Develop long term monitoring stations on Deer Creek/Wabash River.
There is no current monitoring on either stream	
Want clean, unpolluted water in Carroll County	
Want water quality to meet useable standards	
Implement filter strips	Limited buffers are located along watershed waterbodies causing poor water quality.
Soil erosion	Care of soil quality and erosion
Care of soil quality	
Down trees along Deer Creek due to erosion problems	Stream bank erosion occurs along the waterbodies within the watershed
No signs marking Sugar Creek	Education program programs addressing conservation practices, recycling, climate change, and disposing of chemicals need to be developed.
Target the editorial in newspapers that will inform others in the watershed	
Work around political system and act locally	
Tax plan dependent on political system	

Stakeholder Concerns	Grouped Concerns
Education	
Lack of recreation in the watershed	Limited recreation throughout the watershed.
Lack of hiking trails	
Southwest portion of the watershed has potential for recreational development	
Deer Creek – Low flow, less recreation	
Are there land use regulations of standards for these zones	Carroll County zoning regulations are not providing sufficient protection for sensitive and high quality areas.
Carroll County zoning regulations	
Ignoring a lot of sensitive areas due to agriculture interests and crops	
Problem with land value	Problem with land value.
Flooding concerns along Flora, IN residents (especially those with basements)	Flooding concerns within residential areas (Flora and Delphi).
Residential flooding/drainage	
Levees River Park – flooded homes	
Waste water treatment flooding outside of Delphi	
Deer Creek is too flashy	Instream flows are unpredictable.
Decreased water levels (lack of water)	
Interrupted flow by beavers (trees)	
Wells are low – waste contaminants	Wells are low and may be contaminated by nitrate.
Wells have to be dug deeper due to water quality issues (nitrate 70 ppm)	
Effects of highway construction on State Road 25	Effects of highway construction (State Road 25).
Illegal septic systems	Illegal septic systems.
Increased population of zooplankton species	Increased population of zooplankton species.
Waste water needs more conservation of water, don't use drinking water for other uses	Waste water needs more conservation of water, don't use drinking water for other uses.
Dredge river; make it deeper	Dredge river; make it deeper.
Reservoirs – effect on stream flow	Reservoirs – effect on stream flow
Engineering of tile drains in Carroll County	Engineering of tile drains in Carroll County.
Stone quarry being constructed outside of Americus.	Stone quarry being constructed outside of Americus.
Dumping/burying of chemical waste	Dumping/burying of chemical waste

1.4 Social Indicator Survey

The ability of WREC, Carroll County SWCD, and other stakeholders to conduct effective education and outreach depends on:

- understanding how people feel about local water resources
- how much they know about water quality concerns
- what practices they adopt on the land they manage
- what factors affect their land management decisions

Social indicator surveys provide one way to analyze these attitude, awareness, behavior, and constraint measures. The data obtained provide a snapshot of a given time, helping to direct outreach efforts and allowing for measurement of temporal change observed during future assessments. Education, urban, and rural committee members worked with a group of Purdue University social scientists to tailor an existing survey system that was originally developed for use in nonpoint source pollution projects by a regional team of researchers.

1.4.1 Survey Methods

Because the Deer Creek-Sugar Creek watershed is almost entirely agricultural, recipients for the survey were selected from a Farm Service Agency database of agricultural producers. In order to reach a representative variety of both crop and livestock producers, this list of recipients was supplemented by addresses listed on Confined Feeding Operation permits available through IDEM's virtual cabinet portal. The 12-page survey was sent to 612 addresses in the watershed, garnering an overall response rate of 47%.

A standardized delivery and collection method was used. In November 2013, a five-wave mail survey was utilized to collect the data (Dillman, 2000). An advance notice letter was sent to potential respondents to inform them of the survey's purpose and to notify them that they would be receiving a paper survey in the next week. This letter also included instructions on how to complete the survey online. The paper survey was sent the following week and included verbiage similar to the original advance letter, instructions for completing the survey online, and a summary of the survey's purpose. A postcard reminder was sent two weeks later, followed by a replacement survey the following week. After two more weeks, a third replacement survey was sent to all non-respondents.

The survey covered the social indicators developed for use in 319-funded watershed projects. The indicators are grouped into four categories: awareness, attitudes, constraints, and behaviors. Socio-demographic information was also collected. Descriptive summaries for the survey are included below. Detailed tables, including raw statistical data, are included in Appendix B.

1.4.2 Survey Results

As detailed above, the agricultural survey was sent to 612 producers and resulted in a 47% return rate.

Water as a Resource

Respondents were asked to rank the importance of a number of water-related activities. "Scenic beauty/enjoyment" and "fishing" were the highest ranked response categories, while "swimming" in the water received the lowest rating. "Picnicking" and "Canoeing, kayaking, and other

boating" activities ranked in the middle. This suggests a prevalent "look but don't touch" attitude toward recreational use of the water, however clearly respondents seem comfortable with activities which bring them onto or in close proximity to the water. The vast majority of respondents stated that they know where the rainwater goes when it leaves their property and were able to name that body of water.

Water Quality Attitudes

Respondents were asked to rank their level of agreement with a number of statements related to their attitudes toward water quality, including its importance to the community, the financial ramifications of management practices, and levels of personal responsibility. This section assessed a baseline set of attitudes towards water quality that can be used as a basis for comparison in future social indicator surveys once practices, education, and outreach have been implemented. A 1-to-5 "strongly disagree" to "strongly agree" scale was used. In general, respondents believe that recommended agricultural practices can improve water quality and are willing to accept responsibility for improving water quality. They also lean favorably towards the ideas that personal actions can impact water quality, that it is important to protect water quality, and that the quality of life in their communities depends on good water quality in local rivers and streams.

Respondents were more ambivalent about their personal willingness to pay for improved water quality, neither agreeing nor disagreeing with the statement "I would be willing to pay more to improve water quality." In summary, producers recognize that water quality is important for the community and that their actions can affect it, but they are less committed to paying for water quality improvements, which is not an unusual attitude to encounter. Overall, their attitude towards water quality is fairly standard, if not leaning positively, for an agricultural community.

Familiarity with Water Impairments

Respondents were asked to rate the severity of numerous water impairments. Respondents demonstrated awareness of "trash and debris" and "sedimentation" as problematic water quality issues, rating both between slight and moderate problems. Respondents were less aware of water quality problems due to Bacteria, Phosphorus, Nitrogen, and Pesticides, with around 30% of respondents indicating that they "don't know" about the severity these issues. These responses suggest that the most visible water quality problems are the ones readily identified by the respondent community.

Consequences of Poor Water Quality

Respondents were asked to evaluate the consequences of poor water quality. Reduced beauty of streams, reduced quality of water recreation activities, and reduced opportunities for water recreation were seen as the most serious issues, ranked as "slight problems." Respondents were less aware of less visible issues, such as contaminated fish, excessive aquatic plants or algae, fish kills, and lower property values, however, those who were aware of these issues also ranked contaminated fish and excessive aquatic plants or algae as slight problems. Lower property values were ranked lowest by those aware of the issue: somewhere between "not a problem" and "slight problem." These responses suggest that respondents are most aware of visible and recreational-related issues, but for those that are aware of other issues, fish and algae blooms are the

most serious issues. Though it is worth noting that less than a quarter of respondents deem any of the issues to be moderate to severe problems.

Sources of Water Pollution

Respondents were asked to rate the severity of 12 different sources of water pollution. Respondents ranked soil erosion from streambanks and farm fields and littering or illegal dumping of trash as the most serious contributors, ranking them as slight to moderate problems. Respondents were also aware of additional agricultural sources of pollution – such as manure from farm animals, excessive use of fertilizers, pasture grazing, and animal feeding operations – but ranked these lower: between not a problem and slight problem. Respondents were less aware of sources including septic systems, discharge from sewage treatment plants, industrial discharges, and urban stormwater runoff, though those that were aware considered stormwater runoff to be the highest ranked: a slight to moderate contributor. Overall, respondents in this watershed demonstrate the most awareness of agricultural and construction sources of pollution.

Practices to Improve Water Quality

Respondents were asked questions regarding specific land management practices to improve water quality (Figure 2 through Figure 5). An average of 87 respondents felt that questions related to livestock were relevant to their property. Of these, around 40% currently use manure in accordance with its nutrient content, and around 15% currently use animal composting facilities, approved grazing plans, and fences to exclude livestock from streams. An average of 210 respondents felt that questions related to crop agriculture were relevant to their property. Of these, around 70% of respondents currently use regular soil tests to determine nutrient application rates and retain crop residue and use grassed waterways to reduce erosion. Around 60% of respondents currently follow university recommendations for fertilization rates, use variable rate application technology, and consider location and soil characteristics to minimize leaching or runoff. Around 50% of respondents use conservation tillage, however, 20% of respondents said they know how to use conservation tillage but aren't currently using it. Respondents were the least familiar with regular servicing of septic systems; though nearly 50% of respondents currently use this practice, 30% of respondents were only slightly familiar with it or had never heard of it.

Constraints for Specific Practices

Respondents were asked detailed questions about their adoption of four specific conservation practices. Results from individual practices are included below:

Feedlot Runoff Diversion (built structures, filter strips, or grassed waterways)

A majority (73%) of respondents say this practice is not relevant for their operation. Nearly 13% currently use diversion of some kind to prevent surface water from flowing through feedlots, and around 10% had either never heard of this practice or were somewhat familiar with it. Nearly 60% said they might be willing to try this practice ("yes" or "maybe"). Desire to "keep things the way they are," property features which would make installation difficult, and cost were the highest ranking constraints preventing adoption of this practice.

Cover Crops

Around 30% of respondents currently use cover crops, and around 25% are somewhat familiar with this practice. Very few said they had never heard of it. Nearly half of respondents either said they know how to use cover crops but choose not to or feel they aren't relevant for their operation. Responses given for why the practice might not be relevant include "flat ground" and "no erosion," demonstrating that many who are not using the practice feel the primary purpose of a cover crop is to prevent erosion on sloped fields. Over 80% said they might be willing to try this practice ("yes" or "maybe"). Cost, difficulty of using with existing farming equipment, and time required were the highest ranking constraints preventing adoption of this practice.

Two Stage Ditch

Few respondents (8%) currently use this practice. Over 30% know how to use two stage ditches but choose not to or do not feel they would be relevant for their operation. Almost 60% of respondents are only somewhat familiar with this practice or had never heard of it. Around 70% of respondents said they might be willing to try a two stage ditch ("yes" or "maybe"). Cost, time required, and lack of equipment were the highest ranking constraints preventing adoption of this practice.

Vegetated Riparian Buffer

Nearly 35% of respondents currently use this practice. Around 25% know how to use riparian buffers but choose not to or do not feel they would be relevant for their operation. Nearly 40% of respondents are only somewhat familiar with this practice or had never heard of it. Around 75% of respondents said they might be willing to try vegetated riparian buffers ("yes" or "maybe"). Cost and time required were the highest ranking constraints preventing adoption of this practice.

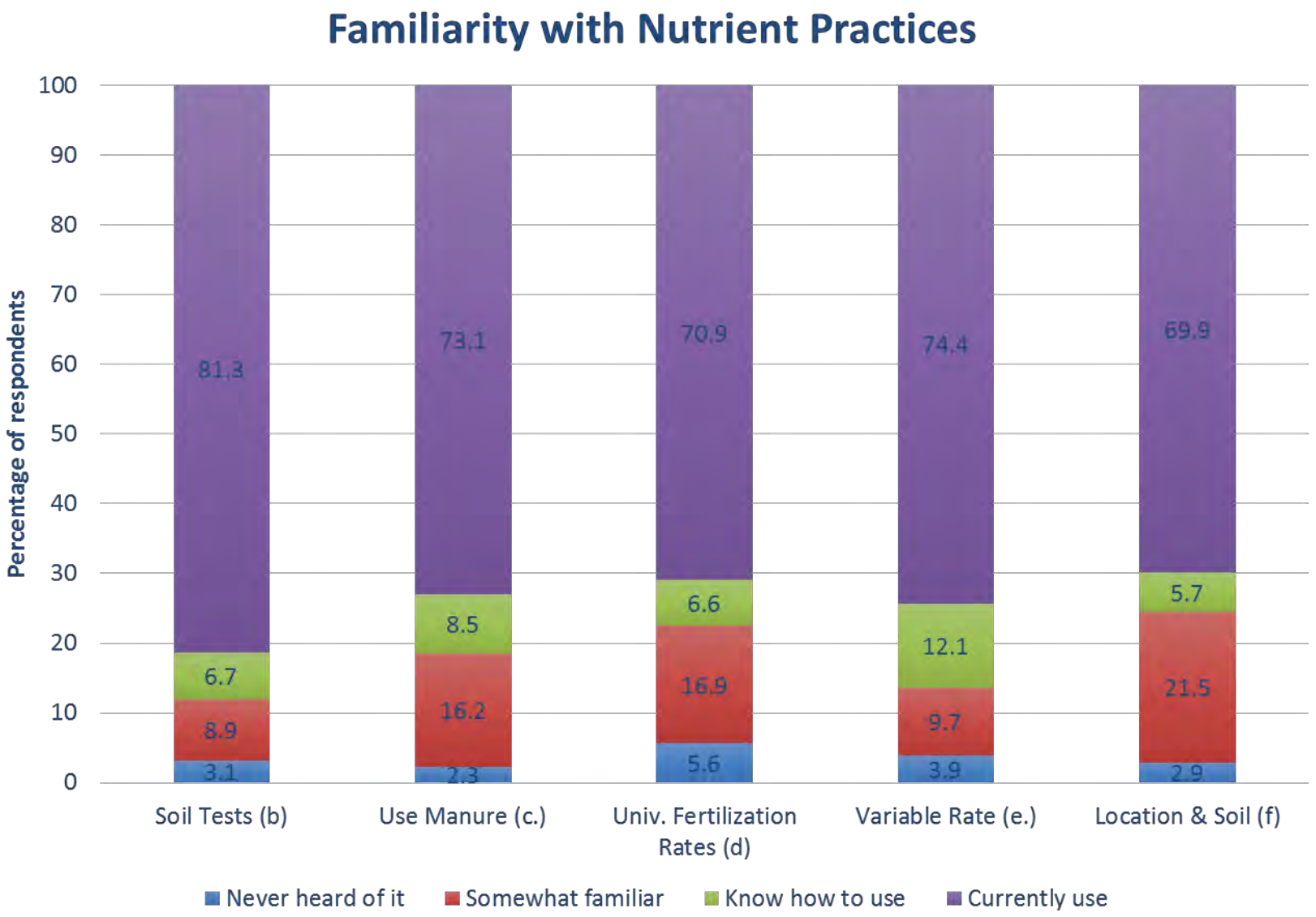

Figure 2. Survey respondents' familiarity with nutrient practices.

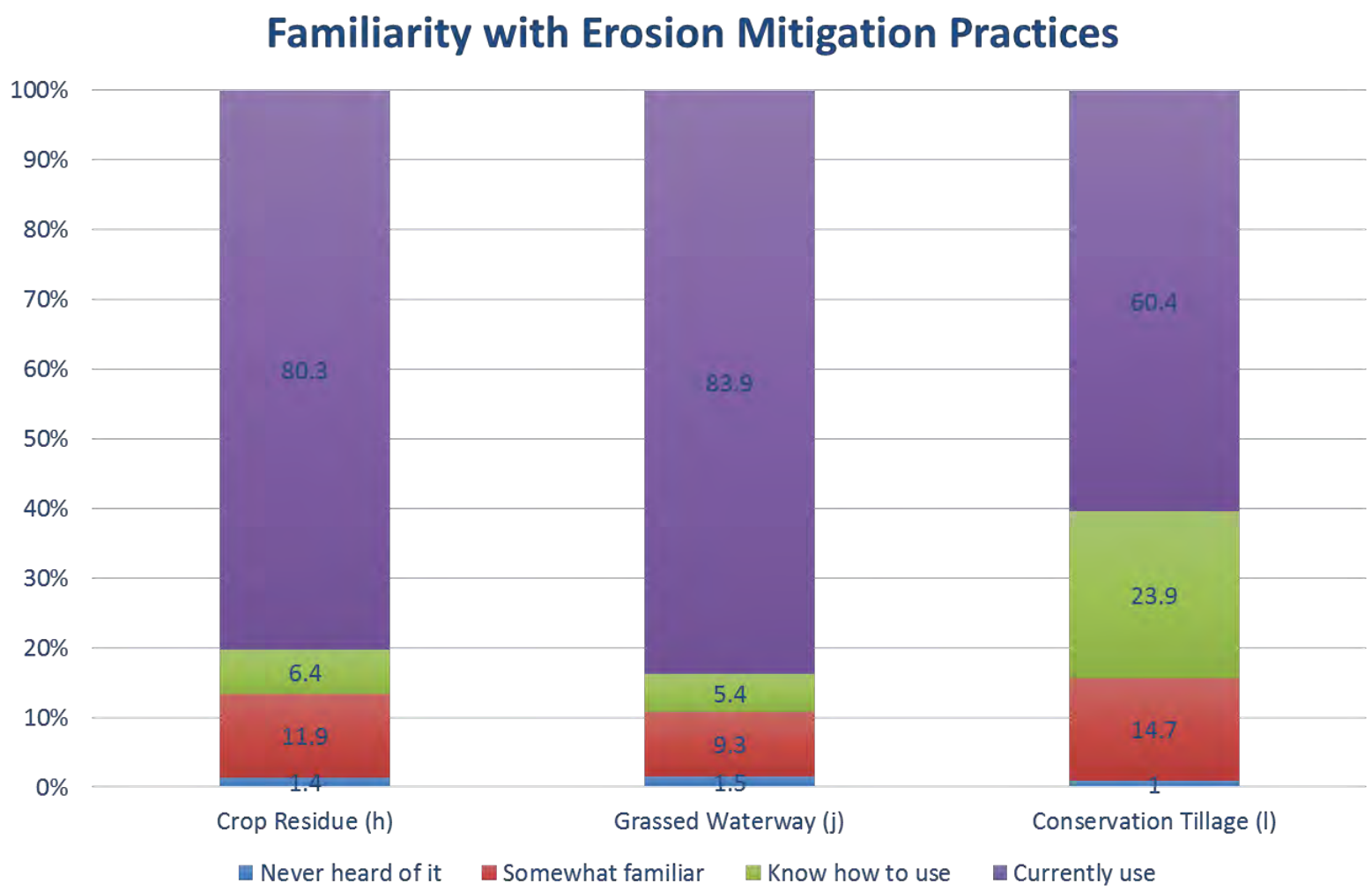

Figure 3. Survey respondents' familiarity with erosion mitigation.

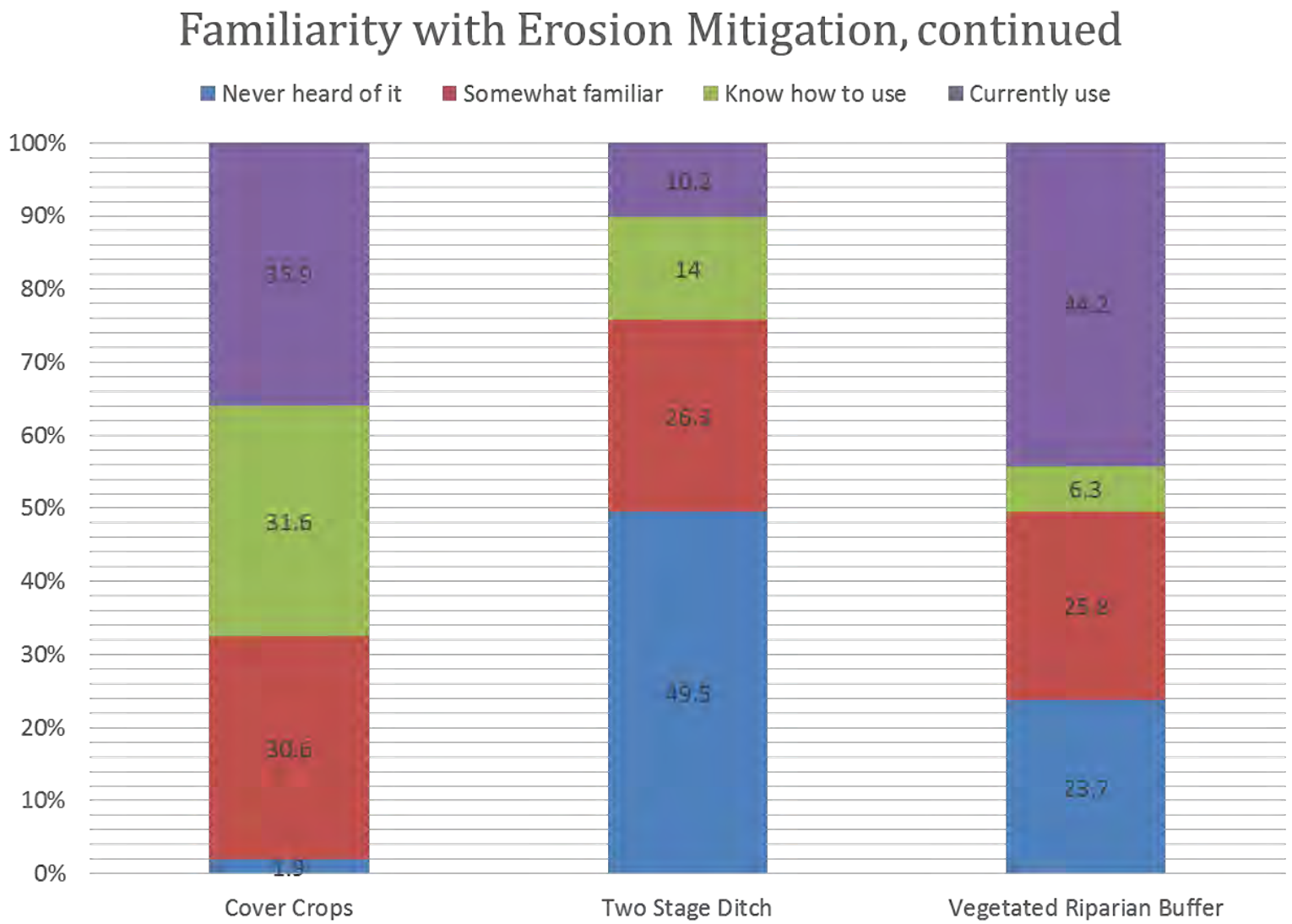

Figure 4. Survey respondents' familiarity with erosion mitigation, continued.

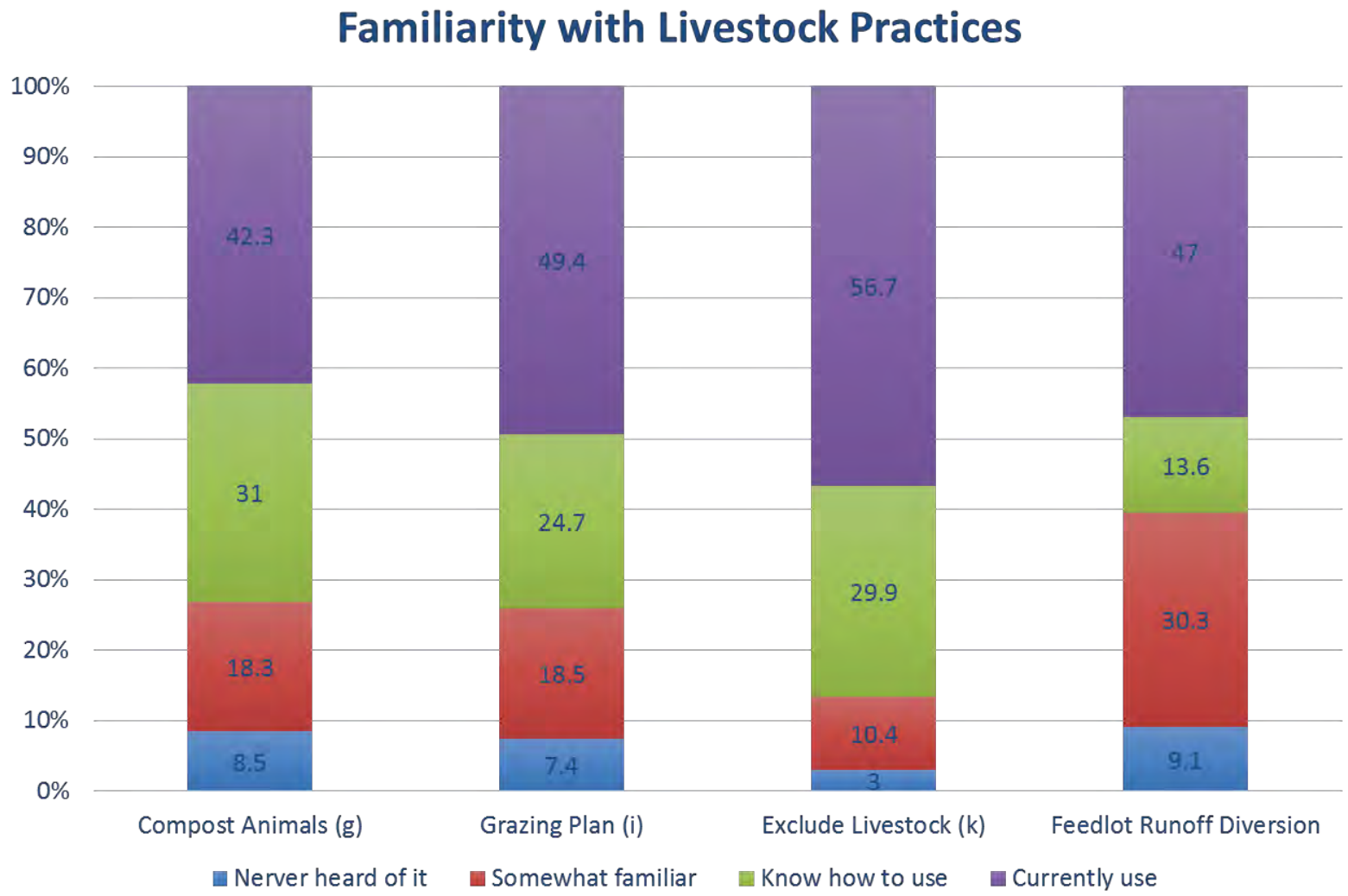

Figure 5. Survey respondents' familiarity with livestock practices.

General Constraints

Respondents were asked about the degree to which a number of constraints limited their ability to change their agricultural management practices. Personal expenses, lack of government funding, and inflexibility to change the practice were the top three constraints identified.

Socio-Demographics

The majority of respondents (over 85%) are male with a mean age of 64. Over 65% run their operation alone, with a spouse, or with family partners. Respondents have been farming for several decades (mean = 33 years), have had the farm in the family for generations (mean = 77 years), and a majority think it likely that family will continue the farming operations after they retire (over 70% said this will probably happen or will definitely happen). A majority of property managed (62%) touches a stream, river, or wetland. A majority of operations (nearly 70%) have a nutrient management plan; of those, 30% said the plan meets NRCS technical standard 590 and 70% said they didn't know. A majority (over 60%) of plans were developed by private sector agronomists or crop consultants.

Information Sources

Respondents were asked to select all the sources where they are likely to seek information about soil and water conservation issues. Newsletters, brochures, and fact sheets (46%); conversations with others (37%); and workshops, demonstrations and meetings (29%) were ranked highest. Respondents were also asked to select all the sources where they are likely to seek information about water quality issues. Newsletters, brochures, and fact sheets (45%); conversations with others (34%); and newspapers and magazines (28%) were ranked highest.

Respondents were also asked about the extent to which they know about or trust a number of conservation groups and related agricultural agencies. The three most trusted information sources were (in order) Soil and Water Conservation District, Purdue Extension, and Natural Resource Conservation Service – all ranked between "moderately" and "very much." These sources would thus be the best options for promotional and outreach materials. Hoosier Environmental Council, NICHES Land Trust, and the EPA garnered the least amount of trust, with all three scoring near the "slightly" trusted mark; though the majority of respondents were unfamiliar with both the Hoosier Environmental Council and NICHES. Respondents indicated that they "slightly" to "moderately" trust the Wabash River Enhancement Corporation, though over 40% reported that they were not familiar with the organization.

Septic Systems

Respondents were asked several questions related to septic systems. A majority of respondents (over 90%) indicated that they have a septic system (n=257). Most respondents with septic systems reported that they did not experience any problems with them in the last five years. Slow drains, toilet backups, and sewage backups in the house were the three most common problems reported if a system did malfunction. Most respondents (76%) said that they have a finger system, while 12% said they did not and 12% said they did not know.

1.4.3 Survey Summary

Most survey respondents, primarily agricultural landowners and producers, believe that good water quality is important for the communities that they live in for both economic and quality-of-life reasons. Most individuals feel a degree of personal responsibility for the actions they take that affect local water resources, though they may be unwilling to pay for improvements. It's clear that individuals frequently feel that they must compromise between desired environmental outcomes and their financial concerns.

In general, survey respondents readily identified visible water quality concerns such as littering and turbidity. Other problems, especially those related to nutrient loading and aquatic habitat alteration, have generated less awareness amongst respondents. Education and outreach efforts are needed across the board in order to effectively change management behaviors. Particularly successful campaigns may target those who have never heard of or are only slightly familiar with a given best management practice (Figure 2 through Figure 5). Respondents frequently identified financial factors as the primary constraint to adopting conservation practices.

Soil and Water Conservation District, Purdue Extension, and Natural Resource Conservation Service are the most trusted information sources for natural resource management concerns and would thus make excellent partners for outreach efforts. This survey indicates that WREC has a fairly low public profile; 42% of respondents were not familiar with the organization. WREC and Carroll County SWCD should take advantage of their partnerships with other well-known agencies in order to bolster its own name recognition and ability to achieve its goals.

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Deer Creek-Sugar Creek watershed is part of the Middle Wabash-Deer watershed and covers portions of Carroll, Cass, Howard, Miami, and Tippecanoe counties (Figure 6). The Middle Wabash-Deer watershed outlined in green, and the target watershed is outlined in black. The watershed has four distinct streams, Buck Creek, Deer Creek, Sugar Creek, and the Wabash River. Deer Creek has two headwater streams, the South Fork of Deer Creek and Little Deer Creek, while Sugar Creek has only one headwater stream, Little Sugar Creek. All of the streams drain into the Wabash River; from upstream to downstream, Deer Creek enters just below Delphi, IN, then Sugar Creek and finally Buck Creek. The Deer Creek-Sugar Creek watershed covers 375 square miles and includes all of Delphi, Flora, Camden, Galveston and portions of Battle Ground, Kokomo and Lafayette.

2.2 Subwatersheds

2.2.1 10-Digit Hydrologic Unit Watersheds

The Deer Creek-Sugar Creek watershed is a portion of the larger 8-digit Hydrologic Unit Code (HUC) watershed, the Middle Wabash-Deer watershed (05120105). Deer Creek-Sugar Creek is composed of three 10-digit HUC watersheds including Deer Creek (0512010505), South Fork of Deer Creek (0512010504), and Sugar Creek-Wabash River (0512010506) (Figure 6). The Deer Creek-Sugar Creek watershed is bordered to the north by the upper portion of the Middle Wabash-Deer watershed, to the north and east by the Upper Wabash watershed, to the south by the Wildcat Creek watershed, to the southwest by the Middle Wabash-Little Vermilion watershed, and to the northwest by the Tippecanoe watershed.

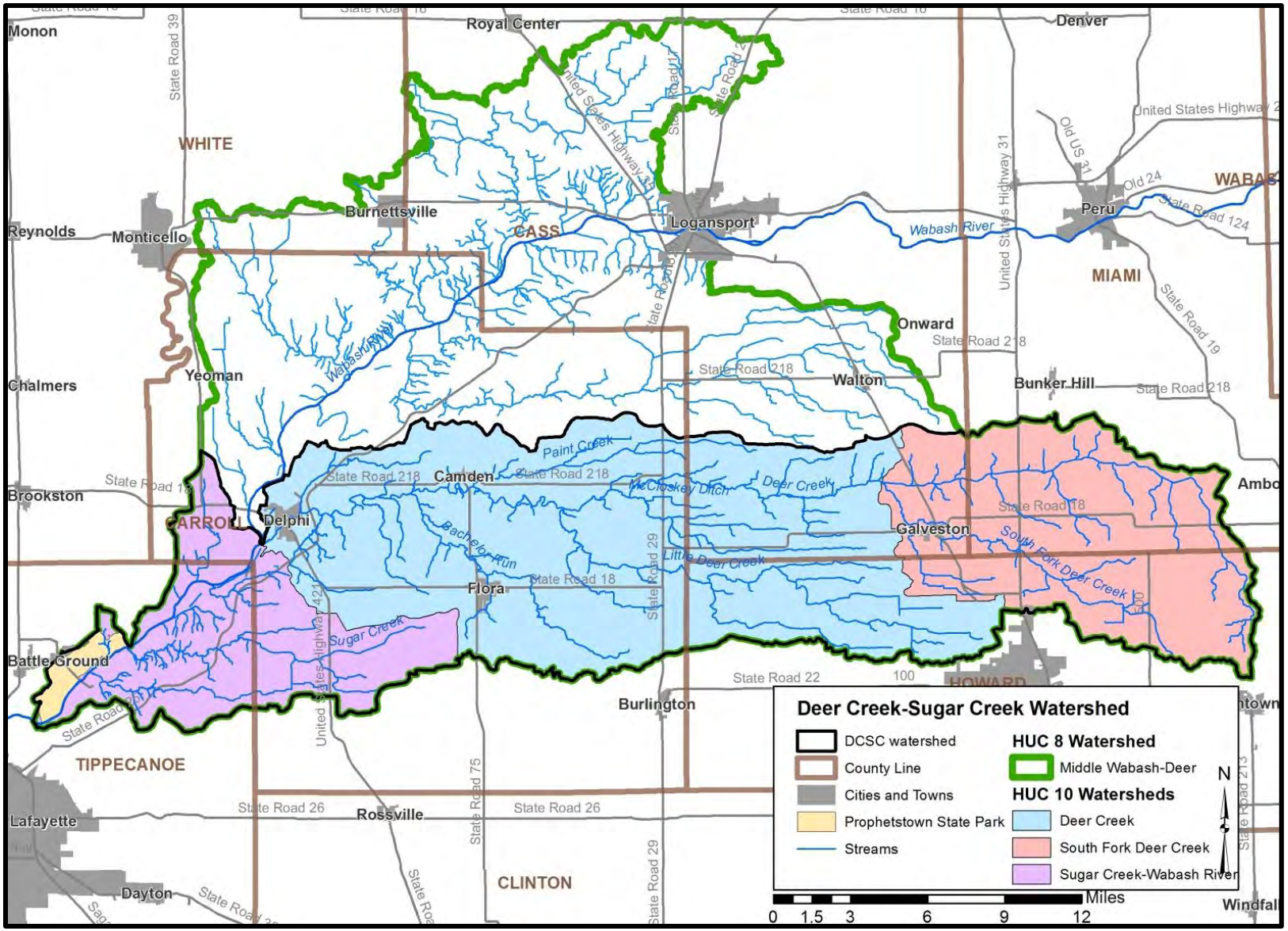

Figure 6. The Deer Creek-Sugar Creek watershed is located in the Wabash River-Deer watershed.
Data used to create this map are detailed in Appendix A.

2.2.2 Deer Creek-Sugar Creek Tributary Watersheds

Sixteen 12-digit HUC watersheds occur within the Deer Creek-Sugar Creek watershed (Figure 7, Table 3). The subwatersheds range in size from 10,301 to 25,532 acres or 16.1 to 39.9 square miles. Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

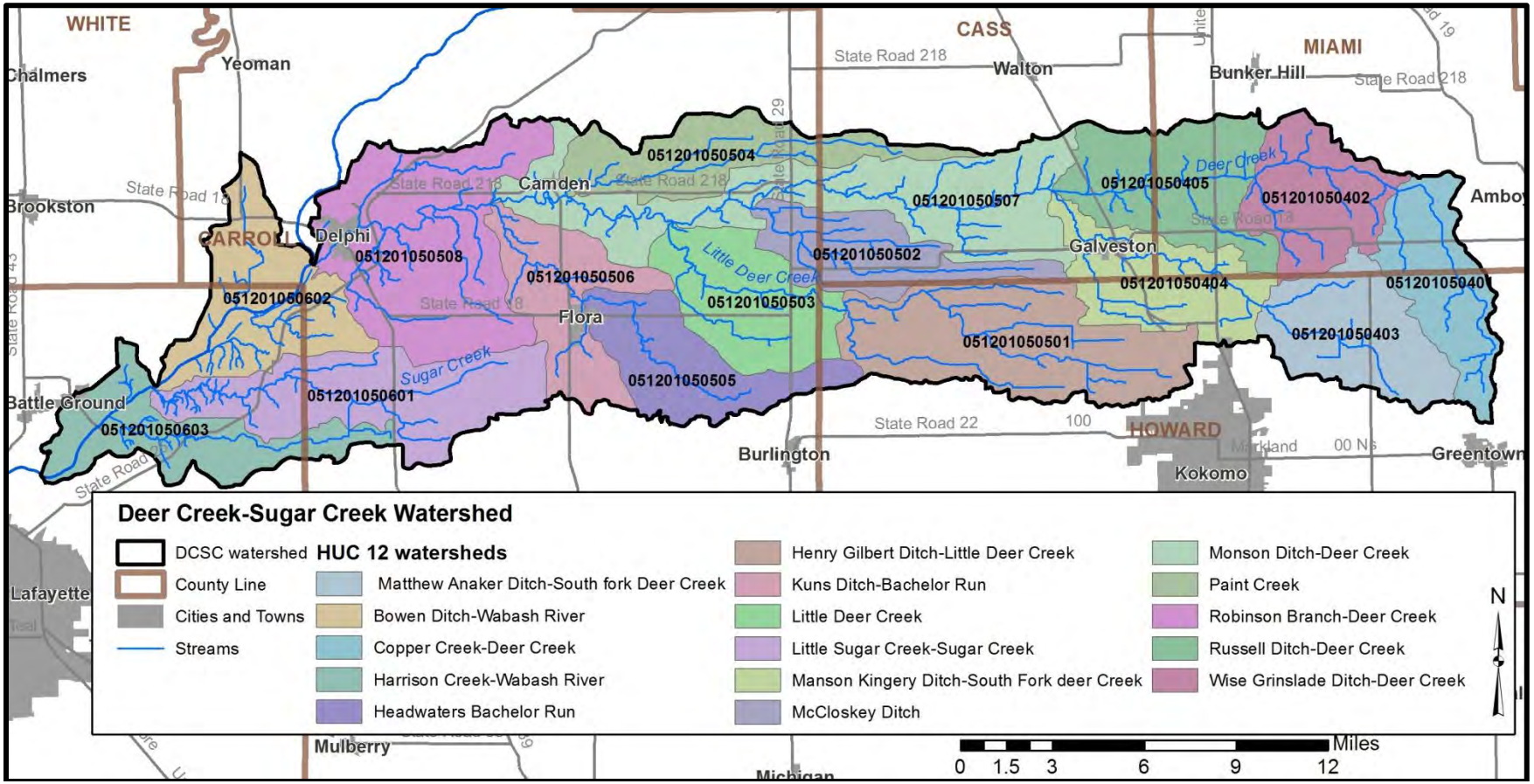

Figure 7. 12-digit Hydrologic Unit Codes in the Deer Creek-Sugar Creek watershed.

Data used to create this map are detailed in Appendix A.

Table 3. 12-digit Hydrologic Unit Code watersheds in the Deer Creek-Sugar Creek watershed.

Name	HUC	Area (Acres)	Area (sq mi.)	Counties
Copper Creek-Deer Creek	051201050401	11,149	17.4	Howard, Miami
Wise Grinslade Ditch-Deer Creek	051201050402	11,665	18.2	Howard, Miami
Matthew Anaker Ditch-South Fork of Deer Creek	051201050403	12,857	20.1	Howard, Miami
Manson Kingery Ditch-South Fork of Deer Creek	051201050404	12,583	19.7	Cass, Howard, Miami
Russell Ditch-Deer Creek	051201050405	14,692	23.0	Cass, Miami
Henry Gilbert Ditch-Little Deer Creek	051201050501	21,980	34.3	Cass, Howard
McCloskey Ditch	051201050502	10,301	16.1	Carroll, Cass, Howard
Little Deer Creek	051201050503	12,851	20.1	Carroll, Howard,
Paint Creek	051201050504	12,134	19.0	Carroll, Cass
Headwaters Bachelor Run	051201050505	11,666	18.2	Carroll, Howard
Kuns Ditch-Bachelor Run	051201050506	11,385	17.8	Carroll
Monson Ditch-Deer Creek	051201050507	25,196	39.4	Carroll, Cass
Robinson Branch-Deer Creek	051201050508	25,532	39.9	Carroll
Little Sugar Creek-Sugar Creek	051201050601	18,330	28.6	Carroll, Tippecanoe
Bowen Ditch-Wabash River	051201050602	15,112	23.6	Carroll, Tippecanoe
Harrison Creek-Wabash River	051201050603	12,608	19.7	Carroll, Tippecanoe

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. Climate in the Deer Creek-Sugar Creek watershed is no different than the rest of the state. There are four seasons throughout the year. The average temperatures measure approximately 72°F in the summer, while low temperatures measure below freezing (29°F) in the winter. The growing season typically extends from April through September. On average, 0.93 meters of precipitation occurs within the watershed per year; approximately 62% of this precipitation falls during the growing season (Carroll County Soil Survey, 1991).

2.4 Geology and Topography

The geology and topography of the Deer Creek-Sugar Creek watershed is influenced by the advance and retreat of the Huron-Erie and Saginaw lobes of the late Wisconsinan age (Fleming, 2011). Bedrock deposits are predominately from the Wisconsinan age, but there are also bedrock deposits from the Devonian, Holocene, Mississippian, and Silurian ages. Unconsolidated drift deposits overlie the bedrock with deposits ranging from a centimeter to 76 meters thick throughout the watershed. Bedrock consists of rocks from the Borden Group, Muscatatuck Group, New Albany Shale, and Wabash Formation. The Deer Creek-Sugar Creek watershed is dominated by the Wabash Formation; it covers approximately 72%, or 173,000 acres, of the watershed (Figure 8).The areas of the watershed where New Albany Shale or the Muscatatuck Group comprise the

bedrock could be areas of concern due to the eroding nature of these bedrocks. This erosivity could cause steep stream banks and the loss of land.

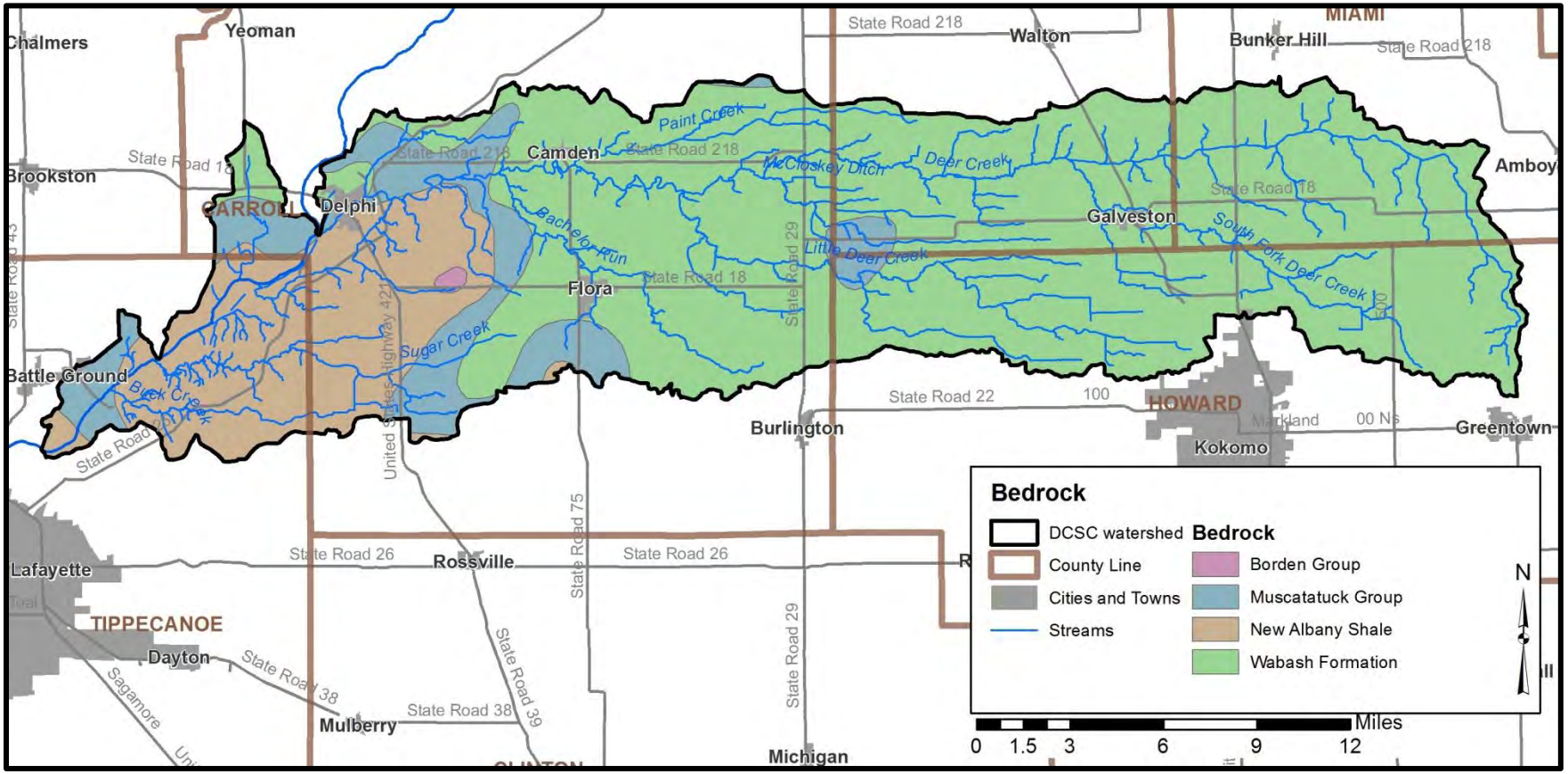

Figure 8. Bedrock in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

The topography, surficial geology, soil development, and bedrock geology in the Deer Creek-Sugar Creek watershed is influenced by the advance and retreat of the Huron-Erie and Saginaw lobes of the late Wisconsinan age (Fleming, 2011). The surficial geology of the Deer Creek-Sugar Creek watershed is dominated by loam till (Figure 9). Approximately 171,500 acres or 71% of the watershed is loam till.

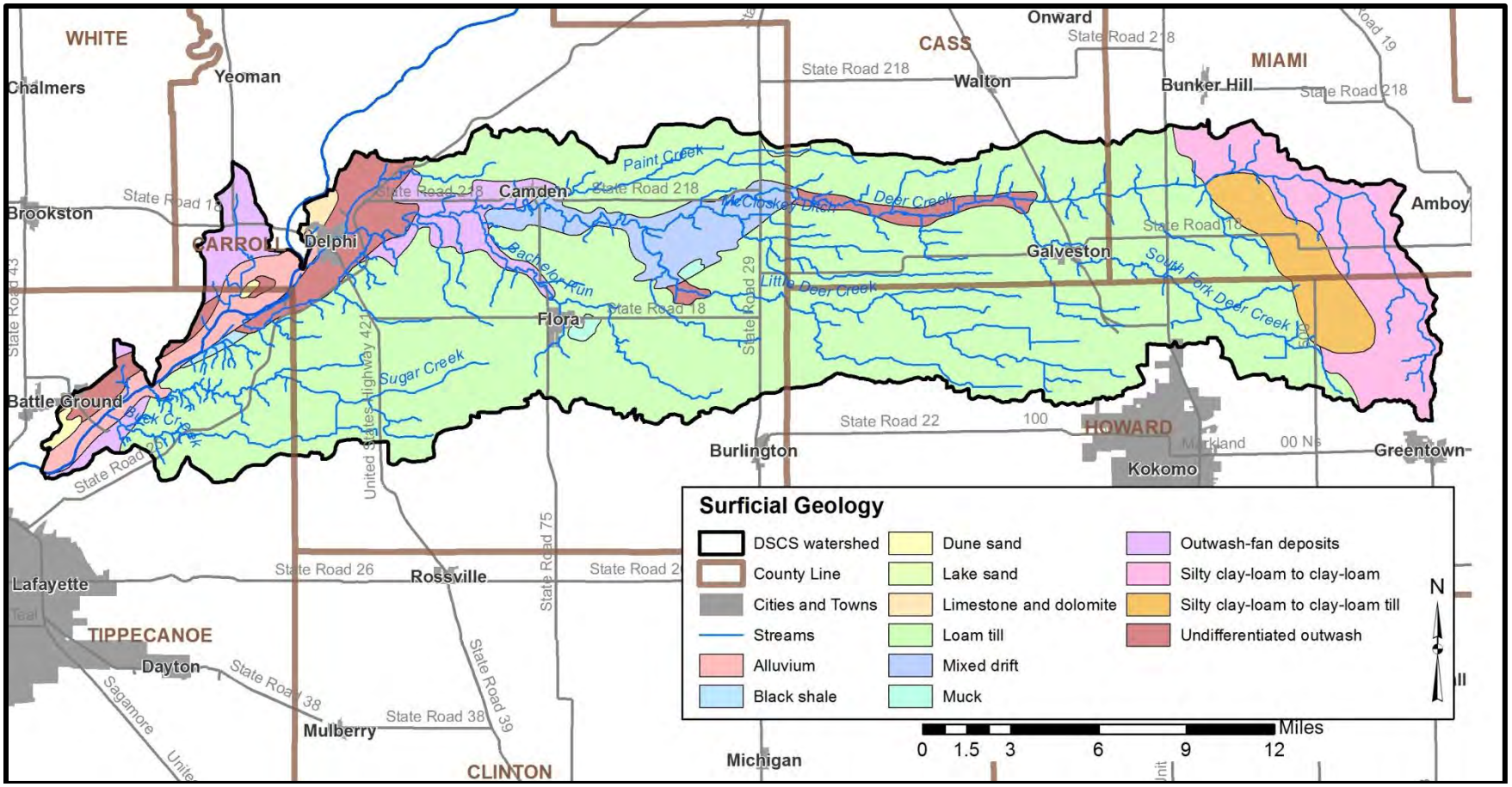

Figure 9. Surficial geology throughout the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

The highest point in the watershed is located in the eastern portion in Howard and Miami Counties (Figure 10). The area with the lowest elevation is located adjacent to the Wabash River. These areas intersect with bedrock that is New Albany Shale; this is most likely due to eroding of the layers of shale from weathering. The topography of the Deer Creek-Sugar Creek watershed is relatively flat. This is characteristic of the Central Till Plain Region where the majority of the watershed is located (Figure 11). The watershed slopes from east to west with the highest percent slope occurring around the streams located from the center of the western edge of the watershed.

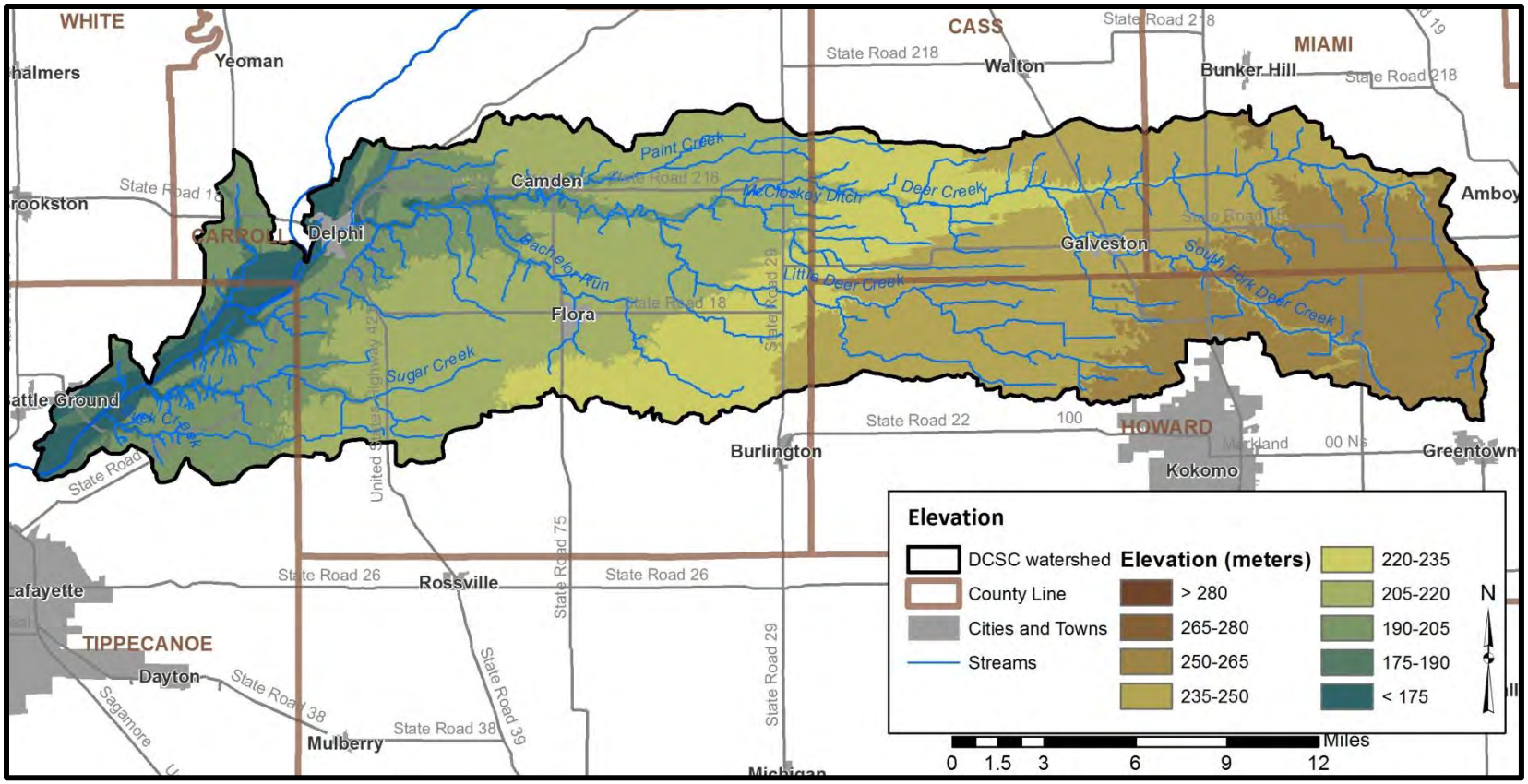

Figure 10. Surface elevation in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

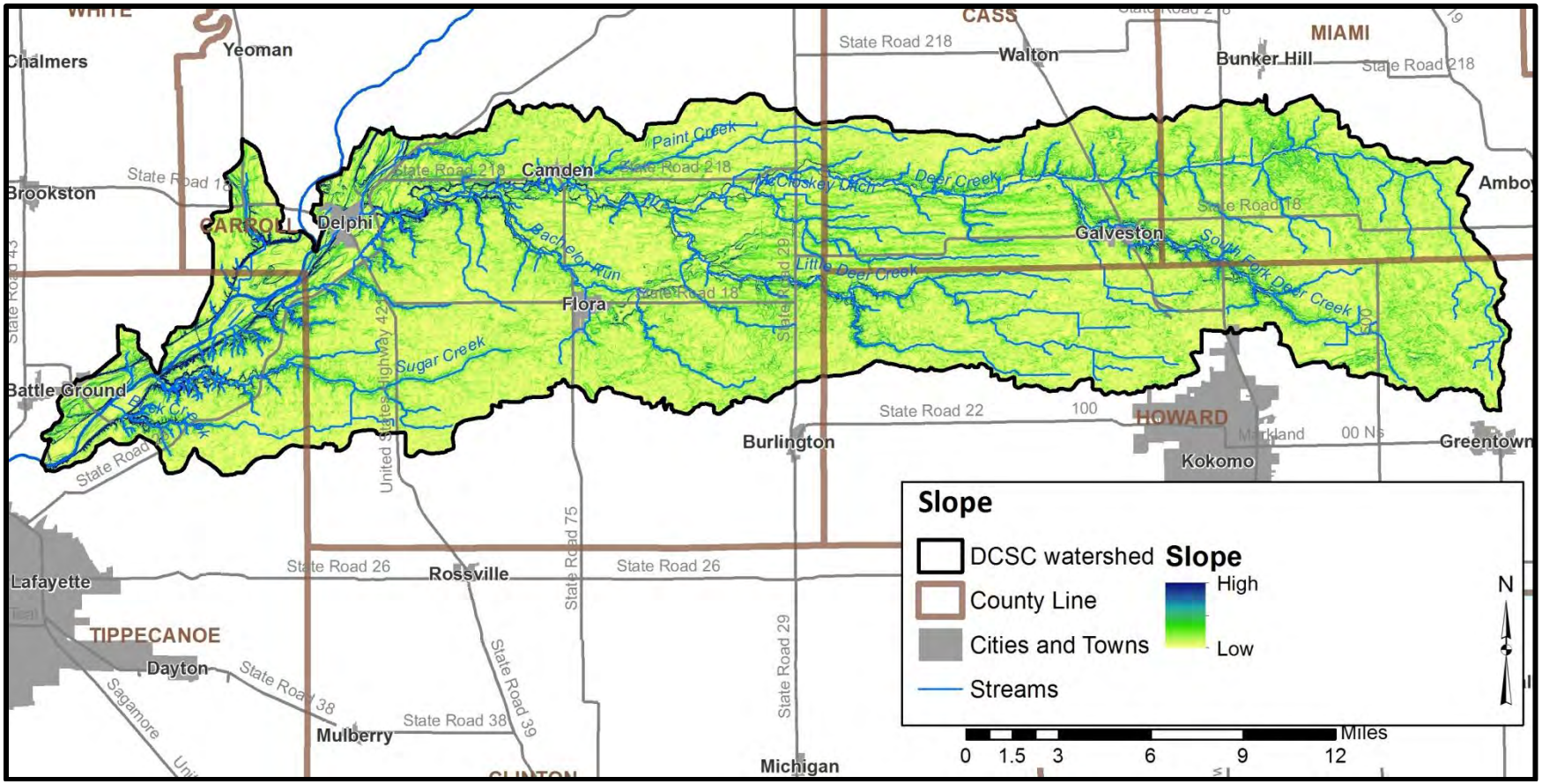

Figure 11. Surface slope of the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5 Soil Characteristics

2.5.1 Soil Associations

The watershed is covered by 13 soil associations with six associations individually accounting for 5% or more of the total watershed area. The Fincastle-Brookston-Miamian soil association covers approximately half of the watershed (50.5% or 121,133 acres; Table 4). The Fincastle-Brookston-Miamian association lies within till deposits (loam till) and is somewhat poorly drained. This association is nearly level and is an upland soil. The Blount-Pewamo-Glynwood association covers 10.5% of the watershed. This association covers the eastern most part of the watershed in Howard and Miami counties, lies within till deposits, and a silty clay-loam to clay-loam. The Blount-Pewamo-Glynwood soil

association is nearly level to gentle sloping. The Fox-Ockley-Westland association is the predominant soil association along Deer Creek's main section in Carroll County to where it enters the Wabash River. Fox-Ockley-Westland soil association lies on glacial outwash deposits and mixed drift. The Russell-Miami-Xenia, Patton-Starks-Kendall, and Rockfield-Fincastle-Camden soil associations are also common in the watershed. The Russell-Miami-Xenia soil association borders Deer Creek's main section in Cass County and also the majority of the South Fork of Deer Creek. In Carroll County, the Patton-Starks-Kendall association borders the eastern parts of the Fox-Ockley-Westland association while the Rockfield-Fincastle-Camden association borders the middle and western parts of the Fox-Ockley-Westland association (Figure 12).

Table 4. Soil Associations in the Deer Creek-Sugar Creek watershed.

Soil Name	Area (acres)	Percent of Watershed
Fincastle-Brookston-Miamian	121,133.0	50.5%
Blount-Pewamo-Glynwood	25,285.8	10.5%
Fox-Ockley-Westland	19,089.3	8.0%
Russell-Miami-Xenia	16,861.3	7.0%
Patton-Starks-Kendall	13,004.0	5.4%
Rockfield-Fincastle-Camden	12,076.7	5.0%
Crosby-Treaty-Miami	11,627.7	4.8%
Sawmill-Lawson-Genesee	6,874.4	2.9%
Miami-Crosby-Treaty	5,297.1	2.2%
Miami-Strawn-Hennepin	3,680.3	1.5%
Elston-Warsaw-Shipshe	3,029.8	1.3%
Millsdale-Newglarus-Randolph	1,635.2	0.7%
Mahalasville-Waynetown-Sleeth	447.0	0.2%
TOTAL	**240,041.6**	**100%**

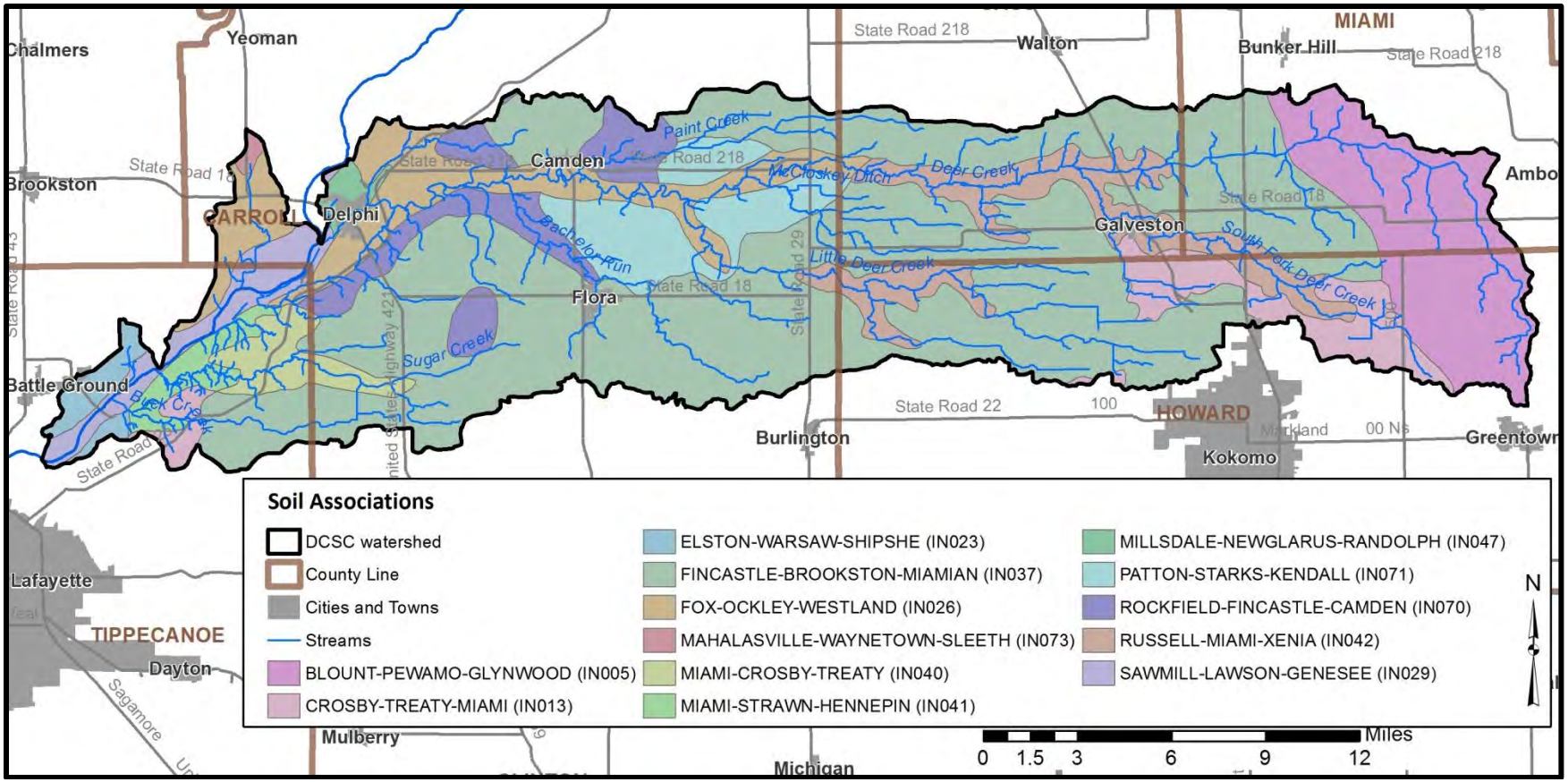

Figure 12. Soil Associations in the Deer Creek-Sugar Creek watershed.

Data used to create this map are detailed in Appendix A.

2.5.2 Soil Erodibility

Soils that move from the landscape to adjacent waterbodies result in degraded water quality, limited recreational use, and impaired aquatic habitat and health. Soils carry attached nutrients, pesticides, and herbicides. These can result in impaired water quality by increasing plant and algae growth, killing aquatic life or damaging water quality. The ability or likelihood for soils to move from the landscape to waterbodies are rated by the Natural Resources Conservation Service (NRCS). The NRCS uses soil texture and slope to classify soils into those that are considered highly erodible, potentially erodible, and non-erodible. The classification is based on an erodibility index which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss T (Tolerance) value. The T value is the maximum annual rate of erosion that can occur for a particular soil type without causing a decline in long-term productivity. The standard NRCS determination of potentially highly erodible soil is based on the steepness and the length of the underlying slope and erodibility index value. Highly and potentially highly erodible soils are mapped in Figure 13.

Watershed stakeholders are concerned with soil erosion. As detailed above, soils which have a high erodibility index value are those that are located on steep slopes and are easily moved by wind, water, or land uses. Figure 13 details locations of highly erodible and potentially highly erodible soils within the Deer Creek-Sugar Creek watershed. In total, highly erodible soils cover 4.7% of the watershed, or approximately 11,288 acres, while potentially highly erodible soils cover 9.7% of the watershed, or approximately 23,187 acres. Tippecanoe County contains the most highly erodible soil (3,461 acres) of the five counties despite only making up 9.6% the watershed (Table 5). Potentially highly erodible soils are concentrated in Carroll and Cass counties. Miami County does not contain any potentially highly erodible soils within the Deer Creek-Sugar Creek watershed.

Table 5. Highly erodible soils (HES) and potentially erodible soils (PHES) in the Deer Creek-Sugar Creek watershed.

County	Highly Erodible Soils (acres)	Potentially Highly Erodible Soils (acres)
Carroll	3,111.3	15,618.0
Cass	1,597.9	5,132.7
Howard	869.2	1,020.1
Miami	2,249.2	-
Tippecanoe	3,460.9	1,416.2

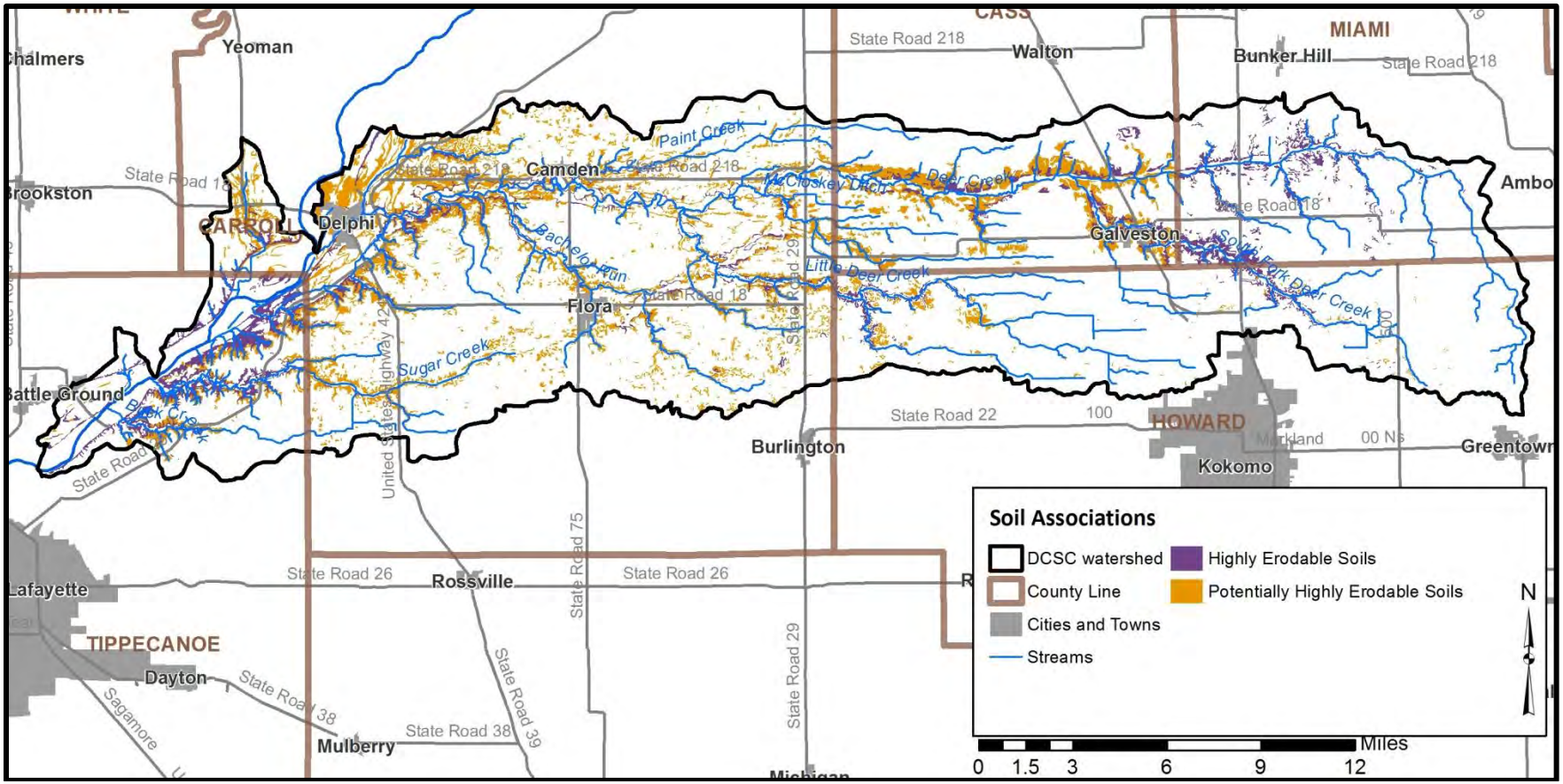

Figure 13. Highly erodible soils and potentially highly erodible soils in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time, thereby generating a series of chemical, biological, and physical processes. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs. Approximately 80,283 acres, or 33% of the watershed, is covered by hydric soils. The majority of the hydric soils are located in the headwaters of Deer Creek (northern Howard/southern Miami counties) and Little Deer Creek (northwest Howard/southeast Carroll counties; Figure 14). As these soils are considered to have developed under wetland conditions, they are a good indicator of historic wetland locations and therefore will be revisited in the land use section.

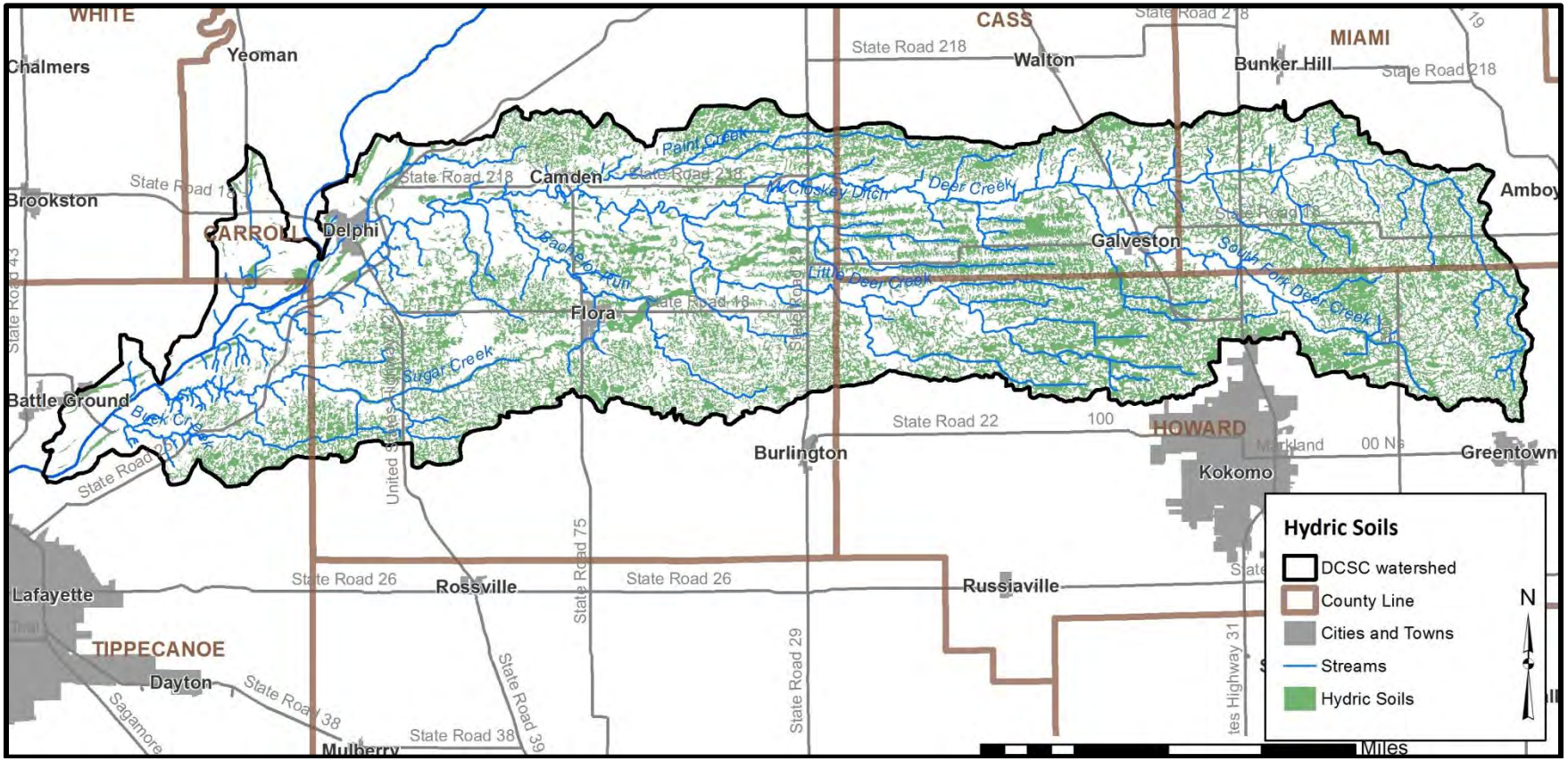

Figure 14. Hydric soils in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5.4 Tile Drained Soils

Soils drained by tile are common in the Deer Creek-Sugar Creek watershed. Tile drained soils are those soils located on cultivated cropland and classified as somewhat poorly, poorly, and very poorly drained. Using GIS data for calculations, tile drained soils cover approximately 65%, or 156,041 acres, of the watershed (Figure 15). Tile drained acres were not field verified. There are minimal tile drained soils west of the Wabash River; this is due to the large amount of outwash and silty-clay loam. The areas of the watershed that are not tile drained are the areas that have

the greatest slope, thus the land would be able to drain without artificial assistance. Additionally, the area west of Flora that is not tile drained is covered by the Rockfield-Fincastle-Camden association, which is a very well-drained soil. In areas where the land is tile drained, the materials applied to agricultural soils are directly transported to waterbodies. Stakeholders are concerned about high *E. coli* concentrations and the volume of manure applied to agricultural land. Since the majority of the areas where manure is applied are tile drained, the nutrients and *E. coli* are likely being transported to the streams were the tiles discharge.

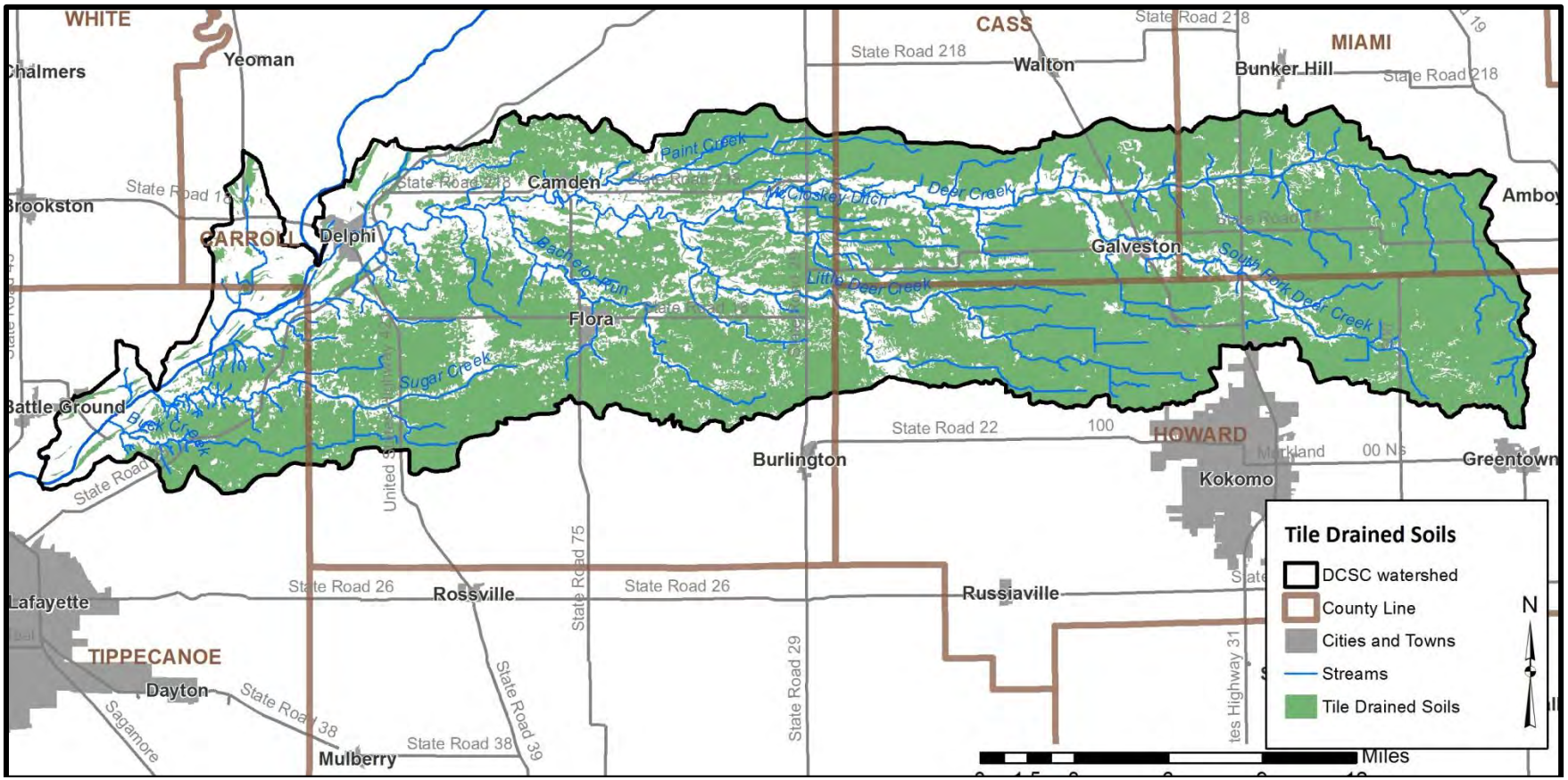

Figure 15. Tile-drained soils in the Deer Creek-Sugar Creek watershed.
Data used to create map is detailed in Appendix A.

2.6 Wastewater Treatment

2.6.1 Soil Septic Tank Suitability

The Natural Resources Conservation Service (NRCS) ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: severely limited, moderately limited, and slightly limited. Some soils are also unranked. Severe limitations delineate areas whose soil properties present serious restrictions to the successful operation of a septic tank tile disposal field. Using soils with a severe limitation increases the probability of the system's failure and increases the costs of installation and maintenance. Areas designated as having moderate limitations have soil qualities which present some drawbacks to the successful operation of a septic system; correcting these restrictions will increase the system's installation and maintenance costs. Slight limitations delineate locations whose soil properties present no known complications to the successful operation of a septic tank tile disposal field. Uses of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function.

In total, approximately 217,000 acres, or 90%, of the watershed, is covered by soils that are considered severely limited for use in septic tank absorption fields (Figure 16). An additional 7,700 acres, or 3%, of the watershed soils rate as moderately limited. The remaining 16,000 acres are slightly limited, covered by water, or not rated. The areas that are identified as slightly limited are similar to the surficial geology areas that are covered by outwash, drifts or fan deposits. Many of the unrated soils are located within the cities of Camden, Delphi, and Galveston where wastewater treatment plants handle septic waste.

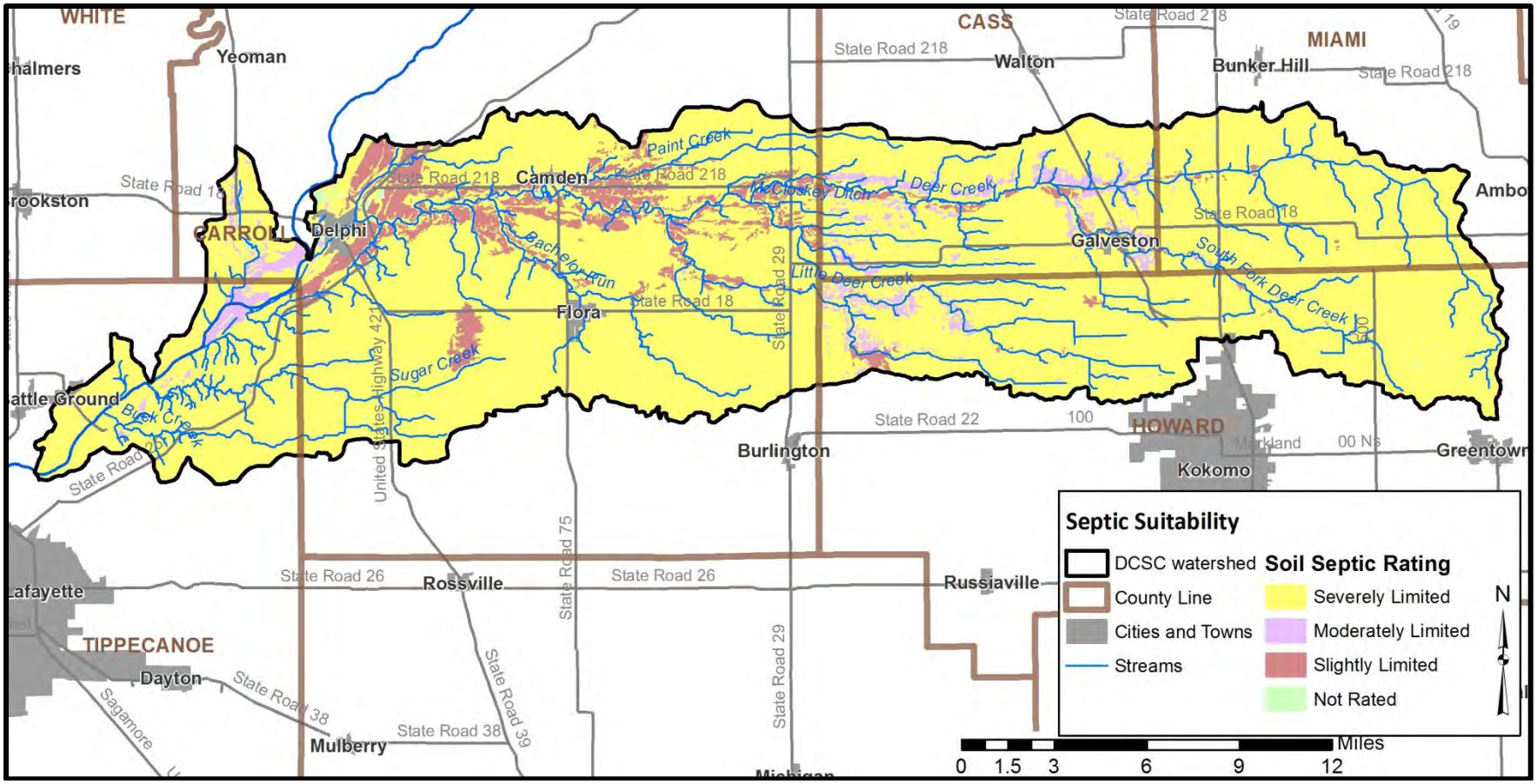

Figure 16. Suitability of soils for septic tank usage within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.6.2 Wastewater Treatment and Solids Disposal

Several facilities which treat wastewater and are permitted to discharge the treated effluent are located within the watershed. These facilities are regulated by National Pollution Discharge Elimination System (NPDES) permits. These include several wastewater treatment plants ranging in size from small, local plants to publicly-owned facilities, industrial dischargers, commercial entities, and school facilities. In total, nine NPDES-regulated facilities are located within the watershed (Figure 17).Table 6 details the NPDES facility name, activity, and permit number. More detailed information for each facility will be discussed on a subwatershed basis in subsequent sections.

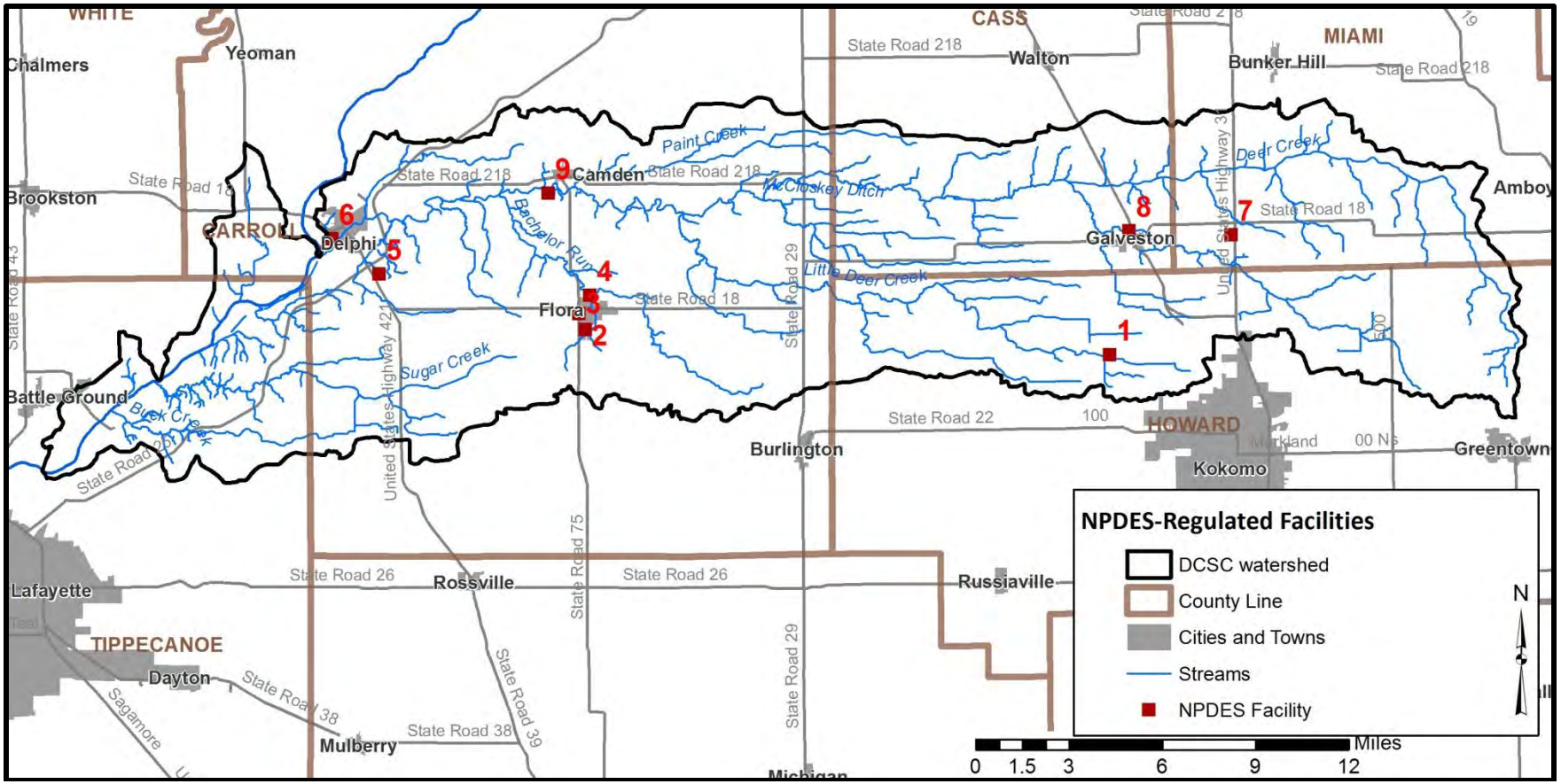

Figure 17. NPDES-regulated facilities in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 6. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Activity Description	Compliance Status	Past Violations	Flow Data	Discharges To
1	IN0034461	Northwestern Elementary and High School	Elementary and secondary schools	No violation	3 violations 2011-2013		Harrison-Harlan Ditch
2	IN0005029	Flora Public Water Supply	Water supply	No violation	None in past 12 quarters		Kuns Ditch
3	INP000011	Briggs Industries, INC., Sayco	Sanitary system	No violation	None is past 12 quarters		Flora Municipal STP
4	IN0020141	Flora Municipal STP	Sewage system	In violation	6 violations 2011-2013	0.428 MGD treated at secondary level	Bachelor Run
5	IN0059471	Indiana Packers Corp.	Pork processing and packaging	No violation	2 violations in 2011		Tributary of Bridge Creek
6	IN0021377	Delphi Municipal STP	Sewage system	No violation	8 violations 2011-2013	0.4 MGD treated at advanced level	Deer Creek
7	IN0052370	Maple Lawn Village M.H.P.	Residential mobile home sites	No violation	5 violations 2011-2013		Deer Creek
8	IN0021199	Galveston Municipal STP	Sewage system	No violation	5 violations 2011-2013	0.28 MGD treated at advanced level	South Fork of Deer Creek
9	IN0030562	Camden Municipal STP	Sewage system	No violation	1 violation in 2011	0.06 MGD treated at secondary level	Deer Creek

Data from USEPA 2008. Flow data for industrial permit holders not available.

2.6.3 Municipal Wastewater Treatment

In total, four municipal wastewater treatment plants service the areas within the Deer Creek-Sugar Creek watershed (Figure 18). The Camden and Delphi Municipal STP discharge to Deer Creek, the Flora Municipal STP discharges to Bachelor Run, and the Galveston Municipal STP discharges into the South Fork of Deer Creek. Sludge from municipal wastewater treatment plants is applied to 22.8 square miles throughout the watershed. The majority of the application sites are located with the 10-digit HUC Deer Creek watershed (Figure 19). Each of these treatment plants likely has some impact on water quality within the Deer Creek-Sugar Creek watershed. Watershed stakeholders are concerned about how the recent upgrades to the Camden sewage treatment plant (STP) affects nitrate levels in the streams.

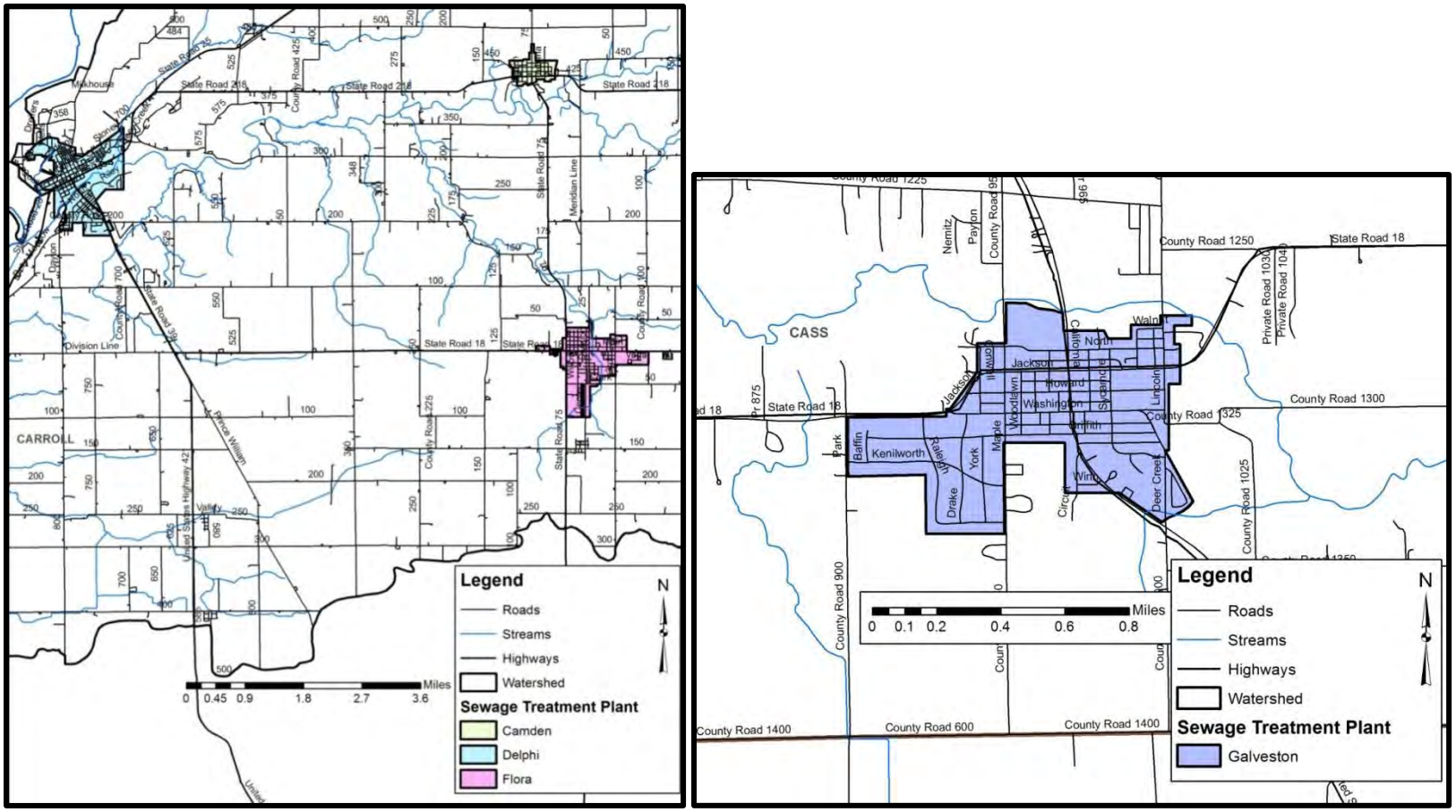

Figure 18. Carroll County sewage treatment areas.
Data used to create this map are detailed in Appendix A.

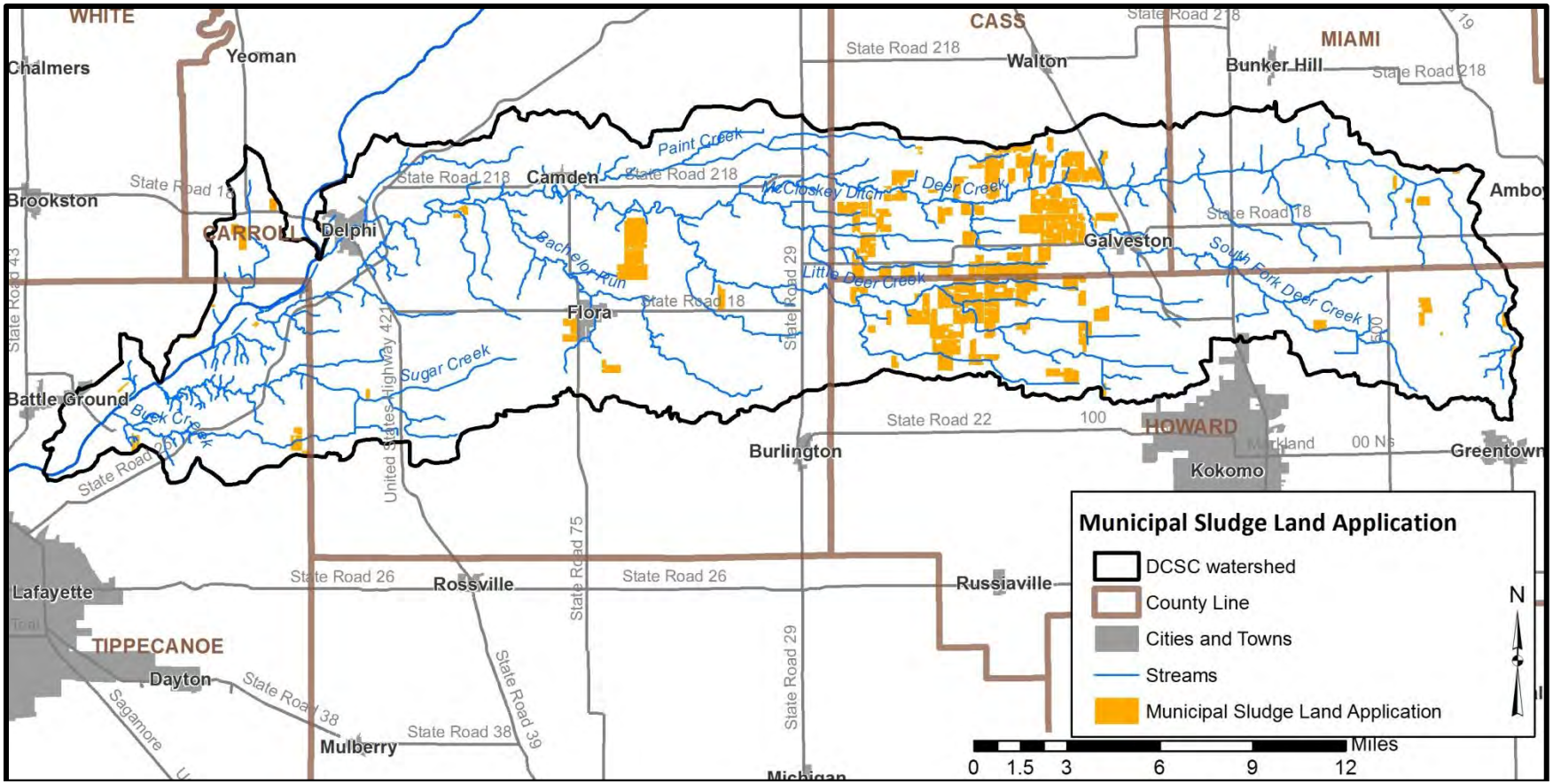

Figure 19. Municipal sludge land application sites within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

Camden

The Town of Camden operates a sewage treatment plant which serves the town's 615 residents. In total, the plant treats 0.06 million gallons per day (MGD) to the secondary level; effluent is then discharged into Deer Creek (USEPA, 2008). The service area is shown in Figure 18.

Delphi
The Town of Delphi operates a sewage treatment plant which serves the town's 3,015 residents. In total, the plant treats 0.4 MGD to an advanced level; effluent is then discharged into Deer Creek (USEPA, 2008). The service area is shown in Figure 18.

Flora
The Town of Flora operates a sewage treatment plant which serves the town's approximately 2,227 residents. In total, the plant treats 0.428 MGD to the secondary level; effluent is then discharged into Bachelor Run (USEPA, 2008). The service area is shown in Figure 18.

Galveston
Galveston operates a sewage treatment plant which serves 1,884 residents. In total, the plant treats 0.28MGDtoan advanced level; effluent is then discharged into the South Fork of Deer Creek (USEPA, 2008). The service area is shown in Figure 19.

2.6.4 Unsewered Areas

Unsewered areas in the Deer Creek-Sugar Creek watershed were determined via desktop and windshield surveys. Areas that have at least 25 houses within a square mile outside of the incorporated areas were classified as dense, unsewered areas. In the watershed, 42 dense, unsewered areas were identified (Figure 20). Additionally, school buildings are mapped as there is typically high density use at these facilities throughout the year.

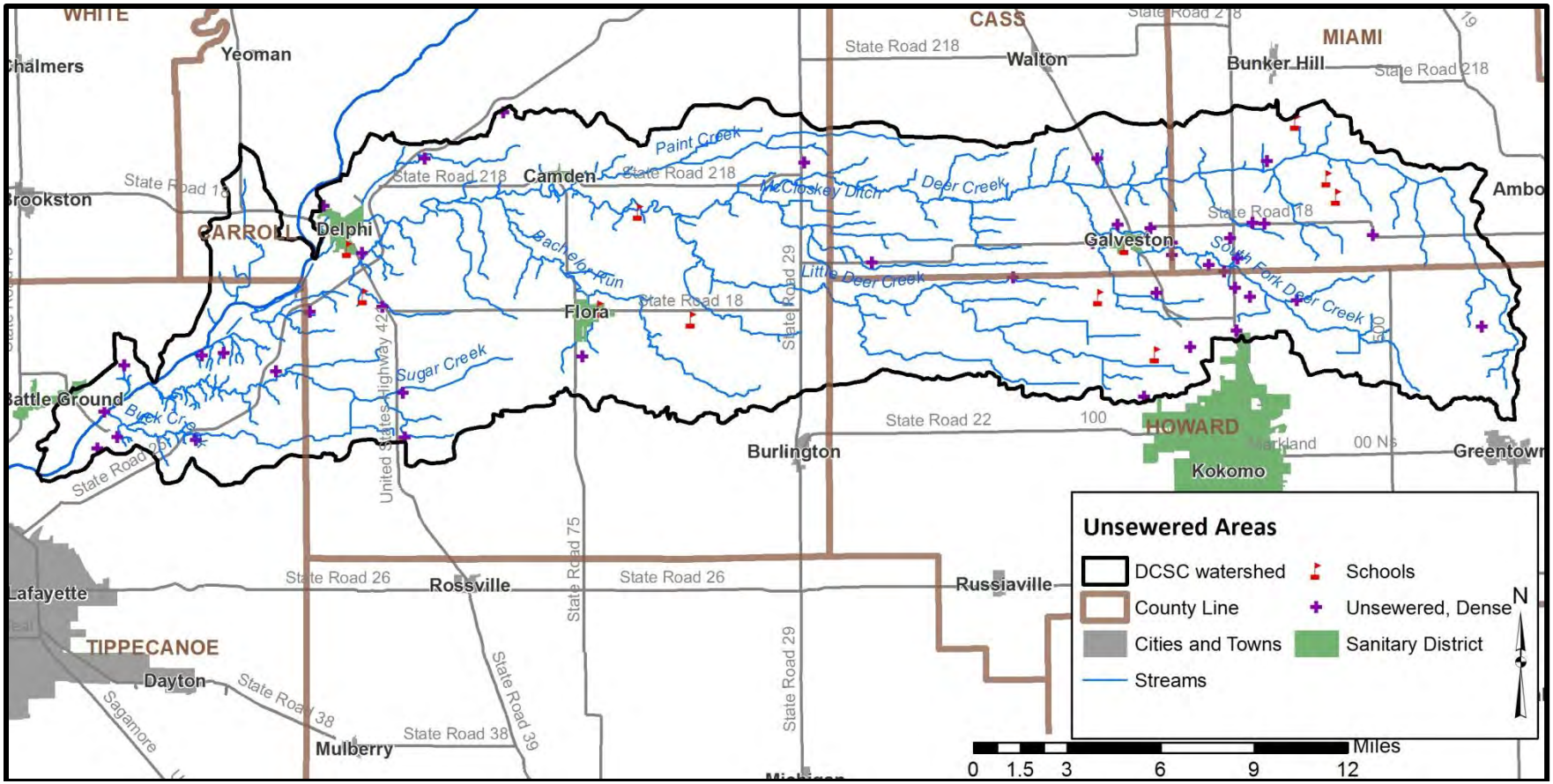

Figure 20. Unsewered areas in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7 Hydrology

Watershed streams, legal drains, floodplains, wetlands, storm drains, groundwater, subsurface conveyances, and manmade drainage channels all contribute to the watershed's hydrology. Each component moves water into, out of, or through the system. Their contributions will be covered in further details in subsequent sections.

2.7.1 Watershed Streams

The Deer Creek-Sugar Creek watershed contains more than 600 miles of waterways (Figure 21 to Figure 23). The watershed has four distinct streams, Buck Creek, Deer Creek, Sugar Creek, and the Wabash River. Deer Creek has two headwater streams, the South Fork of Deer Creek and Little Deer Creek, while Sugar Creek has only one headwater stream, Little Sugar Creek. All of the streams drain into the Wabash River; Deer Creek enters just below Delphi, IN, then Sugar Creek and finally Buck Creek. Deer Creek, Sugar Creek, the Wabash River and their tributaries are used for fishing and full-body recreation. Individuals are concerned about consuming the fish from the waterbodies within the watershed. No beaches are located within the watershed; rather, access to the waterbodies is possible via public parks located adjacent to waterbodies such as Riley Park on Deer Creek.

In total, nearly 400 miles of regulated drains exist within the Deer Creek-Sugar Creek watershed. Drainage information was provided by each county surveyor's office (Figure 21 to Figure 23). It should be noted that some regulated drains are maintained by the county surveyor's office; however, some of the regulated drains within the watershed have neither a maintenance fund nor a maintenance schedule, and some maintained waterbodies and legal drains overlap the pre-existing stream system. In addition, definitions of regulated, legal, and maintained waterways differ from county to county. Maintenance practices can include dredging with large construction equipment to maintain flow, debris removal, and vegetation management both within the regulated drain and the riparian zone. As these waterbodies are subject to periodic cleaning, it is important to work with the county surveyor to establish priorities for these waterbodies in terms of water quality improvement and erosion control.

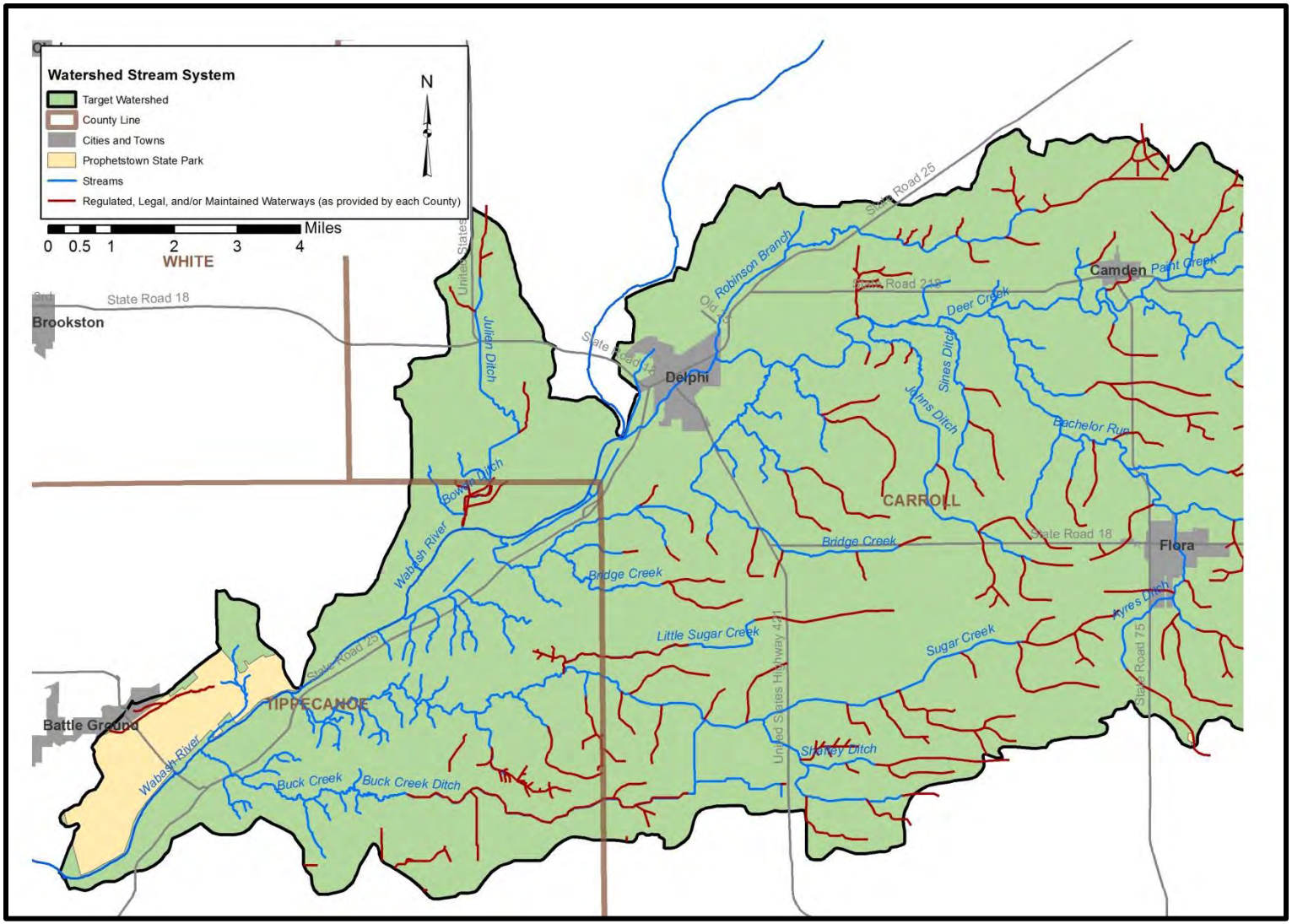

Figure 21. Waterways in the western third of the watershed.
Data used to create this map are detailed in Appendix A.

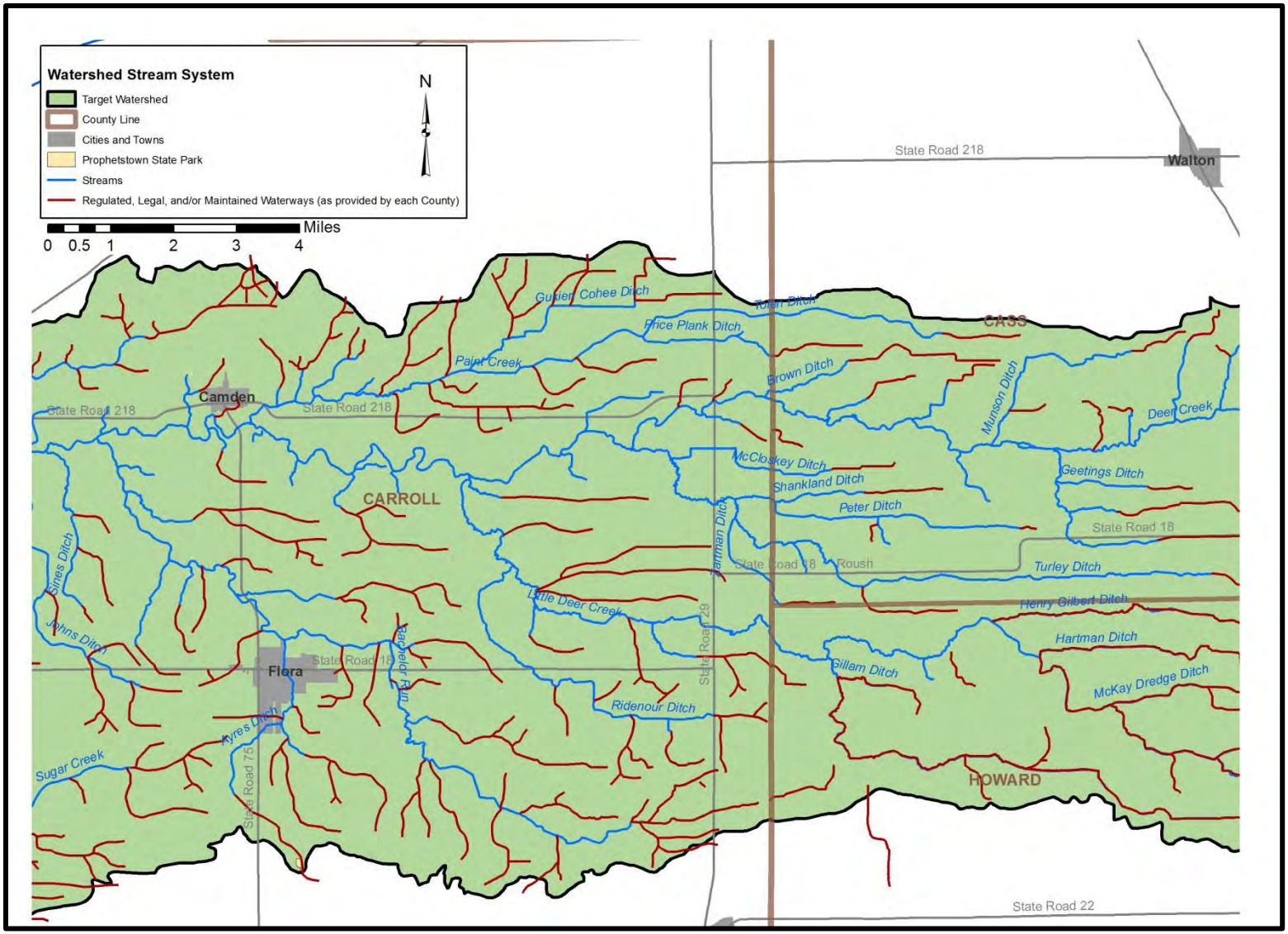

Figure 22. Waterways in the middle third of the watershed.
Data used to create this map are detailed in Appendix A.

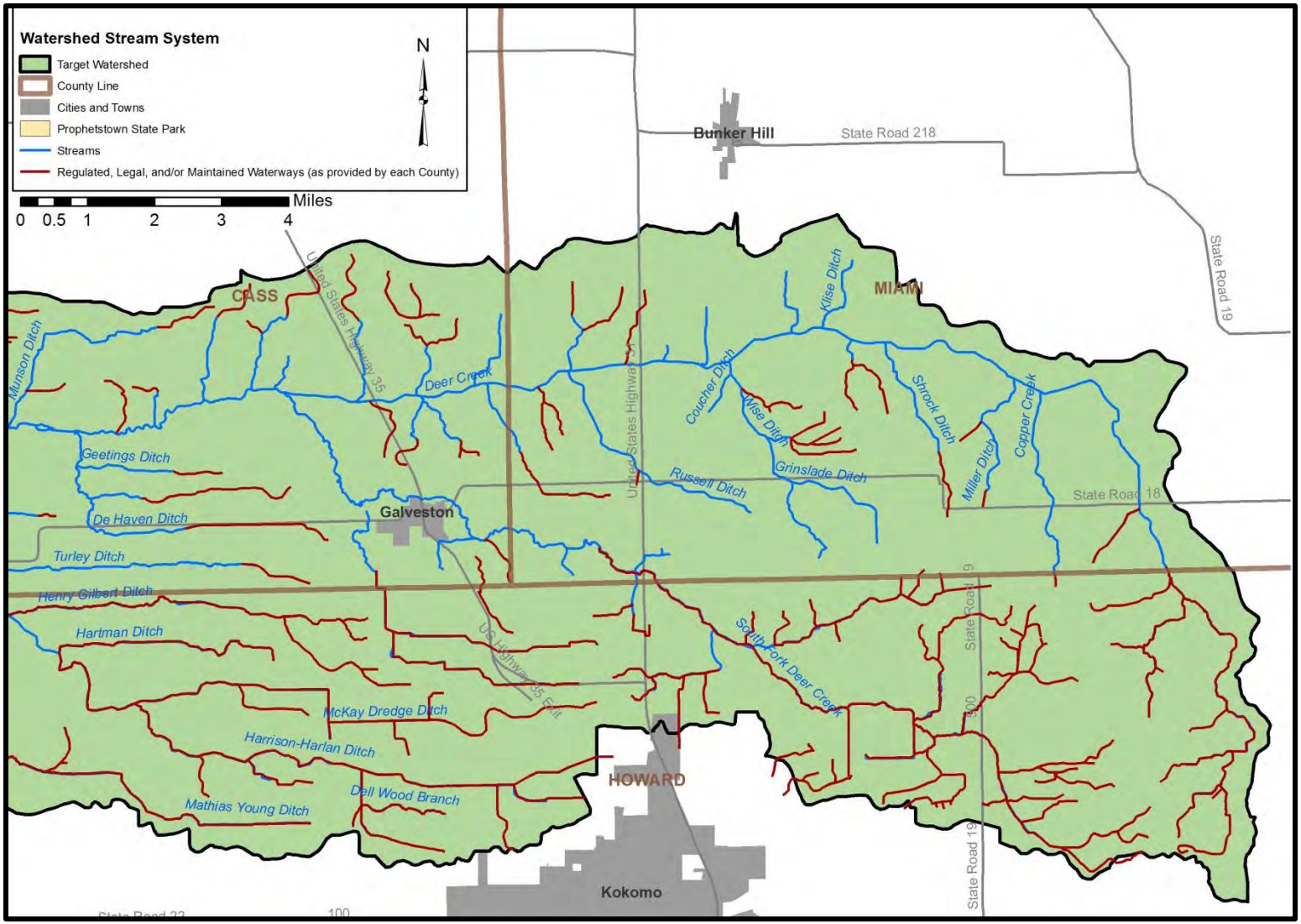

Figure 23. Waterways in the eastern third of the watershed.

2.7.2 Outstanding Rivers

In addition to various stream type classifications discussed above, the state of Indiana also imposes two designations on streams throughout the state. The first is the designation of outstanding rivers. Outstanding rivers or streams are those that are of particular environmental or aesthetic interest and qualify under one or more of 22 categories (NRC, 2007). As such, the 2,000 river miles representing less than 9% of rivers in Indiana were listed by the IDNR Division of Outdoor Recreation.

Only one stream in the Deer Creek-Sugar Creek watershed is designated as an outstanding river (Figure 24). The entire length of the Wabash River that is included in the Deer Creek-Sugar Creek watershed is designated as outstanding. The Wabash River is included as an outstanding river through legislation as part of the Wabash Heritage Corridor. This designation requires that these waterbodies be treated differently with regard to some state statutes and rules. Specifically, log jam removals and utility crossing requirements are more stringent within these waterbodies.

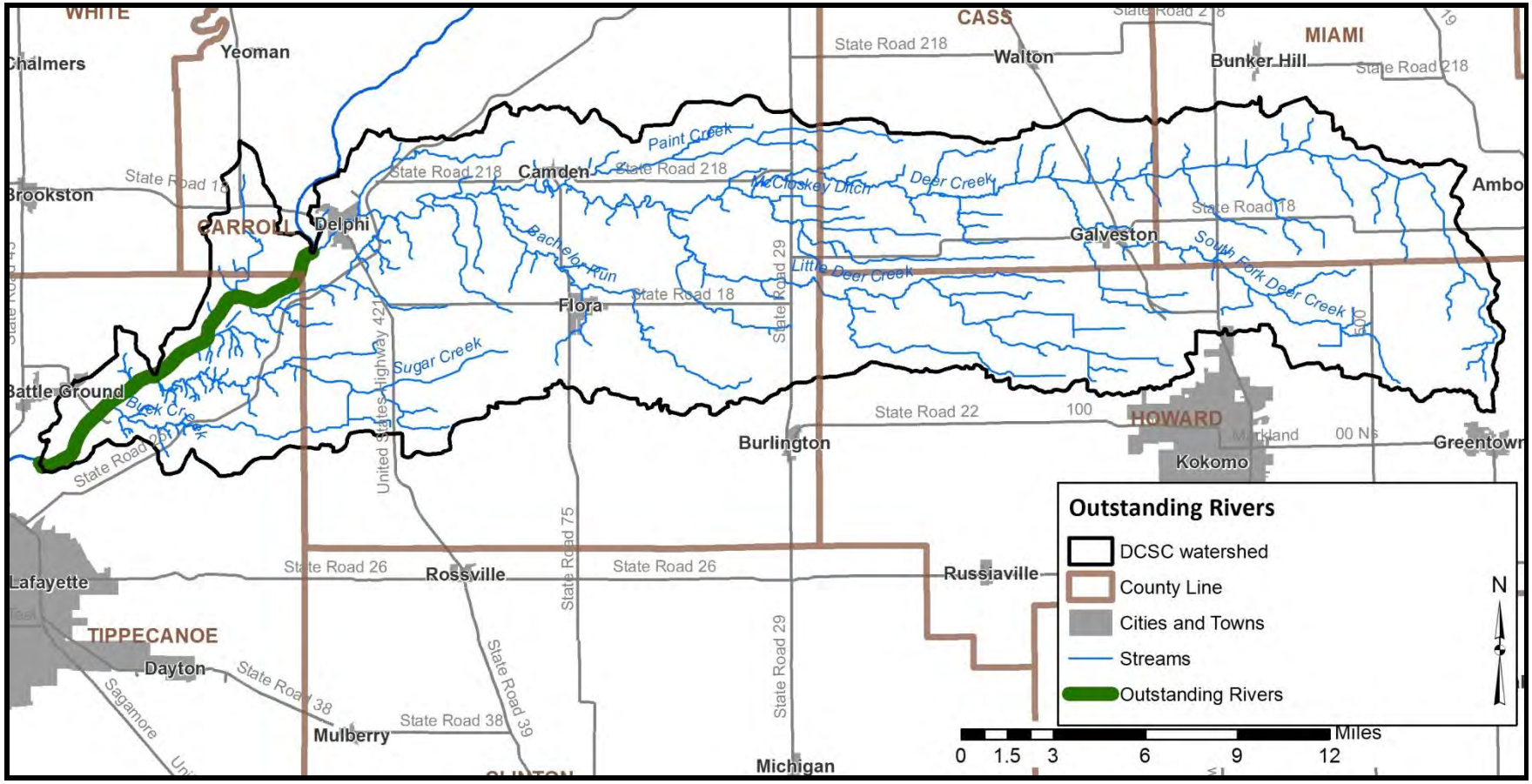

Figure 24. Outstanding river locations in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.3 Impaired Waterbodies (303(d) List)

The second type of designation the state of Indiana uses on streams is impaired waterbodies. The impaired waterbodies list is prepared biannually by the Indiana Department of Environmental Management. Waterbodies are included on the list if they do not meet the state's water quality standards. Waterbodies are removed from the impaired waterbodies list once the waterbody again meets the state standards. In total, 45% of the watershed's streams have been assessed and are included on the 2012 Draft List of Impaired Waterbodies or the 303(d) list (Figure 25).

Table 7 details the listed impaired waterbodies in the Deer Creek-Sugar Creek watershed, while Figure 25 shows the segments and their locations within the watershed. Waterbodies are listed for *E. coli*, impaired biotic communities (IBC), and impairments based on fish tissue data including mercury, and polycarbonate biphenyls (PCBs). Based on these listings, the following conclusions can be drawn:

- The *E. coli* water quality standard is routinely exceeded along Buck Creek, Deer Creek, Sugar Creek, Wabash River and several of their tributaries, as well as Bachelor Run, Cohee Ditch, Kuns Ditch, Little Deer Creek, Munson Ditch, Paint Creek, Price Plank Ditch, and Shirar Ditch.
- PCB levels are elevated in Deer Creek and the Wabash River.
- Mercury levels are elevated in the Wabash River.
- Buck Creek, Deer Creek and Little Deer Creek are listed for impaired biotic communities.

Table 7. Impaired waterbodies as assessed and listed on the 2012 List of Impaired Waterbodies.

Assessment Unit Name	Cause of Impairment
Bachelor Run	*E. coli*
Bachelor Run – Unnamed Tributary	*E. coli*
Buck Creek	*E. coli,* IBC
Buck Creek – Unnamed Tributary	*E. coli*, IBC
Buck Creek Ditch	*E. coli*, IBC
Cohee Ditch	*E. coli*
Deer Creek	*E. coli,* IBC, Nutrients, PCBs in fish tissue
Deer Creek – Unnamed Tributary	*E. coli*
Hughes Ditch	*E. coli*
Kuns Ditch	*E. coli*
Little Deer Creek	*E. coli*, IBC, Nutrients
Little Sugar Creek	*E. coli*
Paint Creek	*E. coli*
Price Plank Ditch	*E. coli*
Shirar Ditch	*E. coli*
Sugar Creek	*E. coli*
Sugar Creek – Unnamed Tributary	*E. coli*
Sugar Creek, Branch One	*E. coli*
Wabash River	*E. coli,* IBC, Total Mercury and PCBs in fish tissue

Source: IDEM, 2012

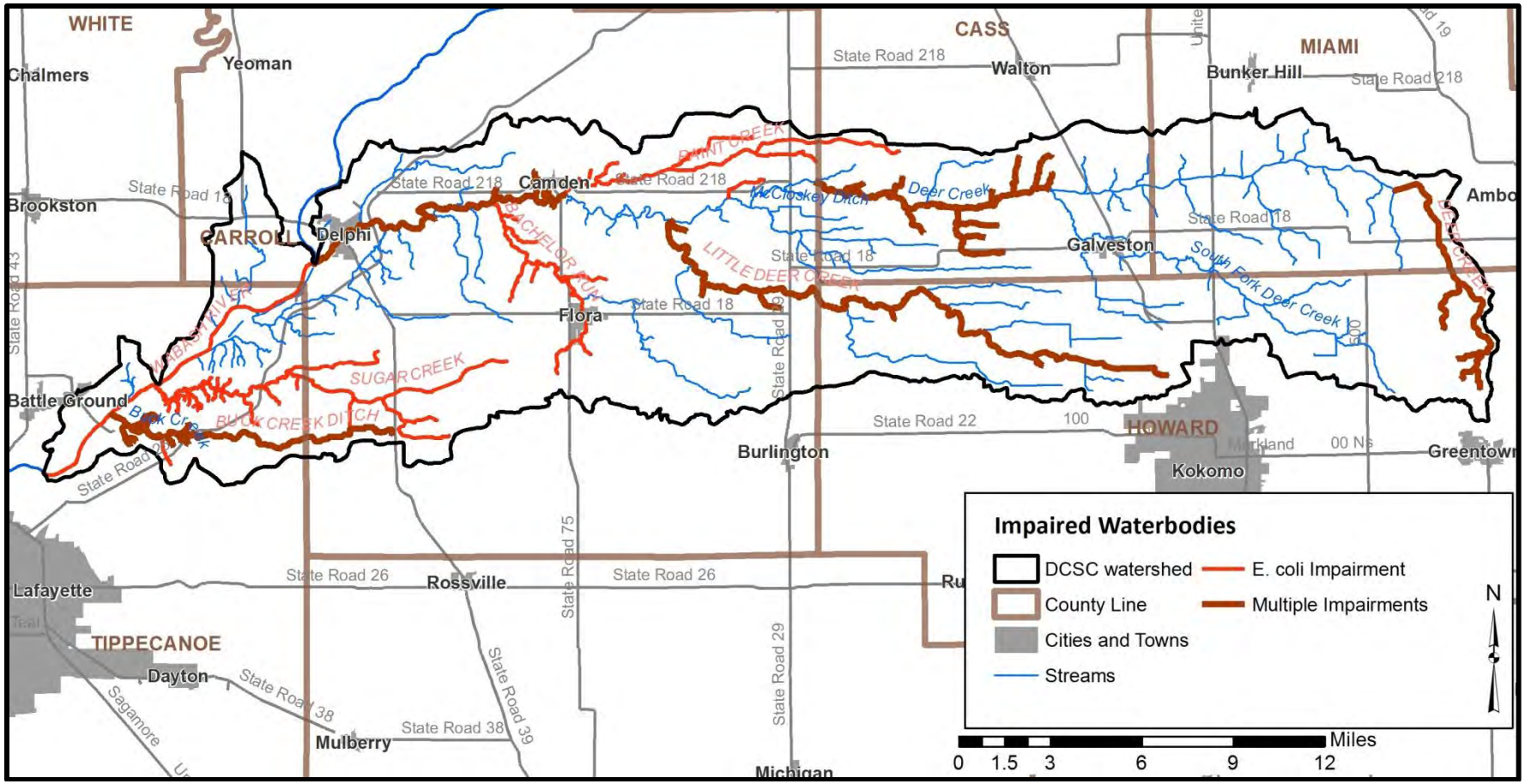

Figure 25. Waterbodies assessed as impaired in the Deer Creek-Sugar Creek watershed.

Data used to create this map are detailed in Appendix A. NOTE: Not all streams in the watershed were assessed; the current 303(d) list did not provide assessment data for the streams on this map which are not marked as impaired.

2.7.4 Floodplains

Flooding is a common hazard that can affect a local area or an entire river basin. Increased imperviousness, encroachment on the floodplain, deforestation, stream obstruction, tiling, or failure of a flood control structure all are mechanisms by which flooding occurs. Impacts of flooding include property and inventory damage, utility damage and service disruption, bridge or road impasses, streambank erosion and riparian vegetation loss, water quality degradation, and channel or riparian area modification.

Floodplains are lands adjacent to streams, rivers, and other waterbodies that provide temporary storage for water. These systems act as nurseries for wildlife, offer green space for humans and wildlife, improve water quality, and buffer the waterbody from adjacent land uses. Approximately 6.0% (14,475 acres) of the Deer Creek-Sugar Creek watershed lies within the 100-year floodplain (Figure 26). This 100-year floodplain is composed of three regions:

- Zone A is the area inundated during a 100-year flood event for which no base flood elevations (BFE) have been established. Zone A covers 72.5% of the Deer Creek-Sugar Creek watershed floodplain for 10,500 acres.
- Zone AE is the area inundated during a 100-year flood event for which BFEs have been determined. The chance of flooding in Zone AE is the same as the chance of flooding in Zone A; however, floodplain boundaries in Zone A are approximated, while those in Zone AE are based on detailed hydraulic models which allows Zone AE floodplains to be more accurate. Zone AE covers 3,742.8 acres or 25.9% of the Deer Creek-Sugar Creek watershed floodplain.
- Zone X includes areas outside the 100-year and 500-year floodplains which have a <1% chance of flooding to a depth of one foot of water. No BFEs are available for these areas and no flood insurance is required. Nearly 232 acres or less than 1.6% of the Deer Creek-Sugar Creek watershed floodplain is located within Zone X.

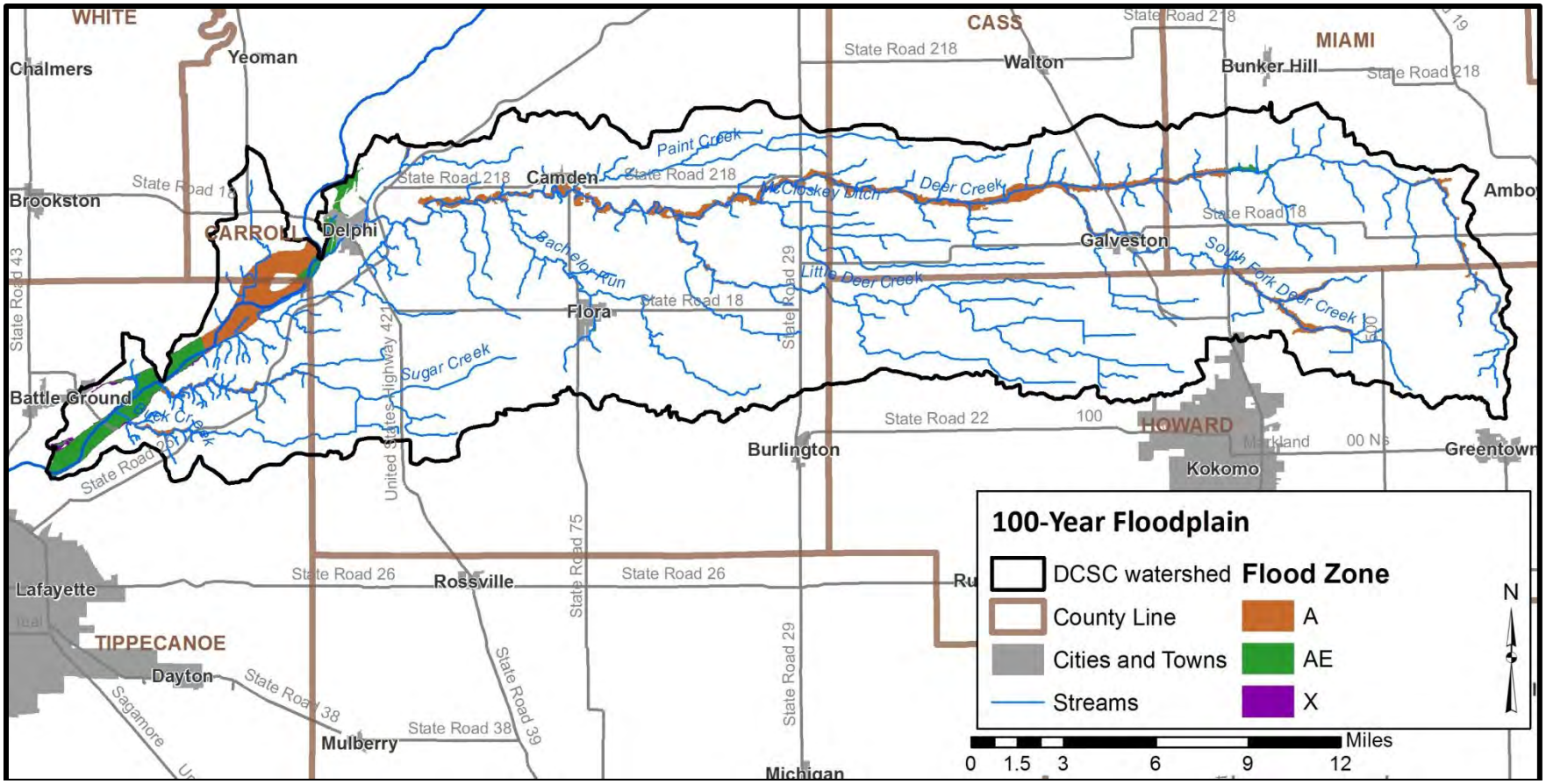

Figure 26. Floodplain locations within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.5 Wetlands

Approximately 25% of Indiana was covered by wetlands prior to European settlement (IDEM, 2007). Overall, 85% of wetlands have been lost resulting in Indiana ranking fourth in the nation in terms of percentage of wetland loss. Wetlands provide numerous valuable functions that are necessary for the health of a watershed and waterbodies. Wetlands play critical roles in protecting water quality, moderating water quantity, and providing habitat. Wetland vegetation adjacent to waterways stabilizes shorelines and streambanks, prevents erosion, and limits sediment transport to waterbodies. Additionally, wetlands have the capacity to increase stormwater detention capacity, increase stormwater attenuation, and moderate low water levels or flow volumes by allowing groundwater to slowly seep back into waterbodies. These benefits help to reduce

flooding and erosion. Wetlands also serve as high quality natural areas providing breeding grounds for a variety of wildlife. They are typically diverse ecosystems which can provide recreational opportunities, such as fishing, hiking, boating, and bird watching. It should be noted that wetlands are regulated through IDEM and the U.S. Army Corps of Engineers. Any modification to wetlands requires permits from these agencies.

The Deer Creek-Sugar Creek watershed contains approximately 7,202 acres (11.3 square miles) of wetlands. In total, wetlands cover 3.4% of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, nearly 92% of wetlands have been modified or lost after European settlement. This represents over 125 square miles of wetland loss within the Deer Creek-Sugar Creek. Figure 27 details the current (pink) and historic (green) distribution of wetlands throughout the watershed. Wetlands displayed in Figure 27 are from compilation efforts by the U.S. Fish and Wildlife Service as part of the National Wetland Inventory (NWI). The NWI was not intended to map specific wetland boundaries that would compare exactly with boundaries derived from ground surveys. As such, NWI boundaries are not exact and should be considered to be estimates of wetland coverage.

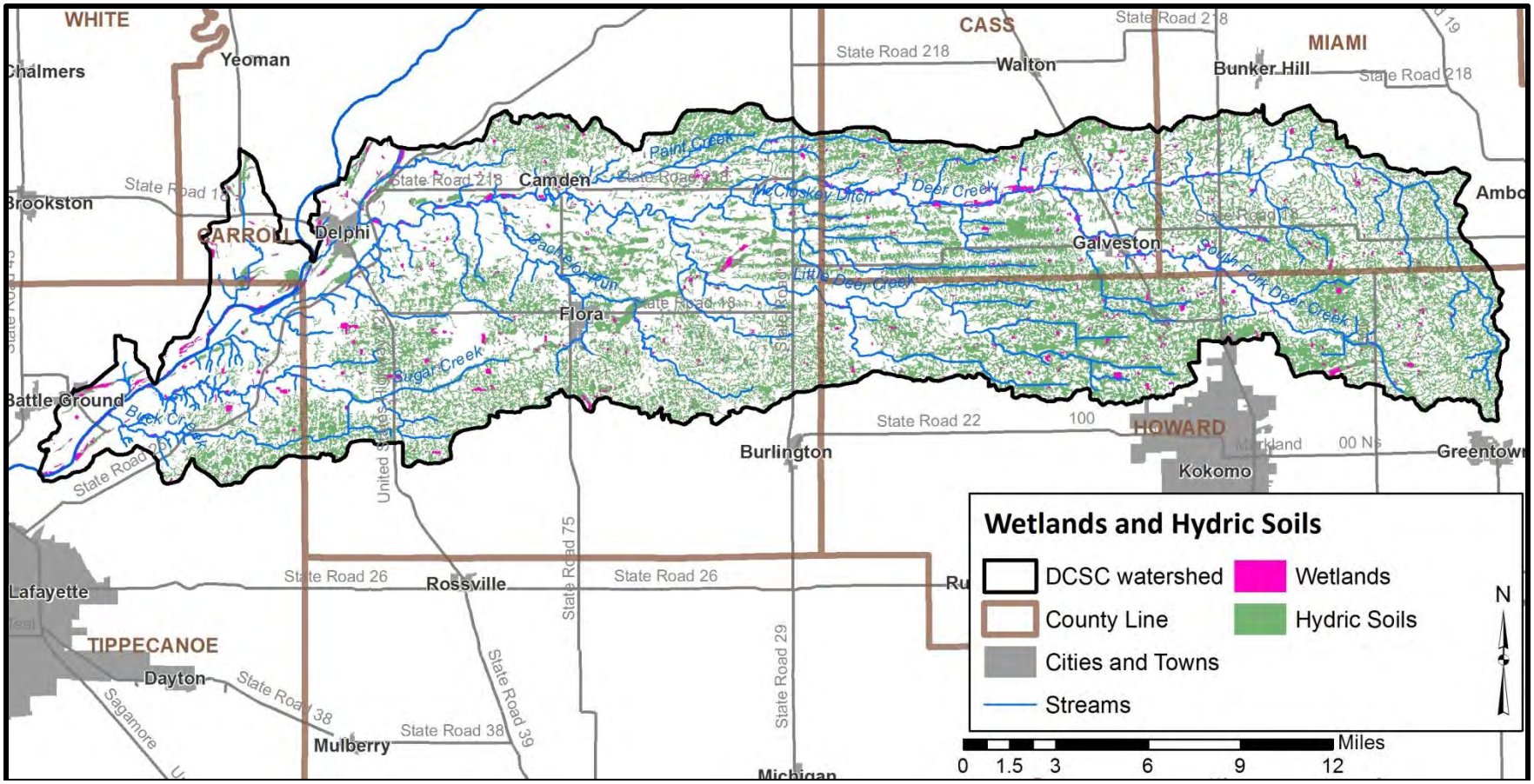

Figure 27. Wetlands and hydric soils located in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.6 Stormwater and Storm Drains

Given the highly agricultural nature of the watershed, only a very small portion of land has infrastructure specifically to manage stormwater. Small parts of both the Howard County and Tippecanoe County Partnership for Water Quality Municipal Separate Storm Sewer Systems (MS4s) encroach into the watershed in Howard and Tippecanoe Counties, respectively (see sections 2.11.4 and 2.11.5), but neither discharge stormwater into the watershed. The City of Delphi, and the Towns of Flora, Camden, and Galveston also have infrastructure to collect and treat stormwater. Flora and Delphi have both separated their stormwater systems from their sewer systems and treat both separately. Only

Galveston has a combined sewer overflow (CSO) which would discharge into the South Fork of Deer Creek. Camden does not have any CSOs. Stormwater and storm drains are not presently a concern for this watershed.

2.7.7 Well Fields and Groundwater

The Silurian-Devonian aquifer (carbonate-rock), and other surficial sand and gravel aquifers may be utilized in the Deer Creek-Sugar Creek watershed by rural wells. Recharge of local aquifers occurs in the same manner as do many of the other aquifers in the state, namely by the downward percolation of local rainfall through the soil horizon and underlying formations. However, localized significant rainstorms can produce relatively quick response to recharge especially if adjacent areas did not receive the rainfall. Table 8 lists the wellhead protection areas within the Deer Creek-Sugar Creek watershed. Potential pollution from construction, sewage outfall, illegal dumping, agriculture, and storm water runoff must be avoided or controlled due to the recharge of these aquifers from runoff and river water. A map showing the location of the wellhead protection areas, generalized to within 2 miles to protect the specific location of drinking water wells, is located in Appendix G. Land use within the wellhead protection areas is primarily agricultural. The utility districts actively engage landowners within the protection areas and assist them in utilizing agricultural practices to protect water quality in the wells.

Table 8. Wellhead protection areas within the Deer Creek-Sugar Creek watershed.

ID Number	System Name	City
5208001	Camden Water Utility	Camden
5208002	Delphi Water Works	Delphi
5208003	Flora Water Works	Flora
5209003	Galveston Water Works	Galveston

2.7.8 Lakes

There are no lakes in the Deer Creek-Sugar Creek watershed.

2.8 Natural History

Geology, climate, geographic location, and soils all factor into shaping the native flora and fauna which occurs in a particular area. Categorization of these floral and faunal communities has been completed by a number of ecologists since the earliest efforts by Coulter in 1886. Since this time, Petty and Jackson (1966) identified regional communities; Homoya et al. (1985) classified Indiana into natural regions, while Omernik and Gallant (1988) categorized Indiana into ecoregions.

2.8.1 Natural and Eco-region Descriptions

The Deer Creek-Sugar Creek watershed mostly lies within the Central Tipton Till Plain natural region. The Central Tipton Till Plain is the largest natural region in Indiana. The Tipton Till Plain subregion of the Central Tipton Till Plain natural region covers approximately 82%, or 196,600 acres, of the watershed (Figure 28). It is characterized by a mix of poorly drained soils, which support a variety of oaks, maples, ash, elm, and

sycamore, and better drained soils that are home to hickory, tulip tree, white ash, sugar maple, and beech (Jackson, 1997). The Bluffton Till Plain and Entrenched Valley subregions cover 28,905 acres (12%) and 14,191 acres (6%), respectively. The Bluffton Till Plain is composed of clay-rich soils with little to no slope, while the Entrenched Valley is identified by the deep entrenched valleys along drainages. Additionally, a very small area (328 acres) along the western edge of the watershed near Battle Ground lies within the Grand Prairie natural region. The Grand Prairie natural region is dominated by communities of tall prairies.

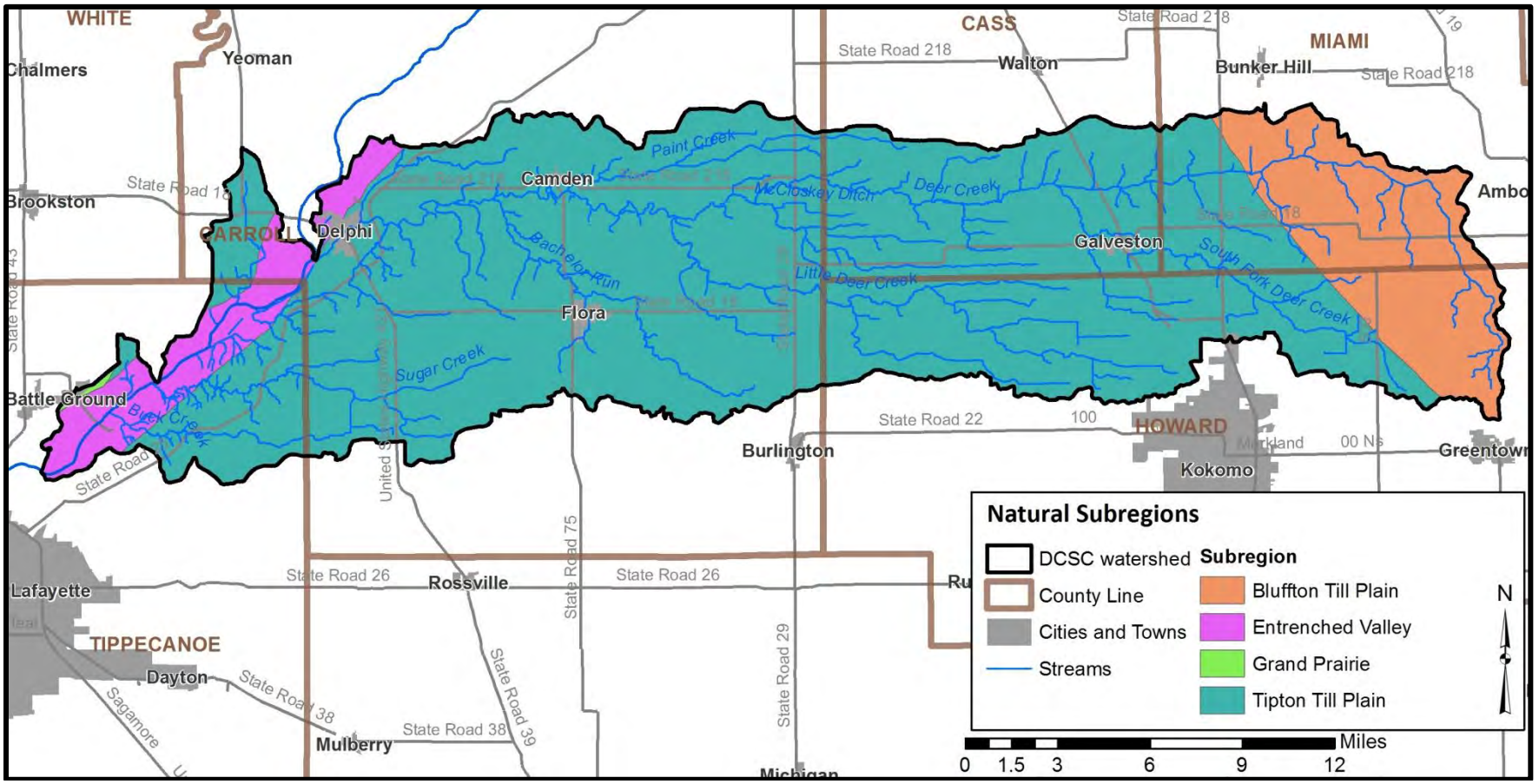

Figure 28. Natural subregions in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

The watershed lies within the Eastern Corn Belt Plains level III eco-region. Omernik and Gallant (2008) describe the Eastern Corn Belt Plains as being primarily composed of gently rolling hills where tree cover occurs naturally. Additionally, soils are rich and well-drained and soybeans, corn and livestock production is common. In respect to level IV eco-regions, the watershed lies within the Clayey High Lime Till Plains and the Loamy High Lime Till Plains (Figure 29). The dividing line between the two eco-regions is located at the far eastern portion of the watershed. Griffith and Omernik (2008) describe the Clayey High Lime Till Plain as being level, having less production and the soils tend to need to be artificially drained. Conversely, the Loamy High Lime Till Plains tend to have descent natural drainage and more productive soils.

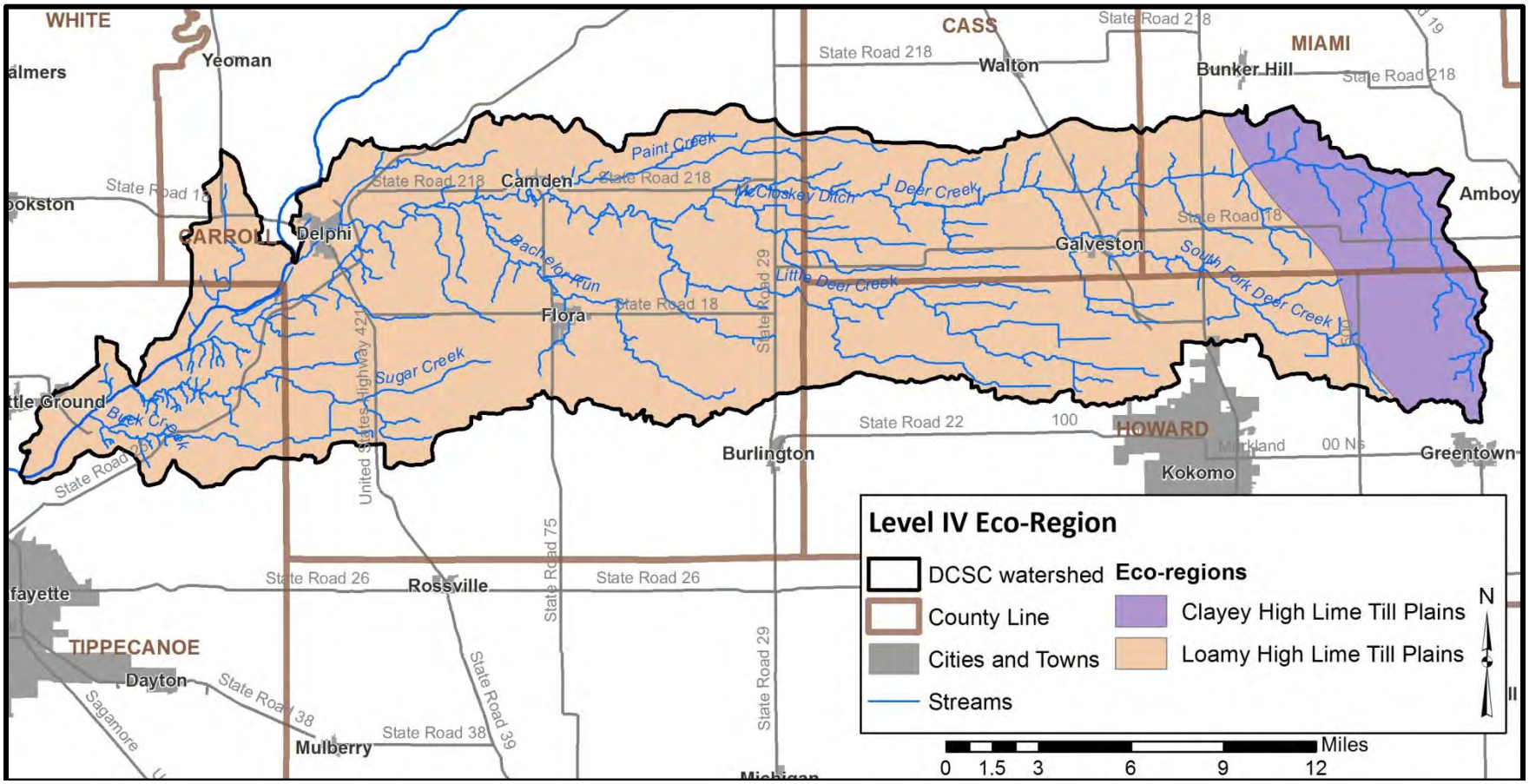

Figure 29. Level IV eco-regions in the Deer Creek-Sugar Creek watershed.

Data used to create this map are detailed in Appendix A.

2.8.2 Endangered Species

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

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

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

In total, 78 observations of special species occurred within the Deer Creek-Sugar Creek watershed (Figure 30). Of these observations, 13 federally listed species have historically been observed in the watershed. These listings include 11 mussel species, one reptile, and one bird. The following are federally endangered species: clubshell, eastern fanshell pearly mussel, fat pocketbook, northern riffleshell, rayed bean, ring pink, sheepnose, snuffbox, tubercled blossom, and white wartyback. The bald eagle, eastern massasauga and rabbitsfoot are federally threatened and are listed as candidates for the endangered, threatened, and rare species, respectively. The local community prioritizes preservation of habitat for endangered, threatened, or rare species. A county-based listing of species which occur within this watershed is included in Appendix C.

On a state listing basis, 20 species, which are listed in the Natural Heritage Database as state endangered, have been observed within the Deer Creek-Sugar Creek watershed including:

- **Mussels:** clubshell, eastern fanshell pearlymussel, fat pocketbook, longsolid, northern riffleshell, pyramid pigtoe, rabbitsfoot, sheepnose, snuffbox, tubercled blossom, and white wartyback;
- **Reptiles:** eastern massasauga, Kirtland's snake, and spotted turtle;
- **Fish:** gilt darter;
- **Birds:** cerulean warbler, peregrine falcon, and sedge wren; and
- **Vascular plants:** shaggy false-gromwell, and Canada burnet.

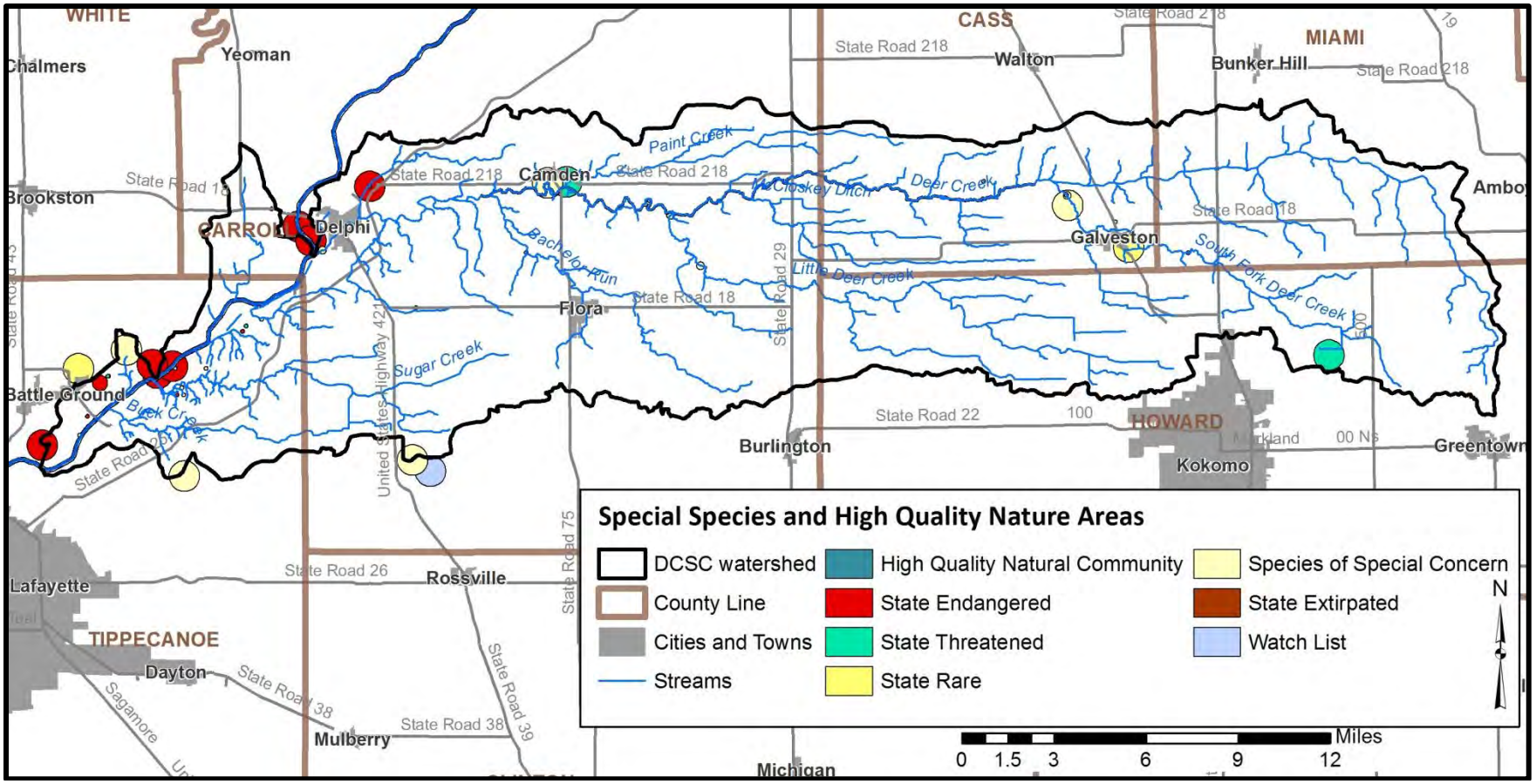

Figure 30. Locations of special species and high quality natural areas observed in the Deer Creek-Sugar Creek watershed.

Data used to create this map is detailed in Appendix A.

Note: Polygons reflect locational uncertainty associated with reported observations. A small circle indicates that there is less uncertainty of where the observation is mapped in relation to its real world location. A large circle reflects more uncertainty. Fish and mussels locations are mapped as linear polygon typically following river and stream stretches based on observational records along that stretch of the stream (R. Hellmich, personal communication November 7, 2012).

2.8.3 Exotic and Invasive Species

Stakeholders have expressed their concerns about the invasive species Japanese honeysuckle along Sugar Creek and Little Sugar Creek. The distribution of honeysuckle or other exotic and invasive species have not been mapped as part of this planning effort.

2.8.4 Recreational Resources and Significant Natural Areas

A limited variety of recreational opportunities exist within the Deer Creek-Sugar Creek watershed. Recreational opportunities include ball fields, campgrounds, a golf course, historical and cultural sites, and parks (Figure 31). Additionally, a few trails are located within the Deer Creek-Sugar Creek watershed. Trails are located in Prophetstown State Park, in the Delphi area, and east of Galveston (Figure 32). There are a variety of trail types such as park, forest, rail, riparian, and towpath. The trails in the Delphi area are managed by the Delphi Historic Trails and the Wabash Erie Canal Association, while the one east of Galveston is managed by the Indiana Trails Fund.

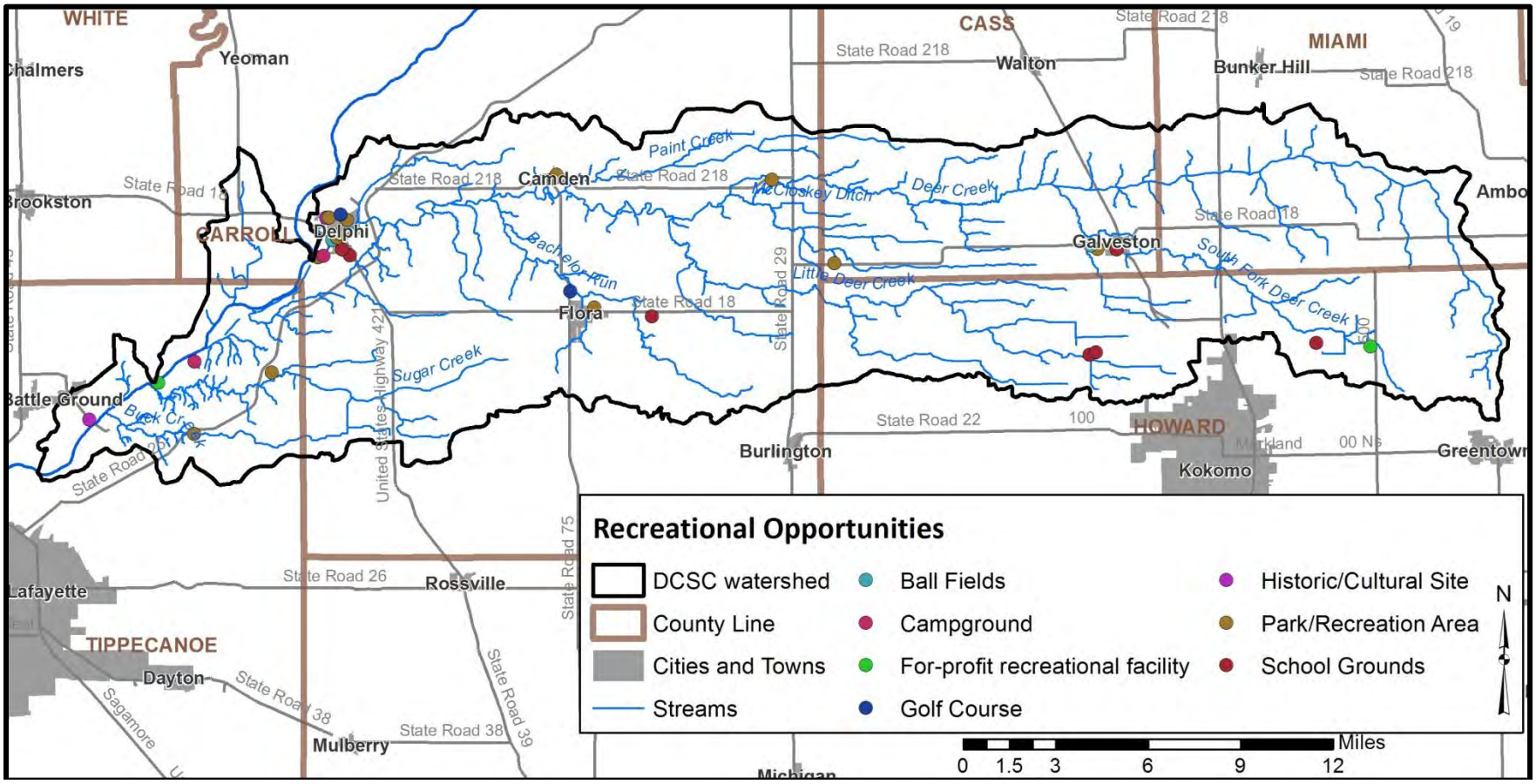

Figure 31. Recreational opportunities in the Deer Creek-Sugar Creek watershed.

Data used to create this map are detailed in Appendix A.

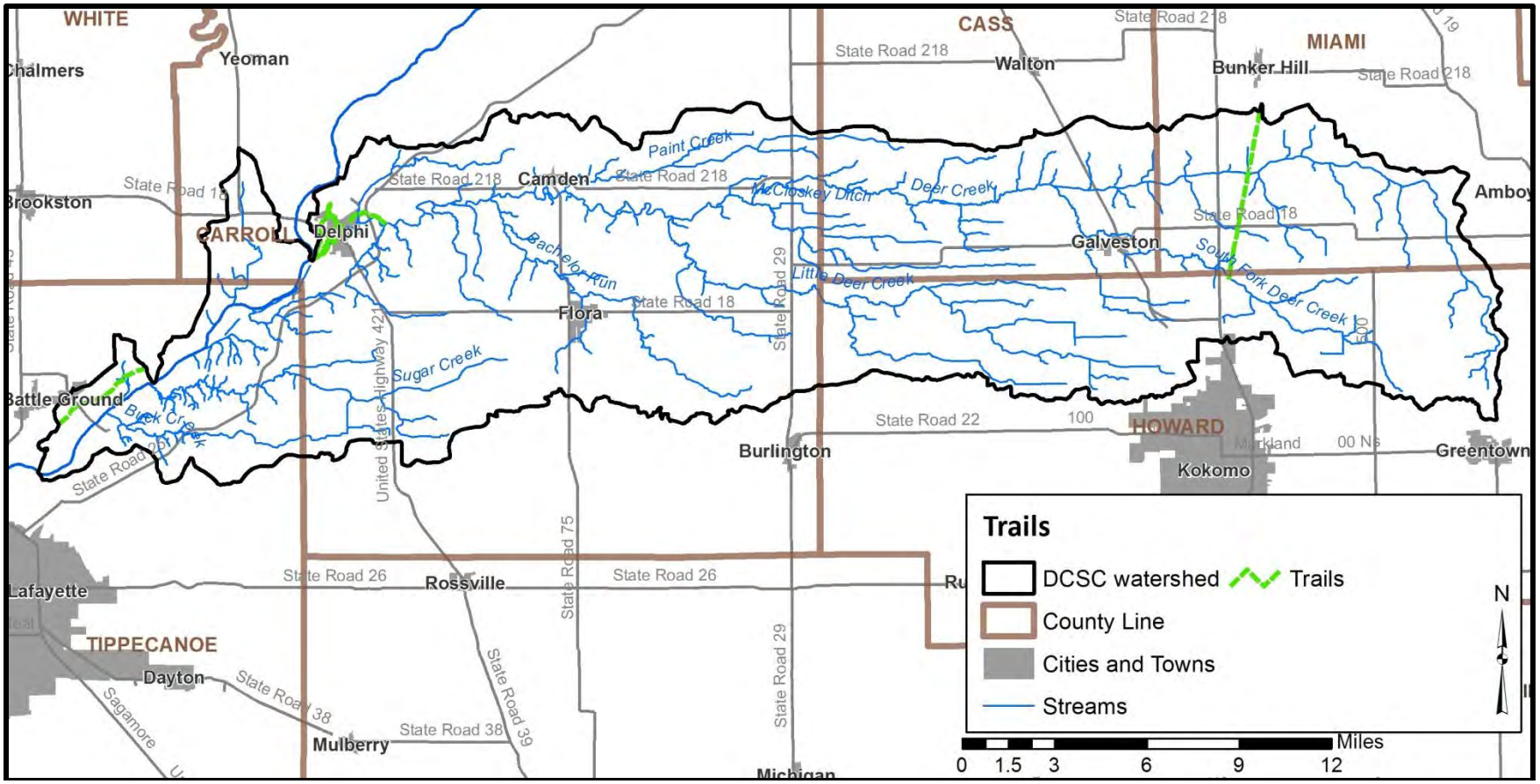

Figure 32. Trails in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9 Land Use

Water quality is greatly influenced by land use both past and present. Different land uses contribute different contaminants to surface waters. As water flows across agricultural lands, it can pick up pesticides, fertilizers, nutrients, sediment, pathogens, manure, and more. However, when water flows across parking lots or from roof tops, it not only picks up motor oil, grease, transmission fluid, sediment, and nutrients, but it reaches a waterbody faster than water flowing over natural or agricultural land. Hard or impervious surfaces present in parking lots or on rooftops create a barrier between surface and groundwater. This barrier limits the infiltration of surface water into the groundwater system resulting in increased rates of transport from the point of impact on the land to the nearest waterbody. A review of the historic land types

present in the watershed will provide an idea of the types of restoration that could occur within the watershed and also a basis for the past uses of the land

2.9.1 Historic Land Use

During its early days, the watershed was described as being resplendent with large trees and prairies as far as the eye could see. Coulter (1886) described the region as part of the prairie region, noting the low water mark of the Wabash River - 504 feet above sea level - and detailing the numerous clear, cold streams and springs which carried water to the Wabash River. Deer Creek was so named for the numerous deer communities found along its bank in early settlement days (Helm, 1878).

The Deer Creek-Sugar Creek watershed is replete with historical significance. A major historically significant location within the watershed includes the Battle Field and Prophet's Rock near Battle Ground. A major skirmish occurred at this site between William Henry Harrison and the remaining Indians formerly led by Tecumseh and the Prophet. The battle occurred on the banks of Burnett Creek and was one of the bloodiest battles recorded in Indian history.

From the mid seventeenth century until well into the nineteenth century, the area was predominantly occupied by the Miami tribe. Nearly all of the land in the watershed belonged to the Great Miami Reservation by way of the St. Mary's Treaty, which was enacted between 1818 and 1840. The end of the treaty marked the end of any Miami land claims in Indiana (Helm 1878). European settlement patterns followed, starting in the 1830s. A sawmill was built along the south fork of Deer Creek in the late 1840s and Galveston was laid out in 1854 (Helm, 1878). Battle Ground was platted in 1858 and consolidated with the Town of Harrisonville nearly ten years later. The first settlements came to what was to become Delphi in 1824 (Helm, 1882).

A canal system was constructed throughout the state of Indiana, beginning in Fort Wayne in 1832 and coming to a close some forty years later. The waterway eventually expanded southward through Delphi in 1840 on its way to the Ohio River. The canal was built adjacent to the Wabash River in the eastern most part of the Deer Creek-Sugar Creek watershed. Though the railroad was in full swing, farmers and merchants searched for alternate and more accessible ways to ship goods. As railroad shipping costs grew, so did the appeal of building small, privately owned boats to cart cargo via the canal systems. Goods such as grain, lime, logs, pork and whisky were all moved along the Wabash-Erie Canal (Wabash and Erie Canal, 2014).

Along the route, a variety of innovations were used by canal engineers to compensate for the changing topography of the land. Swing bridges, systems of counterweights, tumbles, dams, locks, and development of a concrete that would harden under water were all employed for the canal's success (Wabash and Erie Canal, 2014). However, not long after its completion, many realized how inefficient the canal system was compared to the railroad. The canal's wooden structures often needed to be replaced, mosquitoes thrived in the stagnant canal waters, spring flooding, summer drought and freezing waters in the cold months constantly presented issues to farmers and merchants.

Presently, the remaining section of the canal can be seen in Delphi, IN. In recent years, efforts to revive the section of the canal in the Delphi area have been met with community support. Sections of land have been donated surrounding parts of the canal and the city has dedicated those lands to the parks system (Wabash and Erie Canal Park, 2009). Water exists in this part of the canal alone, and the town of Delphi has just completed a warehouse project along the side of the restored canal to house its newly built canal boat.

2.9.2 Current Land Use

In 2006, agricultural land uses dominated the Deer Creek-Sugar Creek watershed (Figure 33, Table 9). In total, 85.2% of the watershed is covered by agricultural row crop or pasture. Urban land uses, including urban open space and low, medium, and high intensity developed areas, account for 7% of the watershed land use, while forested lands and wetlands account for 6% of the watershed. Definitions for each land cover type are included in Appendix D.

Table 9. Detailed land use in the Deer Creek-Sugar Creek watershed.

Classification	Area (acres)	Percent of Watershed
Cultivated Crops	199,943.5	83.3%
Deciduous Forest	13,784.5	5.74%
Developed, Open Space	13,571.3	5.65%
Pasture/Hay	4,558.0	1.90%
Developed, Low Intensity	2,573.9	1.07%
Grassland/Herbaceous	2,501.2	1.04%
Woody Wetlands	1,082.6	0.45%
Open Water	732.5	0.31%
Developed, Medium Intensity	520.9	0.22%
Shrub/Scrub	417.7	0.17%
Developed, High Intensity	215.5	0.09%
Emergent Herbaceous Wetlands	111.1	0.05%
Barren Land	16.2	0.1%
Evergreen Forest	7.8	< 0.1%
Mixed Forest	4.9	< 0.1%
TOTAL	**240,041.9**	**100%**

Source: USGS 2006

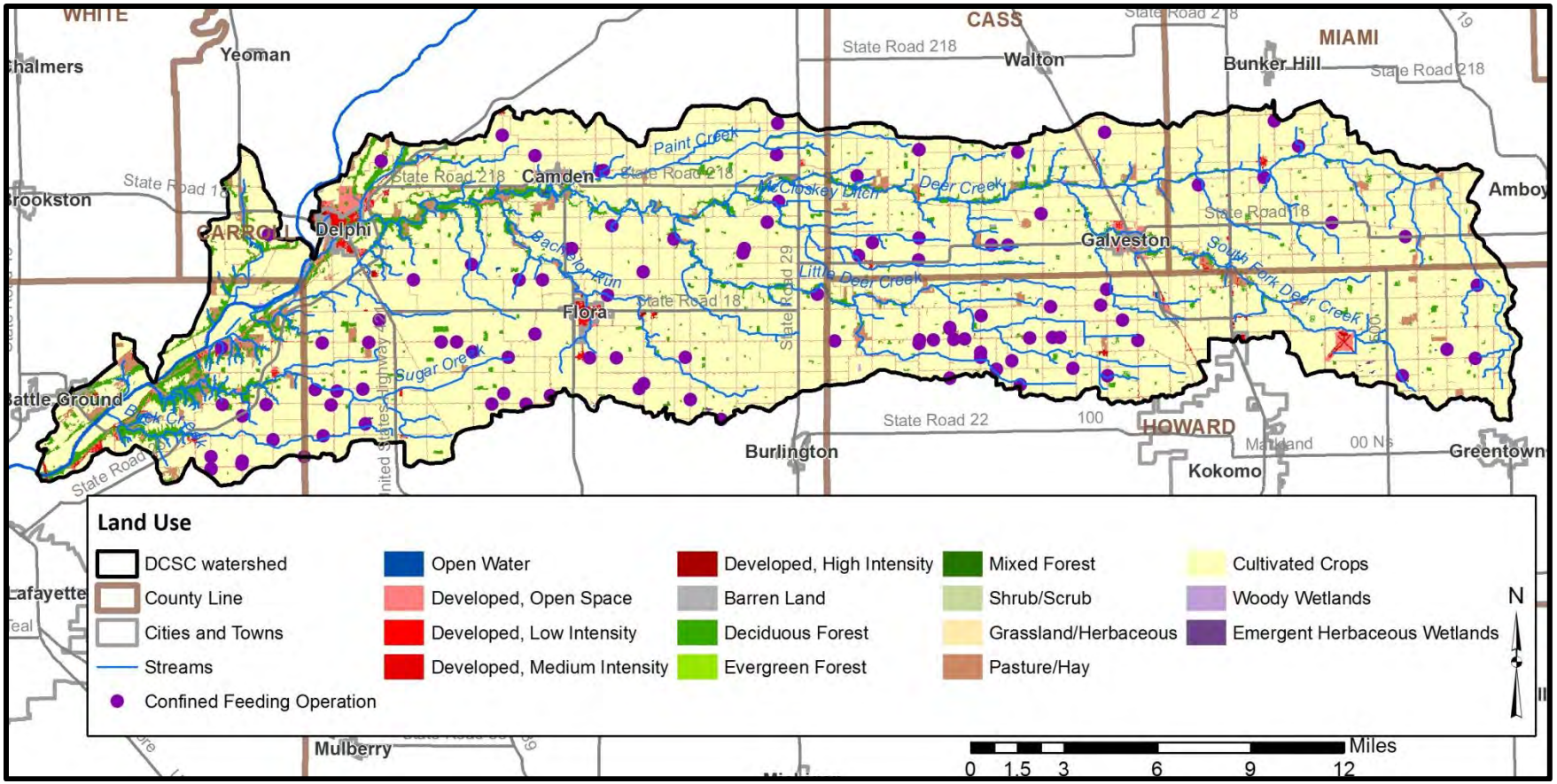

Figure 33. Land use in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.
NOTE: 2006 is the most recent coverage.

2.9.3 Agricultural Land Use

Stakeholders are concerned about the impact of agricultural practices on water quality. Specifically, the volume of soil entering adjacent waterbodies, the use of agricultural chemicals, and the volume of manure applied via unregulated farms and through confined animal feeding operations concern stakeholders. Each of these issues will be discussed in further detail below. These concerns are especially important as according to the 2006 land classification effort, nearly 85.2% of the watershed is used for agricultural purposes. According to USDA data from

2004, cultivated areas cover approximately 99.4% of the watershed with 84.1% of cultivation occurring in densities greater than 75% (Table 10, Figure 34).

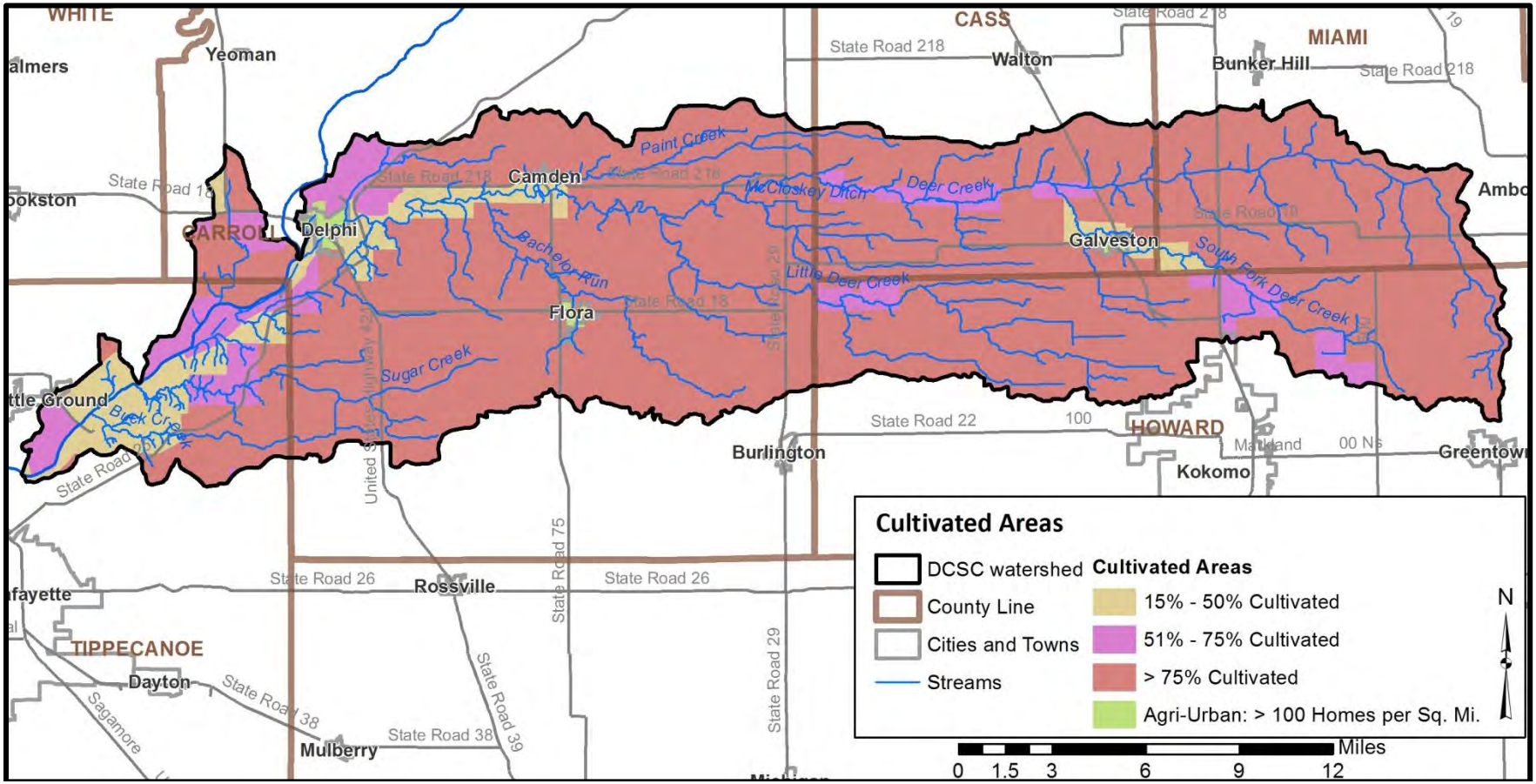

Figure 34. Cultivation density and type within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 10. Cultivation density and type within the Deer Creek-Sugar Creek watershed.

Cultivation Type and Density	Area (acres)	Percent of Watershed
15% - 50% Cultivated	16,872.3	7.0%
51% - 75% Cultivated	19,808.7	8.3%
> 75% Cultivated	201,975.0	84.1%
Agri-Urban: > 100 Homes per Sq. Mi.	1385.9	0.6%
TOTAL	**240,041.9**	**100%**

Source: USDA 2004.

Of the areas that are cultivated, corn and soybean production dominates crop production (Figure 35, Table 11). In total, corn production accounted for 44% of land cover in 2006, while soybeans accounted for 31% of land cover. Non-agricultural uses, such as woodland and developed areas, covered an additional 18% of the watershed. Pasture/hay, grass/pasture, winter wheat, alfalfa, and other crops covered the remaining crop production lands.

Table 11. Crop type (2008) in the Deer Creek Sugar Creek watershed.

Crop	Total Acreage	Percent of Watershed
Corn	105,345.3	43.9%
Soybeans	74,326.4	31.0%
Developed	21,831.3	9.1%
Woodlands	20,657.3	8.6%
Pasture/Hay	9,224.6	3.8%
Winter Wheat	3,946.7	1.6%
Grassland Herbaceous	2,669.1	1.1%
Water	714.0	0.3%
Alfalfa	415.0	0.2%
Grass/Pasture	301.0	< 0.1%
Wetlands	175.1	< 0.1%
Winter Wheat/Soybeans	148.9	< 0.1%
Barren/Fallow	135.8	< 0.1%
Shrubland	76.6	< 0.1%
Other Crops	74.5	< 0.1%
TOTAL	**240,041.6**	**100.0 %**

Source: NASS, 2008

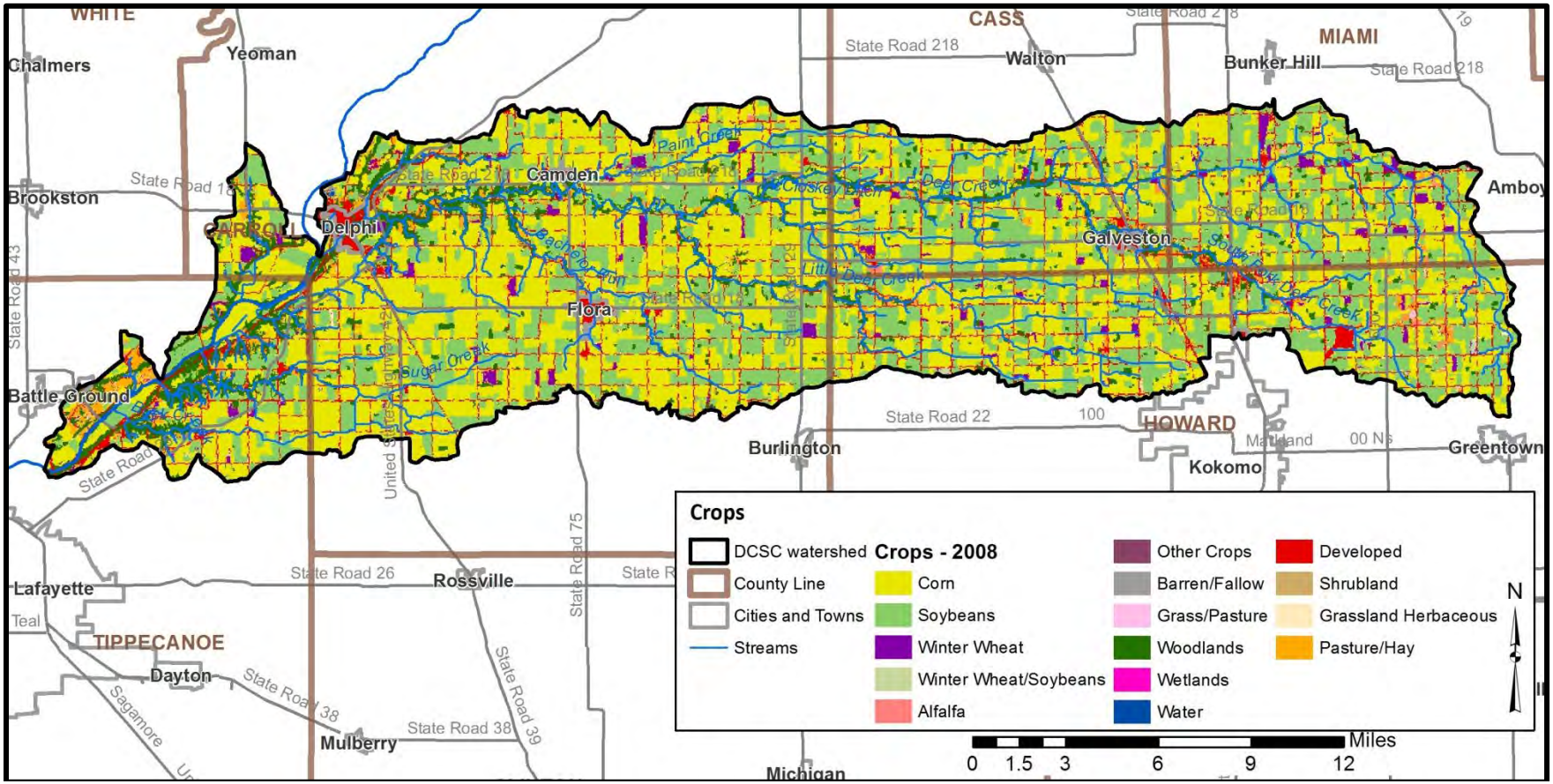

Figure 35. Crop type (2008) in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.NOTE: 2008 is the most recent crop data that is available from Indianamap.org

According to the 2007 Census of Agriculture, Cass, Carroll, and Tippecanoe counties rank in the top 20 statewide for corn production (8th, 15th and 17th, respectively). Tippecanoe County also ranks 15th in soybean production, while the remaining counties in the watershed are not in the top 20 statewide. Miami and Carroll counties rank 17th and 19thin wheat for grain production. Miami, Howard, and Carroll Counties rank 4th-6th, respectively, in popcorn production, though very little is located within the watershed. According to the 2007 survey, conservation tillage practices within the five counties that comprise the Deer Creek-Sugar Creek watershed are at or slightly higher than the average for the state of Indiana (Table 12). Howard County is the only county of the five that is at or below the state median for conventional tillage.

Table 12. Tillage practices in the Deer Creek-Sugar Creek watershed.

County	Conventional Tillage	Reduced Till	Mulch Till	No Till	No Till Acreage	Total Acreage
Corn						
Carroll	32%	52%	1%	15%	15,800	105,000
Cass	37%	27%	12%	24%	24,700	103,000
Howard	27%	60%	5%	7%	4,800	69,000
Miami	63%	20%	4%	13%	8,600	66,000
Tippecanoe	49%	18%	3%	29%	28,100	97,000
INDIANA	**36%**	**22%**	**18%**	**23%**	-	-
Soybeans						
Carroll	14%	56%	1%	27%	18,200	67,500
Cass	7%	16%	18%	58%	42,700	73,600
Howard	10%	17%	46%	27%	19,000	70,500
Miami	4%	17%	21%	59%	47,400	80,300
Tippecanoe	8%	9%	9%	74%	64,600	87,300
INDIANA	**10%**	**11%**	**20%**	**59%**	-	-

Source: ISDA, 2011.

Agricultural Chemical Usage

Agricultural herbicides, pesticides, and synthetic fertilizers are commonly applied to row crops in Indiana. These chemicals can be carried into adjacent waterbodies through surface runoff and via tile drainage. This is especially an issue if a storm occurs prior to the chemicals being broken down and used by the crops.

Data for chemical usage on an individual county or watershed level is not currently collected. Rather, data are collected for the state as a whole in two forms. First, the National Agricultural Statistics Survey (NASS) collects information on chemical usage, number of applications per year, type of chemical applied, and the application rate. This data was last collected in 2010 (NASS, 2010). Second, NASS collects farmland data for the number of acres in agricultural production by type (i.e. corn, soybeans, grains) every five years. The acreage of cropland in the watershed was estimated using 2008 cropland cover data (Table 13).

This data indicates that corn and soybeans are the two primary crops grown in Carroll, Cass, Howard, Miami, and Tippecanoe counties. Fertilizers are more typically applied to corn than to soybeans. This is due to soybeans acting as nitrogen fixers, in essence, they pull the nitrogen that they need from the atmosphere, and then convert it into a form which they can use. Corn does not fix nitrogen; therefore, nitrogen needs to be

applied**.** Nitrogen is typically applied twice in Indiana – once at or before planting and a second time when corn reaches approximately one foot in height (NASS, 2007). Agricultural data indicates that 99% of the acres of corn receive nitrogen fertilizer and 90% receive phosphorus. Based on this data, it is estimated that 18.2 million pounds of nitrogen and 6.4 million pounds of phosphorus are applied annually within the Deer Creek-Sugar Creek watershed.

Table 13. Agricultural chemical usage for corn in the Deer Creek-Sugar Creek watershed.

Nutrient	Acres of Corn	% of Area Applied	Applications (#/year)	Rate/Application (lbs/acre)	Total Applied/Year (Million lbs)
Nitrogen	105,345	99	1.9	92	18.2
Phosphorus	105,345	90	1.2	56	6.4

Source: NASS, 2010.

Confined Feeding Operations and Unregulated Farms

There are over a hundred large, regulated livestock operations (confined feeding operations) located within the Deer Creek-Sugar Creek watershed. Farms that house large number of animals for longer than 45 days per year are regulated by IDEM. These regulations are based on the number and type of animals present. IDEM requires permit applications, which document animal housing, manure storage and disposal, and nutrient management plans for farms which maintain 300 or more cows, 600 or more hogs, or 30,000 or more fowl. These facilities are considered confined feeding operations (CFOs). In July 2012, larger concentrated animal feeding operations (CAFOs) in the watershed began operating under state CFO rule 327 IAC-19, rather than under individual NPDES permits, effectively reclassifying these operations as CFOs for the purposes of 319 funding.

There are 120 active CFOs and approximately 300 small, unregulated farms located within the watershed (Figure 36). The CFOs contain approximately 240,000 animals and are permitted to spread manure on approximately 42 square miles of the watershed. Additional lands likely to receive manure application, as observed during windshield surveys, were also added to the mapped dataset in Figure 36. The unregulated farms contain nearly 3,000 animals. Data for small, unregulated farms and animals were collected via windshield survey in 2012 and 2013.

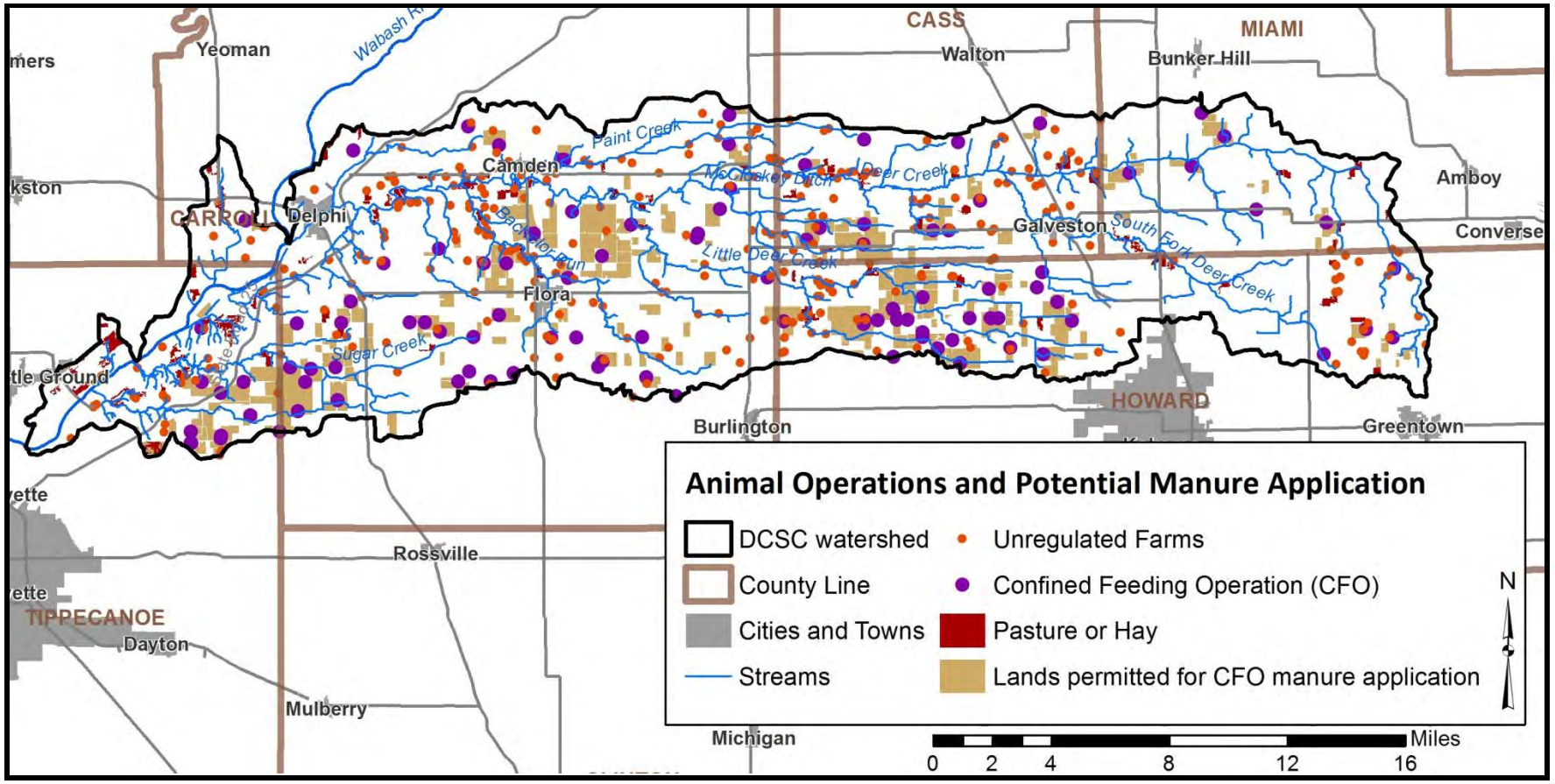

Figure 36. Active confined feeding operations and land permitted for manure application within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.4 Natural Land Use

Natural land uses, including forests, wetlands, and open water, cover 9% of the watershed. Forest cover occurs adjacent to waterbodies throughout the watershed; however, these tracts are not contiguous (Figure 37). Large lengths of the watershed streams no longer contain intact riparian buffers. Specific areas of concern will be discussed in further detail in future sections.

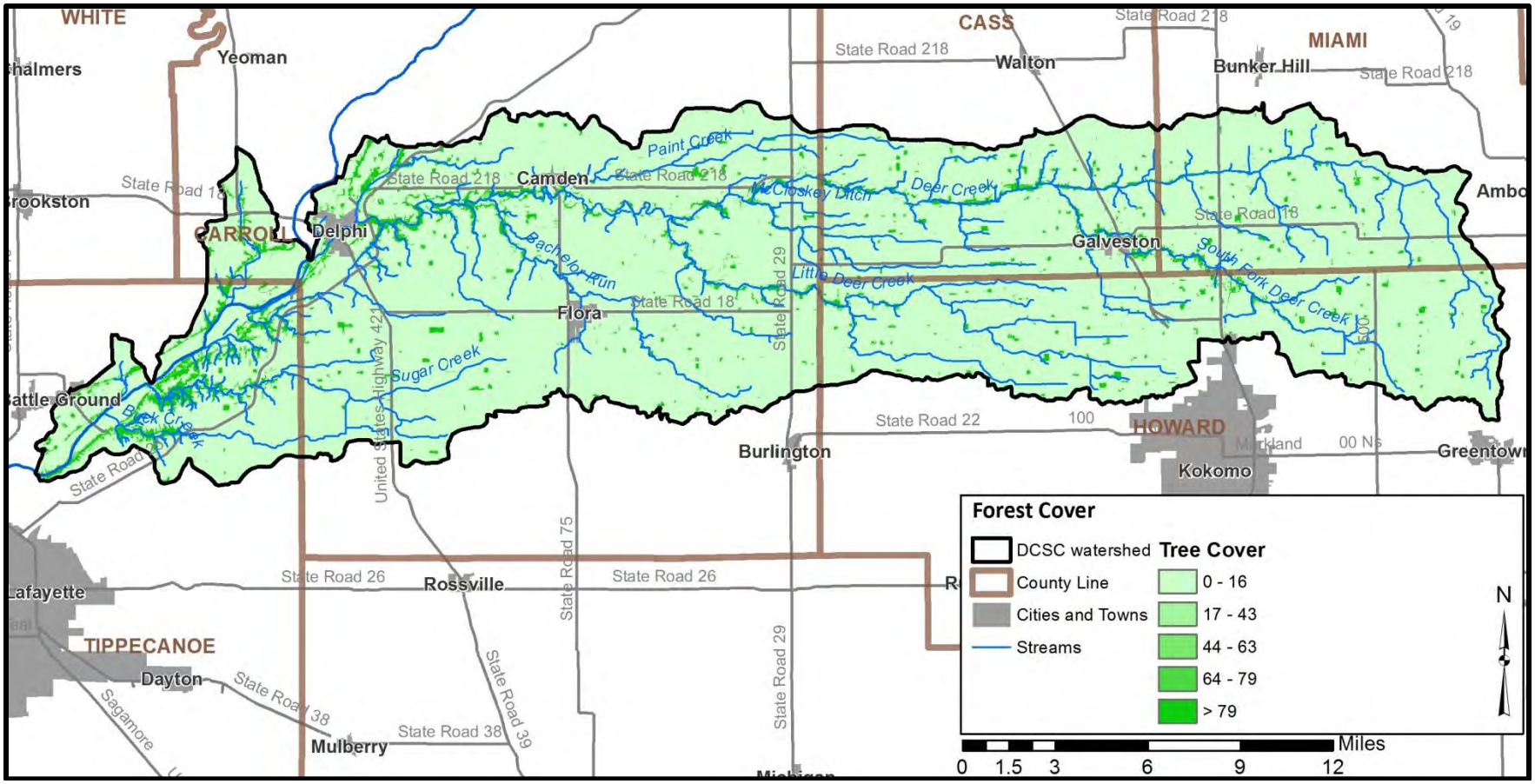

Figure 37. Percent forest cover in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.5 Urban Land Use

Developed areas include over 7% of the watershed. These areas include low, medium, and high density residential and commercial development and urban grasslands. Camden, Delphi, Flora, and Galveston comprise the majority of the developed areas within the watershed.

Impervious Surfaces

Impervious surfaces are hard surfaces which limit water from infiltrating into the land to become groundwater, thereby creating high overland flow rates. Hard surfaces include concrete, asphalt, compacted soils, rooftops, and buildings or structures. In developed areas like Delphi, Flora,

and Galveston, land which was once permeable has been covered by hard, impervious surfaces. This result in rain which is not absorbed into the surface, running off of rooftops and over pavement to enter Deer Creek with high quantities of pollutants. Figure 38 displays the impervious surface cover density within the Deer Creek-Sugar Creek watershed.

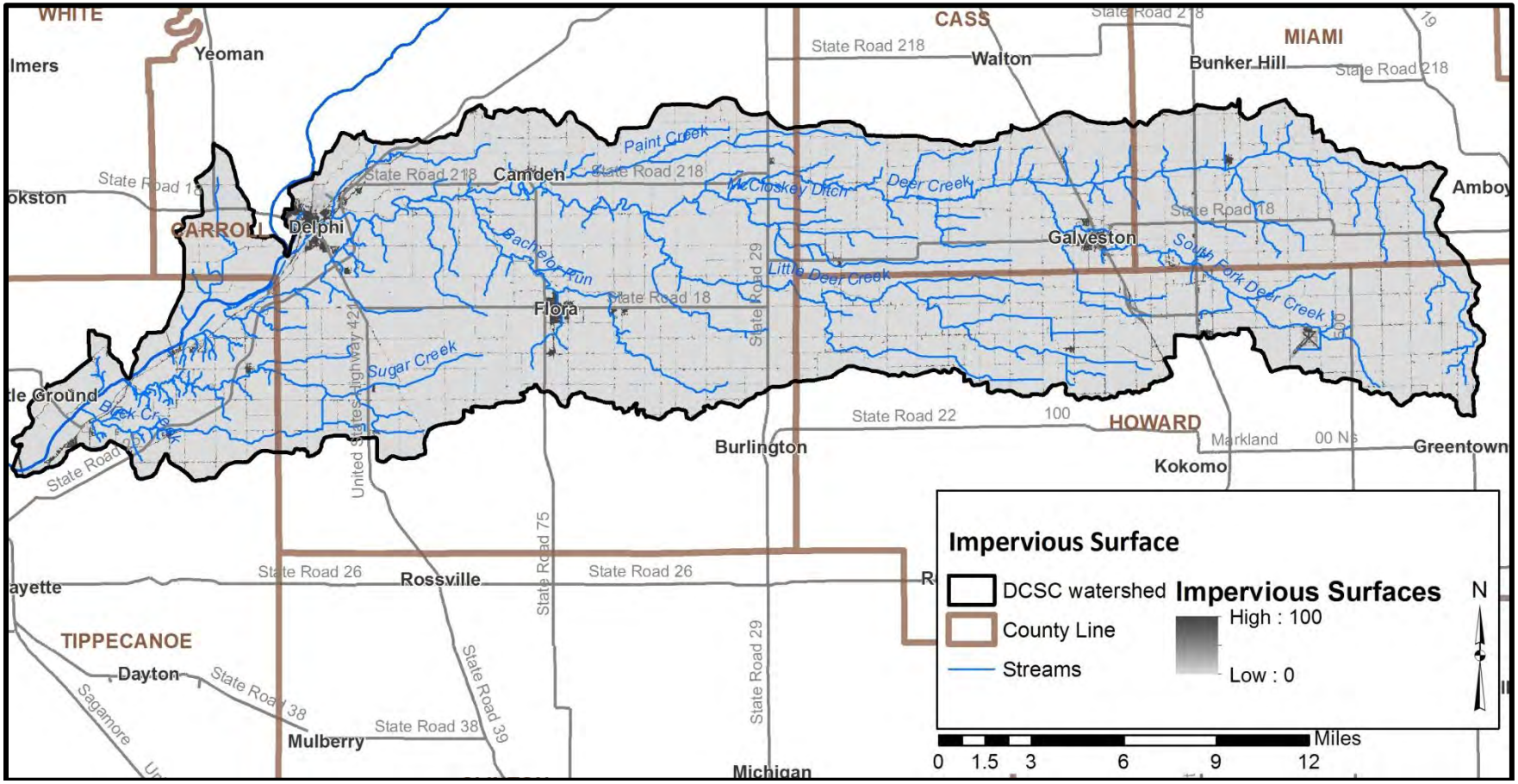

Figure 38. Impervious surface density within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

Overall, the majority of the watershed is covered by low levels of impervious surfaces. However, high impervious densities are present in Delphi, Flora, and Galveston and along roads throughout the watershed. Estimates indicate that only 274 acres (<0.2%) of the watershed is 75% or more

covered by hard surfaces, while 234,005 acres (97%) of the watershed is covered by 10% or less by hard surfaces. Elvidge et al. (2004) indicated that streams in watersheds with greater than 10% impervious surfaces clearly exhibited degradation. The Center for Watershed Protection (CWP) identified similar impacts from impervious surface density on water quality. The CWP study indicates that stream ecology degradation begins with only 10% impervious cover in a watershed (CWP. 2003). Since 97% of the watershed is 10% or less impervious surface, this is not something that will play a huge role in the watershed's implementation phase. The areas that it could play a role in are those that have a greater percentage of impervious surfaces like the tributaries of Deer Creek located near Delphi, Flora, and Galveston, such as Bachelor Run, Kuns Ditch, Robinson Branch, and the South Fork of Deer Creek.

Remediation Sites

Remediation sites including brownfields, industrial waste sites, leaking underground storage tanks (LUST), and open dumps are present throughout the Deer Creek-Sugar Creek watershed (Figure 39). Most of these sites are located near the urban areas around Delphi, Flora, and Galveston. In total, there are three brownfields, three industrial waste sites, 34 LUST facilities, and three open dumps present within the watershed.

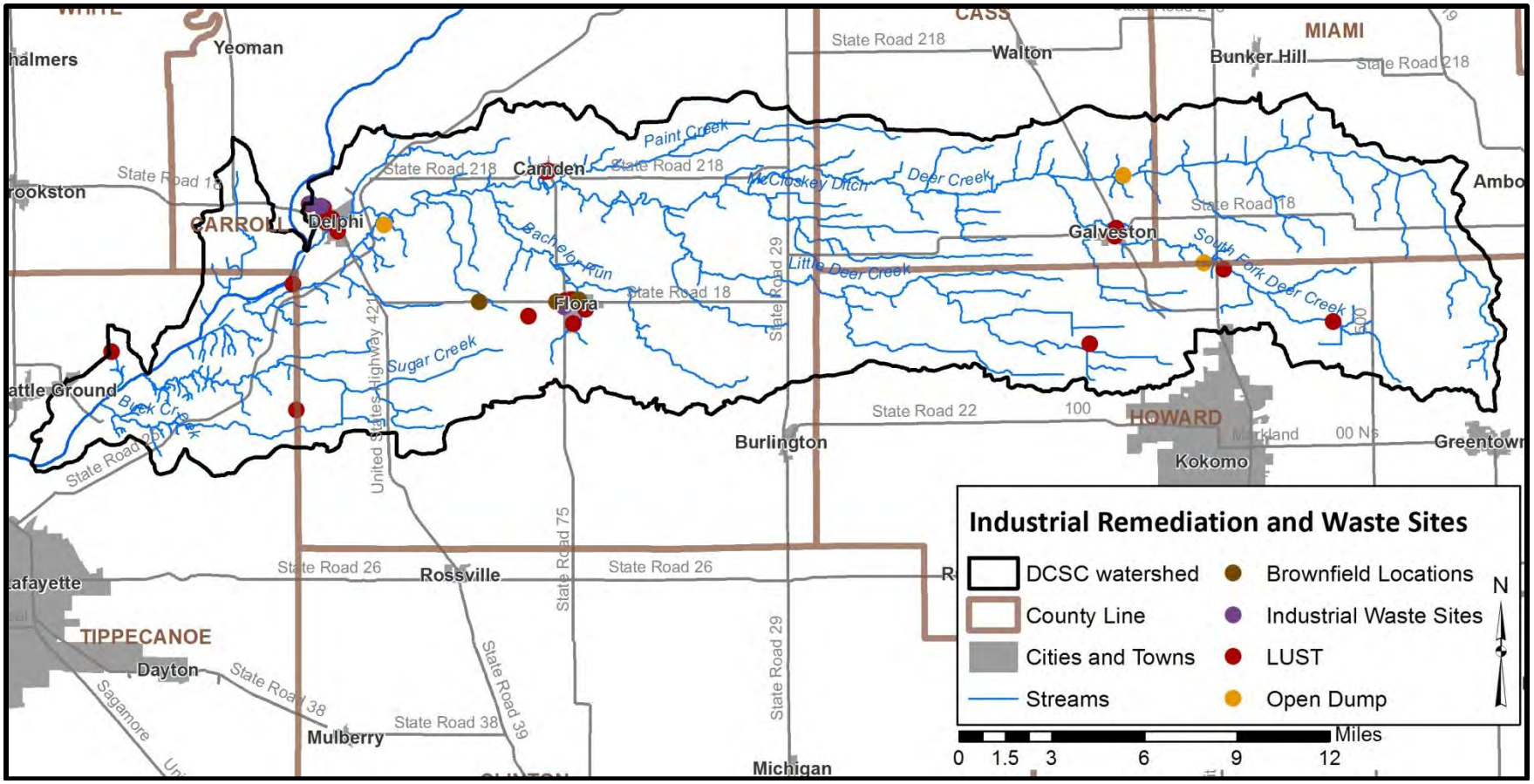

Figure 39. Industrial remediation and waste sites within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.6 Industrial Land Use

The watershed is predominately rural in nature, and not much land is devoted to industrial use. Indiana Packers Corporation, a pork processing and packaging facility, is located just south of Delphi (see Figure 17 and Table 6). Additionally, numerous large-scale animal feeding operations exist throughout the watershed (see Figure 36).

2.9.7 Development Trends

Construction of the Hoosier Heartland Corridor began in 2008. Upon completion, it will connect Lafayette, IN to Fort Wayne, IN. This project will create an alternative to State Road 25 (now Old SR 25) by offering a four-lane, limited-access highway instead of a rural, two-lane highway (Figure 40, INDOT, 2012). The construction of the Hoosier Heartland Highway will have both economic and environmental impacts. Economically, there are both positive and negative aspects of the construction of the highway. The new highway will allow companies, such as The Andersons, Inc, "direct access to the new State Road 25 from a realigned State Road 218 (INDOT, 2004)." The new highway will also remove/decrease the semi-truck and the volume of traffic on the existing State Road 25. However, several businesses and companies will be displaced or need to be relocated due to the acquisition of the right-of-way of the new roadways. Tri-State Cob Limited, Watson Construction Co, J.W. Rentals will be displaced by the construction of new roadways. A potential loss of revenue might occur for the businesses located on Old State Road 25 and in Delphi because the highway will bypass them (INDOT, 2004).

As part of this construction, 1.7 miles of stream length will be crossed and 80.8 acres of riparian/forest and 2.7 acres of wetlands will be directly impacted. Bridge Creek, Buck Creek, Deer Creek, Robinson Branch, and Sugar Creek will be crossed and their riparian/forest will be impacted. All of the sites will have a combination of bridges and pipe/box culvert where the highway will cross the waterbody, except Robinson Branch, which will only have a pipe/box culvert (INDOT, 2004). The 2.7 acres of wetlands are divided up among seven sites. The existing wetland sites include 5.1 acres; after construction, only 2.4 acres of wetland will remain resulting in a 47% decrease in wetlands for this area. The FWS made the following two comments about the impacts of the construction:

- Bridge Creek, Buck Creek, and Sugar Creek crossings: "'Major forest fragmentation would occur', but proposed plans to bridge the creeks would reduce channel impacts (INDOT, 2004)."
- "Bridge Creek tributary north of County Road 100 North, Bridge Creek near a tributary confluence, and Robinson Branch (two crossings): 'Significant stream impacts may occur…' (INDOT, 2004)."

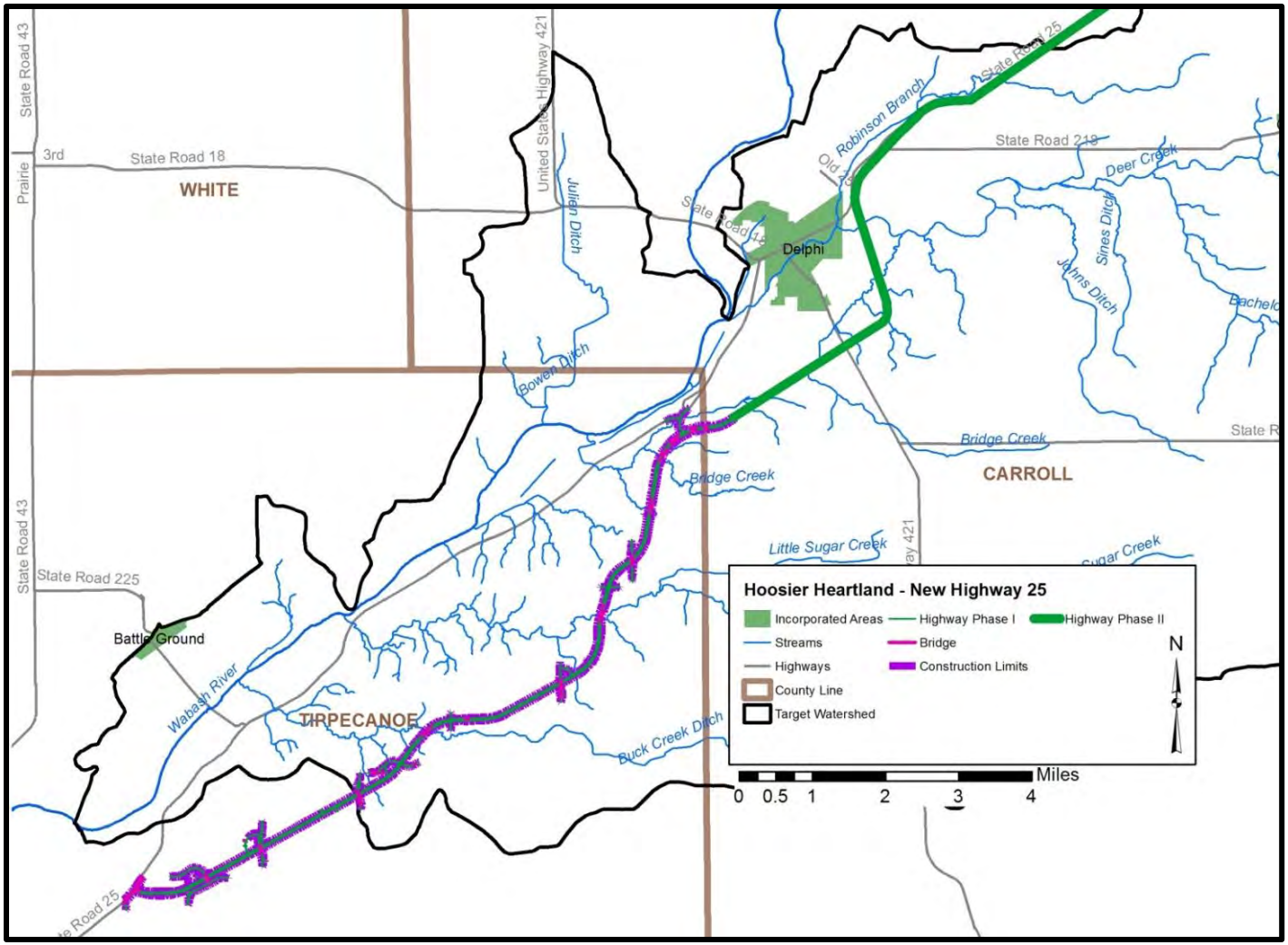

Figure 40. Construction extent of the Hoosier Heartland Corridor located in the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.10 Population Trends

As the land use discussion details above, the Deer Creek-Sugar Creek watershed supports a combination of sparsely and moderately dense populated areas. Tracking population changes within a watershed is difficult as watershed boundaries rarely align with the boundaries (townships, census tract, county) used to report populations. Reported data can be used to estimate current and projected populations, track population growth over the past century, and assist in identifying high and low density populations within the vicinity of the watershed.

The Deer Creek-Sugar Creek watershed lies within five counties. It drains 32% of Carroll County, 26% of Howard County, 12% of Cass and Miami counties, and 7% of Tippecanoe County. Population trends for these counties derived from the most recently completed census (2010) are shown in Table 14, while Table 15 displays estimated populations for the portion of the county located within the watershed. These data indicates considerable growth in Howard and Tippecanoe Counties over the past 110 years (190% and 347%, respectively). Populations decreased in Cass and Howard counties over the past decade.

Table 14. County demographics for counties within the Deer Creek-Sugar Creek watershed.

County	Area (acres)	Population (2010)	Population Change			Population Density (#/sq. mile)
			(1900-2010)	(1990-2010)	(2000-2010)	
Carroll	329,792	20,155	1.0%	7.2%	0.0%	53.8
Cass	265,341	38,966	12.8%	1.4%	-4.8%	94.0
Howard	187,945	82,752	189.6%	2.4%	-2.6%	281.8
Miami	241,305	36,903	30.2%	37.2%	2.3%	97.9
Tippecanoe	321,810	172,780	346.9%	32.3%	16.0%	343.6

Table 15. Estimated watershed demographics for the Deer Creek-Sugar Creek watershed.

County	Area of County in Watershed	Percent of County in Watershed	Population
Carroll	106,054	32.2%	6,481
Cass	32,893	12.3%	4,776
Howard	49,533	26.4%	21,809
Miami	28,397	11.8%	4,343
Tippecanoe	23,165	7.2%	12,437
Total Estimated Population			49,847

Based on the tracts the U.S. Census used in their most recent survey, there are approximately 2,000 tracts within the Deer Creek-Sugar Creek watershed. Population densities within the watershed are relatively low; 62% of the tracts have a population density of ten or less people per square kilometer (Figure 41). Additionally, 95% of the tracts have a population density of less than 50 people per square kilometer and only 19

tracts have a population density greater than 100 people per square kilometer. The highest density is located east of Galveston and has a population density of 324 people per square kilometer.

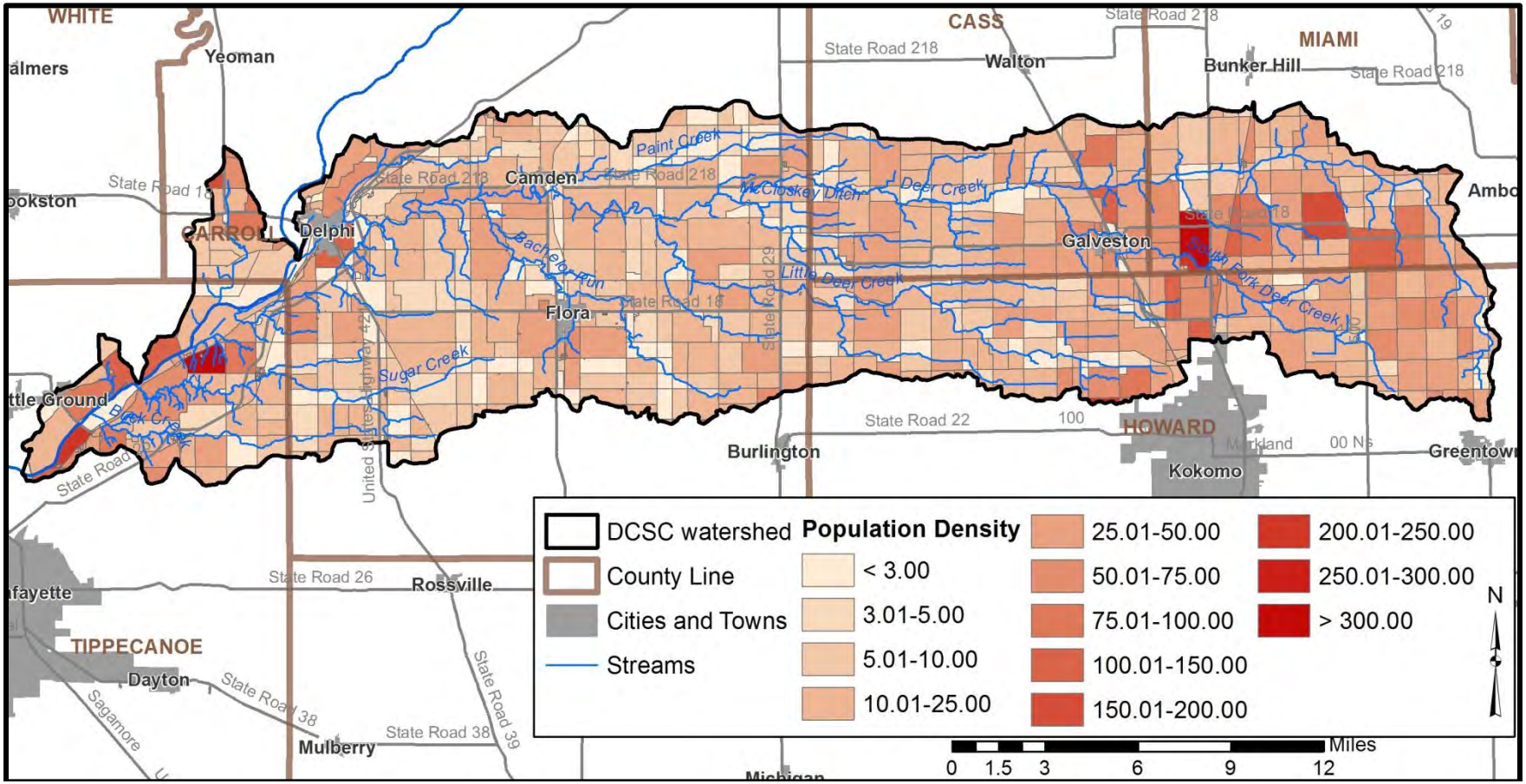

Figure 41. Population Density (#/square kilometers) within the Deer Creek-Sugar Creek watershed.
Data used to create this map are detailed in Appendix A.

2.11 Planning Efforts in the Watershed

2.11.1 Comprehensive Plans

Each county in the watershed maintains an adopted comprehensive plan. The following sections detail each county's comprehensive plan.

Carroll County

The Carroll County comprehensive plan was adopted in 1968. The first update to the 1968 comprehensive plan was made in 2001 and a new comprehensive planning initiative began in 2007. A draft plan was developed and is in the review process (Carroll County, 2008). Future Land Use Maps for Carroll County, the City of Delphi, and the Town of Camden can be found in Appendix G. The key highlights of the plan are described below:

- In terms of land use management, Carroll County's goal is to "provide opportunities for growth and development that enhance quality of life and economic vitality while preserving the County's rural character, agricultural industry, and environmentally sensitive areas (CPCC, 2008)." To achieve this goal two objectives were established:
    - Minimize land use conflicts between agricultural and industrial uses; and
    - To protect prime agricultural land.
- The transportation portion of the comprehensive plan detailed a goal of "providing a quality, safe, efficient, and fiscally responsible transportation network that serves the needs of [Carroll County] (CPCC, 2008)." Several objectives were identified as part of the comprehensive plan including:
    - Maintain and improve the condition of existing roadways;
    - Develop and enhance an efficient vehicular road network;
    - Encourage the expansion of the municipal airport;
    - Promote a safe and appropriate alternative transportation network throughout Carroll County; and
    - Provide opportunity for appropriate development of transportation options near the Hoosier Heartland Highway.
- The environmental goal of the comprehensive plan is to "preserve and enhance Carroll County's natural and historic/cultural resources and environmental features, and protect these features from development (CPCC, 2008)." To achieve this goal, seven objectives were developed as follows:
    - Protect the water quality in lakes, streams, and their watersheds;
    - Minimize conflicts between the natural environment and future development;
    - Conserve existing natural areas;
    - Focus growth in or near municipalities;
    - Preserve historical and cultural resources/amenities;
    - Initiate long-term planning related to the limestone quarry operations; and
    - Consider development of landfill facility to handle County generated wastes in an environmentally sound manner.

Proposed updates to the Carroll County Ordinance, pending County Commissioner approval, add a Rural-Residential (R-R) overlay adjacent to the banks of Deer Creek. This R-R district will not allow large scale feeding operations and restricts the number of animals to 1.2 animals per 1.5 acre lot. Passage of this ordinance would not allow large feeding operations to expand or for new large feeding operations to locate adjacent to Deer Creek in the R-R overlay. A map of the proposed R-R overlay is included in Appendix G.

Cass County

Cass County's comprehensive plan was adopted in July of 2009 (CPCC, 2009). Their plan focuses on the three requirements that are in Indiana Code 36-7-4-502; "a statement of objectives for the future development, a statement of policy for land use development, and a statement of policy for the development of public ways, public places, public lands, public structures, and public utilities" (1981). Maps from the plan, including an Existing Land Use Map, a Future Land Use Map, and a Parks, Recreation, and Connectivity Opportunities Map are in Appendix G. The highlights of the plan in terms of land use, transportation, and the environment are detailed below:

- In terms of land use, the Cass County Comprehensive Plan details goals and objectives that include the "planning principles of agricultural preservation and directing growth to existing communities (CPCC, 2009)." Three goals were identified as part of the plan including:
    - Recognize and strengthen existing communities;
    - Protect the viability of agricultural operations; and
    - Manage development along the Hoosier Heartland Corridor west of State Road 29.
- The transportation portion of the comprehensive plan addresses five goals for Cass County. Specifically, these goals are:
    - Provide a world-class county road system connecting economic development centers to the state road network;
    - Coordinate transportation systems at the "edges" where jurisdiction meets;
    - Encourage implementation and use of transportation alternatives to decrease growth of automobile use;
    - Promote walking, hiking, biking and other human powered transport by supporting walkways, paths and trails to tie existing communities together through a system of greenways and trails; and
    - Respond to the demands of new development without negatively impacting the existing road network.
- Cass County's policies related to the environment are focused on the surface and groundwater resources. That being said, four goals were created to address the surface, groundwater, and wastewater within the county including:
    - Support sustainable and natural systems for stormwater runoff and wastewater treatment;
    - Improve the quality of surface water and groundwater resources;
    - Ensure capacity of water and wastewater treatment facilities to accommodate growth; and
    - Coordinate services across jurisdictional boundaries to ensure efficiency and quality services.

Howard County

Howard County initiated a planning process to develop a comprehensive plan in February of 2003 (CPHC, 2003). "Howard County seeks to address growth, development, economic prosperity, environmental quality, agriculture, government services and quality-of-life issues (CPHC, 2003)." The Howard County Future Land Use Map can be found in Appendix G. The key highlights of the plan are detailed below:

- In terms of land use, Howard County's goal is to "provide opportunities for community growth and development which results in enhanced quality of life, a wide range of housing opportunities, economic vitality, and enhanced recreation while preserving environmental integrity (CPHC, 2003)." To achieve this goal, the following objectives were established:
    - Ensure adequate and suitable land exists for all uses and reflects the market demand;
    - Protect prime agricultural land;
    - Ensure that land uses are compatible with environmental features and surrounding land uses; and
    - Highly restrict development or filling-in of the floodplain.
- The transportation section of the comprehensive plan addresses both vehicular and alternative transportation. The goals and objectives are to "promote a fiscally responsible network of roads" and "provide a safe, appropriate and aesthetically pleasing alternative transportation system (CPHC, 2003)."
- The goal addressing the environment is to "promote an ecologically sound community by balancing the needs of the human, plant, and animal life forms and, to the fullest extent possible, protect and enhance the natural systems in Howard County (CPHC, 2003)." To achieve this goal several objectives were established:
    - Protect the quality and quantity of the water in groundwater, streams, and reservoirs;
    - Preserve and protect natural areas and drainage as well as the 100-year floodplain;
    - Protect and enhance streams and the natural environment;
    - Minimize conflicts between growth and the natural environment; and
    - Encourage the use of innovative methods of storm water management such as wetlands and swales.

Miami County

The Miami County comprehensive plan was adopted in 1967. Since the adoption of the plan several changes have occurred, but most specifically the realignment of Grissom Air Force Base (MCCP, 1999). The current comprehensive plan was readopted in 1999 and addresses constraints, goals, and opportunities in land use, environmental, and transportation. The land use map reflecting policy as of 2001 is included in Appendix G. The key highlights of the current plan are described below (though it is worth noting that Miami County is about to begin the process of updating the plan):

- The land use portion of the comprehensive plan addresses 10 goals for Miami County. The goals have been summarized into the following highlights:
    - Promote the orderly growth and development of Miami County;
    - Reserve sufficient land areas, in appropriate locations, for residential, commercial, and industrial growth and development that is forecasted in this Plan;

  - Foster and encourage a balance in housing opportunities and conserve existing housing;
  - Encourage the stabilization of existing commercial areas and the development of new commercial nodes;
  - Encourage continued expansion and development of industrial land uses;
  - Provide and foster compatibility and stability of land uses and an environment accepting of agricultural practices and lifestyles;
  - Enhance the visual appearance and living environment.
- The environmental portion of the comprehensive plan addresses four goals for Miami County. Specifically, these goals are:
  - Promote the preservation of sensitive natural areas within the county, especially areas prone to flooding;
  - Promote the preservation of historically significant structures, roadways, trails, and so on, within the County;
  - Promote the control and regulation of the adverse effects of development such as noise, light, odor, and so on, within the County;
  - Support farmland preservation and encourage cooperation between farm interest and development interests.
- The transportation section of the comprehensive plan addresses one main goal. The goal is "to ensure that the county's transportation system is adequate to support the growth and diversification of the county's population with minimal congestion and to enhance the ability of federal, state, and local governments to make needed transportation improvements (MCCP, 1999)."

Tippecanoe County

The Tippecanoe Area Plan Commission (APC) completed the comprehensive plan in 1981 (TCAPC, 1981). Multiple updates to the plan occurred since that time. The plan was intended to serve as a guidance document by which development and changes within the county could occur. The key planning pieces contained within the County Master Plan which are relevant to the watershed management plan include transportation and floodplain plans. The Plan's Existing and Future Land Use Map is included in Appendix G. The key highlights of each of these individual plans are described below:

- In terms of transportation, the plan addressed the current and future roadway plans and issues of the Hoosier Heartland Corridor (SR 25) from Lafayette to Logansport. Specific reviews of the Hoosier Heartland will be part of this planning process as should any development or redevelopment of other roads within the watershed.
- The portion of the plan that addresses floodplains is covered as part of the multi-hazard management plan which was updated in 2006 (TCAPC, 2006). The multi-hazard management plan is included as a portion of the County Master Plan. Flooding is noted as a significant concern within Tippecanoe County having occurred three times in the period of July 2003 through February 2005. In total, 14 flood events were recorded within the county from May 1943 through February 2005. These events resulted in more than $67 million in property damage and more than $58 million in crop damage. Flooding is typically limited to riverine flooding but has also historically been associated with flash, overland, lake, and urban flooding.

2.11.2 Soil and Water Conservation Districts (SWCD)

Carroll County

The mission statement of the Carroll County SWCD is "to develop, promote, and utilize current soil and water conservation programs that benefit both rural and urban citizens in Carroll County (CCSWCD, 2008)." The current business plan was adopted in 2008 and addressed issues through 2013. The SWCD identified four critical issues with natural resources: maintaining prime farm land, clean water, clean air, and surface water quality. Based on these issues the following actions were identified:

- Maintain current levels of conservation throughout the county until 2013.
- Installation of buffer strips along all creeks and tributaries by 2013.
- Educate landowners/producers on the practices of conservation tillage, no-tillage, and program opportunities.
- On an annual basis, ensure proper maintenance of conservation equipment.

The Deer Creek-Sugar Creek Watershed Management Plan will assist Carroll County in addressing their water and surface water quality concerns.

Cass County

The mission of the Cass County SWCD is "to provide leadership, education, and technical assistance to empower the citizens of Cass County to conserve and preserve our soil, water, and natural resources (CCSWCD, 2013)." The business plan was adopted in April of 2013 and as part of their plan, the SWCD identified the following areas of concern that will be addressed:

- Soil erosion and sedimentation
- Nutrient and pesticide applications
- Streambank stabilization
- Buffer and waterway protection
- Nutrient and sediment contamination
- Wildlife habitat loss and fragmentation
- Stormwater runoff

Even though only 12.4% of Cass County is within the Deer Creek-Sugar Creek watershed, the concerns identified by the SWCD still apply. These concerns closely parallel the stakeholder concerns listed in Table 2 and are addressed in subsequent analysis in the Deer Creek-Sugar Creek Watershed Management Plan. The following actions were identified by the SWCD to be completed by 2018:

- No-till practices shall be increased by 2,000 acres.
- Cover crops shall be increased by 2,000 acres.
- The SWCD will educate landowners in high manure application areas on best management practices for manure application.
- The SWCD will increase streambank stabilization awareness/education.
- 65 acres of buffers will be installed.
- Educate landowners about the benefits and installation of rain gardens.

- Provide educational and/or outreach opportunities on the environmentally wise use of nutrients and soil health.
- Educate landowners about beneficial native plants and the negative impact of invasive plants on our environment.
- Install 250 acres of wildlife habitat will be installed.
- Work to reduce stormwater runoff by facilitating programs to establish 100 best management practices.

Howard County

The mission of the Howard County SWCD is "to provide leadership and administer programs to help the people of Howard County improve and conserve the county's environment and natural resources (HCSWCD, 2009)." The current business plan was adopted in 2009 and addresses issues through 2015. The SWCD identified five critical natural resource issues: wildlife habitat, soil erosion, water quality, forestry, and land use development. The following actions, which relate to the Deer Creek-Sugar Creek planning efforts, were identified by the SWCD to be completed by 2015:

- Wildlife habitat shall be increased by 150 acres, 50 of those acres are to be reclaimed/restored
- Install 150 erosion control practices
- Increase low-till corn from 38% to 66%
- Increase no-till beans from 36% to 50%
- Increase riparian buffers and/or filter strips by 50% of eligible target areas
- Improve impaired waterbodies by removing five waterbodies from the EPA's impaired waterbody list.
- Establish 100 acres of trees and increase classified forest and wildlife habitat by 100 acres.
- Provide timber stand improvement for 150 acres of established woodlands.

Miami County

The mission of the Miami County SWCD is to "assist citizens in caring for soil, water, and related resources (MCSWCD, 2012)." In 2013, the Miami County SWCD will adopt a new district business plan. As part of their plan, the SWCD identified the following areas of concern that will be addressed beginning in 2013:

- Streams, rivers, and tributaries decreased quality due to sediment, *E. coli*, nutrients, pesticides, pollutants, and lack of buffers;
- Loss of woodlands and inadequacy of food and habitat for wildlife;
- Soil erosion in agricultural and non-agricultural settings;
- Excessive tillage and grading; and
- Noxious and invasive plants throughout the county.

The concerns identified by the SWCD apply to a small portion of the watershed; nevertheless, because these concerns closely parallel the stakeholder concerns listed in Table 2, this watershed management plan aligns with current planning efforts of the Miami County SWCD. The following actions were identified by the SWCD to be completed by 2018:

- No-till corn practices shall be increased from 13% to 25%.

- Install 75 additional miles of buffers.
- Cover crops shall be increased by 2,500 acres.
- Wildlife habitat shall be increased by an additional 500 acres with 250 acres of tree planting.
- Manure management plans used by an additional 2,000 acres and 4,000 acres using nutrient and pest management plans.
- Convert 400 acres from row crops to hay land.
- Install 7,500 feet of fencing for livestock exclusion.

Tippecanoe County

The mission of the Tippecanoe County SWCD is "to provide quality technical, educational, and informational resources for the community through leadership, service, and citizen involvement to foster natural resource conservation and environmental stewardship (TCSCWD)." As part of their plan the SWCD identified three visions for Tippecanoe County: stable soils, clean streams and water resources, and sustainable communities. These concerns closely parallel the concerns addressed by this plan. The following goals were identified by the SWCD to be completed by 2014:

- No till practices shall be increased by 2,500 acres in the Upper Wabash.
- Cover crops shall be increased by 2,500 acres in Tippecanoe County by 2014.
- The SWCD will educate 20 landowners in high manure application areas on best management practices for manure application by 2014.
- The SWCD will increase streambank stabilization awareness/education through 10 partnering opportunities by 2014.
- The SWCD will educate 150 landowners about the benefits and installation of two-stage ditches by 2014.
- The SWCD will provide 10 educational and/or outreach opportunities on the environmentally wise use of lawn fertilizers and pesticides by 2014.
- The SWCD will educate 750 landowners about beneficial native plants and the negative impact of invasive plants on the environment by 2014.
- 350 acres of wildlife habitat will be installed in Tippecanoe County by 2014.
- The SWCD will work to reduce stormwater runoff by facilitating programs to establish 250 best management practices by 2014.

2.11.3 Little Deer Creek Watershed Management Plan

In January 2003, the Howard County Soil and Water Conservation District received a 205j watershed planning grant for the Little Deer Creek Headwaters watershed (HCSWCD, 2005). The grant was funded by IDEM and the U.S. Environmental Protection Agency (USEPA). A combination of education and implementation of practices were used to meet the goals of the watershed management plan. Maps of the subwatersheds and the water quality results from the plan are in Appendix G. The goals of the plan are detailed below:

- Reduce animal waste contamination of surface water.
- Reduce nutrient and Atrazine loads at watershed outlet.
- Reduce soil loss.

To obtain these goals, an implementation strategy was outlined. The timeline for completing these tasks was approximately three years. The tasks that were identified as ways to reach the above goals are detailed below:

- Management of manure on approximately 3,500 acres or 40% of cropland received manure and ten manure storage units.
- Management of nutrients and pests on approximately 3,500 acres or 40% of cropland.
- Installation of riparian filter strips along five miles of ditches.
- Installation of 25 units of grade stabilization structures along ditches.
- Hosting of education meetings and distribution of educational materials.

The following practices have since been implemented:

- 4 auto guidance systems in accordance with Pest & Nutrient Management
- 2,118.63 acres in Pest & Nutrient Management planning
- 2,472,000 gallons of waste hauling
- 555.5 acres in Comprehensive Nutrient Management planning for waste utilization
- 3 waste utilization Injection Knives
- 2,829.75 acres in Comprehensive Nutrient Management planning for manure management
- 1 Animal Mortality Facility
- 1 Waste Storage pit
- 458 acres in Comprehensive Pest Management planning

2.11.4 Howard County Municipal Separate Storm Sewer System (MS4)

The Howard County Stormwater District was formed in response to a federal mandate by the Environmental Protection Agency (EPA) to obtain and maintain a permit from the Indiana Department of Environmental Management (IDEM) in an effort to reduce stormwater pollution. The District works to maintain this permit, makes capital improvements, does field inspections, and increases public awareness about stormwater pollution problems. Management of the District includes a mix of mandated and elected activities to provide education, coordination, maintenance, and development of a high quality stormwater system. The District's six minimum control measures include: public education, public participation, the elimination of polluted discharge from pipes, the cessation of construction site runoff both during and after construction, and the cessation of stormwater pollution on county facilities. The boundary of the Howard County Stormwater District has only a small overlap with the Deer Creek-Sugar Creek watershed (Figure 42). Within the watershed, the District has conducted de-trashing and clean-up efforts on the South Fork of Deer Creek.

Howard County has 2 two-stage ditches in the Deer Creek watershed, and the Howard County MS4 shares maintenance responsibility for the ditches with the Howard County Surveyor. The Rice-Bell ditch was installed as a mitigation project for the new US 31 bypass with funding from INDOT. The James Gallion ditch was installed by the Howard County Surveyor in cooperation with the Nature Conservancy with funding from the Nature Conservancy. Construction of the ditches was finished in March, 2013, and the District hosted a two-stage ditch workshop which was

attended by The Nature Conservancy, NRCS, IDEM, Notre Dame, Ohio State University, and other participants. Together, the Surveyor and Stormwater staff cover the range of management issues for regulated drains. The Howard County Surveyor is responsible for maintaining the water flow in the ditches and for structural issues. The Howard County Stormwater District is responsible for maintaining water quality in the ditches including discharges from tiles or inflowing streams and dumping of trash or contaminants.

None of the District's CSOs are within the watershed boundary.

2.11.5 Tippecanoe County Partnership for Water Quality Plan

Tippecanoe County, Purdue University, Ivy Tech State College, and the Cities of Battle Ground, Dayton, Lafayette, and West Lafayette signed a joint agreement to collectively manage stormwater issues within the state designated Municipal Separate Storm Sewer System (MS4; Figure 42). This partnership is known as the Tippecanoe Partnership for Water Quality (TCPWQ). Collectively, TCPWQ submitted a notice of intent to accept responsibility for the management of the MS4 and the six designated minimal control measures (MCMs) which include: public education and outreach, public participation/involvement, illicit discharge detection and elimination (IDDE), construction site run-off control, post-construction run-off control, and municipal operations pollution prevention and good housekeeping.

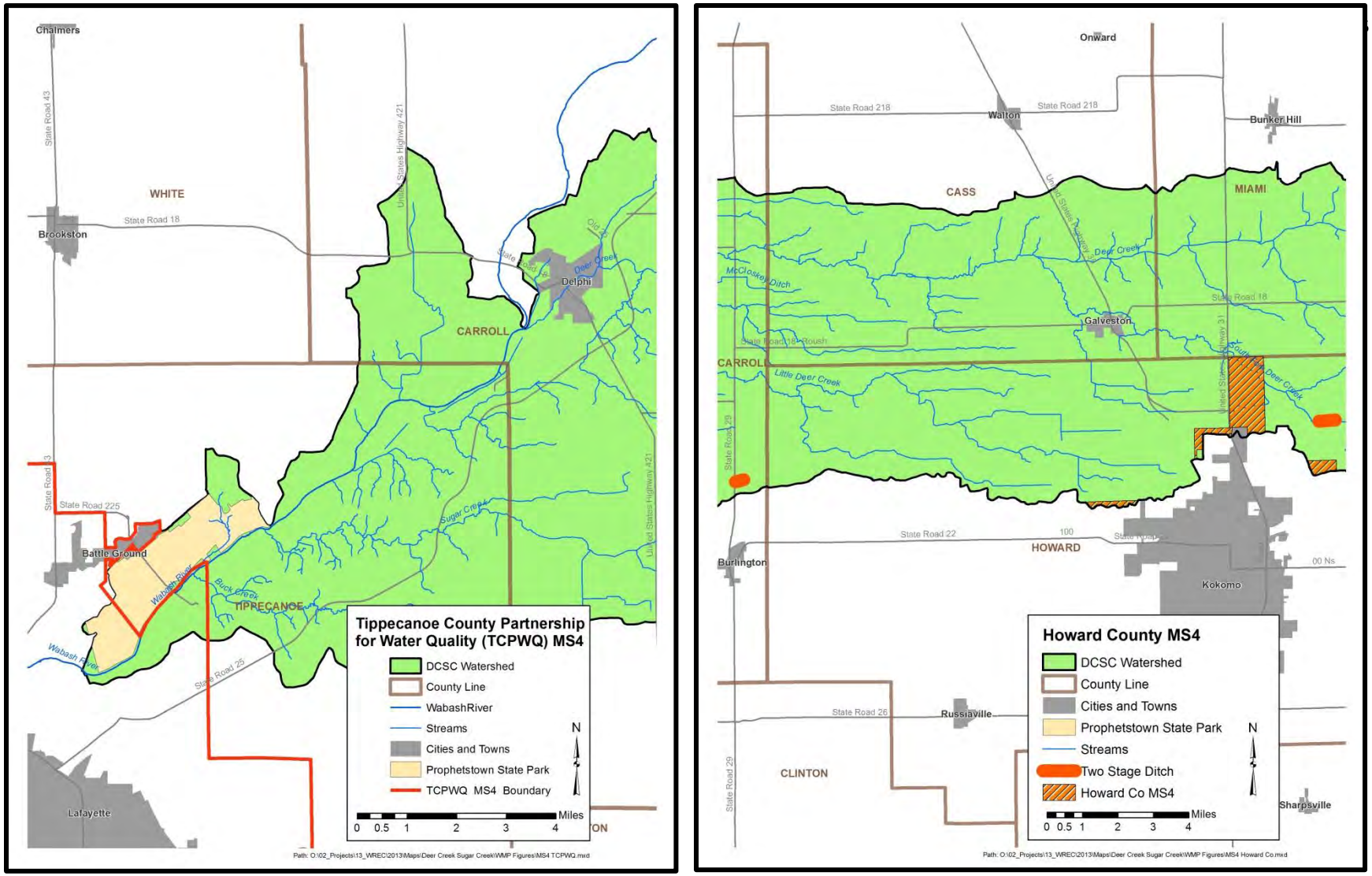

Figure 42. Two Municipal Separate Storm Sewer System (MS4) boundaries overlap the watershed boundary: the Tippecanoe County Partnership for Water Quality MS4 on the left and the Howard County MS4 on the right.
Data used to create this map are detailed in Appendix A.

In May 2004, the Baseline Characterization Report (or Part B) was submitted to IDEM as part of the MS4 permitting process (CBBEL, 2004). The report characterizes the land use and stormwater runoff, identifies sensitive areas and structural and non-structural best management practices,

and specifies priority implementation areas within the MS4. Based on the fact that agricultural land uses dominate the MS4 area (60%), the implementation of agricultural best management practices focused on sediment and nutrient transport reduction are encouraged. The recommended best management practices include conservation tillage, nutrient and pesticide management, buffer strips, and wetland restoration. The implementation of these items will assist in addressing stakeholder concerns relating to sediment erosion and transport and high nutrient concentrations. Addressing the next highest land use as urban land use, accounting for 13% of the MS4 region, the baseline characterization report recommends adoption of a comprehensive stormwater ordinance and identifies urban best management practices for each MCM.

2.12 Watershed Summary: Parameter Relationships

Several relationships among watershed parameters become apparent when watershed-wide data are examined. These relationships are discussed here in general, while specific subwatershed related relationships are discussed in more detail in subsequent sections.

2.12.1 Bedrock, Topography, and Land Forms

Geology throughout the Deer Creek-Sugar Creek watershed is dominated by the Wabash Formation with the exception of the lower portions of Sugar, Buck, and Deer Creeks in Tippecanoe County and the eastern part of Carroll County. These areas are underlain by the New Albany Shale and Muscatatuck Group bedrocks. The erosive nature of these bedrocks paired with a concentration of highly erodible soils in these areas could increase the potential for steep banks and loss of land. The highest concentration of existing steep slopes is already in this portion of the watershed, adjacent to Sugar, Buck and lower Deer Creek. Any water quality improvements required in these areas of the watershed will need to target the unique soils, topography, and land uses associated with this area.

2.12.2 Unsewered Areas and Septic Soil Suitability

Nearly the entire watershed is covered by soils considered severely limited for use in septic tank absorption fields, yet only a small portion of the watershed is served by sewer infrastructure. Though the overall population of the watershed is small and sparsely distributed, 90% of survey respondents have septic systems, most with absorption systems. This presents a good opportunity for focused education and outreach on the importance of proper septic maintenance and the role it can have in impacting water quality.

2.12.3 Floodplains and Land Cover

Flooding is an issue for many farmers in the watershed, and a significant amount of the floodplains are currently used as crop lands. Mitigation measures to ease storm runoff and flooding are important on cropped floodplain areas and also upstream in order to reduce the potential for floods to have deleterious impacts to crop lands.

2.12.4 ETR Species and Recreational Opportunities

The large tract of historically significant and publicly-owned land at Prophetstown State coupled with the variety of endangered, threatened, and rare species in this part of the watershed creates a unique management opportunity. Publicly-owned land that is routinely visited by watershed

stakeholders provides a great opportunity to positively impact water quality. This area could serve as a demonstration site which will allow stakeholders to view management options before enacting them on their own property. Stakeholder's love for this area, willingness to protect high quality species and habitat, and their desire to positively impact water quality and the environment will increase the opportunity present in the watershed to improve water quality.

2.12.5 Impaired Waterbodies

Public concern about water quality is supported by state impairment designations. State-assessed waterbodies in the watershed are listed as impaired because they routinely exceed the *E. coli* water quality standard. Four waterbodies are listed with multiple impairments in addition to *E. coli* such as nutrients, impaired biotic communities, mercury, and PCBs in fish tissue samples.

2.12.6 Manure Application and Farming in Floodplains

Most of the waterbodies in the watershed run through agricultural land that is intensely cultivated (greater than 75%). Many of the confined feeding operations and smaller unregulated farms are located adjacent to streams and tributaries. Some of the lands permitted for manure and municipal sludge application are also adjacent to creeks and streams in the watershed. The proximity of these activities to watershed waterbodies increases the chance for runoff to carry nutrients into the streams and eventually into the Wabash River.

2.12.7 Coordinated Efforts

Jurisdictions within the watershed are also actively working towards water quality improvement goals. The county comprehensive plans state broad goals to protect water quality and natural areas in the floodplains. Soil and Water Conservation Districts have all identified issues of concern which closely parallel the issues identified by watershed stakeholders including soil erosion, nutrient application, stormwater runoff, and loss of wildlife habitat. The SWCDs are each committed the installation of specific quantities of water quality improvement best management practices such as manure, nutrient, and pesticide management; filter strips; conservation and no till practices; habitat restoration; stormwater runoff reductions; education; cover crops; and livestock access exclusion. All of these practices will be included in this plan to further efforts to improve water quality, and each of the SWCDs are ideal partners for accessing watershed communities interested in conservation practices. Additional entities in Howard and Tippecanoe Counties (the Howard County MS4 and TCPWQ) are also already taking a proactive stance in promoting best management practices and also make ideal partners for the implementation of the WMP.