Big Pine Creek
and Mud Pine Creek
Watershed Management Plan

HUC 0512010803 and 0512010804

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The Soil and Water Conservation District staff from Benton, Warren and White counties, Jon Charlesworth, Debra Lane, and Sharon Watson, have been active members of the steering committee and over the course of two years have successfully taken on leadership of the watershed management planning process and implementation of BMPs going forward.

We would like to thank all those community members and conservation professionals who have participated in the planning process, providing valuable input for the development of this watershed management plan and dedicating time and resources to implementing the recommendations in the plan. With their dedication to this work, the steering committee is confident that the plan will be successfully implemented, resulting in improved water quality and quality of life in the Big Pine Watershed.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF APPENDICES

ACRONYM LIST

ac	acre
APC	Area Plan Commission
BFE	Base Flood Elevation
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CFO	Confined Feeding Operation
cfs	cubic feet per second
CR	County Road
CSO	Combined Sewer Overflow
CTIC	Conservation Technology Information Center
CWP	Center for Watershed Protection
D/S	downstream
E. coli	Escherichia coli
FCA	Fish Consumption Advisory
FEMA	Federal Emergency Management Agency
FIRMS	Flood Insurance Rate Maps
FNR	Fisheries and Natural Resources
GIS	Geographic Information Systems
HES	Highly Erodible Soil
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ISDH	Indiana State Department of Health
IWF	Indiana Wildlife Federation
IWMA	Integrated Water Monitoring Assessment
lb	pound
lb/yr	pound per year
LEED	Leadership in Environment and Energy Design
LID	Low Impact Development
L-THIA	Long-Term Hydrologic Impact Assessment
LUST	Leaking Underground Storage Tank
MCM	Minimum Control Measure
mg/L	milligram per liter
MGD	Million Gallons Per Day
mIBI	macroinvertebrate Index of Biotic Integrity
MS4	Municipal Separate Storm Sewer System
msl	mean sea level
NASS	National Agricultural Statistics Service
NICHES	Northern Indiana Citizens Helping Ecosystems Survive
NO3	Nitrate-nitrogen

NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PCB	Polychlorinated Biphenyls
PHES	Potentially Highly Erodible Soils
PTI	Pollution Tolerance Index
QHEI	Qualitative Habitat Evaluation Index
RC&D	Resource Conservation and Development
RM	River Mile
SRCER	Stream Reach Characterization Evaluation Report
SWCD	Soil and Water Conservation District
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TP	Total Phosphorus
TSS	Total Suspended Solid
U/S	Upstream
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
UZO	Unified Zoning Ordinance
WMP	Watershed Management Plan
WQI	Water Quality Index
WQS	Water Quality Standard
WREC	Wabash River Enhancement Corporation
WRHCC	Wabash River Heritage Corridor Commission
WWTP	Wastewater Treatment Plant

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 drainageways 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 Wabash River watershed includes all the land that drains into the Wabash River. The river starts in Ohio and drains about 7,300 square miles by the time it passes through the current watershed project area, before turning to the south from its westward course upstream (Figure 1). The Big Pine Creek and Mud Pine Creek watersheds include the area that drains into the Wabash River from portions of Benton, Tippecanoe, Warren, and White counties in west-central Indiana.

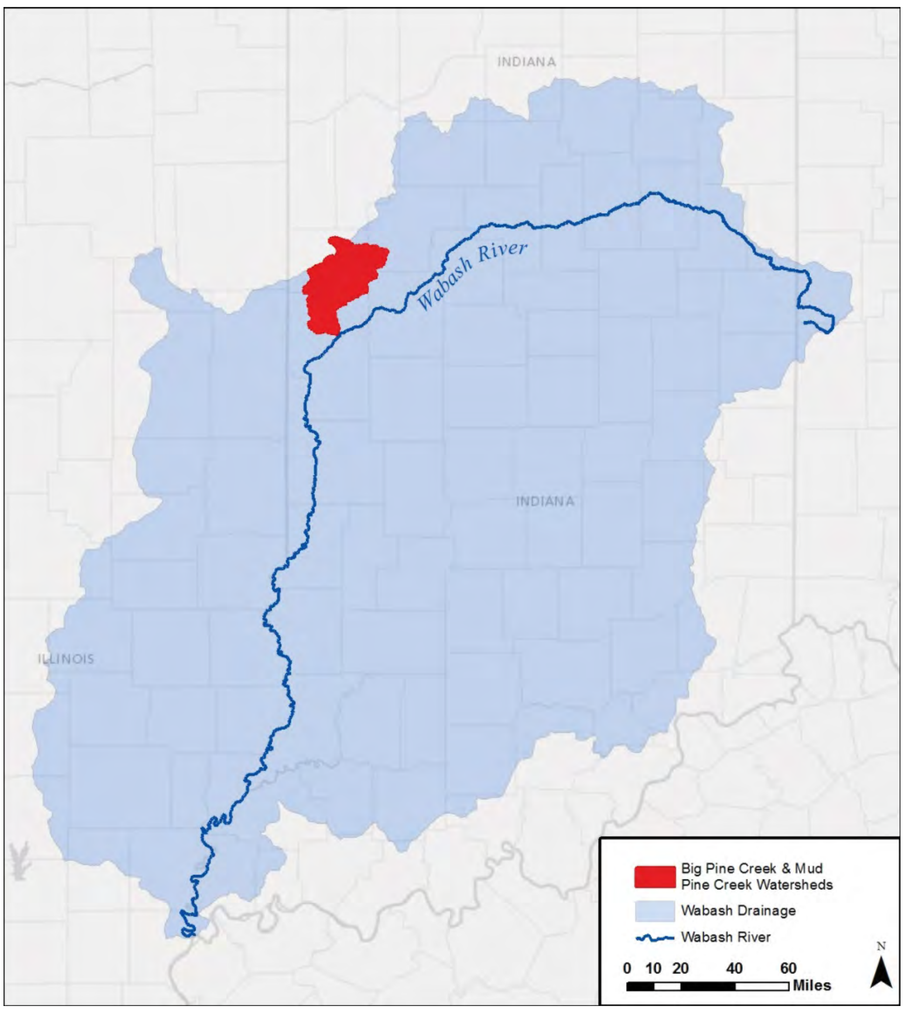

Figure 1. Wabash River watershed, highlighting the Big Pine Creek and Mud Pine Creek project area.
Data used to create this map are detailed in Appendix A.

By managing and improving this portion of the Wabash River watershed, we can do our part to improve water quality in the Wabash River. The following section describes the history of the project including funding details, project purpose, and stakeholder involvement.

1.1 Project History

In the fall of 2007, The Nature Conservancy contracted with Midwest Biodiversity Institute to develop a comprehensive assessment of the current research related to water quality and diversity in the Wabash River (Armitage and Rankin, 2009). That assessment led to the development in 2010 of a list of Wabash River subwatersheds that were the largest contributors of sediment, nutrients, and other contaminants to the river. These watersheds were no regrets places to engage in watershed protection, develop the missing science to narrow down the stresses and then address those issues through education and on the ground best management practice installation. In total, approximately 20 such subwatersheds were chosen as potential project areas and prioritized for further work by the Conservancy and its partners. In 2013, a proposal to the Pulliam Foundation was awarded to work on some of these priority watersheds, including Big Pine Creek in west central Indiana. The Big Pine had interested local support and it fell within the programmatic interests of potential partners such as the Wabash River Enhancement Corporation (WREC), Niches Land Trust, and the Conservation Technology and Information Center (CTIC). In the summer of 2013, the Conservancy assembled a group of partner organizations interested in improving water quality in the Big Pine, including WREC, Niches Land Trust, CTIC , Benton and Warren County Soil and Water Conservation Districts, and the Natural Resources Conservation Service (NRCS). This group formed a Steering Committee (Table 1), conducted windshield surveys of the watershed, and held several meetings open to the public in order to generate input in the development of a watershed management plan for the Big Pine. All of these efforts were guided by the following mission and vision developed by public participants and committee members:

Mission: *Voluntarily conserve and improve the natural environment while balancing interests of stakeholders in the Big Pine Creek watershed*.

Vision: *Big Pine Creek watershed is the anchor and an asset to the community.*

The mission and vision are works in progress and may change as the project moves forward.

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. We involved stakeholders in the watershed management planning process through a series of public meetings, and education and outreach events including windshield surveys, water quality monitoring opportunities, and meetings with local officials.

1.2.1 Steering Committee

Individuals representing the towns and counties within the watershed, environmental groups, natural resource professionals, agricultural and commercial representatives, and private citizens comprised the steering committee. The steering committee has met nearly every month to develop the WMP, starting in July 2013. The group continues to meet on a monthly basis to discuss implementation strategies, progress of the cost-share program, outreach, grant opportunities, and make revisions to the WMP. Table 1 identifies the steering committee members and their affiliation.

Table 1. Big Pine watershed steering committee members and their affiliation.

Steering Committee Member	Organization(s) Represented
Alan Anderson	A Plus Farms
Linda Anderson	Citizen
Dave Bechman	Farm Manager
Bryan Berry	Benton County Commissioner, Farmer
Bob Brutus	Citizen
Jason Carlile	Carlile Ag
Pat Carlson	Benton County Councilman, Farmer
Jon Charlesworth	Benton County SWCD
Wayne Creech	Citizen
Denny Dispennett	Ceres Solutions
Steve Eberly	Warren County Commissioner
Gwen Erwood	Citizen
Macy Fawns	Purdue Extension, Benton County
John Fielding	Farmer, White Co. SWCD member
Dave Fisher	Benton County Surveyor
Chris Freeland	Dwenger Excavating
Dana Goodman	Citizen
Ron Haston	Haston Habitat
Larry Johnson	Dow Agrosciences
Larry Killmer	Farmer, White Co. SWCD member
Ben Lambeck	Warren County NRCS
Deb Lane	Warren County SWCD
Kevin Leuck	Benton County Commissioner
Tim Muller	Citizen
Mike Murr	Friends of Big Pine
Brian Nentrup	Pheasants Forever/Quail Forever
Gus Nyberg	NICHES Land Trust
Sara Peel	Wabash River Enhancement Corp
Mani Phengrasmy	NRCS
Mike Pluimer	Ceres Solutions
Lamar Reinhart	Dow Research Facility
Art Reumler	Farmer
Karen Scanlon	Conservation Technology Information Center
Michelle Scherer	Benton County SWCD
John Shuey	The Nature Conservancy
Willie Smith	Senesac Inc
Robert Sondgeroth	Farmer
Angela Sturdevant	The Nature Conservancy
Geneva Tyler	ISDA
Carl Voglewede	NRCS APHIS
Kent Wamsley	The Nature Conservancy
Matt Washburn	Pheasants Forever
Sharon Watson	White County SWCD
Chad Watts	Conservation Technology Information Center
Matt Williams	The Nature Conservancy

Steering Committee Member	Organization(s) Represented
Sarah Wolf	ISDA

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. There were two public meetings held – one in Warren County and one in Benton County. The purpose of the public meetings was to provide information on the overall planning effort and its progress; solicit stakeholder input, opinions, and participation; create opportunities for the public to recommend programs, policies, and projects to improve water quality; and build support for future phases of the project.

The public meetings were advertised through press releases distributed to local newspapers in the watershed, as well as a community calendar on a local radio station (WIBN). The meetings were also advertised through word of mouth as staff from the Soil and Water Conservation District put together mailings that advertised the events, and The Nature Conservancy sent e-mails to its members who live within the watershed.

The first public meeting was held on January 9, 2014 at the Pine Village Christian Church in Pine Village, Indiana. Attendees represented citizens, farmers, and city officials. During this meeting, the Conservancy detailed the history of the project; described opportunities for individuals to volunteer as part of the project; and provided attendees with the opportunity to identify their concerns about the Big Pine Creek and its watershed, and develop goals for the long-term vision of the stream.

A second public meeting was held on March 20, 2014 at the Government Center in Fowler, in an effort to reach more agricultural producers in Benton County. A focus group of influential producers in the watershed was gathered for an hour before the public meeting began, to allow producers to discuss in more detail their concerns and needs. This was an effective way of increasing participation among this group, and it generated some good discussion.

1.2.3 Educational Materials and Events

A Big Pine watershed brochure was developed to highlight opportunities for individuals to get involved with the project, identify community partners, and provide general information and fun facts about the watershed, watershed management planning, and the project (see Appendix B). The brochure will be distributed at committee, public, and group meetings and at education events throughout the lifetime of the project. Material about the Big Pine watershed will be developed and included on The Nature Conservancy’s website as well as the website for the Wabash River Enhancement Corporation and the Conservation Technology and Information Center’s website. SWCD staff attended the Warren and Benton county fairs in 2014 and 2015 to distribute information about the watershed project.

1.3 Public Input

Throughout the planning process, project stakeholders, the steering committee, and the general public listed concerns for Big Pine Creek, its tributaries, and its watershed. Public and committee meetings were the primary mechanism of soliciting individual concerns. All comments were recorded and included as part of the concern documentation and prioritization process. Concerns voiced throughout the process are listed in Table 2. Similar stakeholder concerns were grouped roughly by topic and condensed by the committee. The order of concern listing does not reflect any prioritization by watershed stakeholders.

Table 2. Stakeholder concerns identified during public input sessions, July 2013 to July 2014, and watershed inventory process.

Stakeholder Concerns	Condensed Concerns
What is a watershed management plan?	Limited understanding of the planning process and its goal.
Why are we embarking on this project?	Limited knowledge of inputs and issues within the watershed.
Groundwater impacts and hydrology of the system needs to be better understood.	Groundwater understanding and management needed.
Confined feeding operations identified during inventory process.	Confined feeding operation management needed
Manure and nutrient management issues identified during inventory.	Nutrient management on cropland needed.
	Manure storage facilities needed.
Need clear water – very muddy.	High turbidity.
High turbidity.	
Flashiness – big rain causes a big jump in water levels very quickly.	Stream is too flashy
Water level fluctuations.	
High flashiness and high turbidity.	
Maintain drainage outlet – be careful to balance drainage needs with other needs.	Stream is a drainage outlet and should be maintained as such.
Invasive species are present on the streambanks.	Invasive species are present along the stream banks and in the creek.
Poor water quality (compared to other streams).	Poor water quality.
Trash.	Trash needs to be kept out of the creek.
Keep the creek clean.	
Maintain aesthetic conditions.	Maintain the aesthetic conditions.
Community needs to maintain its connection to the stream.	Community needs to connect to the stream more.
Get people out on the creek – celebrate Big Pine Creek.	
Log jams – prevention and removal are needed especially in Mud Pine Creek.	Too many logjams; untimely logjam removal.
Keep land where it is at/reduce erosion.	Soil erosion occurs throughout watershed.
Soil erosion occurs throughout the basin especially in Mud Pine Creek.	
HES identified during watershed inventory.	Highly erodible soils are cropped and need to be managed better
Oxford wastewater treatment plant operations are of concern.	Oxford needs to expand their WWTP; they currently use a lagoon system for finishing.
Water quality data indicate high nutrients and E. coli immediately upstream of the IDEM fixed station.	Pine Village needs to improve their septic practices.
Pine Village needs a town wide wastewater treatment system (underway).	
Boswell septic and sewer issues; flooding impacts the town.	Boswell needs to improve their septic practices.
Fowler wastewater effluent enters Big	Fowler's wastewater treatment plant drains into

Stakeholder Concerns	Condensed Concerns
Pine Creek.	the watershed.
Templeton – excessive irrigation pumping.	Templeton's stormwater and wastewater is not understood.
Improve grassland habitat and reduce erosion.	Healthy grassland habitat needs to be emphasized for wildlife.
Woodland habitat needed.	Woodland habitat needs to be improved for wildlife
Cattle have access to Big Pine Creek.	Livestock access to the stream.
Livestock access identified during inventory.	
Producers are starting to use cover crops but no till use could be improved; overall increase use of both practices.	Producers need to be educated on potential practices they could use to increase production and reduce impacts to the stream.
Cover crop and no till need identified during inventory.	
Drainage water management-few have been installed in the watershed but most producers don't like labor intensive nature of the practice.	
Additional farming BMP's would be helpful in the upper reaches of the Big Pine drainage in Warren County.	
No official public access site.	No official public access is available.
Aquifers, recharge, and the Teays River Valley need to be protected and better understood.	Aquifers, recharge, and the Teays River Valley need to be protected and better understood.
Tile nutrient transport – is this a problem and if so, how big of a problem. Education on this issue is needed.	Tile nutrient transport- is this a problem, and if so, how big of a problem?
Irrigation education needed – use, need for it, etc.	Water quantity issues are a concern given the pumping for agriculture and the recent problems with dry wells in Templeton.
Water quantity issues, given the pumping for agriculture and the recent problems with dry wells in Templeton.	

2.0 WATERSHED INVENTORY I: WATERSHED DESCRIPTION

2.1 Watershed Location

The Big Pine watershed is part of the Middle Wabash-Little Vermilion watershed and covers portions of Benton, Warren, Tippecanoe, and White counties (Figure 2). The watershed extends from Interstate 65 in White County to west of State Road 41 in Benton County, and drains southward until emptying into the Wabash River near the town of Attica. The Big Pine watershed covers 209,709 acres or 329 square miles and includes all of Boswell, Pine Village, and Oxford, as well as the southern half of Fowler.

2.2 Subwatersheds

2.2.1 10-digit Hydrologic Unit Code Watersheds

Big Pine Creek watershed is composed of two 10-digit Hydrologic Unit Codes (HUC): Mud Pine Creek (0512010803) and Big Pine Creek (0512010804) (Figure 2). The Mud Pine Creek watershed covers 61,900 acres and the Big Pine Creek watershed covers 147,809 acres. Big Pine Creek watershed is bordered to the north by the Iroquois watershed, to the west by the Vermillion watershed, to the east by the Great Bend of the Wabash and Tippecanoe watersheds, and to the south by the Wabash River.

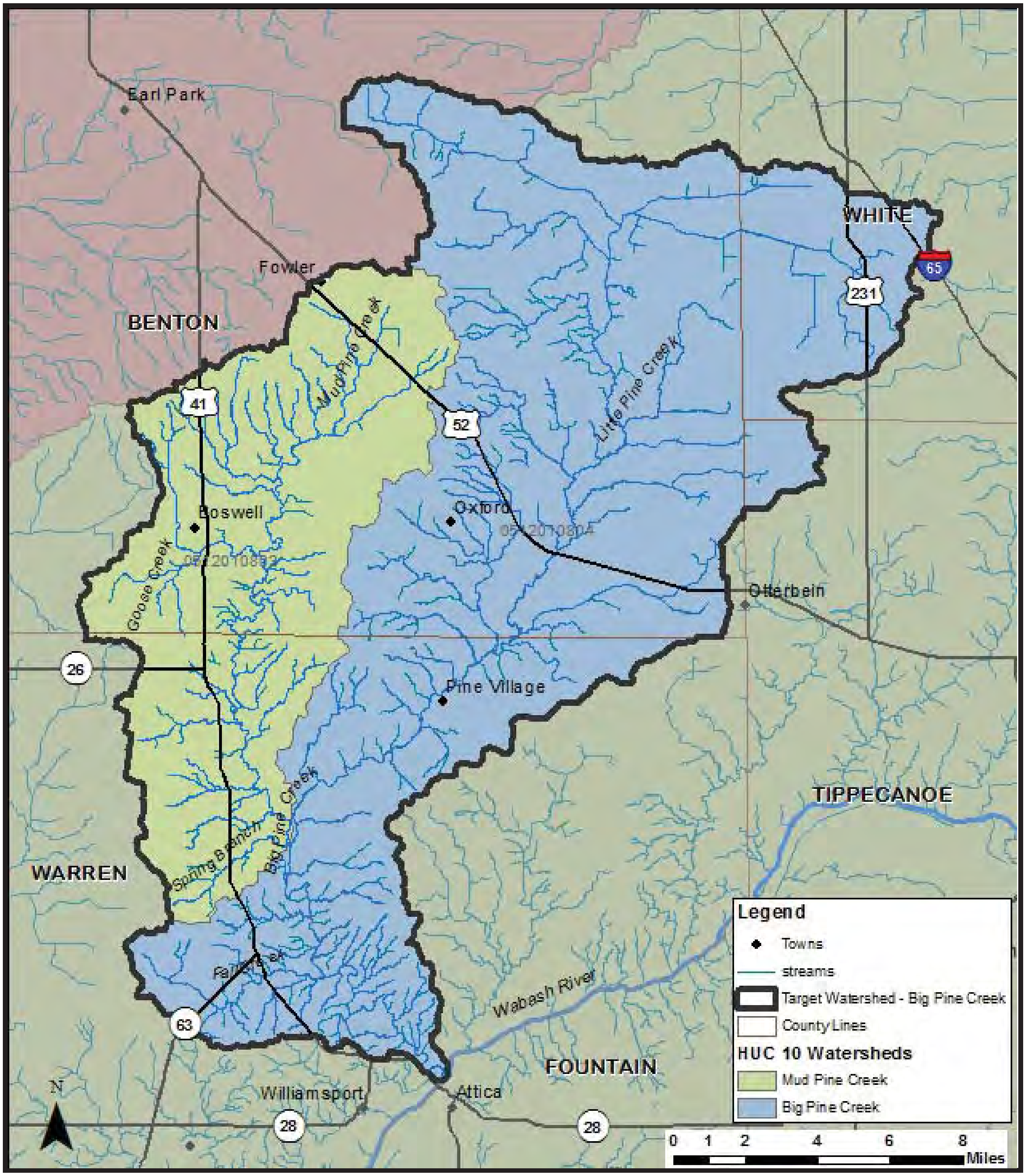

Figure 2. Big Pine Creek watershed highlighting the two 10-digit Hydrologic Unit Code (HUC) watersheds.

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

2.2.2 Big Pine Creek Tributary Watersheds

In total, fourteen 12-digit Hydrologic Unit Codes are contained within the Big Pine Watershed (Figure 3, Table 3). The subwatersheds range in size from about 10,000 acres or

16 square miles to nearly 24,000 acres or 37 square miles. Each of these drainages will be discussed in further detail under *Watershed Inventory II*.

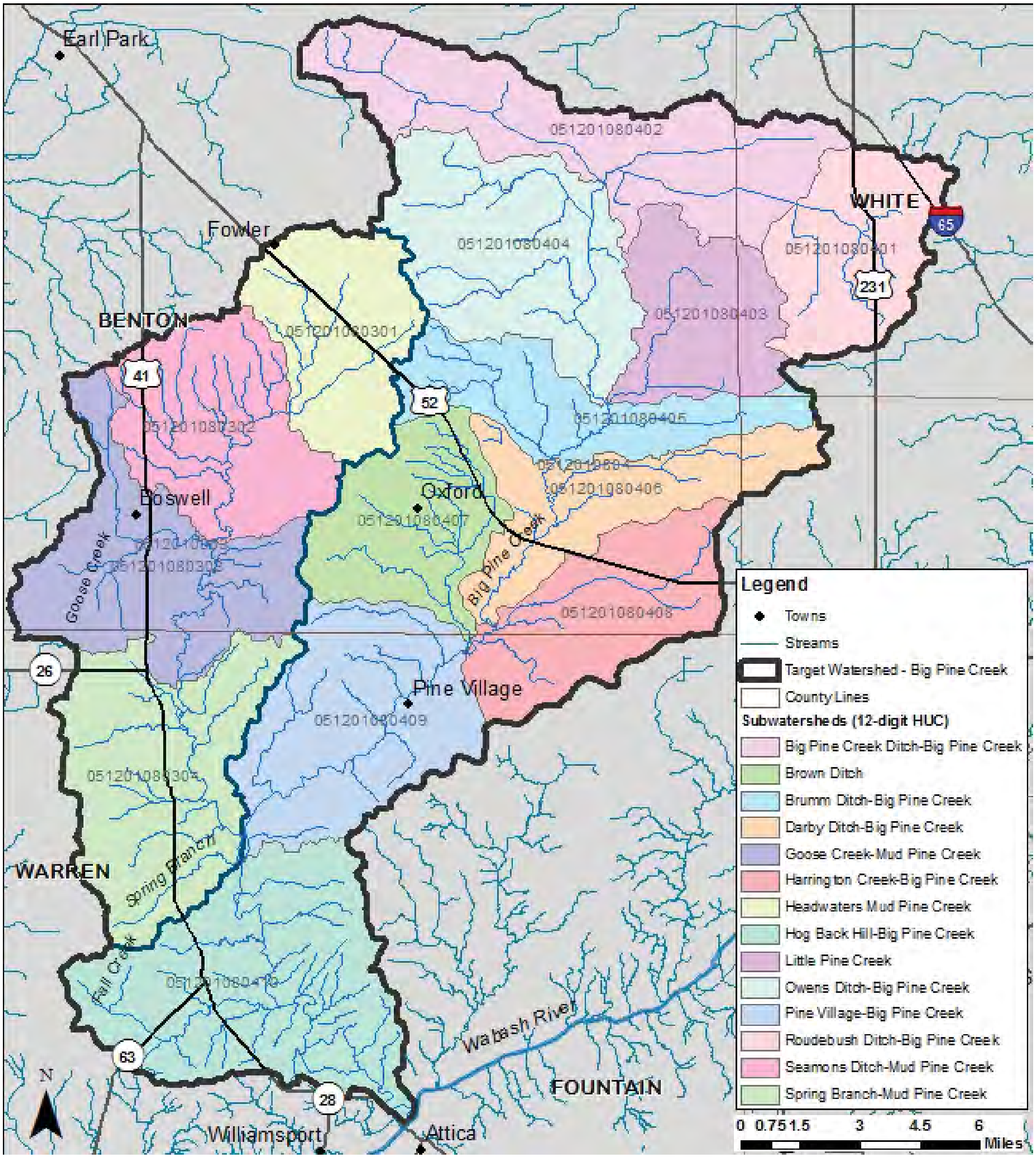

Figure 3. 12-digit Hydrologic Unit Codes in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 3. 12-digit Hydrologic Unit Code (HUC) watersheds in the Big Pine Creek watershed

Name	HUC 12	Area (Acres)	Area (Sq mi.)
Headwaters Mud Pine Creek	051201080301	12,019	19
Seamons Ditch-Mud Pine Creek	051201080302	14,432	23
Goose Creek-Mud Pine Creek	051201080303	16,867	26
Spring Branch-Mud Pine Creek	051201080304	18,582	29
Roudebush Ditch-Big Pine Creek	051201080401	11,273	18
Big Pine Creek Ditch-Big Pine Creek	051201080402	19,725	31
Little Pine Creek	051201080403	10,058	16
Owens Ditch-Big Pine Creek	051201080404	17,921	28
Brumm Ditch-Big Pine Creek	051201080405	11,030	17
Darby Ditch-Big Pine Creek	051201080406	11,756	18
Brown Ditch	051201080407	11,850	19
Harrington Creek-Big Pine Creek	051201080408	12,873	20
Pine Village-Big Pine Creek	051201080409	17,652	28
Hog Back Hill-Big Pine Creek	051201080410	23,671	37

2.3 Climate

In general, Indiana has a temperate climate with warm summers and cool or cold winters. The Big Pine watershed is no different. Climate in this watershed is characterized by four distinct seasons throughout the year. High temperatures measure approximately 85^{o}F in July and August, while low temperatures measure near freezing (31^{o}F) in January. The growing season typically extends from early April through late October with the season being slightly longer in the southern portion of the watershed, including Warren County, and slightly shorter in the northern portion of the watershed (White County). On average, 32 inches of precipitation occur within the watershed with precipitation as small, frequent rain events spread almost evenly throughout the year. Figure 4 details average precipitation from just outside the watershed in West Lafayette from 1971 to 2007. Meliora Environmental Design (2009) note that more than 93% of rain events include less than one inch of rain with these events accounting for more than 70% of annual rainfall.

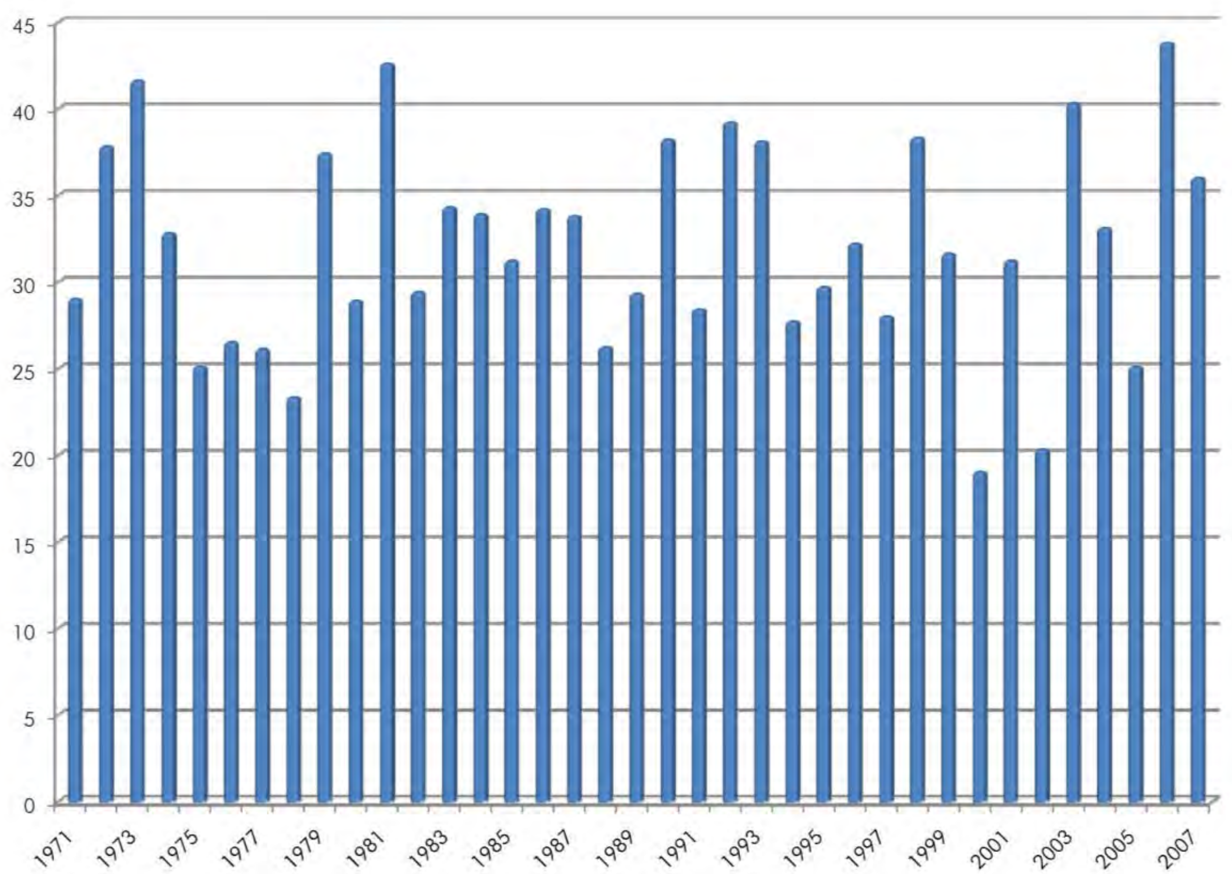

Figure 4. Average rainfall in inches per year from 1971 to 2007.

2.4 Geology and Topography

The geology and topography of the Big Pine watershed in west-central Indiana is directly influenced by the advance and retreat of the Saginaw and Erie Lobes of the Wisconsinian glaciation (IDNR, 1980). Bedrock deposits are from the Devonian and Mississippian ages and generally consist of shale, siltstone, and limestone (Rosenshein, 1958). Unconsolidated drift deposits overlie the bedrock with deposits ranging from a few inches to 425 feet thick throughout the watershed. Glaciofluvial and waterlain till deposits cover nearly 75% of the watershed with dense clay and sand predominating. Within these locations, water stands on the clay soils resulting in slow percolation. Water moves quickly through the outwash soils. In some cases, irrigation is used for crop growth. In the northern portion of the watershed, lake sand covers much of area. This lake plain is a remnant of the Kankakee Lake, which covered much of west-central Indiana during historic glaciation (McBeth, 1901).

The topography, surficial geology, soil development, and bedrock geology in the Big Pine watershed were directly influenced by the advance and retreat of the Saginaw-Huron, Michigan, and Erie lobes of ice during the Wisconsinan glaciation (McBeth, 1899). The bedrock deposits of the watershed are from the Devonian and Mississipian ages. These rocks consist of dolomite and limestone overlain by shale (Clark, 1980). The unconsolidated deposits above the bedrock range from 150-200 feet thick in the watershed. The deepest unconsolidated unit is a dense, clay-loam till. In most of the watershed glaciofluvial deposits overlie the clay till. The glaciofluvial deposits consist of sand and gravel imbedded with clay (Clark, 1980).

The topography of the Big Pine watershed is relatively flat as is typical of the Tipton Till Plain region in which the watershed is located (Figure 5). The relatively flat topography is interrupted both by a series of parallel end moraines or hills and by the Wabash River. The Wabash River at the very southern end of the watershed cuts through the flat plain flowing through a wide deposit of gravel (McBeth, 1899), and is the lowest point in the Big Pine watershed, while the highest ground is found in Benton County between Fowler and Oxford (Figure 6).

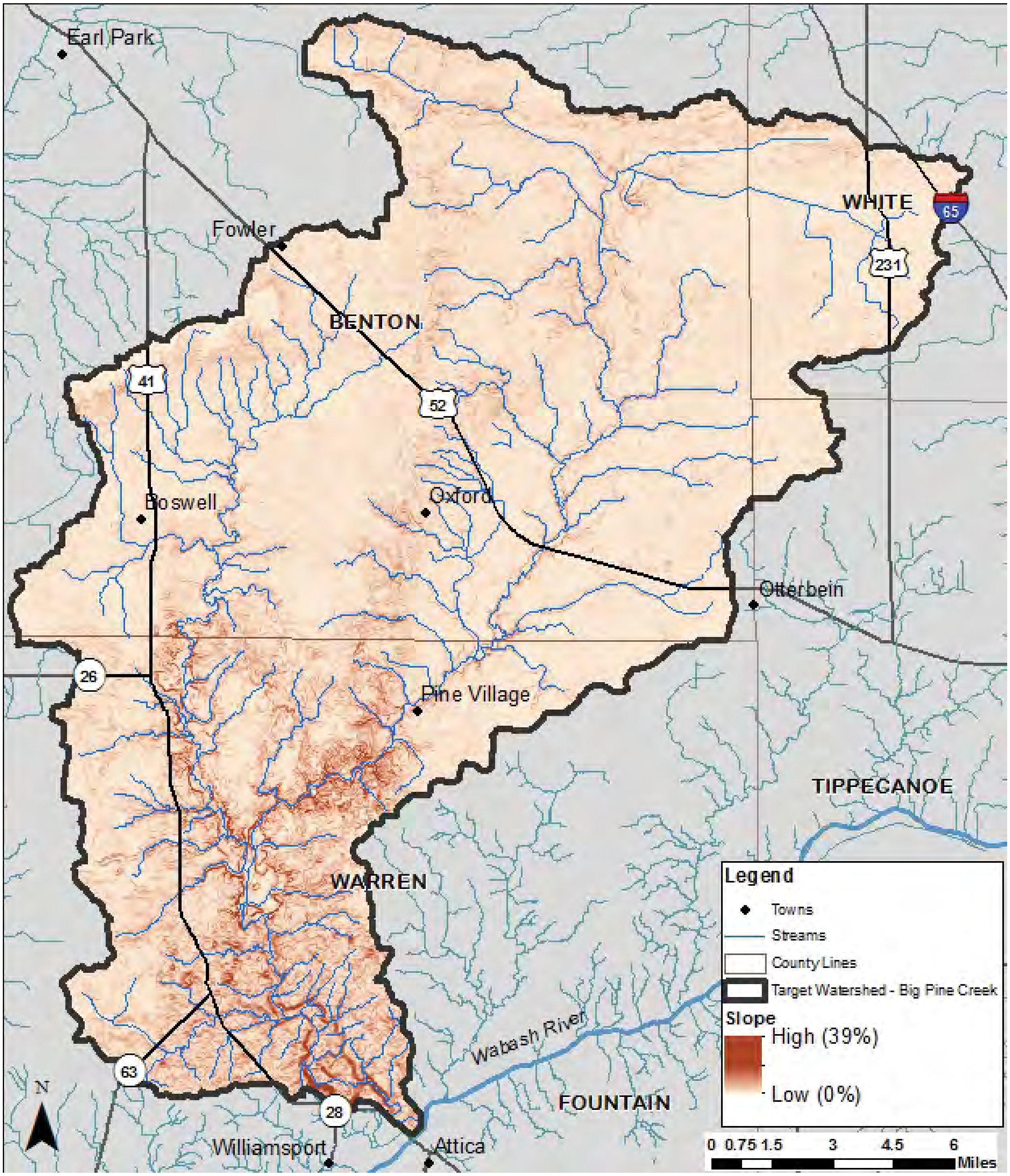

Figure 5. Surface slope of the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

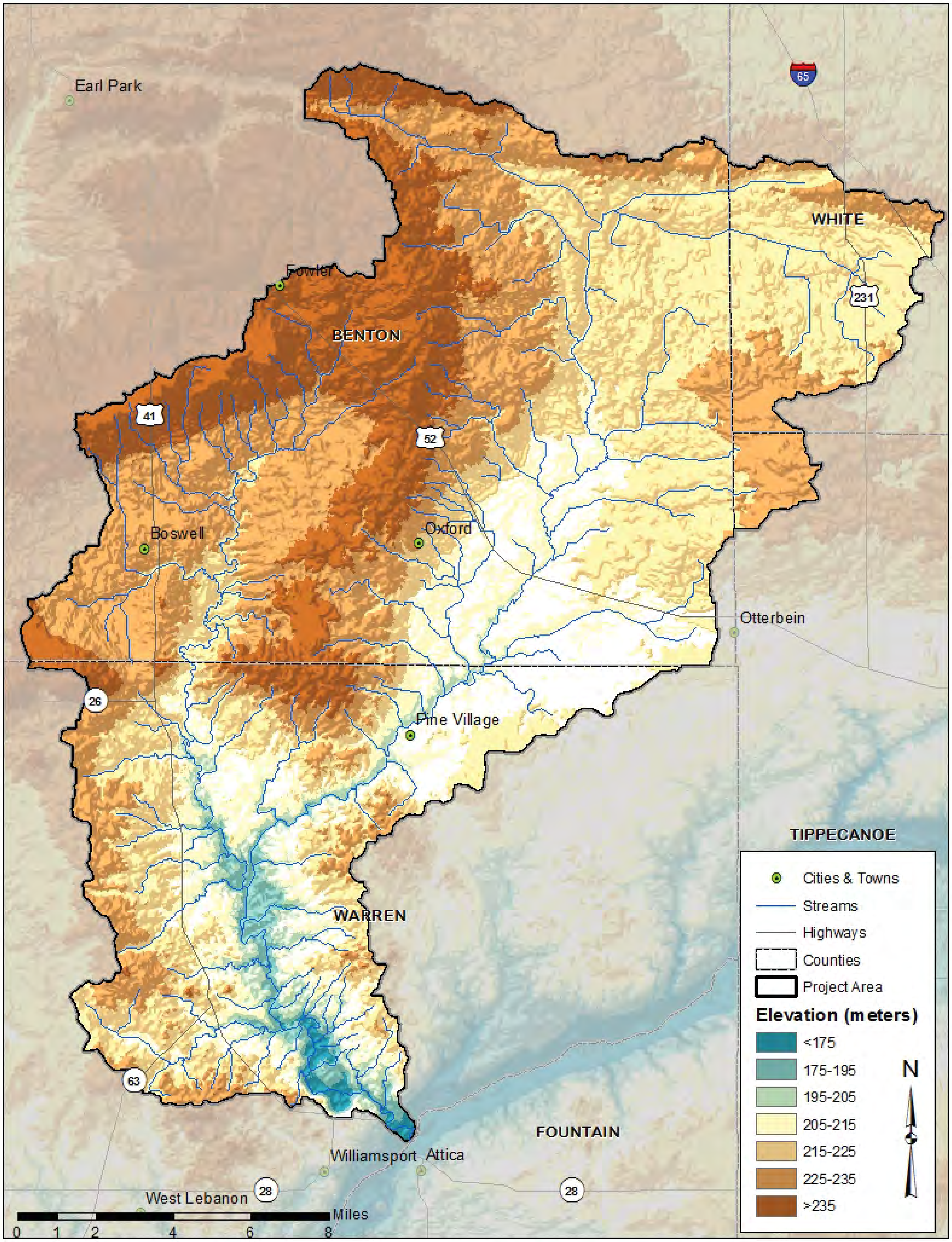

Figure 6. Surface elevation in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5 Soil Characteristics

There are hundreds of different soil types located within the Big Pine watershed. These soil types are delineated by their unique characteristics. The types are then arranged by relief, soil type, drainage pattern, and position within the landscape into soil associations. These associations provide the overall characteristics across the landscape. Soil associations are not used at the individual field level for decision making. Rather, the individual soil types are used for field-by-field management decisions. Some specific soil characteristics of interest, including septic limitations and soil erodibility, for watershed and water quality management are detailed below.

2.5.1 Soil Associations

The watershed is covered by 10 soil associations with three associations combining to cover nearly two-thirds of the total watershed area. The Drummer-Toronto-Wingate soil association dominates east of Big Pine Creek, covering nearly 24% of the watershed (Table 4). The Drummer-Toronto-Wingate association lies within till deposits and is somewhat poorly drained with slow permeability. This association possesses slopes of 0 to 6% and most are cropped in a corn-soybean rotation (USDA, 2014). The Saybrook-Drummer-Parr association dominates in the northwest portion of the watershed in Benton County, with moderately well drained soils formed on till plains with 0-20% slope. The Sawmill-Lawson-Genesee soil association borders Big Pine Creek at the lower end of the watershed, characterized by poorly drained soils formed on floodplains. Adjacent to this on steeper slopes, the Miami-Miamian-Xenia soil association is found, with a high potential for surface runoff (Figure 7).

Table 4. Soil associations in the Big Pine Creek watershed

Soil Name	Area (Acres)	Percent of Watershed
DRUMMER-TORONTO-WINGATE	48,757	23.7%
SAYBROOK-DRUMMER-PARR	47,734	23.2%
MIAMI-MIAMIAN-XENIA	39,725	19.3%
BARCE-MONTMORENCI-DRUMMER	23,383	11.4%
WARSAW-LORENZO-DAKOTA	14,523	7.1%
WOLCOTT-ODELL-CORWIN	11,924	5.8%
SAWMILL-LAWSON-GENESEE	10,539	5.1%
MORLEY-MARKHAM-ASHKUM	7,522	3.7%
BLOUNT-GLYNWOOD-MORLEY	1,448	0.7%
MARTINSVILLE-WHITAKER-RENSSELAER	434	0.2%
Total	**205,989**	**100%**

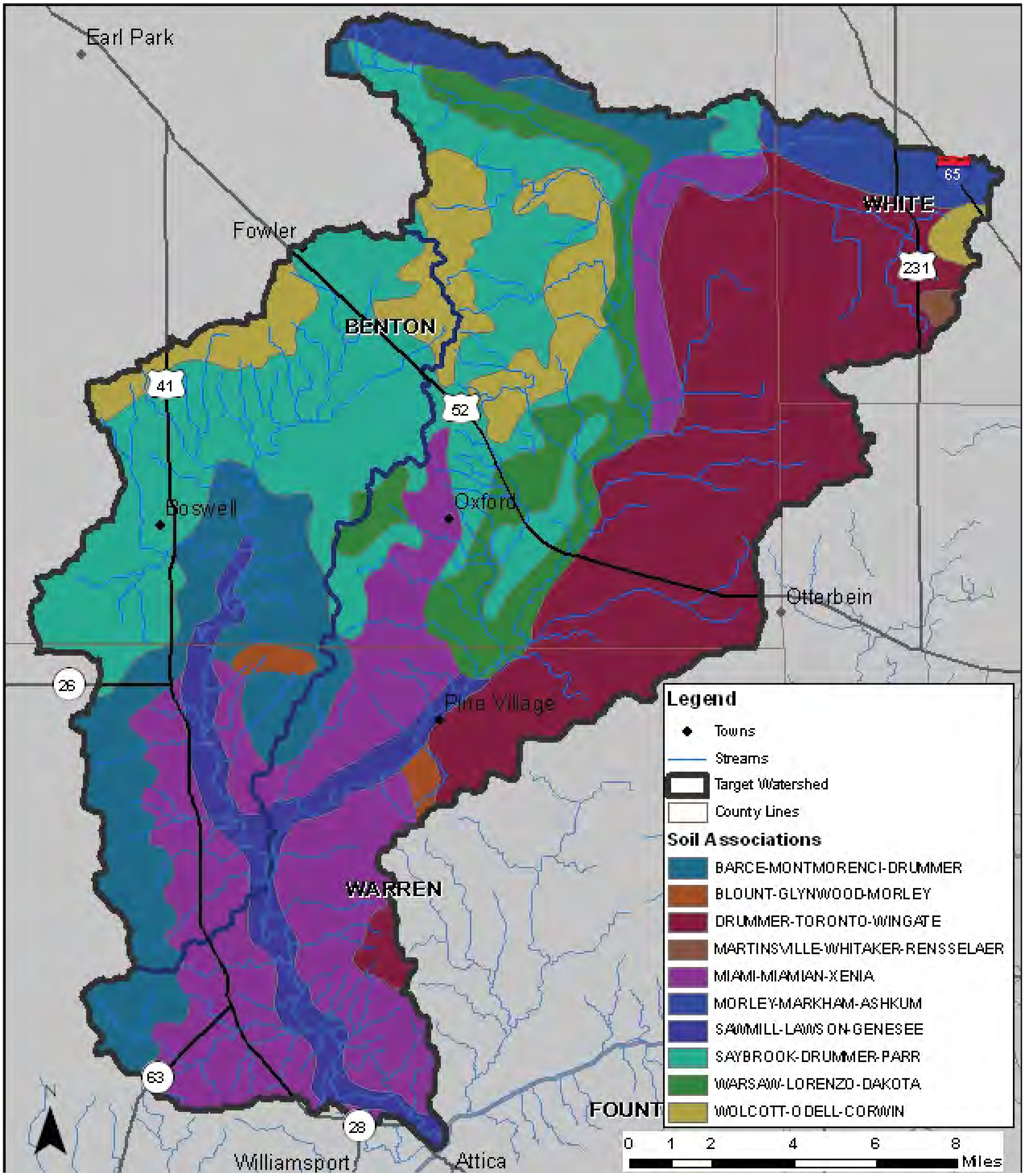

Figure 7. Soil associations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 and pesticides, which can result in impaired water quality by increasing plant and algae growth or even killing aquatic life. The ability and/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 highly erodible, and not highly 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 value or tolerance value. The T value is the maximum annual rate of erosion that can occur for a particular soil type without causing a decline in long-term productivity. Potentially highly erodible soil determinations are based on the slope steepness and length in addition to the erodibility index value.

Watershed stakeholders are concerned about soil erosion. As detailed above, soils which have high erodibility index values are those that are located on steep slopes and are easily moved by wind, water, or land uses. Figure 8 details locations of highly erodible and potentially highly erodible soils within the Big Pine Creek watershed. Highly erodible soils cover 4% of the watershed or approximately 7,590 acres, while potentially highly erodible soils cover 29% of the watershed or approximately 60,828 acres. Highly erodible soils are found throughout the watershed, but are more concentrated in the southern end of the watershed in Warren County.

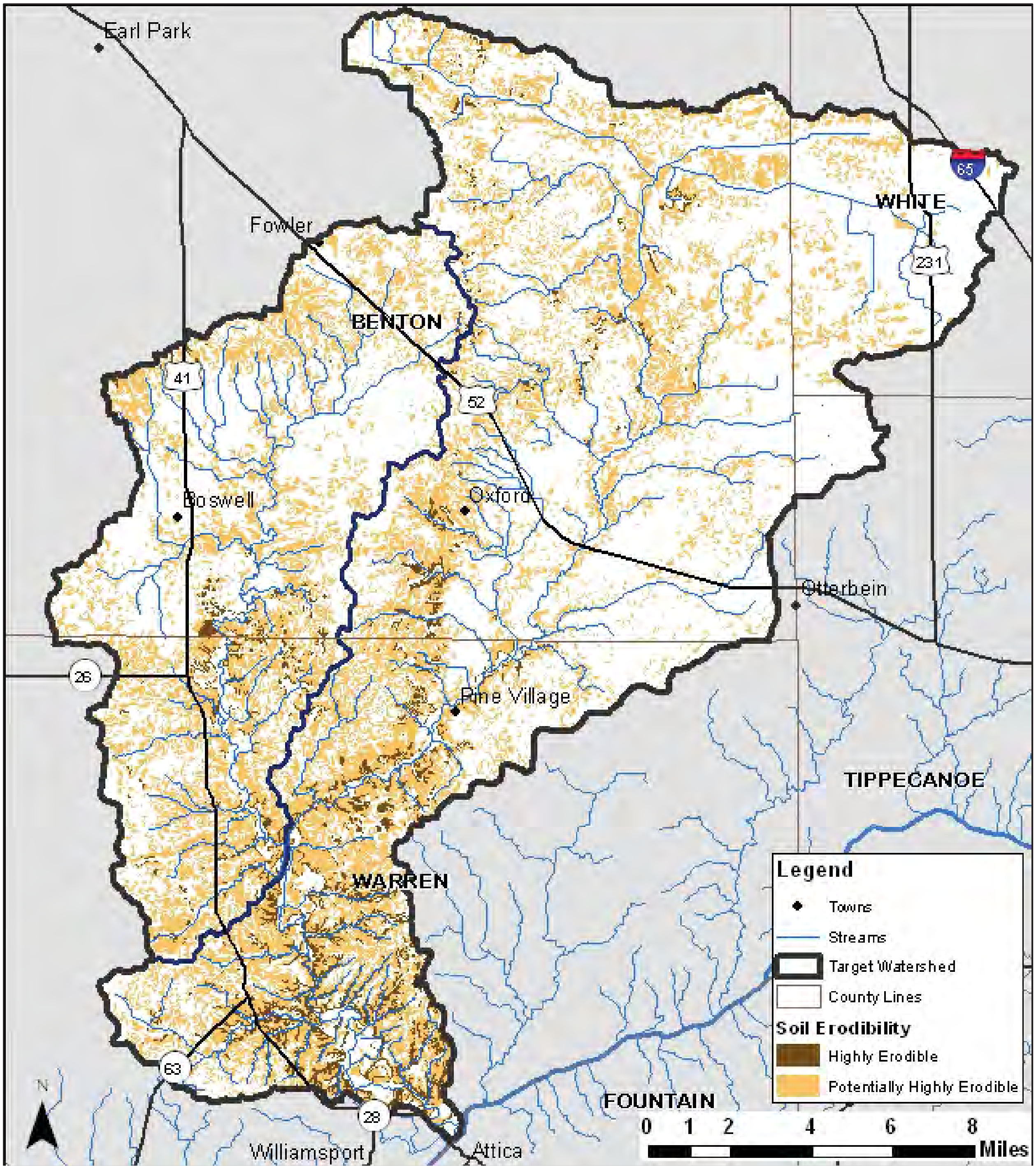

Figure 8. Highly erodible (HES) and potentially highly erodible soils (PHES) in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.5.3 Hydric Soils

Hydric soils are those which remain saturated for a sufficient period of time to generate a series of chemical, biological, and physical processes. The oxidation and reduction of iron in the soil, or “redox”, causes color changes characteristic of prolonged fluctuations in the water table. After undergoing these processes, the soils maintain the resultant characteristics even after draining or use modification occurs. Watershed stakeholders are concerned about the conversion of wetlands into agricultural and urban land uses. Approximately 75,000 acres (36%) of the watershed are covered by hydric soils (Figure 9). Hydric soils are found throughout the watershed, with the highest densities being located in the northern half of the watershed, especially in White County. 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.

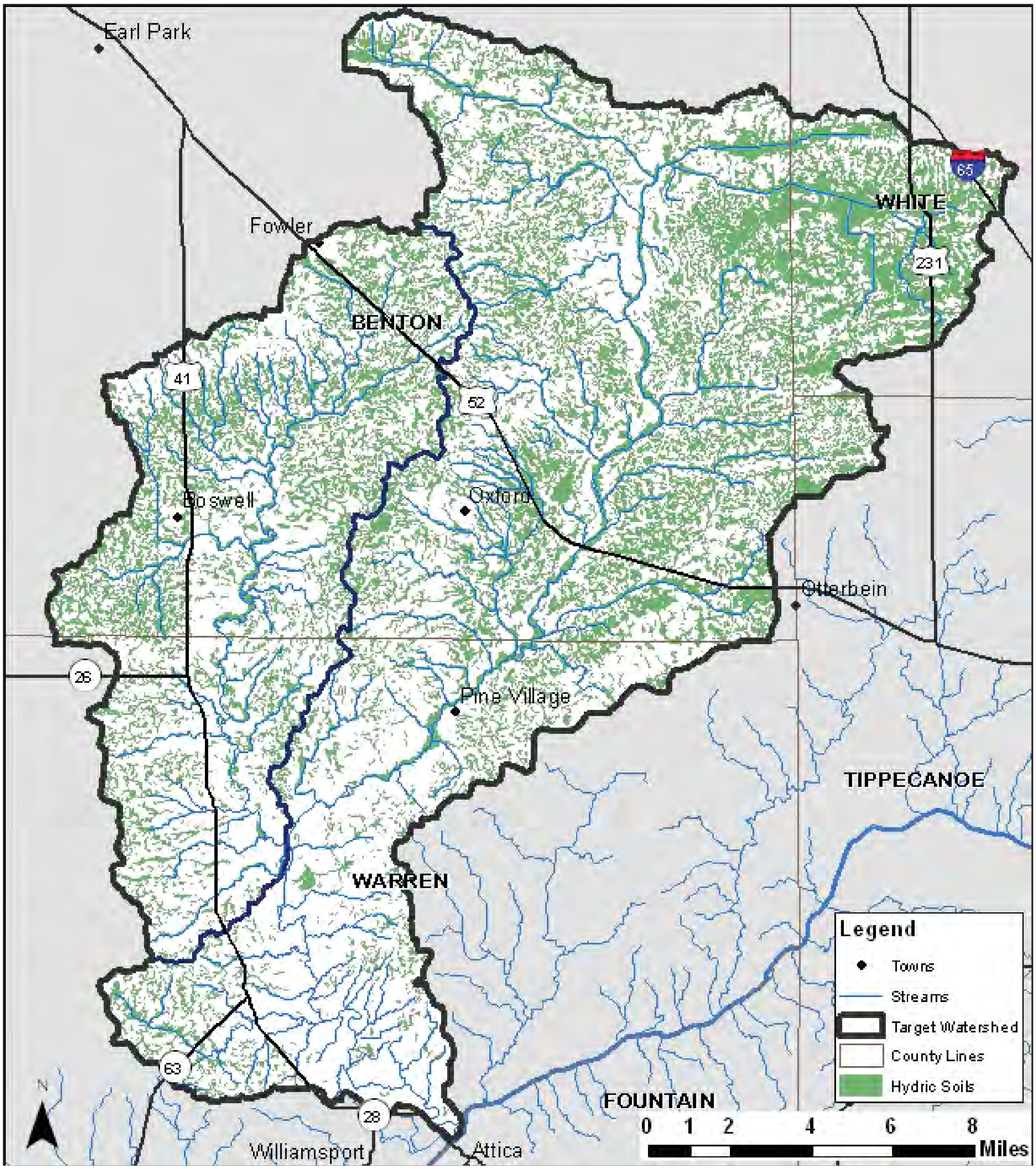

Figure 9. Hydric soils in the Big Pine Creek watershed.

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

2.5.4 Tile-Drained Soils

Soils drained by tile drains are very common in the Big Pine Creek watershed. This method of drainage is widely used in row crop agricultural settings within the watershed, and has become even more intensively used within the last ten years. This results in altered hydrology, allowing the water to drain from the landscape more quickly to improve conditions for farming, but also potentially exacerbating downstream flooding and incising streams which cuts them off from their natural floodplains. In these areas, materials such as nutrients applied to agricultural soils are directly transported downstream, bypassing natural features such as filter strips that might otherwise filter out or assimilate nutrients. All of the counties represented in the Big Pine watershed use extensive series of tile to drain their lands. The upper northeast corner of the watershed in White County may be the most densely tiled area of the watershed. As the demands of production on each acre of land increases more tile is put in, typically in a network or series as extensive as 30 to 50 foot spacing between tiles. Impacts to stream water quality can be reduced by the use of tile control structures and drainage water management.

2.6 Wastewater Treatment

2.6.1 Soil Septic Tank Suitability

Throughout Indiana, households depend upon septic tank absorption fields in order to treat wastewater. Seven soil characteristics, including position in the landscape, soil texture, slope, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table, are utilized to determine suitability for on-site septic treatment. Septic tanks require soil characteristics that allow for gradual movement of wastewater from the surface into the groundwater. A variety of characteristics limit the ability for soils to adequately treat wastewater. High water tables, shallow soils, compact till, and coarse soils all limit soils abilities in their use as septic tank absorption fields. Specific system modifications are necessary to adequately address soil limitation; however, in some cases, soils are too poor for treatment and therefore prove inadequate for use in septic tank absorption fields.

Until 1990, residential homes located on 10 acres or more and occurring at least 1,000 feet from a neighboring residence were not required to comply with any septic system regulations. In 1990, a new septic code corrected this loophole. Current regulations address these issues and require that individual septic systems be examined for functionality. Additionally, newly constructed systems cannot be placed within the 100-year floodplain and systems installed at existing homes must be placed above the 100-year flood elevation. However, many residences grandfathered into this code throughout the state have not upgraded or installed fully functioning systems (Krenz and Lee, 2005). In these cases, septic effluent discharges into field tiles or open ditches and waterways and will likely continue to do so due to the high cost of repairing or modernizing systems ($4,000 to $15,000; ISDH, 2001). Lee et al. (2005) estimates that 76,650 gallons of untreated wastewater is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the Big Pine watershed cannot be determined without a complete survey of systems.

The 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. Use of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function.

Watershed stakeholders are concerned about the lack of maintenance associated with septic tanks, the use of soils that are not suited for septic treatment, and the presence of straight pipe systems within the watershed. These concerns are exacerbated by the fact that severely limited soils cover essentially the entire watershed (Figure 10). Nearly 209,180 acres or 99.7% of the watershed is covered by soils that are considered very limited for use in septic tank absorption fields. The remaining 530 acres are somewhat limited or not rated.

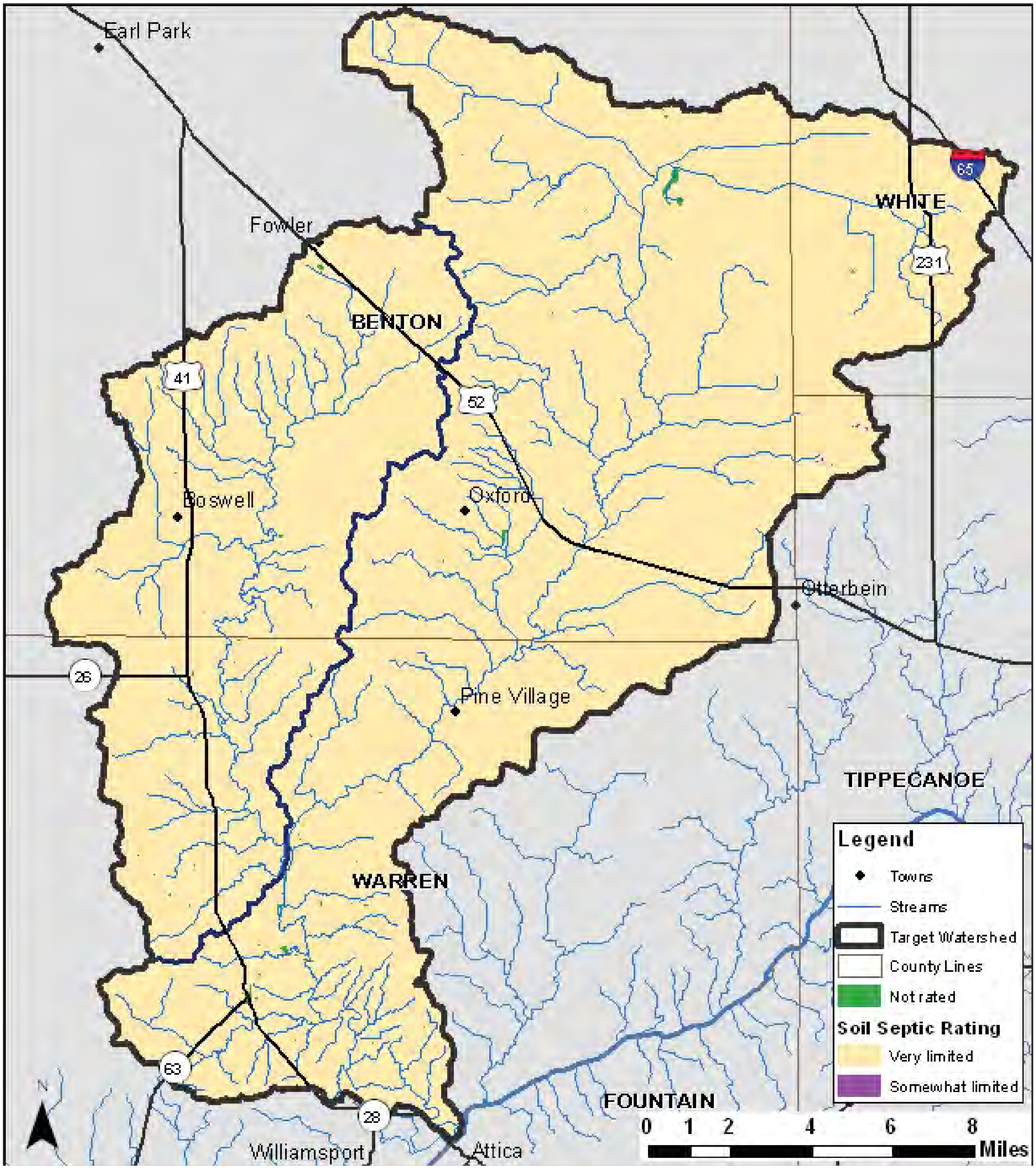

Figure 10. Suitability of soils for septic tank usage in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 larger, publicly-owned facilities, and school facilities. In total, five NPDES-regulated facilities are located within the watershed (Figure 11). Table 5 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.

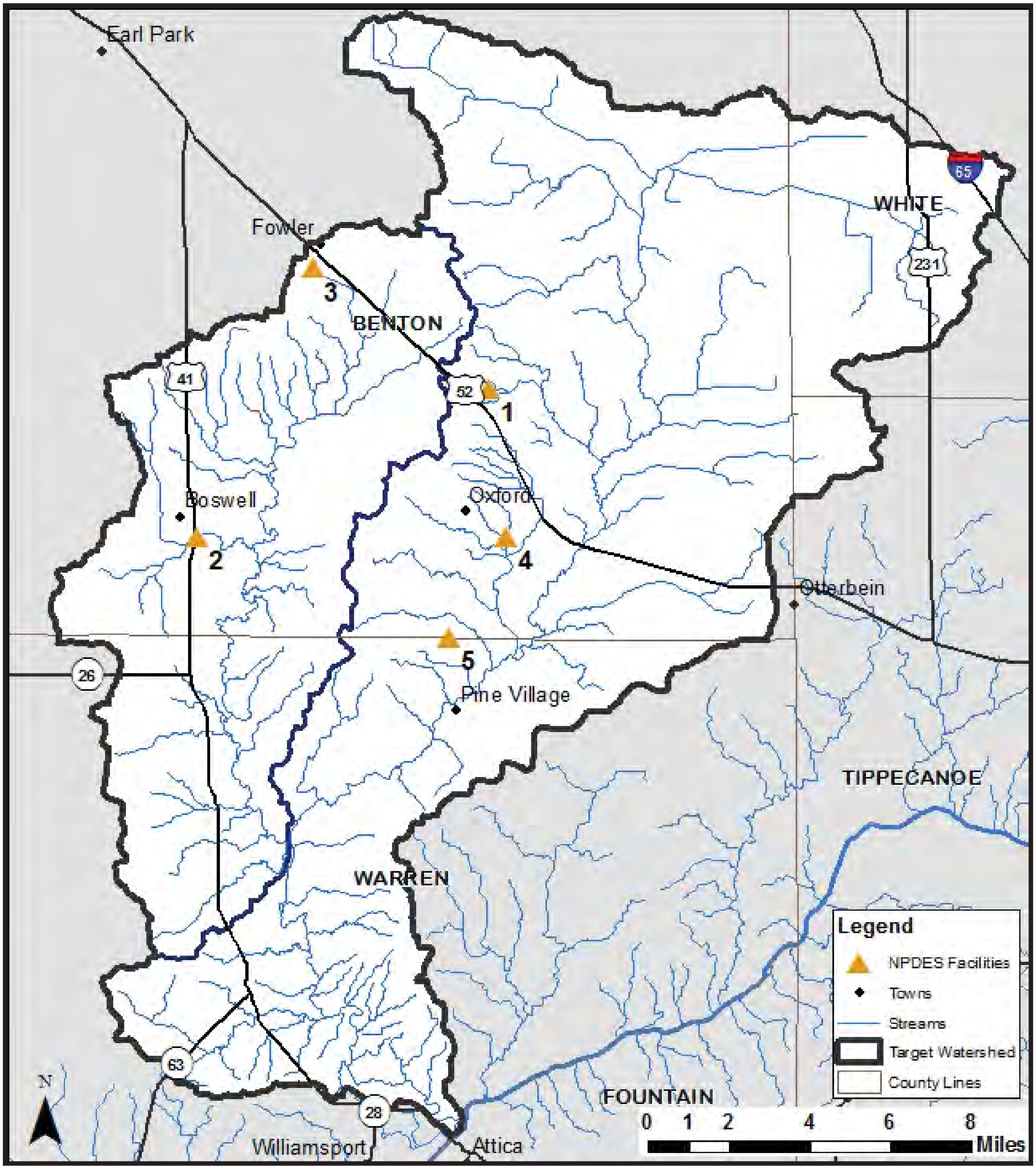

Figure 11. NPDES-regulated facilities in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 5. NPDES-regulated facility information.

Map ID	NPDES ID	Facility Name	Activity Description
1	IN0021164	Benton Central Jr Sr High School	Sewerage system
2	IN0039756	Boswell Municipal WWTP	Sewerage system
3	IN0050253	Fowler Municipal Sewage Treatment Plan	Sewerage system
4	IN0021342	Oxford Utilities	Sewerage system
5	IN0061476	Oxford Water Utility	Water Supply

Source: USEPA EnviroFacts Warehouse, 2013

2.6.3 Municipal Wastewater Treatment and Combined Sewer Overflows

In the relatively rural Big Pine watershed, there are only four wastewater treatment facilities, associated with three of the four incorporated towns and the Benton Central Jr Sr High School. All four facilities discharge into tributaries of either Big Pine Creek or Mud Pine Creek. Sludge from municipal wastewater treatment plants is applied on 3,584 acres throughout the watershed. Much of this application occurs within the Darby Ditch, Brumm Ditch and Big Pine Ditch subwatersheds (Figure 12). Watershed stakeholders are concerned about the limitations of municipal wastewater treatment facilities, especially the intensity and duration of combined sewer overflows in the town of Oxford.

Town of Oxford

The Town of Oxford operates a wastewater treatment plant which serves the town's approximately 1270 residents. The plant is designed to treat 0.2 MGD of wastewater, although the average is less than 0.075 MGD during dry weather. The system consists of two lagoons with a holding time of 90 days, followed by chlorination and dechlorination. The treated water is discharged to Brown Ditch. The service area is shown in Figure 12. The town's sanitary and storm sewers are combined and there are two permitted combined sewer overflows that discharge into Brown Ditch on the south side of the town. In 2013, 18 combined sewer overflow discharge events occurred, with a total volume of 12.97 million gallons of combined stormwater and wastewater entering Brown Ditch.

The WWTP is currently in noncompliance with its NPDES permit, with two formal enforcement actions by IDEM over the last five years. The Town of Oxford has been working with an engineering firm to submit a Long Term Control Plan (LTCP) Amendment to IDEM. The current draft of the LTCP Amendment proposes to capture and fully treat flows from the first flush. Wet weather flows from greater than the first flush up to and including the 10-year, 1-hour design storm will receive a minimum of primary treatment and disinfection at a constructed wetland. Phase 1 includes building a third lagoon to increase capacity and relocating the effluent discharge outlet to a larger receiving stream. Phase 2 includes building a fill and draw wetland to intercept wastewater before it reaches the lagoon system, and separation of storm and sanitary sewers. The town has secured a low interest loan from the State Revolving Fund to begin implementation of Phase 1 and is currently seeking the remainder of the funding needed in order to keep rate increases low. These improvements will result in less organic material, nutrients and bacteria released to Big Pine Creek within the next ten years (Jeff DeWitt, pers comm 2014).

Town of Boswell

The Town of Boswell operates a wastewater treatment plant which serves the town's approximately 770 residents. The plant is designed to treat 0.13 MGD of wastewater through a system of two aeration tanks, two clarifiers and a concrete polishing pond. During dry weather, the plant treats 0.035 MGD of wastewater while wet weather typically brings 0.06-0.08 MGD. Treated water is discharged to Mud Pine Creek via Goose Creek. In the past, sludge was applied to a local farmer's field, but under the current permit sludge will be applied to a five acre hay field adjacent to the plant annually in the spring. The sanitary sewers are not combined with storm sewers (JR Witt, pers comm 2014). The Boswell WWTP is currently in compliance with its NPDES permit.

Town of Fowler

The Town of Fowler operates a wastewater treatment plant which serves the town's approximately 2330 residents. While the town straddles the watershed boundary, the plant is located south of town and discharges into Mud Pine Creek via Humbert Ditch. Fowler maintains over 15 miles of sewers, five sewer pumping stations, and three pumping stations at the wastewater plant. The plant is designed to treat 0.75 MGD of wastewater through a system of an equalization basin, a surge control basin, two oxidation tanks, several clarifiers, and disinfection. Following treatment and dewatering, land application of biosolids occurs. The NPDES permit lists the sewer system as 100% separated. The plant treats storm water from rain events only until such time as the remaining 25% of the old sewer system can be replaced. The current capacity of the plant during dry weather is 20-25%, allowing room for expansion. The Fowler WWTP is currently in compliance with its NPDES permit.

Benton Central Jr Sr High School

The Benton Central Jr Sr High School operates a wastewater treatment plant which serves both the high school and Prairie Crossing Elementary School, with a total of approximately 1100 students. The small concrete plant was designed to treat 0.042 MGD of wastewater, but typically only receives 0.01 MGD. Treated water is discharged to Big Pine Creek via an unnamed ditch. Sludge is held in a 12,000 gallon tank onsite and twice a year is hauled offsite for land application (Fred Flook, pers comm 2014). Land application sites are shown in Figure 12. The Benton Central Jr Sr High School WWTP is currently in compliance with its NPDES permit.

2.6.4 Unsewered Areas

Five unsewered areas were identified within the watershed (Figure 12). Areas that have at least 25 houses within a square mile outside of the sanitary district boundaries were classified as dense, unsewered areas. The largest of these areas were associated with the towns of Pine Village and Templeton. The town of Pine Village is in the process of investigating wastewater treatment plant alternatives and funding, in coordination with IDEM. Currently, much of the town has failing septics. Funding is being pursued through grants which would allow the town to create a modern sewage treatment facility which would greatly reduce the amount of pollutants (*E. coli*, nutrients, etc.) leaching into Big Pine Creek.

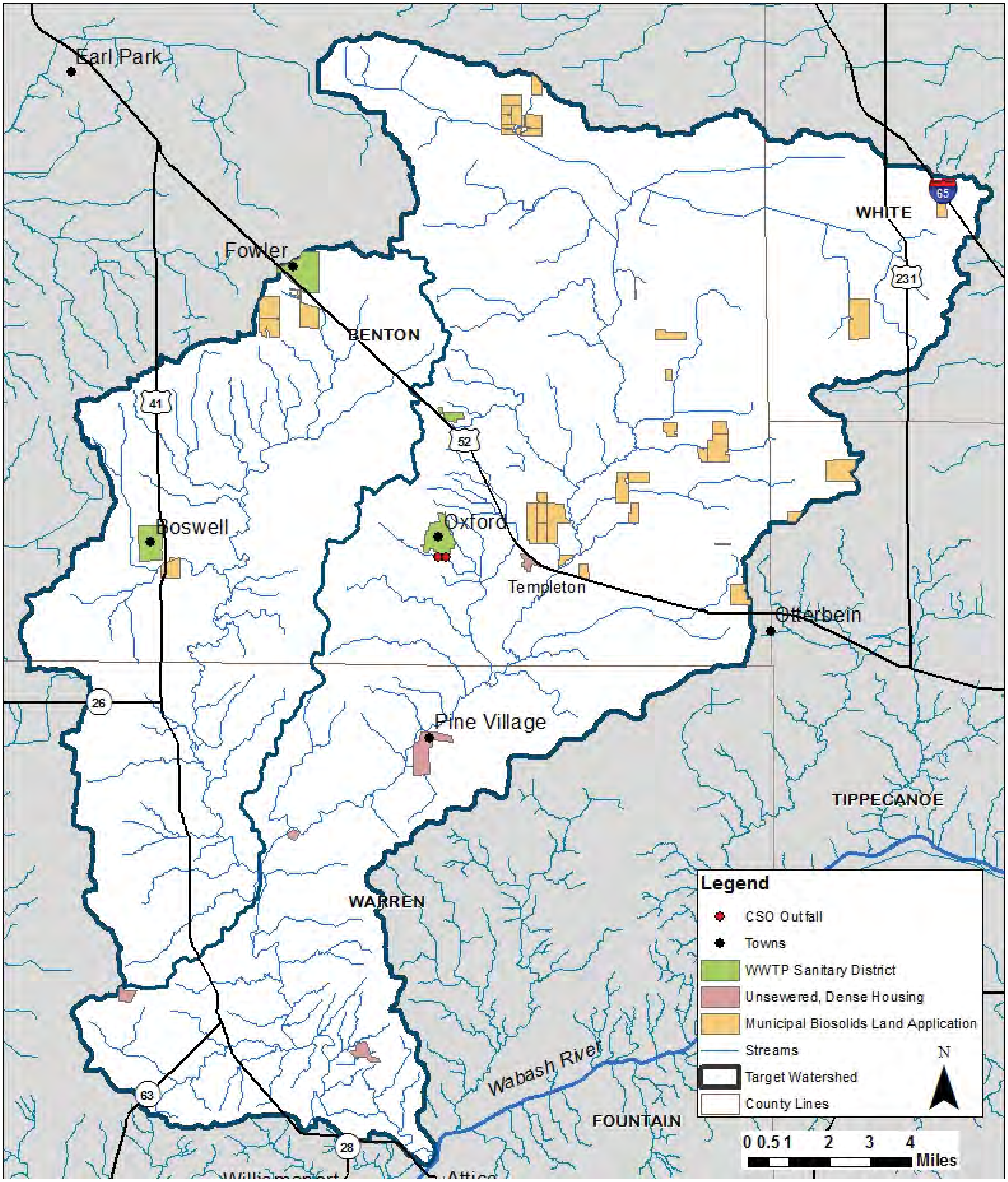

Figure 12. Wastewater treatment plant service areas, municipal biosolids land application sites, dense unsewered housing, and combined sewer overflow outfalls within the Big Pine Creek watershed.

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

2.7 Hydrology

As part of his study, Gammon cataloged historic references to the Wabash River, assessed the fish community, and the overall river habitat. Each of these comments indicate the changing hydrology in the Wabash River and its tributaries. Some of the comments recorded by Gammon (1995) include:

- The Wabash River was clear and sparkled in the sunlight; Logansport, 1833 (McCord, 1970).
- The Wabash and its tributaries routinely rise above their banks and overflow into the low adjoining land; location unknown, undated.
- The Wabash River was low (July) and its rocky bed was exposed and dotted by small island. In 1845, Winter noted the effects of partially clearing the area stating that the islands were beginning to wash away under the influence of the greater volume of water; Logansport.
- Rolfe (1920) noted the continued change in water quality stating that the waters of the Wabash River were commonly brown and opaque with suspended sediments and that waters never cleared even in the lowest stages; Attica to Vermillion.
- Gerking (1945) identified “city sewage, cannery waste, mill waste, coal mine drainage, and dairy-products waste” as sources of water quality problems within the middle and lower Wabash River.
- Visher (1944) indicated four reasons for increased flooding within the Wabash River and its tributaries: abundant rainfall, concentration of rainfall, inadequate size and number of runoff channels, and changes produced by man.

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 detail in subsequent sections.

2.7.1 Watershed Streams

The Big Pine watershed contains approximately 568 miles of streams, regulated drains, and regulated tile drains. Of these, approximately 234 miles are regulated drains and 91 miles are regulated tiles. In Benton County, all drains and tiles are regulated with the exception of Big Pine Creek and Mud Pine Creek. Likewise, in Tippecanoe and White counties nearly all the stream miles are either regulated drains or tiles. The majority of streams in Warren County are not regulated, with only six reaches of regulated drains. It should be noted that 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. 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. Each time a ditch is cleaned out or maintained, this action increases the amount of sediment going downstream towards the mainstem of the Big Pine. Therefore, practices such as the two-stage ditch that minimize sediment transport should be considered in areas of the watershed with high densities of legal drains, or where they are otherwise desirable for reducing sediment and nutrient loads.

The major tributaries to Big Pine Creek include Roudebush Ditch, Big Pine Ditch, Little Pine Creek, Owens Ditch, Brumm Ditch, Darby Ditch, Brown Ditch, Harrington Creek, Hog Back Hill, and Fall Creek (Figure 13). Mud Pine Creek discharges into Big Pine Creek upstream of its confluence with Fall Creek. The major tributaries to Mud Pine Creek include Goose Creek, Seamons Ditch and Spring Branch. Several minor tributaries also drain to Big Pine within this watershed. Big Pine Creek is used extensively for recreational kayaking and canoeing, as well as fishing, swimming, and aesthetic enjoyment. Stakeholders are concerned with maintaining the recreational value of the creek, and have some concerns because portions of the watershed have been designated as impaired by IDEM for *E. coli*, nutrients, and impaired biotic communities.

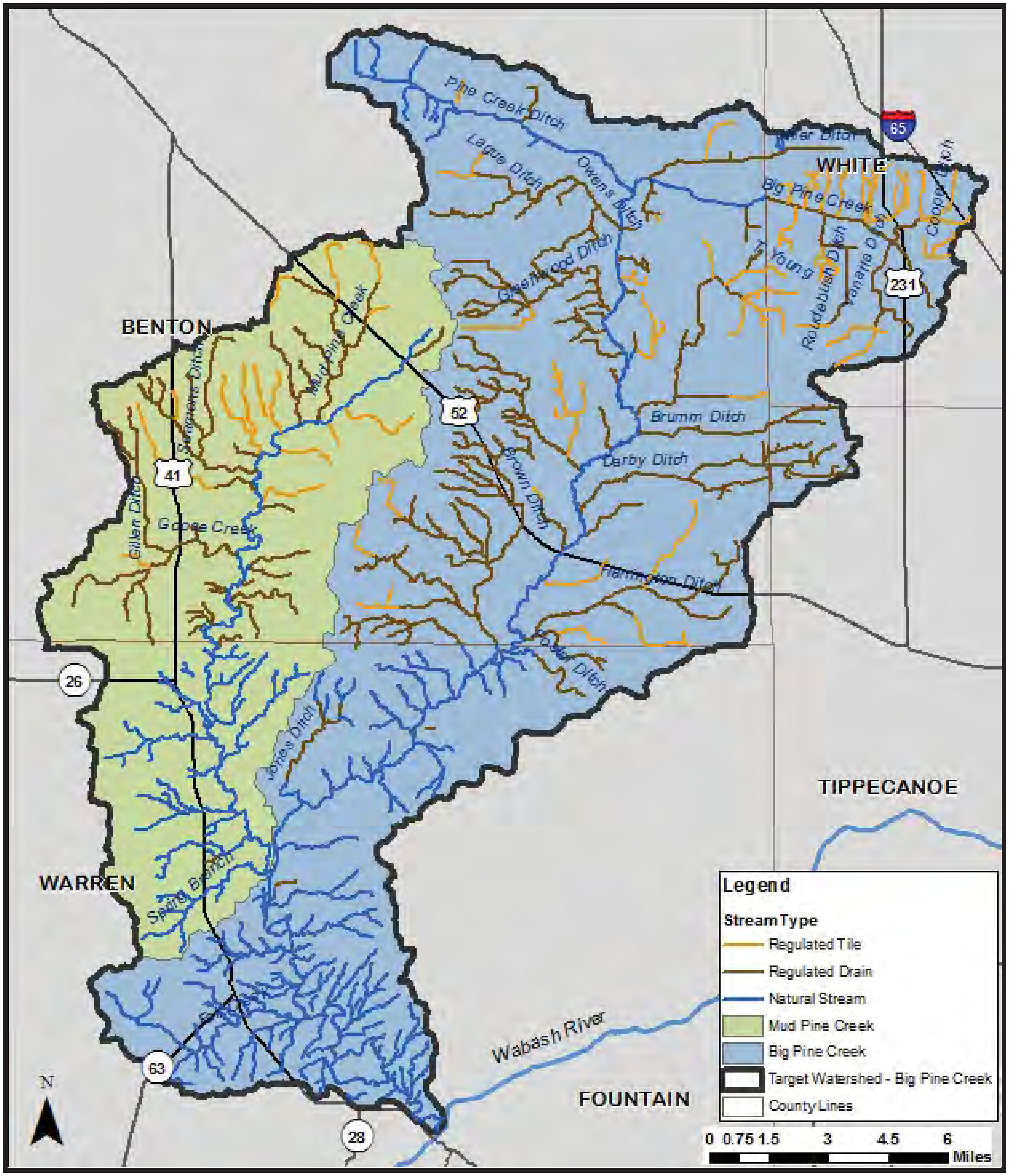

Figure 13. Streams, legal drains, and tile drains in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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. These include the designation of outstanding rivers and impaired waterbodies. 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. Conversely, the impaired waterbodies listing designates those waterbodies which do not meet state water quality standards. All waterbodies assessed by the IDEM are reviewed every two years to determine whether their water quality meets the state's requirements. Those waterbodies that do not contain sufficient water quality levels are included on the state's impaired waterbodies or 303(d) list.

Three streams in the Big Pine Creek watershed are designated as outstanding rivers (Figure 14). These include portions of the mainstem of Big Pine and Mud Pine Creeks, as well as a portion of Fall Creek, a small tributary to Big Pine. This designation requires that these waterbodies be treated differently with regard to some state statutes and rules. Specifically, logjam removals and utility crossing requirements are more stringent within these waterbodies.

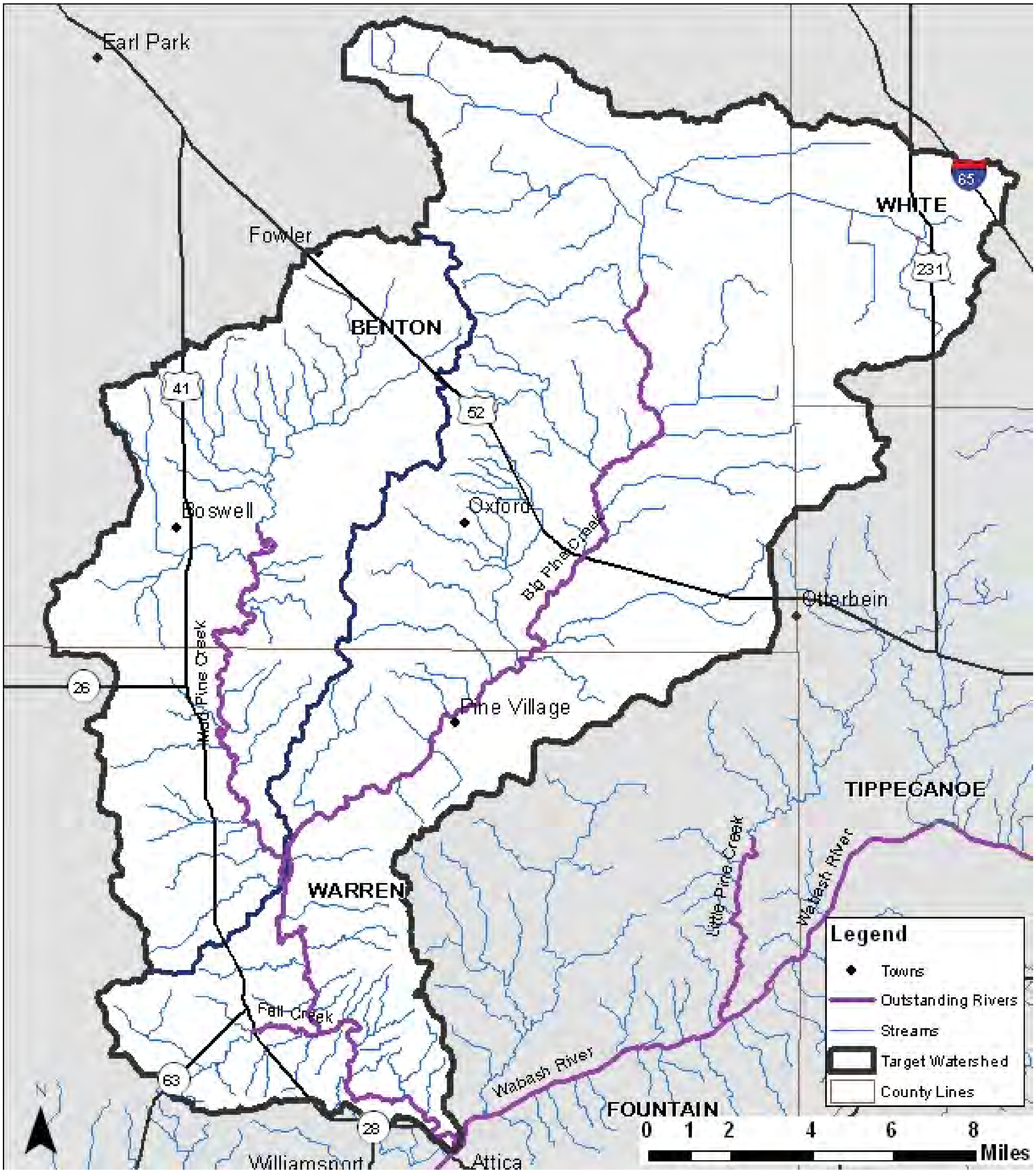

Figure 14. Outstanding river locations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.3 Impaired Waterbodies (303(d) List)

The impaired waterbodies, or 303(d), list is prepared biannually by the Indiana Department of Environmental Management. Waterbodies are included on the list if water quality assessments indicate that they do not meet their designated use. More information on the listing process is included in section 3.2.1 below.

Eleven stream segments within the Big Pine Creek watershed, a total of 151.2 miles, were included on the list of impaired waterbodies. Table 6 details the listings in the watershed, while Figure 15 maps the segments and their locations within the watershed. Waterbodies are listed as impaired for *E. coli*, impaired biotic communities, nutrients, dissolved oxygen, and polychlorinated biphenyls (PCBs).

Table 6. Impaired waterbodies in the Big Pine Creek watershed, from the draft 2012 IDEM 303(d) list.

HUC	Assessment Unit Name	County/Location	Cause of Impairment
51201080304	Mud Pine Creek	Warren Co.	PCBs in fish tissue
51201080304	Spring Branch	Warren Co.	PCBs in fish tissue
51201080304	Mud Pine Creek - Unnamed Tributary	Warren Co.	PCBs in fish tissue
51201080401	Big Pine Creek (Headwater)	White Co.	Impaired biotic communities, Dissolved Oxygen, Nutrients*
51201080401	Big Pine Creek - Unnamed Headwater Tributary	White Co.	Dissolved Oxygen, Nutrients*
51201080401	Vanatta-O'Conner Ditches	White Co.	Impaired biotic communities, Dissolved Oxygen, Nutrients*
51201080401	Roudebush Ditch	White Co.	Dissolved Oxygen, Nutrients*
51201080402	Big Pine Creek (Big Pine Creek Ditch)	Benton Co./White Co. (south of Miller Ditch)	Impaired biotic communities
51201080402	Miller Ditch	Benton Co./White Co.	Impaired biotic communities
51201080403	Little Pine Creek	Benton Co.	*E. coli*
51201080403	Little Pine Creek - Unnamed Tributary	Benton Co.	*E. coli*
51201080404	Owens Ditch	Benton Co.	Impaired biotic communities
51201080405	Brumm Ditch	Benton Co./ Tippecanoe Co.	Impaired biotic communities
51201080406	Darby Ditch	Benton Co./ Tippecanoe Co.	Impaired biotic communities
51201080407	Big Pine Creek - Unnamed Tributary (Brown Ditch)	Benton Co.	Nutrients
51201080409	Big Pine Creek - Unnamed Tributary	Warren Co.	*E. coli*
51201080409	Big Pine Creek	Warren Co.	*E. coli*
51201080410	Big Pine Creek	Warren Co.	*E. coli*, PCBs in fish tissue

*Included on the 2012 draft list as algae impairments, but changed to nutrients on the 2014 list.

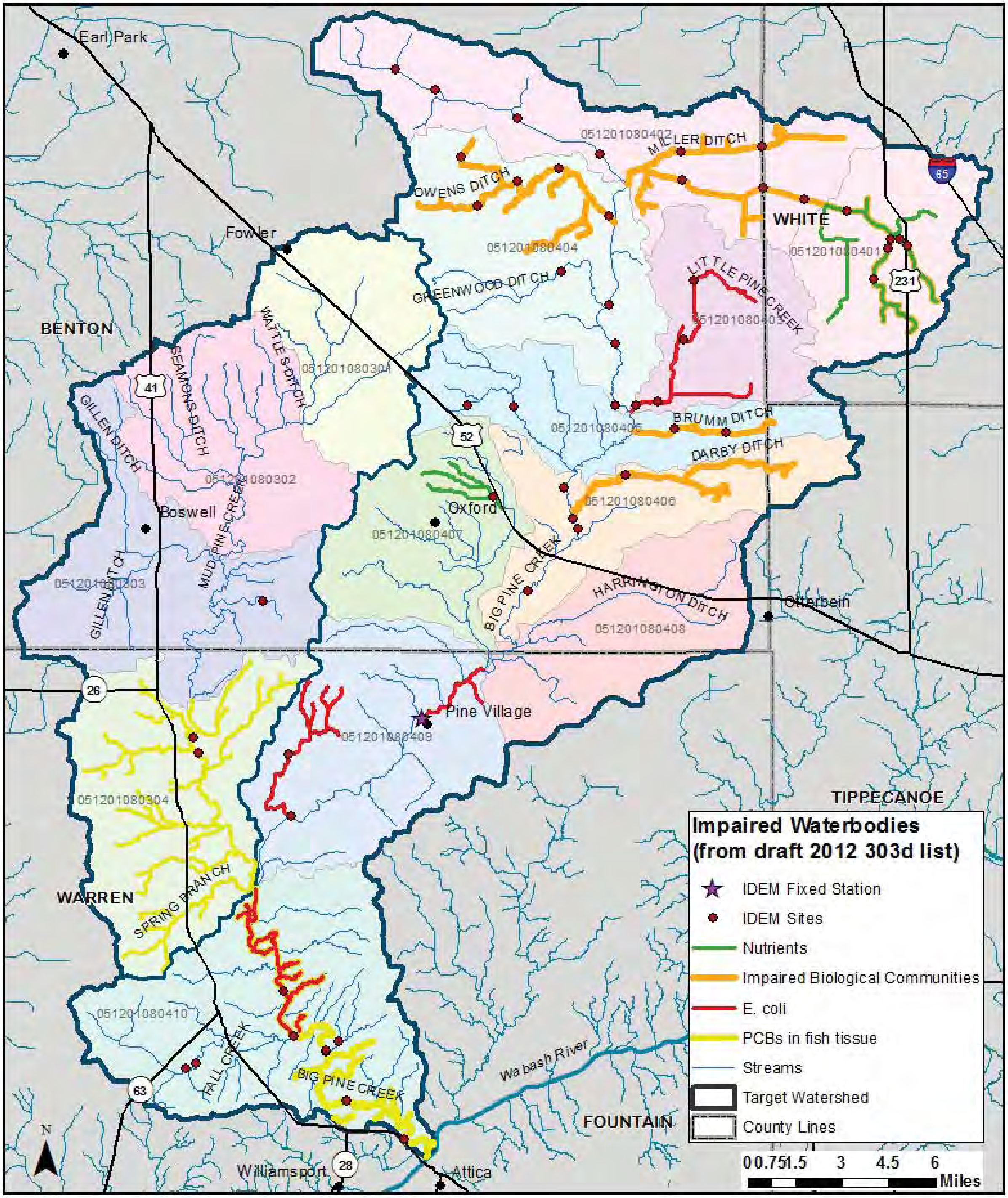

Figure 15. Impaired waterbody locations in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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. Local stakeholders are concerned about impacts to floodplains from development, lack of landowner maintenance, and soil erosion and deposition within the floodplain. Figure 16 details the locations of floodplains within the Big Pine Creek watershed. Extensive floodplain land east and west of Pine Village are areas that can be expanded on. Past storm events have blown down trees along Mud Pine Creek that are resulting in a backup of water into productive floodplain lands.

Approximately 3% (5,972 acres) of the Big Pine watershed lies within the 100-year floodplain (Figure 16). 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. All of the floodplain in the Big Pine watershed is classified as Zone A.
- 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 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. The remainder of the watershed is classified as Zone X.

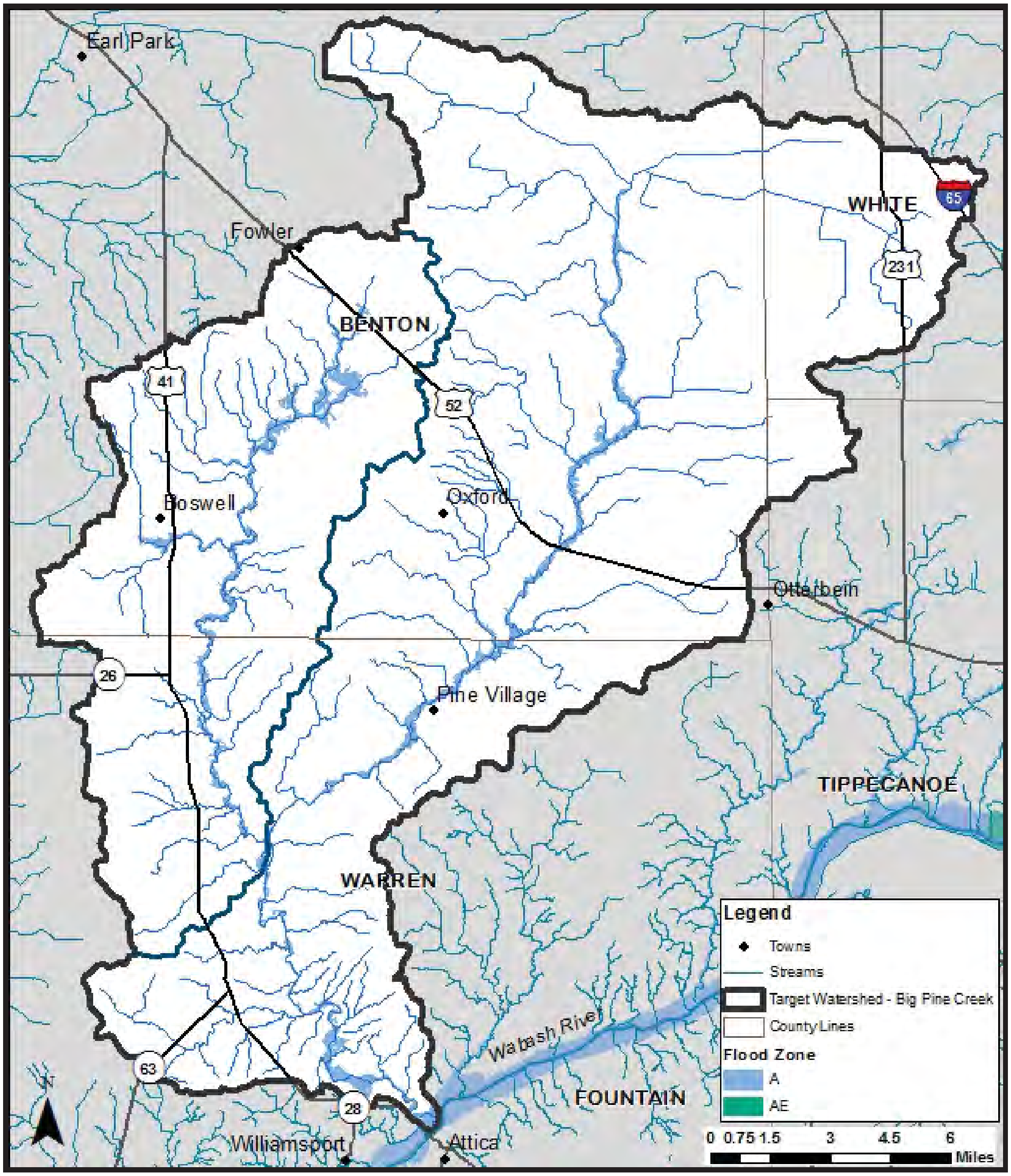

Figure 16. Floodplain locations within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

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 natural wetlands are regulated through the IDEM and the U.S. Army Corps of Engineers while USDA has jurisdiction over wetlands on agricultural fields. Any modification to wetlands requires permits from these agencies.

Wetlands cover 3,651 acres, or 2%, of the watershed. When hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that 95% of wetlands have been modified or lost over time. This represents 111 square miles of wetland loss within the Big Pine watershed. As commodity prices continue to go up and down, area land values remain high and as a result individuals are spending a great deal of money to drain small natural wetlands in their fields in order to be able to farm that additional couple acres of land as it is cheaper to tile it than to buy ground already in production.

Figure 17 shows the current (pink) and historic (green) extent of wetlands within the Big Pine watershed. Wetlands displayed in Figure 17 result 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. Using this map will help us to identify which portions of the watershed would make ideal candidates for wetland restoration efforts which would reduce the amount of sediment and nutrients reaching the creek, as well as helping to restore the natural hydrology of the area which could help to reduce flooding impacts locally.

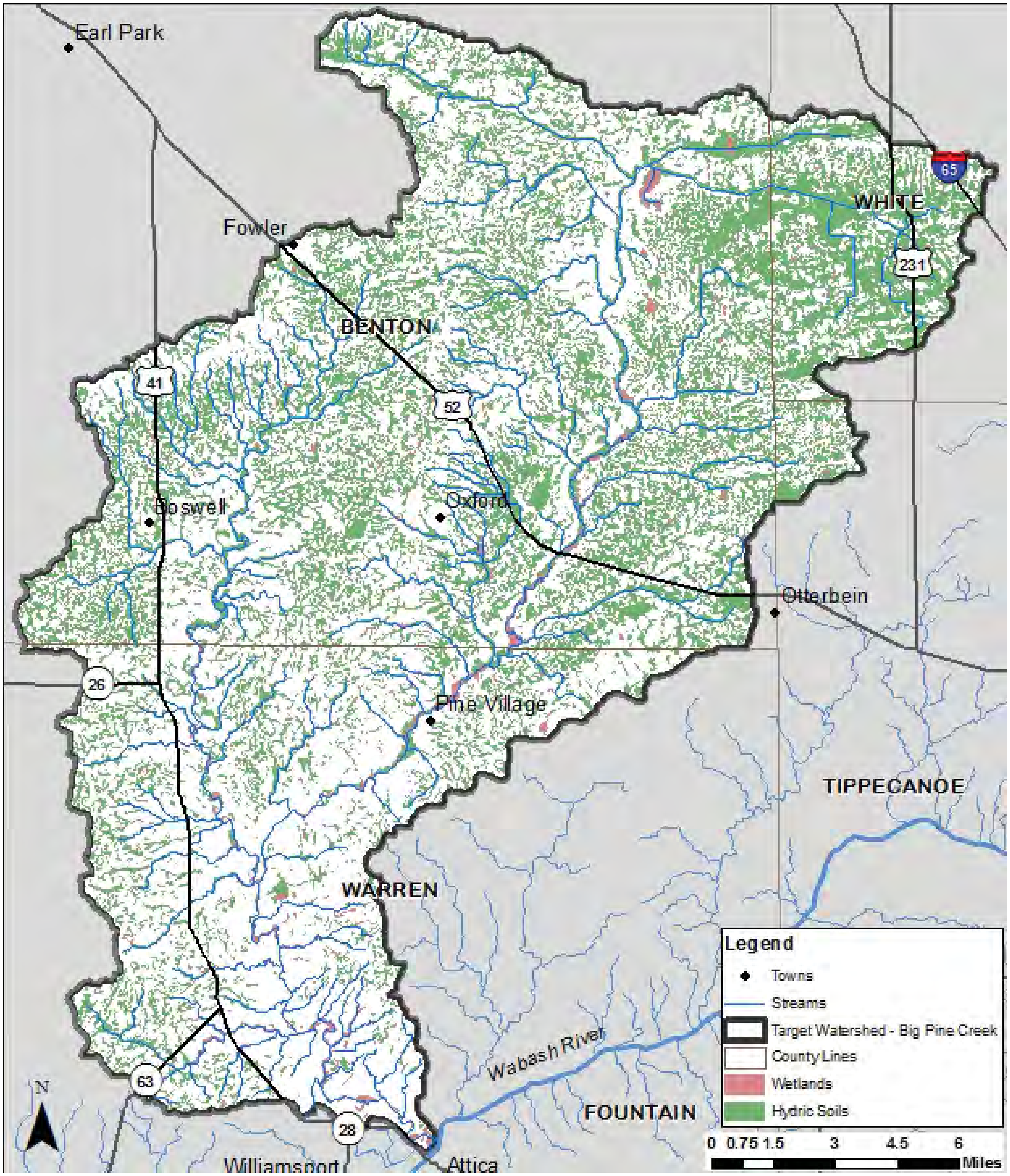

Figure 17. Wetlands and hydric soils located in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.7.6 Stormwater and Storm Drains

Under natural conditions, the majority of precipitation is allowed to infiltrate the soil and recharge groundwater resources. The volume of infiltration and groundwater recharge diminishes as development increases. To handle the large volume of precipitation falling in urban areas, stormwater systems have been constructed. Because of the small size of the towns within the Big Pine watershed, storm drains are generally not present, or present in only a very limited basis.

2.7.7 Wellfields/Groundwater

In general, municipal water supply is taken from the Lafayette (Teays) Bedrock Valley System, associated with the Wabash River which traverses north-central Indiana. Groundwater conditions are generally good to excellent in many parts of this segment of the Lafayette (Teays) Bedrock Valley. Both an intermediate level and a basal sand and gravel aquifer are present within and above the bedrock valley. The intermediate zone, which occurs at a depth of about 100 to 150 feet, appears in most areas to offer the greater potential for obtaining wells yielding 500 to 1,000 gallons per minute (gpm) (Bruns and Steen, 2003).

In sections of the Teays Valley Green Hill to Little Pine Creek the bedrock valley here gently bends to the northwest and then returns to a west trend. In the eastern portion of this segment the valley is broad, five to six miles across. The sudden narrowing of the valley also is a change in bedrock to a more resistant bedrock type. This segment has thick continuous sand and gravel bodies capable of yielding significant quantities of water. Properly constructed wells in this area should be able to produce enough water for most needs. Two high-capacity wells have reported yields of 300 to 1,000 gpm. Well depths in this area range from 40 to 250 feet, with most wells in the 90 to 180 foot range (Bruns and Steen, 2003).

From Little Pine Creek to Mud Pine Creek, the Teays Valley continues its westward trend following the Benton-Warren county line. It is a complex area where overflow channels and classic stream course morphology lie buried beneath deposits from multiple glacial advances. To the communities of Otterbein and Oxford, the buried valley has become an essential source of high-quality ground water. The valley width remains approximately two to three miles in the eastern portion of this segment, but about three miles northwest of Pine Village the valley width constricts to less than two miles. At the western edge of this segment, along Mud Pine Creek, the valley widens to four to five miles across. Two miles southeast of Oxford a major tributary enters the valley, divides and runs for miles. The basal aquifer should be capable of yielding 1,000 gpm to properly constructed wells. Water levels are usually between 25 and 60 feet. The thick, largely untapped, basal sand and gravel zone represents a major water-supply source in this portion of Indiana (Bruns and Steen, 2003).

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. Layers of clay and hard infrastructure can limit this recharge. Care must be taken to ensure the quality of the water from alluvial and surficial aquifer source waters. Table 7 lists wellhead protection areas within and adjacent to the Big Pine watershed. The wellhead protection areas correspond to the communities shown in Figure 2. 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.

Table 7. Wellhead protection areas in and adjacent to the Big Pine Creek watershed.

County	PWSID	System name	Population	Next Plan due	Due date
Benton	5204002	Boswell Water Department	810	Phase 2	12/13/2012
Benton	5204004	Otterbein Water Department	1,262	Phase 2	3/17/2015
Benton	5204005	Oxford Water Utility	1,200	Phase 2	9/2/2014
Benton	5204006	Fowler Water Works	2,324	Phase 2	9/15/2014
Warren	5286004	Williamsport Water Utility	2,435	Phase 2	12/15/2013

Pumping of groundwater in the watershed for agricultural purposes (center pivot irrigation systems) has caused a drop in the groundwater in some locations. Recently, the town of Templeton ran out of water due to a drop in groundwater locally. It is suspected that a combination of the drought in 2012 along with increased pumping for agricultural purposes were the causes. In the last few months more wells have been drilled for center pivot irrigation. This can be a critical issue as we face summer drought, fence rows are cleared and wetlands are filled in to provide this infrastructure, resulting in a loss of natural filters that hold and slow down water. Local stakeholders are concerned with protecting groundwater availability in the Teays River valley. Groundwater contamination from the surface was not a concern raised by stakeholders.

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. In 1886, Professor John Coulter placed the Big Pine watershed into the prairie region. The prairie region was characterized by sparse trees and shrubs most commonly including black walnut, buroak, white ash, shagbark hickory, black cherry, sugar maple, beech, pawpaw, buckeye, sassafras, redbud, mulberry, crabapple, and dogwood. DeHart (1909) details the presence of wildflowers and prairie grass intermingled with trees especially in the bottom lands adjacent to the Wabash River and its tributaries. Descriptions from that time period detail the presence of kingfishers, bluejays, blackbirds, cranes, and heron waiting patiently for schools of fish including salmon, bass, redhorse, and pike within the river. DeHart (1909) lamented the loss of forests throughout the region as more settlers arrived. He described Indiana as becoming a “treeless state” where native timber stands were removed for farming purposes. He wrote “with more timber our streams would again flow with more water; our climate would be better, crops would be better and prosperity would be insured to those that come after us.” He further noted issues with forest removal, citing the Wabash River drainage as one of the most concerning areas in the state creating vast nude areas along the Wabash River bluffs.

2.8.1 Natural and Ecoregion Descriptions

According to Homoya et al.’s (1985) classification of natural regions in Indiana, the Big Pine Creek watershed lies within two natural regions: the Tipton Tillplain and the Grand Prairie natural regions (Figure 18). The central till plain natural region follows the entrenched southern Big Pine Creek valley northward through southern Warren County. The valley and adjacent uplands were originally forested and much of that forest still remains today in areas that are too steep for agricultural production. These forests were characterized by a mix of oaks, maples, ash, elm, and sycamore and better drained soils home to hickory, tulip tree, white ash, sugar maple, and beech (Jackson, 1997). The uplands fall within the Grand Prairie Natural Region, and supported a mosaic of open wetlands and grasslands. These habitats were maintained by frequent fires, set by Native Americans to manage habitats for wildlife. Because of their productivity, virtually all of the wetlands and grasslands have been converted to agriculture.

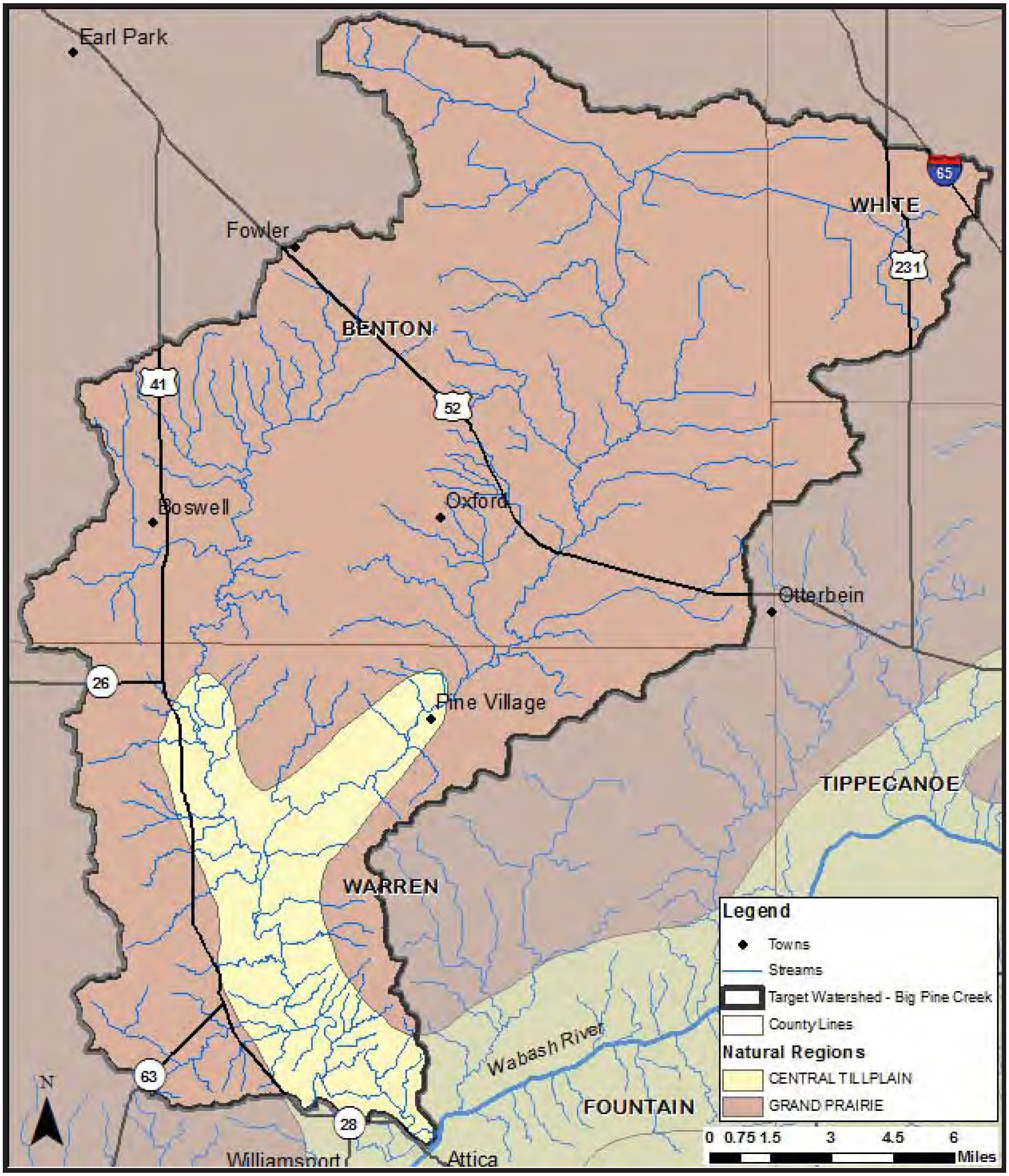

Figure 18. Natural regions in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

On a national scale, the watershed is split between two ecoregions that follow the same lines defined by Homoya et al. (1985), the watershed lies within two ecoregions: the central tallgrass prairie ecoregion and the central tillplain ecoregion (Figure 19).

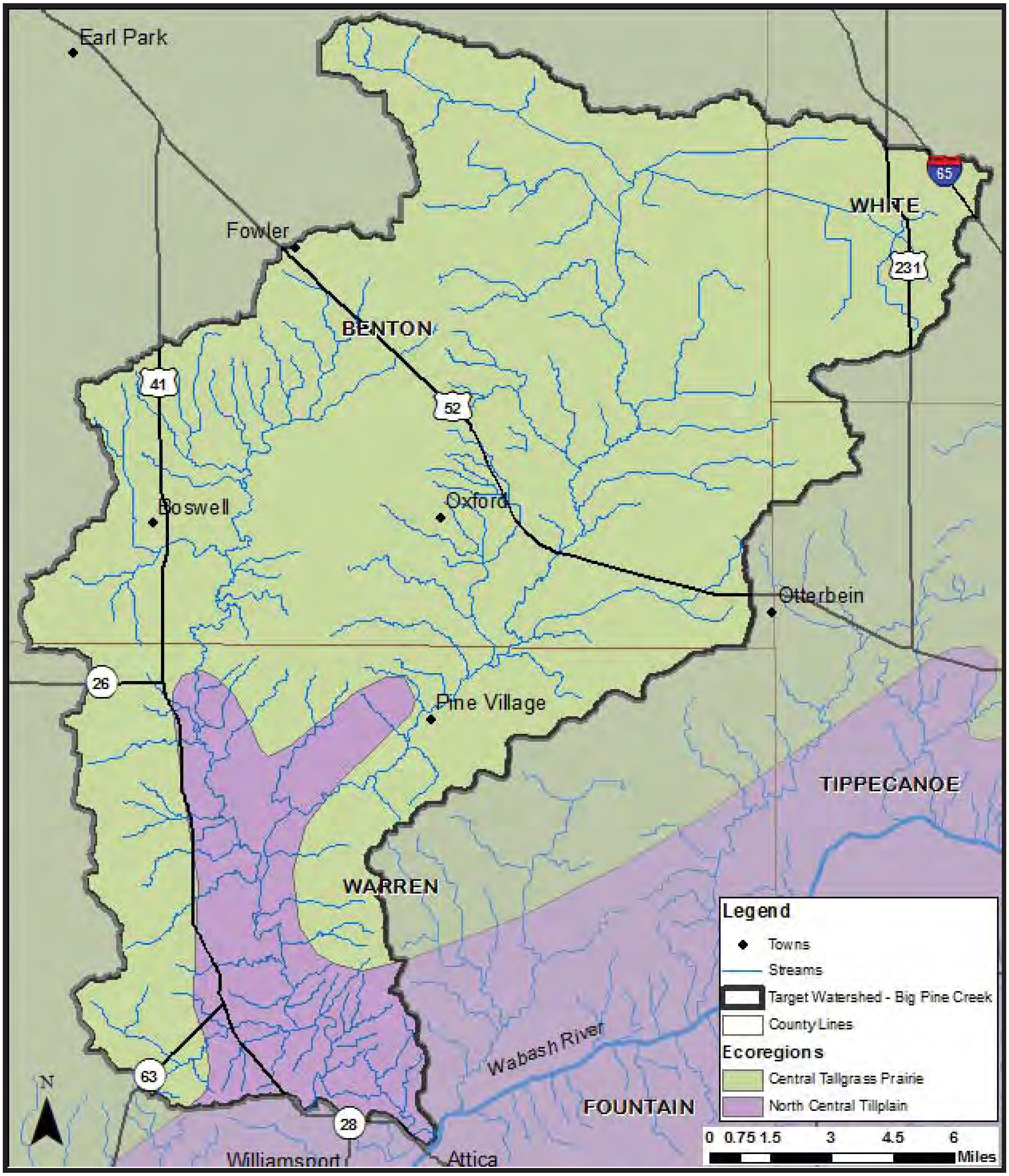

Figure 19. Level III eco-regions in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.8.2 Wildlife Populations

Individuals are concerned about lack of knowledge of local wildlife populations and the impact that changing land uses could have on these populations. Additionally, pathogen inputs from wildlife are also a concern. These will be quantified in subsequent sections. With these concerns in mind, wildlife density can be estimated from a variety of sources. The Indiana Department of Natural Resources (IDNR) is tasked with managing wildlife populations throughout the state. In order to complete this task, the IDNR must have an idea of the population density within specific areas, counties, or regions. Much of the Big Pine watershed lies within the northwest region as defined by the IDNR. Although we were unable to locate wildlife density information specifically for the Big Pine watershed, we were able to use density information from 2005 for a neighboring watershed (Region of the Great Bend of the Wabash River). It is likely that wildlife densities would be similar between these two watersheds. Those densities are shown in Table 8, with deer and squirrel being the most common wildlife present within the region. It should be noted that these numbers could both underestimate and overestimate populations within the watershed. Densities are recorded based on animal observations per 1000 hours of overall observation. If observation areas are not equally spread throughout the region, over or underestimates of the populations could occur. Likewise, animals are not likely equally distributed throughout the region; therefore, the regional density may again over or underestimate the true density of the animal in question. Nonetheless, these estimates provide the best guess at wildlife densities.

Table 8. Surrogate estimates of wildlife density in the Big Pine Creek watershed (from the Region of the Great Bend of the Wabash River watershed).

Animal	2005 Population Observation (per 1000 hrs of observation)
Coyote	21
Squirrel	650
Opossum	12
Rabbit	42
Raccoon	43
Fox	8
Turkey	158
Geese	487
Duck	219
Deer	947

Source: Plowman, 2006

2.8.3 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.

Appendix C includes the database results for the Big Pine watershed, as well as county-wide listings for those counties which occur within this watershed.

In total, 98 observations of listed species and/or high quality natural communities occurred within the Big Pine watershed (Figure 20). These observations include five birds, three fish, eight mammals, one reptile, seven freshwater mussels, eighteen plants, and three community types. Reptiles, fish and mussels are all tied directly to the Big Pine and Mud Pine Creeks and/or riparian habitats. The associated birds are spread throughout the watershed but primarily in greater abundance along the wooded river/stream corridors, especially in the southern portion of the watershed where extensive forests occur in the deeply dissected lands surrounding the stream. Mammals and plants dot the watershed landscape however do occur in particular hotspots in the natural lands and floodplain in the watershed.

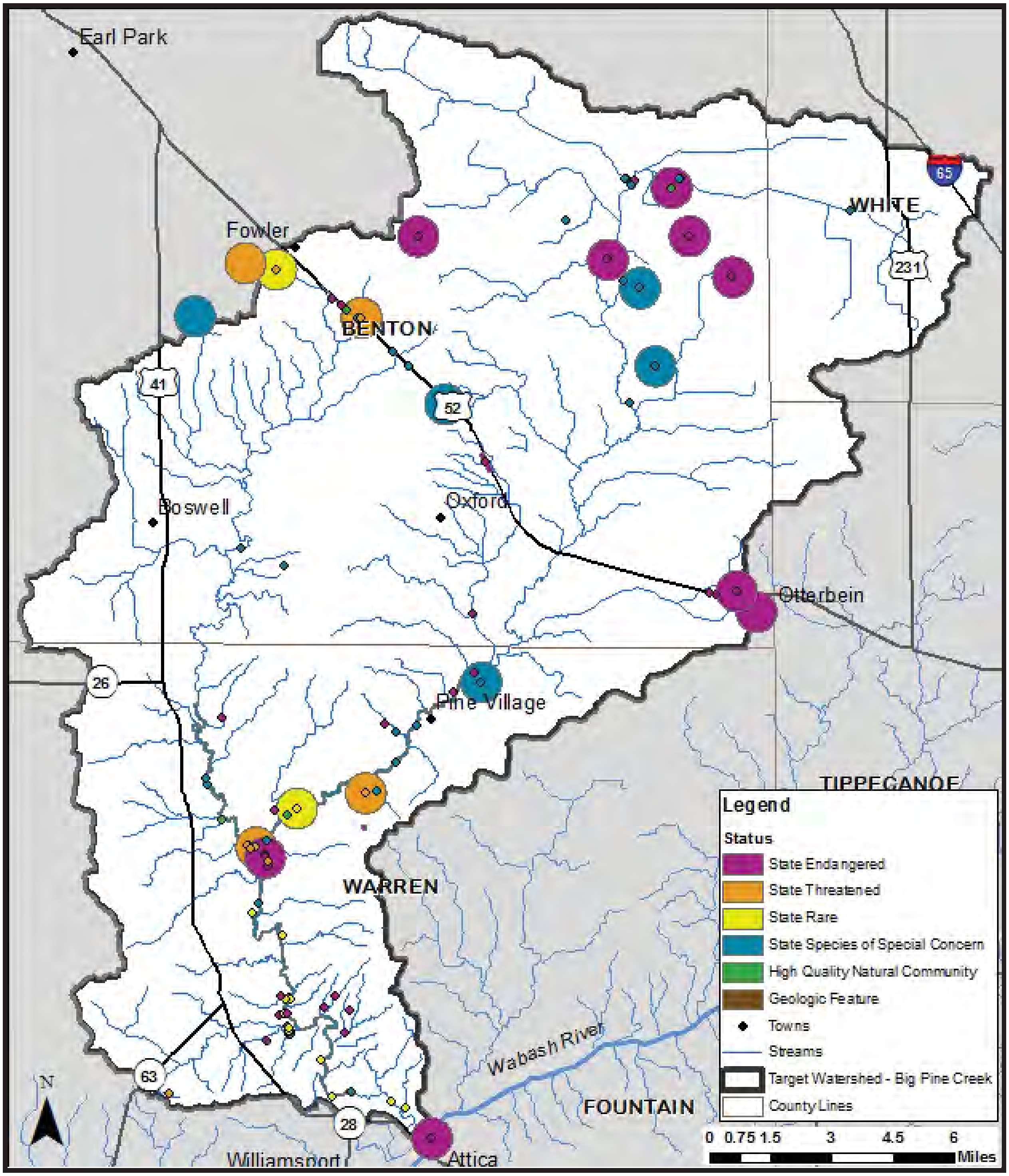

Figure 20. Locations of special species and high quality natural areas observed in the Big Pine Creek watershed.

Data used to create this map are detailed in Appendix C. 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 polygons typically following river and stream stretches based on observational records along that stretch of the stream (R. Hellmich, personal communication June 12, 2014).

2.8.4 Exotic and Invasive Species

Exotic and invasive species are prevalent throughout the state of Indiana. Their presence throughout the watershed and their potential impacts on high quality natural communities and regional species are of concern to stakeholders. Individuals are especially concerned about the prevalence of garlic mustard and honeysuckle species, reproducing populations of grass carp, and the long-term impacts of zebra mussels and Asian carp on the Wabash River. Many species impact portions of the Big Pine Creek watershed. Exotic species are defined as non-native species, while invasive species are those species whose introduction can cause environmental or economic harm and/or harm to human health. Hundreds of thousands of dollars are spent annually controlling exotic and/or invasive species populations within both publicly-owned natural areas and on privately-owned land. While this section is current as of the plan’s publication, the threat of exotic and invasive species is continuously evolving. Therefore, new species or treatment methods may be available since the publication of the plan. Table 9 lists exotic species observed within the counties which comprise the watershed.

Table 9. Observed exotic and / or invasive species by county within the Big Pine Creek watershed.

Species	Benton	Tippecanoe	Warren	White
Plant species				
Asian bush honeysuckle	X	X	X	X
Autumn olive	X	X	X	X
Black locust		X	X	
Buckthorn		X		
Canada thistle	X	X	X	X
Chinese yam		X		
Common reed	X	X	X	X
Creeping Charlie	X	X	X	X
Creeping Jenny	X	X	X	X
Crown vetch	X	X	X	X
Dame's rocket	X	X	X	X
Garlic mustard	X	X	X	X
Japanese hedge parsley		X		
Japanese honeysuckle	X	X	X	X
Japanese knotweed	X	X		
Mulitflora rose	X	X	X	X
Norway maple	X	X		X
Oriental bittersweet				X
Periwinkle	X	X	X	X
Privet		X	X	X
Purple loosestrife				X
Purple winter creeper	X	X	X	X
Reed canary grass	X	X	X	X
Russian olive		X		
Siberian elm	X	X	X	X
Smooth brome	X	X	X	X
Spotted knapweed		X		
Star-of-Bethlehem	X	X	X	X
Sweet clover	X	X	X	X
Tall fescue	X	X	X	X
Tree of heaven	X	X	X	X
White mulberry	X	X	X	X
Winged burning bush		X		
Fish and Mussel Species				
Silver carp		X	X	
Bighead carp		X	X	
Grass carp		X	X	
Common carp		X	X	
Zebra mussel		X	X	

Source: Bledsoe, 2009; Fisher et al., 1998

2.8.5 Recreational Resources and Significant Natural Areas

A variety of recreational opportunities and natural areas exist within the Big Pine Creek watershed. Recreational opportunities include parks, fish and wildlife areas, nature preserves, fairgrounds, golf courses, and school grounds (Figure 21). There are several DNR Fish and Wildlife Areas in Benton County, located along Big Pine and Mud Pine Creeks, which are managed for gamebird habitat. The Nature Conservancy owns and maintains Fall Creek Gorge Nature Preserve, near Fall Creek's confluence with Big Pine Creek in Warren County. Niches Land Trust manages seven nature preserves totaling over 800 acres encompassing forest and wetlands. Big Pine itself is also a very popular stream with canoe and kayak enthusiasts at certain times of the year when the water is high. The nearby cities of Lafayette, West Lafayette, and Attica all maintain multiple park-based facilities, although these are just outside the watershed.

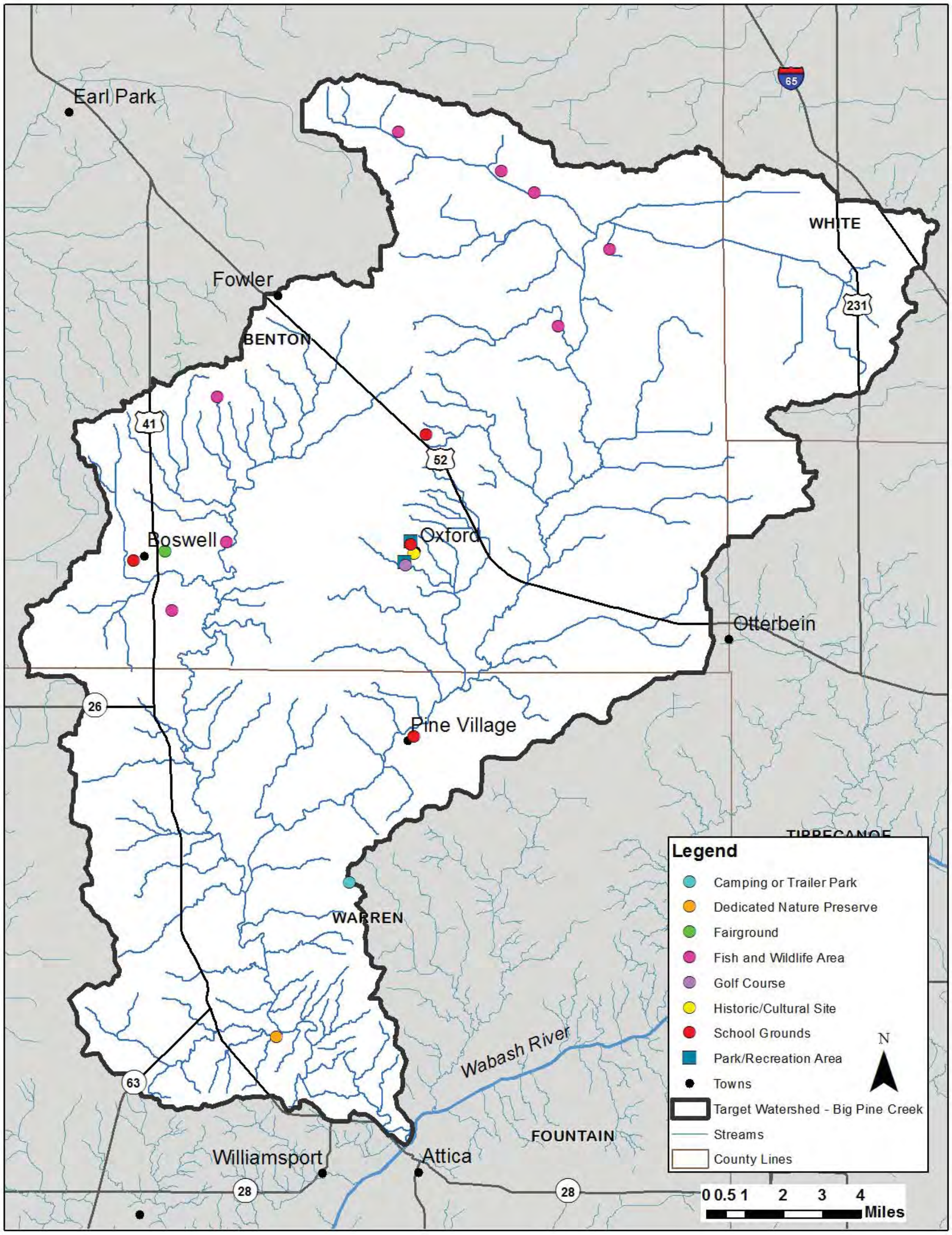

Figure 21. Recreational opportunities and natural areas in the Big Pine Creek watershed.

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, and manure, to name a few. 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

Historical accounts and data infer that the Big Pine was a full and slow moving stream, with clarity of water, surrounded by wetlands and tall grass prairie that allowed scant storm water runoff (Ladd, 2004). The region was described as being resplendent with large trees and prairies as far as the eye could see. Coulter (1886) described the area as part of the prairie region. Black and white walnut; black, white, and bur oak; white ash; pignut, bitternut, shagbark, and scale bark hickory; wild cherry, sugar maple; and beech were the most common trees (DeHart, 1909). Willow, dogwood, hazelnut, crabapple, plum, pawpaw, buckeye, sassafras, redbud, and mulberry were also prevalent. Coulter (1886) described the low water mark of the Wabash River as being 504 feet above sea level and detailed the numerous clear, cold streams and springs which carried water to the Wabash River.

Native American tribes such as the Miami, would have undoubtedly used the Big Pine for fishing and transportation, as there were numerous villages along the nearby Wabash River (IDNR, 2014). Beginning in the early 19th century, the Native American people were slowly forced out of the region by the white settlers. This included the famous battle at Prophetstown where Native Americans led by Tecumseh were defeated by General William Harrison's troops just east of the Big Pine watershed.

As white settlement increased, land use in the Big Pine became more intensive, and included the clearing of forests for the purposes of agriculture. The first towns began to be incorporated in the early to mid-1800's including Attica in 1825, Oxford (the first town in Benton County) in 1843, and Pine Village in 1851. The completion of the Wabash and Erie Canal through the area in the late 1840's helped to bring growth to the region as did the completion in 1883 of the Chicago and Great Southern Railroad which connected Attica to Fair Oaks. The railroad became known as the "Coal Road" because of the great quantities of coal that was shipped to Chicago along this line (Wikipedia, 2014).

2.9.2 Current Land Use

Today, over 80% of the land in the Big Pine watershed is in row crop agriculture because of the rich soils that were formerly prairies and wetlands (Table 10, Figure 22). In fact, in 2011, Benton and Warren Counties alone produced over 37 million bushels of corn (NASS, 2011). Only about 7% of the land remains forested—largely in areas along the Big Pine or other places too difficult to make row crop agriculture feasible. Almost all the wetlands in the watershed have been drained—less than 1% of the land is currently characterized as wetlands by USGS. In 2013 land values for this productive farm land were over $10,000/acre. There is little urban development, much of the landscape in the Big Pine watershed remains rural with only scattered small towns. Only a little over 5% of the landscape could be classified as developed lands. Definitions for each land cover type are included in Appendix D.

Table 10. Detailed land use in the Big Pine Creek watershed.

Classification	Area (acres)	Percent of Watershed
Cultivated Crops	174,932	83.4%
Deciduous Forest	14,614	7.0%
Pasture/Hay	8,394	4.0%
Developed, Open Space	5,520	2.6%
Developed, Low Intensity	5,484	2.6%
Open Water	269	0.1%
Grassland/Herbaceous	259	0.1%
Developed, Medium Intensity	188	0.1%
Woody Wetlands	90	<0.1%
Developed, High Intensity	86	<0.1%
Barren Land	30	<0.1%
Emergent Herbaceous Wetlands	5	<0.1%
Evergreen Forest	3	<0.1%
Total	**209,875**	**100%**

Source: USGS, 2001

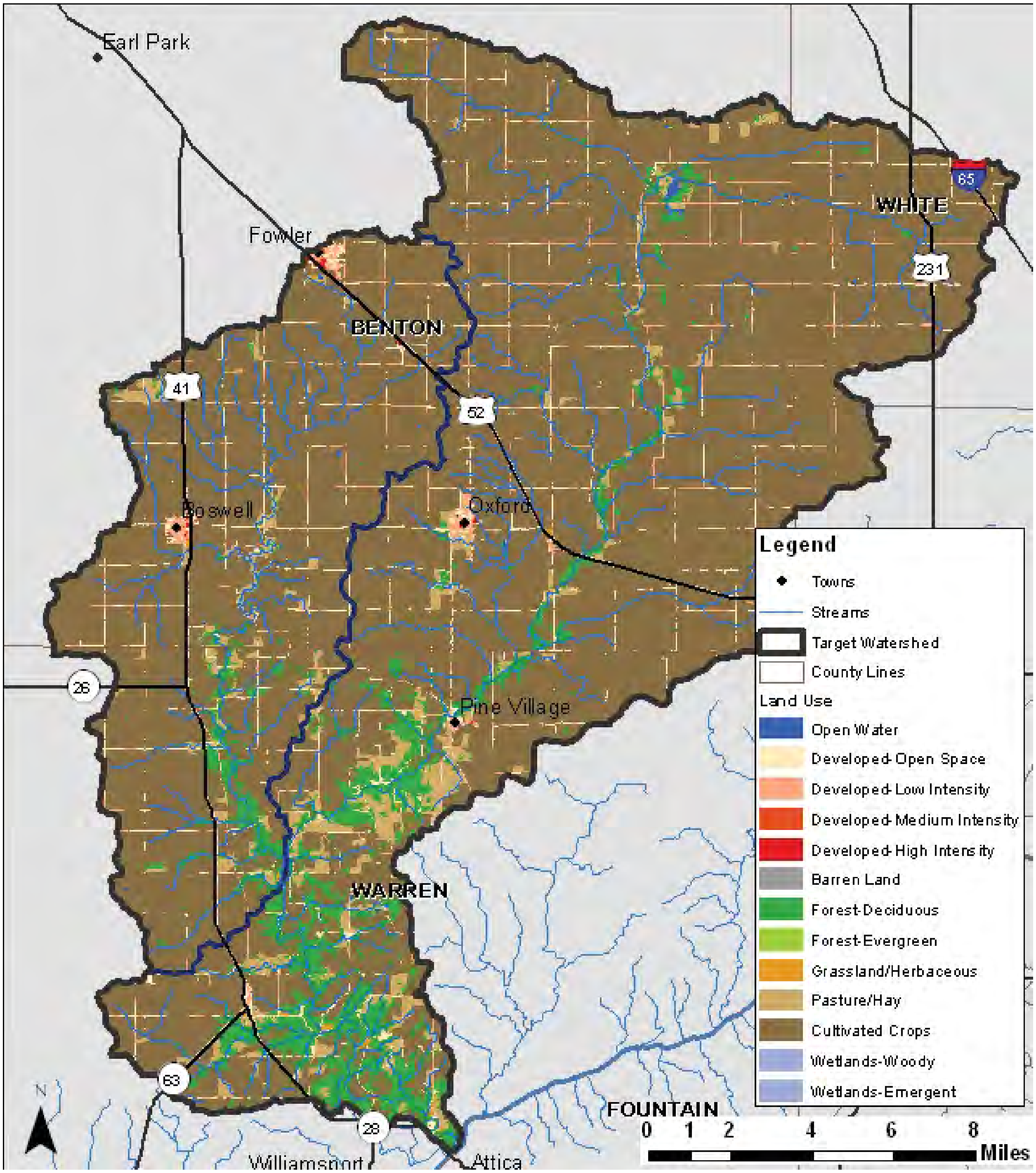

Figure 22. Land use in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.3 Agricultural Land Use

Individuals are concerned about the impact of agricultural practices on water quality. Specifically, the volume of exposed soil entering adjacent waterbodies, the prevalence of tiled fields and thus the transport of chemicals into waterbodies, the use of agricultural chemicals, and the volume of manure applied via small animal farms and through confined animal feeding operations are concerning to local residents. Each of these issues will be discussed in further detail below. According to USDA data from 2004, cultivated areas cover much the watershed with two-thirds of cultivation occurring in densities of 75% or greater (Table 11, Figure 23).

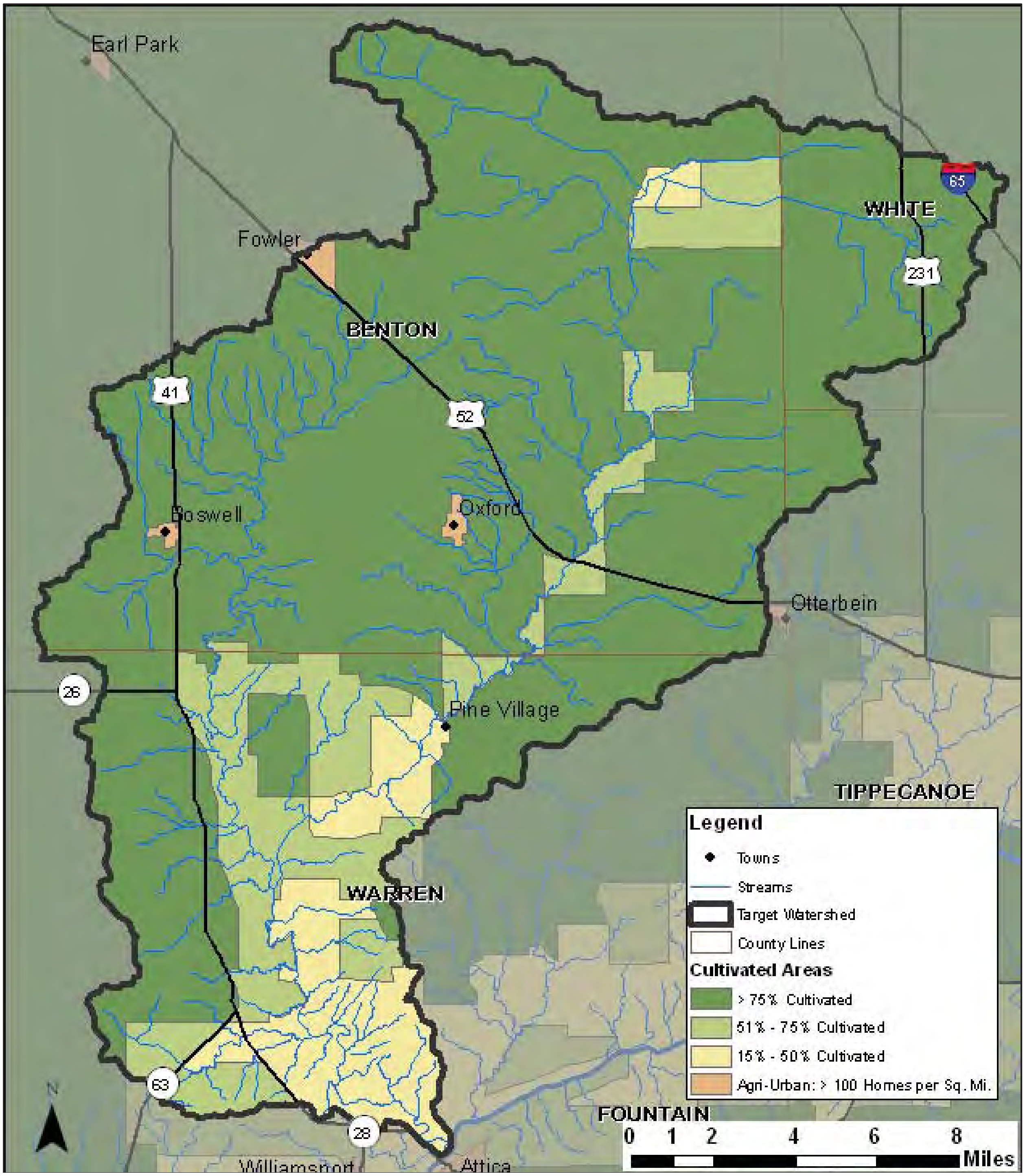

Figure 23. Cultivation density and type (2004) in the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Table 11. Cultivation density and type in the Big Pine Creek watershed

Cultivation Type and Density	Area (acres)	Percent of watershed
> 75% Cultivated	162,922	78%
51% - 75% Cultivated	28,986	14%
15% - 50% Cultivated	16,820	8%
< 15% Cultivated	0	0%
Agri-Urban: > 100 Homes per Sq. Mi.	982	0%
Commercial: > 100 Homes per Sq. Mi.	0	0%
Non-Agricultural	0	0%
Water	0	0%
Total:	**209,709**	**100%**

Source: USDA, 2004

The landscape is over 80% agriculture production, primarily corn and soybeans (Table 12). There are a few cases of corn on corn production while others do a rotation of corn and beans. Much of the local demand for corn is driven by Tate and Lyle, a food company based in the United Kingdom that purchases corn in the Big Pine watershed and converts it to a variety of food products for human and animal consumption.

Table 12. Crop type in the Big Pine Creek watershed based on satellite imagery.

Crop	Area (acres)	Percent of Watershed
Corn	97,053.1	46.3%
Soybeans	69,760.3	33.3%
Forest	15,026.5	7.2%
Grassland/Pasture	12,380.4	5.9%
Developed/Open Space	5,610.6	2.7%
Developed	5,594.9	2.7%
Winter Wheat	2,830.3	1.3%
Alfalfa	1,059.1	0.5%
Open Water	202.3	0.1%
Popcorn or Ornamental Corn	96.8	0.05%
Barren	38.3	0.02%
Winter Wheat/Soybeans	15.5	0.01%
Fallow/Idle Cropland	13.5	0.01%
Other Hay/Non Alfalfa	11.6	0.01%
Clover/Wildflowers/Herbs	8.2	<0.01%
Wetlands	6.4	<0.01%
Oats/Rye	0.7	<0.01%
Corn/Soybeans	0.4	<0.01%
Shrubland	0.2	<0.01%
Total	**209,709**	**100%**

Source: USDA, 2013

Maintaining proper drainage is essential to these rich prairie soils. Extensive tile has been placed in fields and most recently center pivot irrigation has been increasing in the watershed. There are a few farmers using tile control structures and managing the water for production. Farmers in the watershed stress the importance of drainage using tiles and ditches. Many in the past have invested several thousand dollars in tiles to still not get the performance they need and now they realize that their outlets (larger tiles or open ditches) have been compromised with sediment build up and inadequate capacity to hold the water volumes they are receiving today. Figure 24 and Figure 25 depict the tillage transect results for Benton and Warren counties, which make up the majority of the watershed (ISDA, 2013).

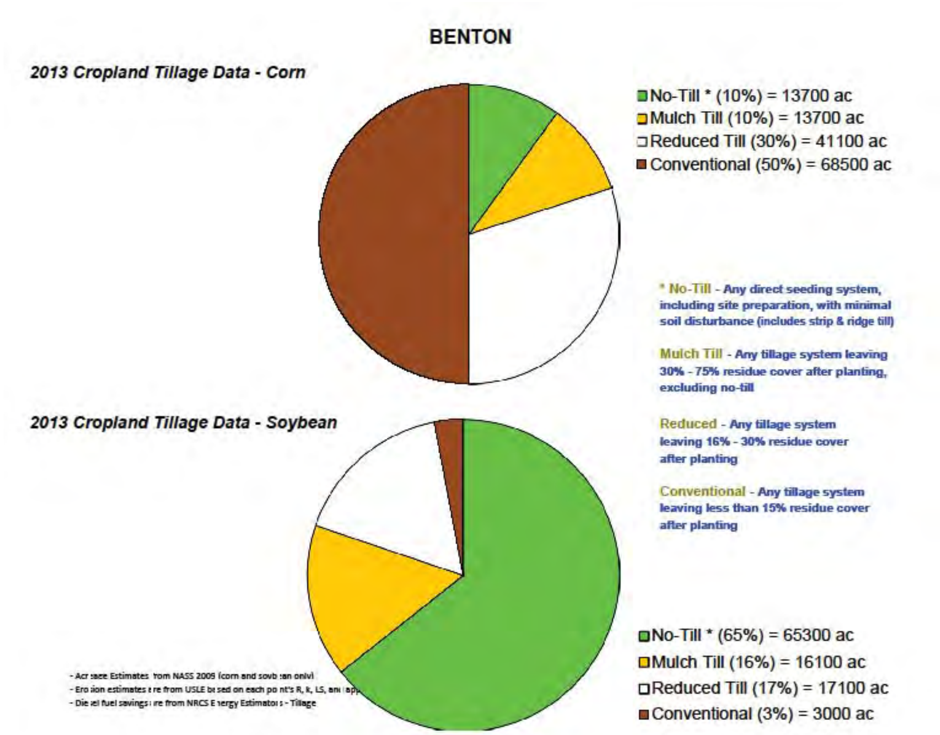

Figure 24. Tillage transect data for Benton County from 2013.

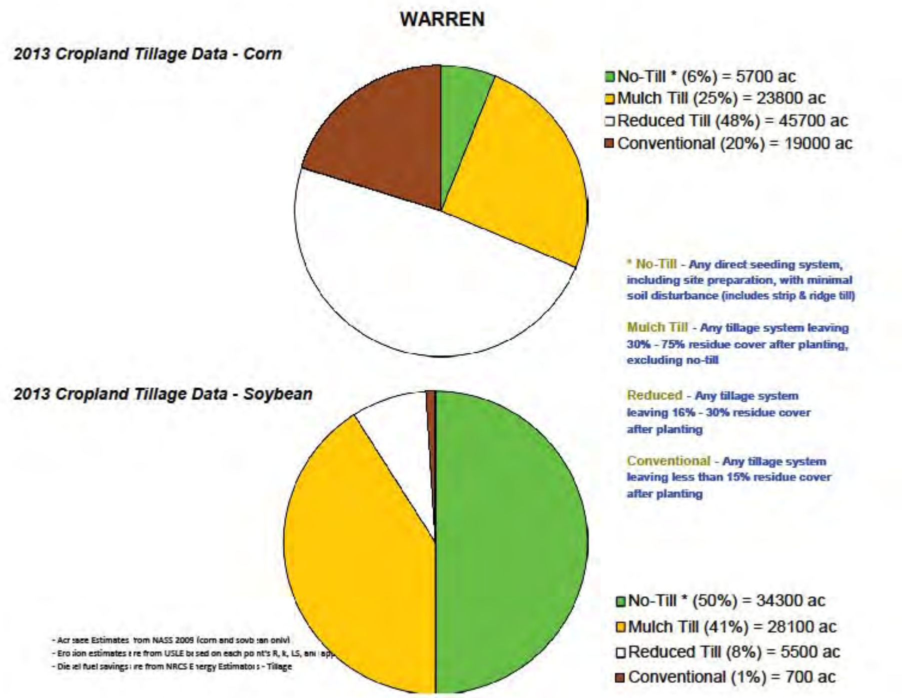

Figure 25. Tillage transect data for Warren County from 2013.

Several producers do what is termed mulch or minimum till in the watershed, but with such an open landscape if the tillage is done in the fall, heavy rain and wind events in the winter and early spring can cause a great deal of soil loss. There may be a need to raise the bar on what ranks as mulch or minimum till in terms of the soil residue left in place, as the residue left from the harvest of GMO crops is more difficult to break down. The preferred conservation cropping method includes bolstering soil microbial populations and implementing a nitrogen management program appropriate for corn on corn systems.

Agricultural Chemical Usage

Agricultural pesticides and 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 are not currently collected. Rather, data is 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. These data were last collected in 2006 (NASS, 2006). Additionally, NASS collects farmland data for the number of acres in agricultural production by type (i.e. corn, soybeans, grains) (NASS, 2007). These data indicate that corn (97,053 acres) and soybeans (69,760 acres) are the two primary crops grown in the watershed (Table 12).

Nitrogen is more typically applied to corn than to soybeans. Soybeans have symbiotic bacteria on their roots that act as nitrogen fixers, which means that they pull the nitrogen that they need from the atmosphere 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). Fall application of nitrogen also occurs, and is particularly problematic. Agricultural data indicate that corn receives 98% of the nitrogen applied in the state and 87% of the phosphorus. For these reasons, nutrient calculations were only completed for corn as applications to soybeans are likely negligible. Based on these data, it is estimated that 7,153 tons of nitrogen and 3,538 tons of phosphorus are applied annually within the Big Pine watershed (Table 13).

Table 13. Agricultural nutrient usage for corn in the Big Pine Creek watershed.

Nutrient	Acres of Corn	% of Area Applied	Applications (# / year)	Rate / Application (lb / acre)	Total Applied / Year (tons)
Nitrogen	97,053	100	2.2	67	7,153
Phosphorus	97,053	93	1.4	56	3,538

Source: NASS, 2007

Pesticides are also used on crops grown in Indiana. The Office of the Indiana State Chemist indicates that the two predominant herbicide active ingredients applied are atrazine and glyphosate. Atrazine is most commonly applied as a corn herbicide, while glyphosate is used on both corn and soybean fields as an herbicide. NASS indicates that in 2005, an average of 1.24 pounds of atrazine and 0.6 pounds of glyphosate were applied per acre of corn, and 0.73 pounds of glyphosate were applied per acre of soybeans (NASS, 2006). Using these rates, we estimated that a little over 60 tons of atrazine and approximately 54.6 tons of glyphosate are applied to cropland in the Big Pine watershed annually (Table 14).

Table 14. Agricultural herbicide usage in the Big Pine Creek watershed.

Crop	Acres	Application Rate (lb / acre)	Total Applied (lbs)	Total Applied / Year (tons)
Corn (Atrazine)	97,053	1.24	120,346	60.2
Corn (Glyphosate)	97,053	0.60	58,232	29.1
Soybeans (Glyphosate)	69,760	0.73	50,925	25.5

Source: NASS, 2006

Confined Feeding Operations and Hobby Farms

A mixture of small, unregulated and larger, regulated livestock operations (confined feeding operations) is found within the Big Pine watershed. Small farms are those which house less than 300 animals, while larger farms that house large numbers 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 (CFO). There are five active confined feeding operations located in the watershed, none of which are large enough to be classified as a concentrated animal feeding operation (CAFO) (Figure 26). Four of the CFOs house swine, with capacities ranging from 680 to 5,080 animals at each facility. One of the CFOs in the Spring Branch subwatershed houses 420 dairy cows. There is one dairy CFO located just north of the Big Pine Creek watershed. Although the facility is located outside of the watershed, about 15% of the land used for manure application is within the watershed, so its contribution to the watershed was prorated accordingly. In total, approximately 32,000 animals per year are housed in CFOs in the watershed, generating over 129 million pounds of manure per year spread over 3,074 acres in the watershed. This much manure contains nearly 820,000 pounds of nitrogen and 262,000 pounds of phosphorus.

Fifty-two small, unregulated animal farms were identified during the windshield survey, which is most likely an underestimate of the actual number. These small “mini farms” have small numbers of cattle, horses, or goats, which could be sources of nutrients and *E. coli* as these animals exist on small acreage lots with limited ground cover.

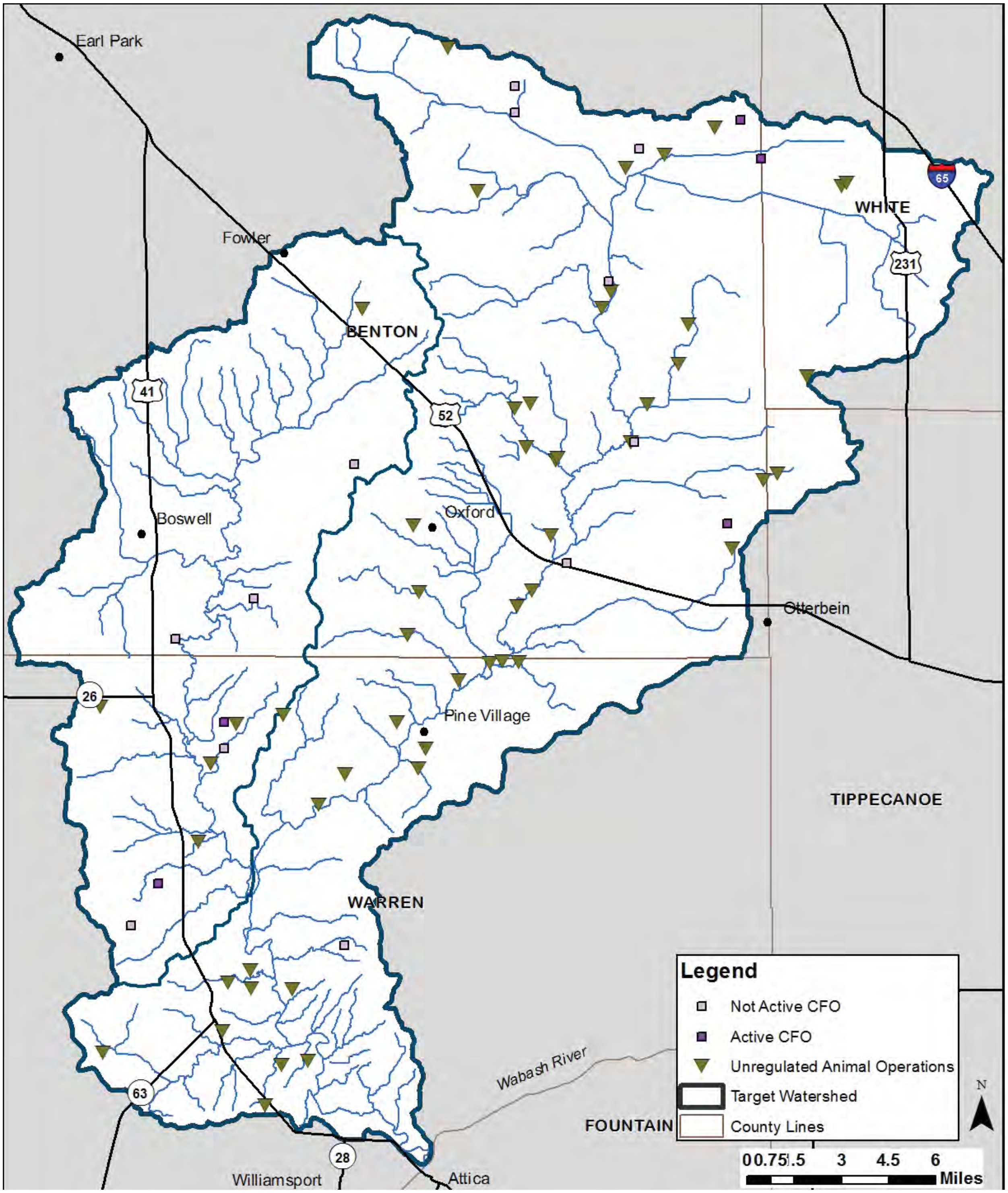

Figure 26. Confined feeding operation and unregulated animal farm locations within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.9.4 Natural Land Use

Natural land uses including forest, wetlands, and open water cover less than 8% of the watershed. Individuals are concerned that too much forested land is being lost within the watershed and would like to see reforestation prioritized. Approximately 14,700 acres or 7% of the watershed are covered by trees. Forest cover occurs adjacent to waterbodies throughout the watershed, with the extent of forests increasing towards the southern end of the watershed where the steeper terrain has made it more difficult to clear for agriculture (Figure 22). However, most forested tracts are not contiguous and large lengths of the watershed streams no longer contain intact riparian buffers. Specific areas of concern will be discussed in further detail in subsequent sections. Altered hydrology is a major issue in the watershed and natural filters need to be established (grasses, trees, wetlands) to capture and hold water back. This is a critical factor as more land is cleared and drained for row crop production.

2.9.5 Urban Land Use

Urban land uses cover less than 1% of the watershed (Table 10). Although this is only a very small portion of the watershed, there are some significant issues related to the developed areas. Especially troublesome are issues related to failing septics and CSO's that allow untreated sewage to flow into the watershed during heavy rain events. Upgrades needed for facilities such as WWTP's can be cost-prohibitive. Strategies such as the wetland cells being used by Oxford are a great option that balances need and expense.

Impervious Surfaces

Impervious surfaces are hard surfaces which limit surface water from infiltrating into the land surface 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 Oxford and Boswell, land which was once permeable has been covered by hard, impervious surfaces. This results in rain which once absorbed into the soil running off of rooftops and over pavement to enter the stream with not only higher velocity but also higher quantities of pollutants.

Overall, the watershed is covered by low levels of impervious surfaces. However, high impervious densities are present in Oxford, Boswell, Fowler and Pine Village and along roads throughout the watershed (Figure 27). Estimates indicate that only 5,015 acres (2%) of the watershed are 25% or more covered by hard surfaces, while 202,268 acres (96.4%) of the watershed is covered by 10% or less of 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. Higher impervious surface coverage results in further impairments including water quality problems, increased bacteria concentrations, higher levels of toxic chemicals, high temperatures, and lower dissolved oxygen concentrations (CWP, 2003). Since 96.4% of the watershed is 10% or less impervious surface, this is not something that will be a focus during the implementation phase of the watershed management plan. The areas where it could play a role are those that have a greater percentage of impervious surfaces, like the tributaries of Big Pine Creek located near Oxford, Boswell, Fowler and Pine Village, such as Brown Ditch, Goose Creek, the headwaters of Mud Pine Creek, and the mainstem of Big Pine Creek near Pine Village.

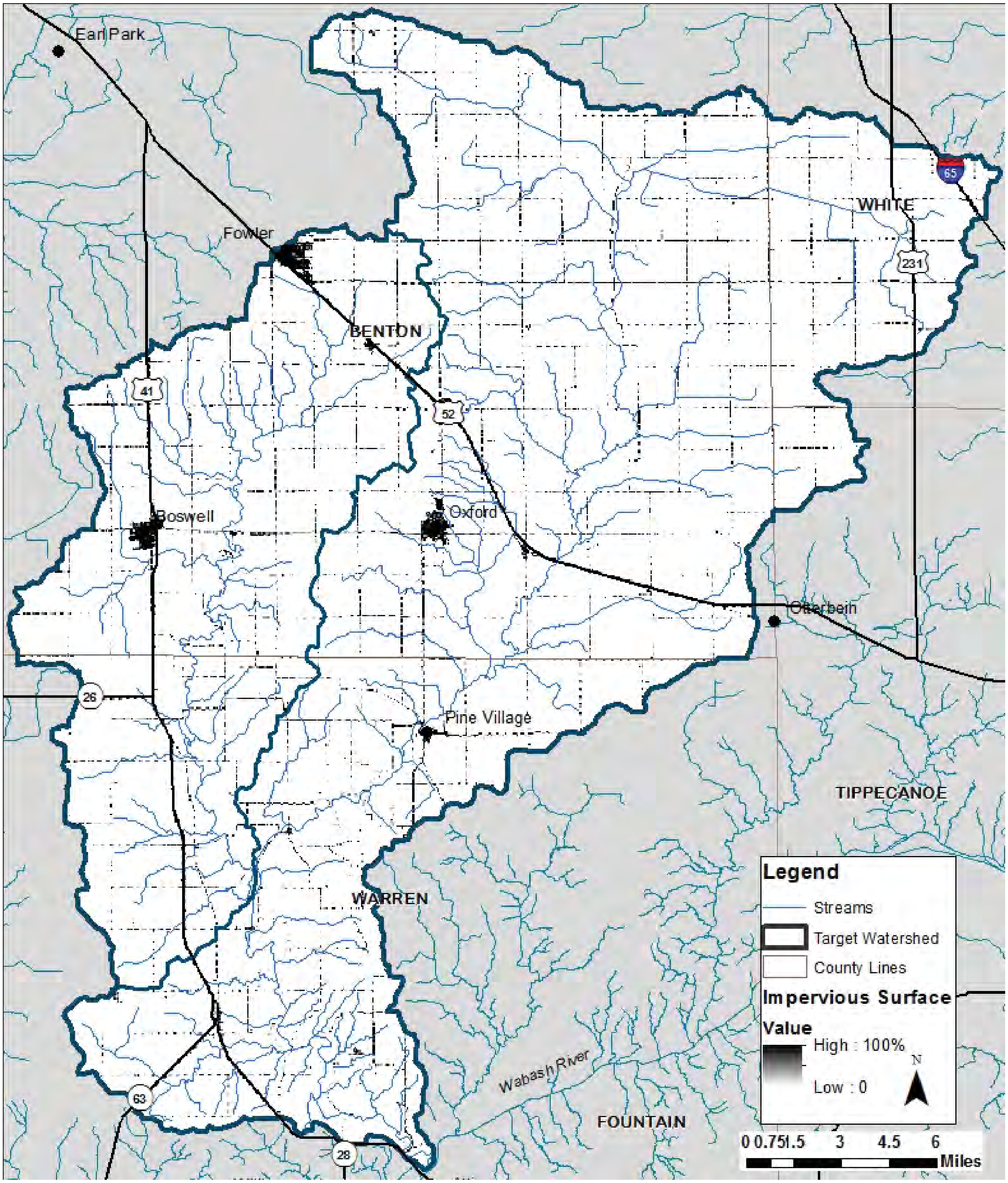

Figure 27. Impervious surface density within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

Remediation Sites

Remediation sites including industrial waste, leaking underground storage tanks (LUST), open dumps, and brownfields are present throughout the Big Pine Creek watershed (Figure 28). Most of these sites are located within the developed areas around Fowler, Oxford, Boswell and Pine Village. In total, two industrial waste sites, 14 LUST facilities, four open dumps, and two brownfields are present within the watershed. There are no Superfund sites within the watershed.

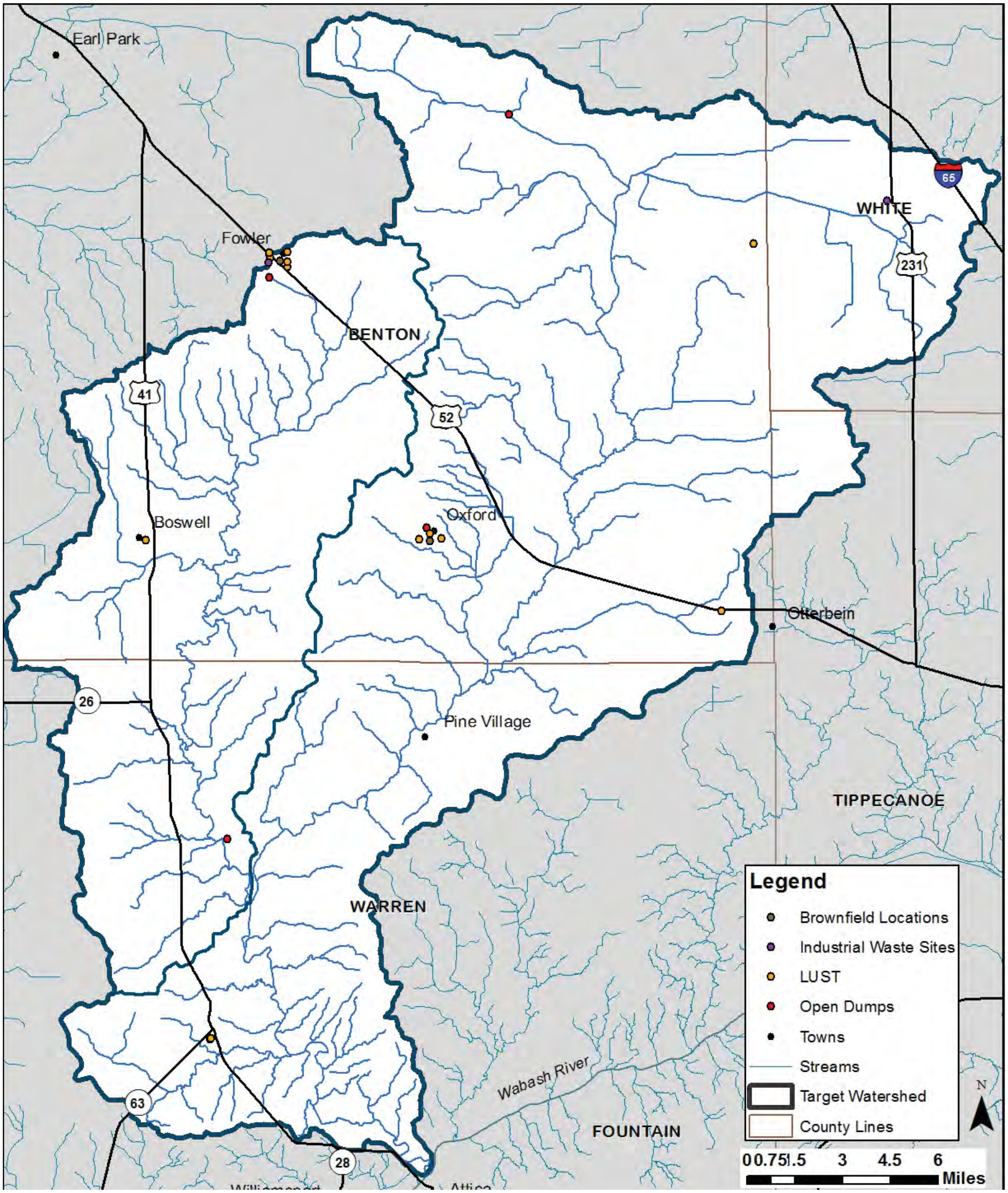

Figure 28. Industrial remediation and waste sites within the Big Pine Creek watershed.

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

2.9.6 Development Trends

There is little development pressure within the Big Pine Creek watershed. From 2001 to 2006, only 190 acres (<0.1%) experienced a change in land use (USGS 2006). Most of this change was a conversion to emergent herbaceous wetlands (38%) and shrub/scrub (34%), with cultivated crops accounting for 18% of the land use change. Low and medium intensity development (5%), barren land (4%), and open water (2%) account for the remaining converted land. In the period since 2006 it is likely that there has been further conversion of fallow ground and natural areas to cultivated crops. This was confirmed during the windshield survey, as at least one woodlot visible on the aerial photo had been converted to agriculture.

2.10 Population Trends

The Big Pine Creek watershed is a sparsely populated area in general with a few larger towns near the boundaries of the watershed. Tracking population changes within a watershed is challenging as data is published by counties and townships rather than watershed boundaries. Estimates of the population of the watershed are derived by calculating percentage of the watershed within a county and extrapolating from county-wide data.

The Big Pine Creek watershed lies within four counties. It drains nearly 50% of Benton County, 28% of Warren County, and less than 7% of Tippecanoe and White counties. Population trends for these counties derived from the most recently completed census (2010) are shown in Table 15, while Table 16 displays estimated populations for the portion of each county located within the watershed. These data indicate considerable growth in Tippecanoe County over both the past century and over the previous decade, however most of that growth is associated with Lafayette and West Lafayette and the immediate area, not the northwest corner of the county that lies in the watershed. Over the past century, White County has grown while Benton and Warren counties have experienced population declines. In the most recent decade, Benton and White counties have slightly decreased, while Warren County has remained stable.

Table 15. County demographics for counties within Big Pine Creek watershed.

County	Area (acres)	Population (2010)	Population Growth		Pop. Density (#/sq. km)
			(1890-2010)	(2000-2010)	
Benton	259,953	8,854	-25.6%	-6.0%	8.4
Tippecanoe	321,810	172,780	392.6%	16.0%	132.7
Warren	234,303	8,508	-22.3%	1.1%	9.0
White	325,372	24,643	57.2%	-2.5%	18.7

Table 16. Estimated watershed demographics for the Big Pine Creek watershed.

County	Acres of County in Watershed	Percent of County in Watershed	Population
Benton	124,285	47.8%	4233
Tippecanoe	2,786	0.9%	1496
Warren	65,107	27.8%	2364
White	17,531	5.4%	1328
		Total Estimated Population	**9,421**

Population densities within the watershed are relatively low; the majority of the watershed has a population density of less than ten people per square kilometer (Figure 29). Southern Benton County, associated with Boswell and Oxford, has densities ranging from 12 to 28 people per square kilometer. The highest density is associated with Fowler, with 1096 people per square kilometer.

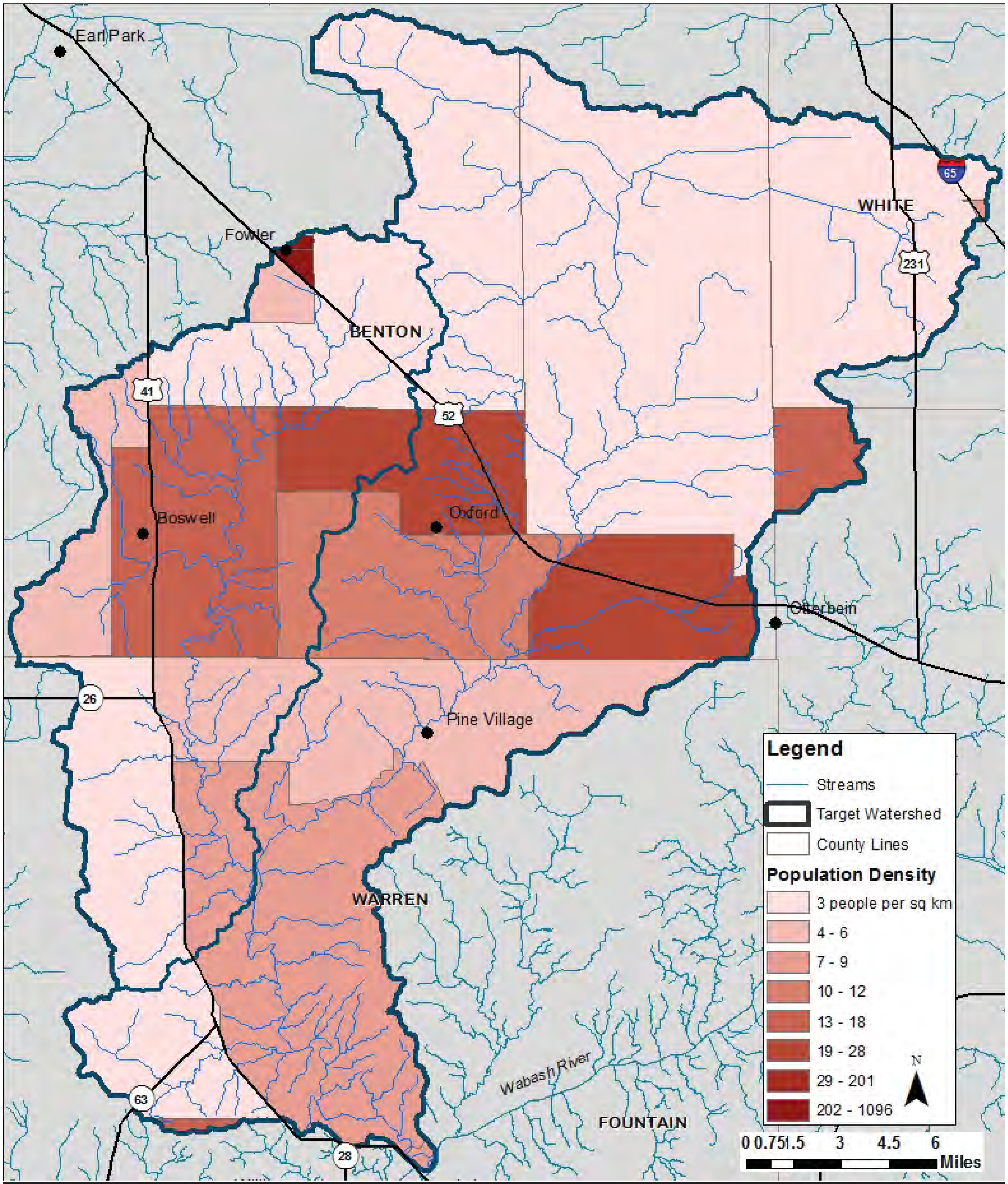

Figure 29. Population density (# / square kilometer) within the Big Pine Creek watershed.
Data used to create this map are detailed in Appendix A.

2.11 Planning Efforts in the Watershed

While no one single plan has been dedicated to the Big Pine Creek Watershed until the development of this one, several larger plans have encompassed portions of the Big Pine Creek Watershed or areas which it drains or outlets into. Planning efforts include those by the Wabash River Heritage Corridor Commission along the length of the Wabash River, including Warren and Tippecanoe Counties, and the Tippecanoe County SWCD Master Plan. Tippecanoe County has a county-wide master plan; however, much of their planning focuses on Greater Lafayette, which is outside our planning area. White, Benton and Warren Counties have not developed county-wide comprehensive plans or SWCD master plans.

Wabash River Heritage Corridor Commission Master Plan

In 1990, the Indiana Department of Natural Resources created the Wabash River Heritage Corridor Fund to provide assistance with conservation and recreational development projects along the Wabash River. In 1991, the Wabash River Heritage Corridor Commission (WRHCC) was created by House Enrolled Act 1382. The WRHCC protects and enhances the natural, cultural, historical and recreational resources of the Wabash River within the nineteen counties through which the river runs. This includes Warren and Tippecanoe counties, which are part of the current planning project. Since 1990, approximately 60 projects received funding totaling more than $13 million through the corridor fund (WRHCC, 2004). Additional efforts by the WRHCC include maintenance of a visible presence within the corridor counties, provision of interaction along the length of the corridor, and promotion of the Wabash River and its historical and recreational opportunities.

In 2004, the WRHCC updated its master plan via a series of public meetings along the Wabash River corridor. The master plan focused on eight main areas including land use, natural resources, historic resources, recreational resources, corridor connection and linkages, scenic by-way linkages, thematic connections, and tourism. As portions of the watershed are contained within the Wabash River Heritage Corridor, it is important that the goals, strategies, and actions developed as part of this plan be in line with those developed as part of the WRHCC master plan. The master plan identified the following action items:

- Maintain and enhance the natural diversity of the corridor.
- Restore natural landscapes of the Wabash River Heritage Corridor.
- Ensure that mineral extraction is environmentally sensitive.
- Stabilize the riverbank.
- Re-establish riparian forests and wetlands along the Wabash River.
- Develop and implement set-back programs to reduce surface runoff and non-point source pollution.
- Enforce existing regulations regarding point source pollution related to wastewater treatment plants and septic systems and explore the need for new regulations.
- Promote monitoring of water quality and public education about water quality.
- Preserve large regional natural areas.
- Fish stocking and wildlife reintroduction in and along the Wabash River.
- Conduct a historic resource inventory of the corridor resource and nominate eligible properties for National Register designation within the corridor.
- Develop a prioritized list of historic and cultural resources that are threatened for focused preservation effort by county.
- Identify long-term funding opportunities for historic preservation along the corridor.
- Acquire and develop more recreational areas and opportunities.
- Promote and enhance hunting and fishing opportunities.
- Promote and enhance birding opportunities in the corridor.
- Promote and enhance bicycling opportunities in the corridor.
- Develop trail connections along the river linking corridor communities.

- Increase access to the Wabash River for recreational use, boating, fishing, and enjoyment of the river. Increase overnight facilities access.
- Establish designation of scenic by-way along the river.
- Install directional or identification signs for scenic by-ways along the river.
- Create an image to connect and interpret significant resources.
- Develop a Wabash River Heritage Corridor Center that would introduce and interpret the significance of the Wabash River and the Heritage Corridor and serve as a central repository or records center for Wabash studies.
- Develop a Wabash River and Heritage Corridor education curriculum for teacher training opportunities.
- Create corridor identification.
- Promote and market corridor resources and events.
- Develop and coordinate corridor events as part of the Heritage Corridor identity.
- Provide information to promote local and corridor recreational resources and facilities.
- Develop a natural resources guide specific to the Wabash River Heritage Corridor that will be site specific including river and public access information.

In 2009 legislation was revised to allow a new source of dedicated money to be placed in the fund, derived from royalties of oil and mineral rights beneath the Wabash River. This fund will be used to once again fund projects in the Wabash River Corridor.

The grants have been awarded every other year, in 2012 and 2014 so far, and total approximately $300,000 every two years. Two of the four Big Pine Creek Watershed counties would be eligible to apply for funding: Warren and Tippecanoe.

Tippecanoe County SWCD Master Plan
The Tippecanoe County Soil and Water Conservation District (SWCD) was created in 1940 and was tasked with coordinating the conservation of soil, water, and related natural resources within Tippecanoe County (Tippecanoe SWCD, 2010). The SWCD’s vision of natural resources for Tippecanoe County is: stable soils, healthy forests and riparian buffers, clean streams and water resources, productive farms, and sustainable communities. Although only four sections comprising approximately 2,500 acres of Tippecanoe County fall within the Big Pine watershed it is essential to communicate to those landowners the work of the Big Pine Watershed group and promote opportunities developed through the Big Pine WMP to the appropriate landowners.

As part of their planning process, the SWCD identified the following areas of concern:

- Accelerated erosion on areas under construction resulting in downstream silting of drainage ways, bottomlands, and streams.
- Increased surface water management problems and flooding due to runoff from impervious surfaces.
- Improper soil use in construction of buildings, streets, and other structure that fail due to soil limitation that were not addressed.
- Limited riparian buffers resulting in the loss of natural topography.
- Negative impacts from water pollution on drinking water, household needs, recreation, fishing, transportation, and commerce.
- Rapid urban growth demands more space for housing developments and shopping centers at the direct expense of family farms and traditional farming mechanisms.

The following actions were identified by the SWCD to be completed by 2014:

- No till practices shall be increased by 2,500 acres in the Upper Wabash and Wildcat Creek watersheds.

- 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 stream bank stabilization awareness/education through 10 partnering opportunities by 2014.
- 125 acres of buffers will be installed in the Wea Creek and Wildcat Creek watersheds 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 storm water runoff by facilitating programs to establish 250 best management practices by 2014.

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 relationships within specific subwatersheds are discussed in more detail in subsequent sections.

2.12.1 Soils, Topography, and Land Forms

Topography within the watershed is generally flat, especially in the northern portion of the watershed. Soils in this area formed on till deposits, are somewhat poorly drained to moderately well drained, and are well suited to agriculture. As a result, approximately 80% of the watershed is in a corn-soybean rotation. Because of the low slope and poor drainage, tile drains are extensively used, especially in the portions of the watershed in Benton and White counties. It will be important to address the impacts of row crop agriculture and tile-drained systems, by promoting practices to reduce nutrients transported through tiles and to repair and prevent streambank erosion, in order to improve water quality in the watershed.

The highest ridge in the watershed runs from the Fowler area in Benton County down to just west of Oxford. The steepest terrain in the watershed is along the Big Pine Creek itself in Warren County where steep cliffs along the creek provide dramatic scenery. The steepness of the terrain in this area likely made it very difficult to remove timber, making this portion of the watershed one of the most heavily forested areas today. This area is also where the highest concentration of highly erodible and potentially highly erodible soils are found. Protecting and restoring the forested riparian buffer in this area will be important to reducing streambank erosion and in-stream sediment levels.

2.12.2 Unsewered Areas and Septic Soil Suitability

In general, the watershed is relatively sparsely populated with no large cities. The watershed is dominated by rural areas and small farming communities. The towns of Fowler, Oxford and Boswell support the highest population densities. Nearly the entire watershed is covered by soils considered very limited for use in septic tank absorption fields, yet only a small portion of the watershed is included in a wastewater treatment district, primarily associated with these three towns and the Benton Jr Sr High School. This presents a good opportunity for education and outreach focused on the importance of proper septic maintenance and the role it can play in impacting water quality.

2.12.3 High Quality Habitat and ETR Species

In general, most of the higher quality upland habitat in the watershed occurs in the southern portion of the drainage along and in the steep topography associated with Big Pine Creek, Fall Creek and Mud Pine Creek. The topography, bedrock and soils in this area support spectacular ravines and mature forest habitats, several of which have been assessed by IDNR, the Conservancy and Niches Land Trust. Many of these areas are owned or sought for ownership by NICHES Land Trust or the Conservancy for protection and preservation as they are the diamonds in the sea of agriculture that is the Big Pine Creek Watershed. The streams and gorges provide rare habitat that is home to many species of wildlife, fish, and plants. The topography here made this area less suitable for farming and so more of the natural community and habitat has been preserved here. Many of the endangered, threatened and rare species and high quality natural communities in the watershed are found along this stretch of the stream corridor, making this an important area to focus habitat preservation and restoration efforts.