2014 Pigeon Creek Watershed Management Plan

Steuben, LaGrange, DeKalb & Noble Counties
Indiana

Prepared By: Northwater Consulting

Prepared For: Steuben County Soil and Water Conservation District

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Steuben County Government

City of Angola/Trine University MS4

Table of Contents

Table of Figures

Table of Tables

List of Appendices

Project Contact Information:

Kayleen Hart
Administrative Coordinator
Steuben County Soil & Water Conservation District
Peachtree Plaza 200
1220 N 200 W
Angola, IN 46703
(260) 665-3211, X 3

List of Acronyms

AFO – Animal Feeding Operation
BMP – Best Management Practice
CAFO – Confined Animal Feeding Operation
CFO – Confined Feeding Operation
CFS - Cubic Feet Per Second
CSO – Combined Sewer Overflow
CRP – Conservation Reserve Program
CFU – Colony-Forming Unit
DO – Dissolved Oxygen
EQIP - Environmental Quality Incentives Program
EMC – Event Mean Concentration
EPA – Environmental Protection Agency
FEMA: Federal Emergency Management Agency
GIS – Geographical Information System
GLRI – Great Lakes Restoration Initiative
HEL – Highly Erodible Soils
HUC – Hydrologic Unit Code
IBI – Index of Biological Integrity
IDEM – Indiana Department of Environmental Management
IDNR – Indiana Department of Natural Resources
IBC – Impaired Biotic Community
LARE: Lake and River Enhancement Program
MS4 – Municipal Separate Storm Sewer System
MIBI – Macroinvertibrate Index of Biological Integrity
MGD – Million Gallons per Day
NPDES – National Pollutant Discharge Elimination System
NRCS: Natural Resources Conservation Service
NHD – National Hydrography Dataset
NPS – Nonpoint Source Pollution
N – Nitrogen
NWI – National Wetlands Inventory
P – Phosphorus
PCWMP – Pigeon Creek Watershed Management Plan
QHEI – Qualitative Habitat Evaluation Index
SCSWCD – Steuben County Soil and Water Conservation District
SCLC – Steuben County Lakes Council
SWAMM – Spatial Watershed Assessment and Management Model
STEPL – Spreadsheet Tool for Estimating Pollution Loading
TSS – Total Suspended Solids
TMDL – Total Maximum Daily Load
TSI - Trophic State index
TNC – The Nature Conservancy
T&E – Threatened and Endangered Species
USACE – U.S. Army Corps of Engineers
USLE – Universal Soil Loss Equation
USDA – U.S. Department of Agriculture
WLA - Waste Load Allocation
WWTP – Waste Water Treatment Plant
WQS – Water Quality Standards
WRP - Wetland Reserve Program
WASCOB – Water and Sediment Control Basin
WMP – Watershed Management Plan

Executive Summary

The Pigeon Creek Watershed

The Pigeon Creek watershed is 135,911 acres in size and located in the northeast corner of Indiana. Of this acreage, 71 percent is within Steuben County, and small sections of the watershed extend into three other counties; LaGrange (22 percent), DeKalb (6 percent), and Noble (0.5 percent). The Pigeon Creek watershed is primarily agricultural with three municipalities and small, unincorporated residential areas throughout. The lakes within the watershed are an important local resource for passive and active recreation, as well as for natural habitat.

The Pigeon Creek Watershed Management Plan

Reflecting the concerns of local residents and other area stakeholders about water quality and flooding, the goals of the *Pigeon Creek Watershed Management Plan* (WMP) are to reduce bacteria, nutrient, and sediment loads in the area's waterways, as well as to reduce and control flooding. High bacteria levels can harm human health and impact aquatic and recreational resources. Excessive sediment and nutrients have led to algae growth in the watershed's lakes and streams, and pose a concern for human health and aquatic resources. Besides damaging infrastructure, flooding contributes to excessive runoff and high levels of sediment, nutrients and bacteria entering the watershed's streams and lakes.

The 2014 WMP provides a framework for meeting these stated goals, while balancing the needs of the communities and stakeholders. As an update to the original WMP completed in 2006, it communicates the current health and function of the watershed, outlines the water quality and flooding issues, and defines the strategies to preserve and improve upon its current health. The WMP is the outcome of a comprehensive analysis that incorporates the 33-element checklist required by the Indiana Department of Environmental Management (IDEM) for WMP approval and eligibility for implementation funds under Section 319 of the Clean Water Act. Further, this plan exceeds the IDEM requirements by defining actionable implementation strategies, associated costs, and the expected resulting watershed benefits. The implementation strategies are directly tied to meeting the standards specified in the 2012 *Pigeon River Total Maximum Daily Load* (TMDL) *Plan*.

With the WMP in place, the Steuben County Soil and Water Conservation District (SCSWCD), adjoining counties and other watershed stakeholders have a mechanism to request and obtain funding to implement the suggested tools to accomplish the plan's goals for the public's health and quality of life.

The Results of the Watershed Assessment & Inventory

Since 1996, much work has been implemented in the watershed to reduce pollutants, including the installation of 140 treatment practices, as well as education and outreach campaigns and programs. This work demonstrates a willingness to address watershed concerns and achieve measurable success in improving water quality.

The 2014 watershed assessment and inventory, however, indicate that the watershed continues to produce high bacteria and nutrient loading, along with a moderate sediment load. *Loads* and *loading* refers to the amount of pollutants that enter a waterbody. Based on computer modeling, total loading estimated for phosphorus was 1.16 pounds from one acre of land per year; for nitrogen, 7.13 pounds; sediment, 0.94 tons; and bacteria, 2.72 billion colony-forming units. With the exception of sediment, all of these pollutants exceed state standards and require reductions established in the 2012 Pigeon River TMDL Plan.

In addition, water quality monitoring in the watershed shows that 269 of 627 samples exceed state standards for bacteria, 40 of 577 exceed the standard for phosphorus, 39 of 129 for nitrogen, and 46 of 574 for sediment. Nine of the watershed's 734 lakes and reservoirs and 179 of 257 stream-miles in the watershed are considered impaired by IDEM. The in-stream aquatic habitat in the watershed ranges from poor (low species diversity and sparse populations) to good (average species diversity with sufficient abundance). Flooding is also identified as an issue in the watershed. In 17 of the last 36 years, peak floodstage has been exceeded.

Most of the sediment and nutrients in the watershed originate from crop and pasture ground, whereas bacteria loads are believed to be the result of an estimated 1,365 failing septic systems, residential runoff, and concentrated animal waste. Wastewater discharges from the four treatment plants in the watershed are not the primary contributors to stream impairments. During the recreational months (April – October), when wastewater is being treated for bacteria (wastewater facilities do not treat for bacteria during the winter), monitoring results show these facilities to be operating within permitted limits. Conditions affecting flooding include changes in precipitation, soil types with high runoff potential, increases in impervious surfaces, and modifications to watershed hydrology such as channelization.

Recommendations to Meet Watershed Goals

Results of the planning process and a detailed assessment of the watershed indicate that specific Best Management Practices (BMPs) can reduce pollution loading, alleviate flooding, and meet stakeholder goals, if implemented on a large scale. Direct recommendations to meet the goals of the watershed plan include a wide range of improvement measures (Table 1).

These BMPs can be applied throughout the watershed; however, rather than leave these recommendations open-ended and for later study, this plan identifies a series of site-specific practices to treat 5,300 acres which can be implemented once the plan is finalized. Upon finalization of the plan, applications will be submitted to obtain grant funding for implementing these improvement measures.

Table 1 - Summary of Watershed Best Management Practices

Watershed Best Management Practices (BMPs)

BMP	Benefits	Rural	Urban
Water and sediment control basins & terraces	Earthen berms constructed where water concentrates efficiently reduce sediment and phosphorus-loading and eliminate gully erosion.	✓	
Streambank stabilization	Rock placed along a streambank reduces or eliminates eroding stream banks.	✓	
Filter strips	Grass strips along a waterway efficiently reduce soil erosion and nitrogen runoff.	✓	
Cover crops on agricultural land	Temporary crops cost-effectively and efficiently reduce both sediment and nutrient loss.	✓	
Grassed waterways	Grassed channels or swales in a field stabilize gully erosion and manage runoff. Grassed waterways efficiently reduce nitrogen and sediment.	✓	
Tile inlet controls (blind inlets)	Restrictive plates installed on tile inlets (the entrance points to drain tiles) efficiently reduce phosphorus and sediment. Blind inlets (trenches filled with gravel or rock) replace open tiles and allow water to drain more slowly from a field.	✓	
Two-stage ditches	Two-stage ditches replace a traditional channelized ditch by extending out the banks and creating a "bench" or floodplain within the channel to improve water storage and capacity, and filter sediment and nutrients.	✓	
Bioreactors	A denitrifying bioreactor is a trench packed with carbonaceous material such as wood chips that allow colonization of soil bacteria that convert nitrates in drainage water to nitrogen gas. Installed before tile water enters a stream, bioreactors are extremely efficient at reducing nitrogen loading.	✓	
Pasture and livestock waste management	Pasture management and waste management can significantly reduce localized bacteria loading from livestock. If completed as a system, for an entire pasture and pastures across a watershed, these practices can substantially reduce sediment and nutrient runoff. Waste management systems include treating runoff and waste from small, non-permitted and concentrated feed areas. Pasture management includes rotating grazing areas, fencing off streams and crossings, diverting fresh water from entering already polluted water, and providing alternative water supplies for livestock fenced off from creeks.	✓	
Septic system inspections	This is recommended as a first step in addressing septic issues; identifying and repairing failing septic systems throughout the watershed.	✓	✓
Urban green infrastructure - rain barrels, rain gardens, and porous pavement	These urban BMPs reduce pollution loads from runoff and impervious surfaces (nonporous and paved). Reasonably efficient at reducing sediment, bacteria, and nutrient loads, primarily though reducing runoff, many urban BMPs (such as porous pavement) entail high costs associated with retrofitting or installation.		✓
Detention basins and ponds	Detention basins or ponds efficiently reduce sediments and nutrient and bacteria loads. In urban settings, they reduce stormwater runoff; in agricultural settings, they manage soil and nutrient loss or runoff from livestock waste.	✓	✓
Wetlands	Wetland restoration or creation is extremely efficient at reducing sediment, nutrient, and bacteria loads as wetlands act as natural filters and storage areas for runoff. Additional benefits include habitat for wildlife and passive recreation.	✓	✓

The Methodology; How the Assessments & Plan Were Completed

To complete the 33 elements that make up the IDEM's 33-element checklist, the detailed watershed assessment used a data-driven approach. All known and available information were gathered to verify and update the 2006 plan, as well as to generate new data and results. Methods comprised the latest technology such as Geographic Information Systems (GIS) and computer modeling to evaluate pollution causes and sources, along with conventional manual means such as direct observations of the watershed (through windshield surveys) and meetings with landowners. Independent assessments were made of water quality data, local soils, hydrology (water movement and drainage patterns), land use, precipitation, geology, and biology. A land-based pollution load model was developed to estimate annual and storm-event bacteria, nitrogen, phosphorus, and sediment loads. The windshield survey and landowner consultations resulted in identifying of a series of site-specific projects, and a GIS mapping platform and aerial image interpretation were used to further identify and delineate project areas, evaluate their drainage characteristics, and analyze data used to identify critical or priority subwatersheds.

These critical or priority subwatersheds were identified through applying a series of weighted criteria related to the plan's goals. In this way, the quality of each subwatershed could be scored and ranked. For example, the goal to reduce bacteria-loading was supported by assessing the data on total bacteria loads, acres of pasture, and number of bacteria impairments; the key indicators of bacteria issues. Each criterion was assigned a weight that was based on the quality of the data (for instance, whether the data source was a new sampling analysis or an older water quality analysis) and its relevance to the goal. The proportion of water quality samples in the watershed that exceed state standards was considered directly relevant; and broadly defined habitat areas for Threatened and Endangered (T&E) species or bacteria discharges within permitted limits would be less relevant.

Public input and participation is the foundation of this plan. The primary strategy for the 2014 update applied targeted personal-level meetings with key landowners, other watershed stakeholders, and local agency staff, such as from the Soil and Water Conservation Districts, the National Resources Conversation Service (NRCS), county assessor office, GIS Coordinator, and city governments. This approach verified that the information and concerns gathered at the public meetings originally held to develop the 2006 plan remain relevant today. The still-active Pigeon Creek Steering Committee, formed in 2006, updated the stakeholder concerns and facilitated further public participation in an April 9, 2013, meeting and in a later online posting of the results to garner additional input.

1.0 Introduction & Watershed Description

The 2014 Pigeon Creek Watershed Management Plan (WMP) is intended as a guide for the preservation and enhancement of the environment and quality of the watershed, while balancing the different uses and demands of the community and landowners. This current document is a comprehensive update to the 2006 WMP.

1.1 Introduction

Conservationists have developed comprehensive watershed management plans for the Pigeon Creek watershed since the mid-1960s. The 1967 *"Preliminary Investigation Report,"* a joint effort of the Steuben County and DeKalb County Soil and Water Conservation Districts (SWCD), was one of the first such plans for the watershed. The report identified the major watershed issues, such as frequent flood damage, inadequate drainage outlets, pollution of lakes and streams, and the necessity for additional fish and wildlife resources. A combination of land treatment and structural measures were proposed for implementation over a five-year period.

The Steuben County SWCD re-examined the watershed 20 years later, in 1987. The *"Watershed Protection Plan – Environmental Assessment for Pigeon Creek Watershed"* identified sheet and rill erosion as a major conservation, agricultural, and economic concern for the watershed. Through rain and shallow water flows, sheet erosion removes the thin layer of topsoil. When sheet flows begin to concentrate on the surface through increased water flow and velocity, rill erosion occurs. Rill erosion scours the land even more, carrying off rich nutrients and adding to the turbidity and sedimentation of waterways. These problems, along with sediment loads, have been abated somewhat with measures such as cover crops and tillage management, but they remain central concerns in the 2014 WMP.

The previous assessments, reports, and plans made important contributions to the watershed. The original 2006 Pigeon Creek WMP, however, was the first comprehensive assessment that fully engaged the public in a large concentrated and collaborative effort. The 2006 WMP laid the groundwork for securing funding for numerous on-the-ground and public education projects that have led to substantial watershed improvements. Since then, the 2012 *Pigeon River Watershed Total Maximum Daily Load (TMDL) Study* has complemented the WMP by providing additional goals to meet federally mandated load reduction targets.

This 2014 WMP, then, extends this series of watershed improvement efforts. In updating the 2006 WMP, it features these expanded benefits:

- ***Builds on past successes.*** This 2014 plan update summarizes BMP implementation, such as the 140 treatment practices installed since 2006 and the educational efforts over the past seven years.
- ***Reflects changes in the watershed***. The new treatment practices, as well as new sampling analyses and land uses, have created a different picture of the watershed from 2006 - revealing improvements as well as new impairments.

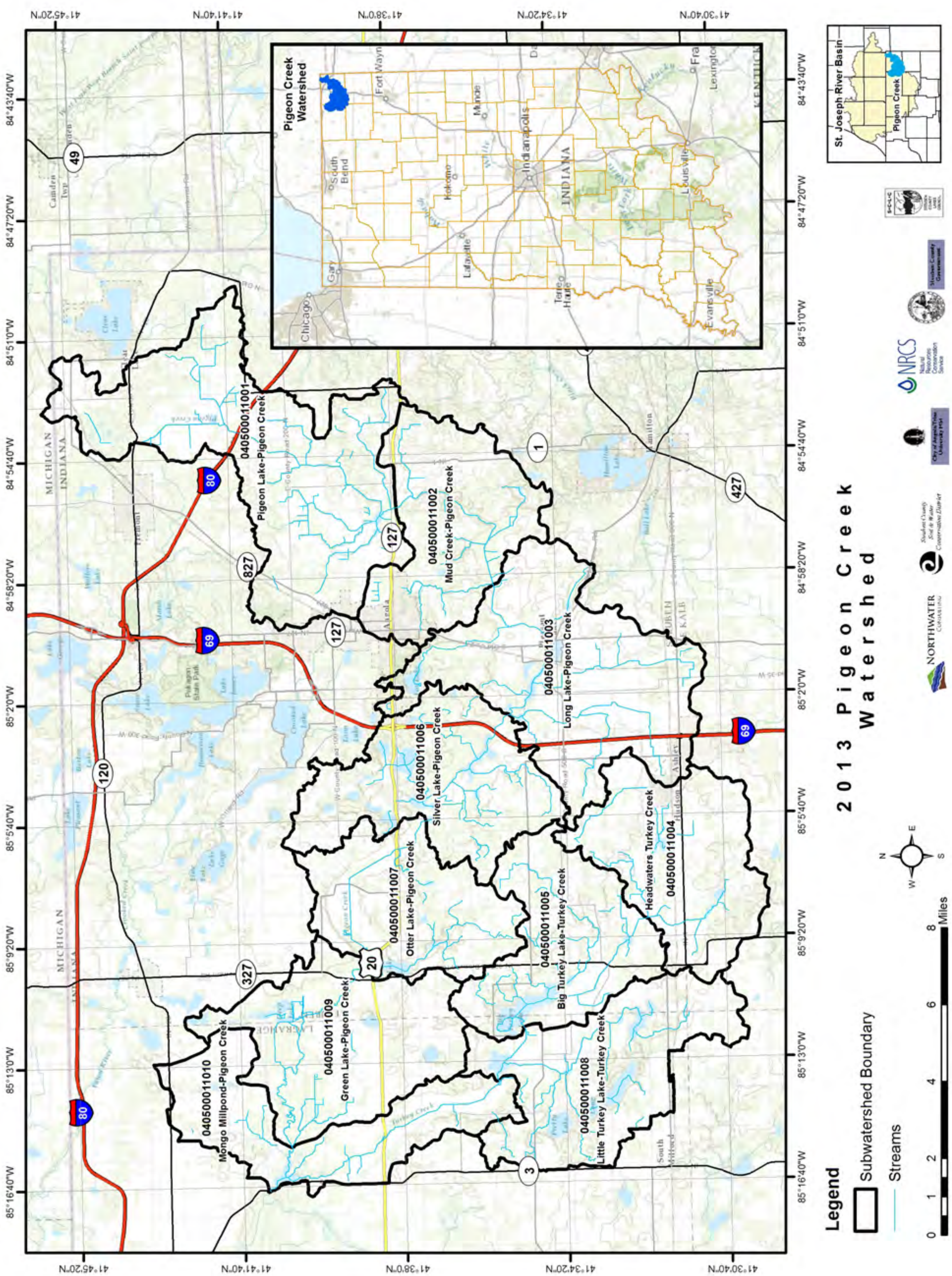
- ***Expands the geographic extent to include additional subwatersheds***. The 2006 WMP's watershed comprised 79,335 acres, mostly focused on Steuben County. Now it covers 135,911 acres and the watershed area that expands into the adjoining counties of DeKalb, Noble, and LaGrange. It is now geographically consistent with the federally designated hydrologic boundaries of Pigeon Creek (HUC 0405000110).
- ***Specifies actions to address water quality issues***. These actions are directly linked to load reduction targets defined in the 2012 *Pigeon River Watershed Total Maximum Daily Load* (TMDL) Study for *E. coli* and Impaired Biotic Community (IBC).
- ***Includes additional local stakeholder input and supplemental analysis***. The plan reflects changes in watershed goals identified by local stakeholders through the ongoing efforts of the Pigeon Creek Steering Committee.

Many of the historical planning documents, including the 2006 WMP, focused heavily on flooding. Although this plan addresses flooding, its focus is more concentrated on an integrated approach. This approach recognizes how water quality, flooding, and drainage are interrelated, so, for instance, management practices that reduce pollution loads can also achieve watershed goals related to flooding.

One of the plan's best management practices, for example, is the two-stage ditch that benefits both agriculture and the environment. The design of the two-stage ditch mirrors the natural processes of stable streams to reduce erosion, sediment and nutrients runoff, and flooding that conventional ditches can cause. The floodplain that runs alongside the ditch allows the water to have more area to spread out. This decreases the velocity of the flow while increasing the volume of water the ditch can process - improving drainage, water quality, and habitat and agricultural conditions.

Two-Stage Ditch; Pigeon Creek Watershed

Figure 1 - Pigeon Creek Watershed



1.2 General Watershed Description

The Pigeon Creek watershed is 135,911 acres and located in the northeast corner of Indiana. It is 71 percent within Steuben County, and small sections of the watershed extend into three other counties: LaGrange (22 percent), DeKalb (6 percent), and Noble (0.5 percent). The watershed is rural with predominant agricultural land use, and includes the small communities of Angola (population of 8,604), Ashley (population of 985), and Hudson (population of 516).

The watercourse includes seven reservoirs and generally flows westward for 31 miles across Steuben County, from its headwaters at Cedar Swamp to just beyond the border with LaGrange County where Pigeon Creek merges with Turkey Creek and other tributaries to form the Pigeon River at the Mongo Reservoir. Outside the watershed, the Pigeon River flows into the St. Joseph River, which flows into Lake Michigan. The watershed is in the Steuben Moranial Lake Physiographic region, characterized by rolling and hummocky or pot-hole topography. Most of the watershed soils are of sandy silt to silty clay composition. The mean annual temperature is 48°F with mean annual precipitation of 35 inches and monthly precipitation ranging from 2.3 to 3.6 inches.

The 2014 Pigeon Creek WMP consists of ten subwatersheds identified by a 12-digit Hydrologic Unit Code (HUC12) (Table 2).

Table 2 - 2014 & 2006 Pigeon Creek Watersheds

HUC 12 Subwatershed Codes	Total Watershed Area (acres)	Subwatershed Name	Portion of Subwatershed Assessed	
			2006 Plan	2014 Plan
040500011001	22,036	Pigeon Lake-Pigeon Creek	All	All
040500011002	11,641	Mud Creek-Pigeon Creek	All	All
040500011003	18,620	Long Lake-Pigeon Creek	Most	All
040500011004	11,798	Headwaters Turkey Creek	Portion	All
040500011005	11,015	Big Turkey Lake-Turkey Creek	Most	All
040500011006	12,954	Silver Lake-Pigeon Creek	All	All
040500011007	10,491	Otter Lake-Pigeon Creek	All	All
040500011008	13,255	Little Turkey Lake-Turkey Creek	Small Portion	All
040500011009	13,581	Green Lake-Pigeon Creek	Portion	All
040500011010	10,520	Mongo Millpond-Pigeon Creek	None	All

The watershed holds important recreational resources with permanent and seasonal residences around the open water lakes. Wildlife, fish, and game resources are also important within the watershed. The area's distinction noted in the 1967 *Preliminary Investigation Report* remains valid today: "Pigeon River and its watershed have been recognized over the years as one of the outstanding fish, game, and recreational areas of Indiana." Today, excellent fishing opportunities are available in various lakes and streams throughout the watershed. There is an abundance of wildlife in the watershed and large, contiguous blocks of habitat, primarily in the lower sections of Pigeon Creek, provide excellent hunting opportunities.

2.0 Plan Purpose & Public Participation

This section describes the reasons or motivation for this updated watershed management plan, the water quality concerns driving its development, and the key local leaders. It also describes the local Steering Committee and the public participation component that solicited the watershed concerns of local stakeholders. Much of the language found within this section is adapted from the 2006 WMP.

2.1 Plan Purpose

The decision to update the 2006 WMP was driven by the desire of local stakeholders to build upon the successes in the watershed and continue to seek funding resources for further improvement. Along with its purpose as a guide to protect and enhance the environment and quality of the Pigeon Creek watershed, the plan shall be used as a platform to request and obtain financial and technical resources to implement the recommended actions. Additional considerations include the need to expand the planning area to cover the entire Pigeon Creek watershed, including those subwatersheds within neighboring counties.

Local project partners felt that much of the work since the 2006 plan had been completed and the time was right to update the plan to establish a new direction for the watershed, identify new problems, assess changes in the watershed, and develop a site-specific plan with a vision more focused on water quality.

2.2 Watershed Steering Committee

For the 2006 watershed planning process, the Pigeon Creek WMP Steering Committee (Table 3) was formed to provide guidance and direction to the plan based on the members' broad array of experience to the planning process, including representation from conservationists, regulators, public officials, wastewater treatment facility operators, and other stakeholders. Meetings were open to the public and attended by state officials.

Despite some turnover in the Steering Committee membership, improvements realized by the implementation of watershed BMPs, and slightly less concern for flooding, local stakeholder concerns remain consistent with those originally identified in the 2006 WMP. The Steering Committee, therefore, continues to meet regularly to monitor and maintain watershed improvements.

Table 3 - Pigeon Creek Steering Committee Members

Name	Affiliation
Kayleen Hart	Steuben County SWCD
Chad Hoover	Steuben County GIS
Amanda Courtright/Zachary Martin	Steuben County SWCD
Brian Musser	Steuben Co. NRCS
Eric Henion	City of Angola
Representative	Steuben County Health Department
Bill Schmidt	Lakes Council
Bob Glick	Long Lake
Tom Green	Steuben County SWCD Chairman
Beth Warner	The Nature Conservancy
Ron Smith	County Commissioner
Leon Weaver	Pigeon Creek Dairy Owner
Pete Hippensteel	Pigeon Creek Landowner & Steuben County Lakes Council
Art & Sue Myers	Steuben County Lakes Council
Dana Slack	West Otter Lake
John & Nancy Williamson	West Otter Lake
Larry Gilbert	Steuben County Surveyor
Craig Williams	Angola Wastewater Treatment Plant
Lisa Ledgerwood	Wood Land Lakes
Jim Aikman	Hogback Lake
Kristy Clawson	Steuben County Emergency Management Director
Representative	Purdue Extension
Matt Meersman	Friends of the St. Joe
Frank Charlton	Steuben County Planning Commission

2.3 Stakeholder Concerns

As true for the results achieved from the 2006 WMP, this plan's success depends on continuing education, community involvement, and support from municipal, county, and state levels. During the 2006 planning process, the Steering Committee encouraged participation from a wide range of stakeholders in the watershed. Stakeholders included private landowners, operators or producers of large farmlands, governmental agencies, and industrial and commercial businesses. Environmental groups that monitor and promote habitat conservation within the area also continue to have a prominent interest in the watershed.

Given that watershed concerns have remained fairly constant, the Steering Committee decided to utilize and update what has already been gathered through previous and ongoing stakeholder participation meetings. To accomplish this, and build on the earlier public participation process, the Steering Committee held a formal open meeting on April 9, 2013, which was advertised locally through the Steuben County SWCD. The meeting focused on reviewing past stakeholder concerns, the goals identified in the 2006 plan, and changes in the watershed since then. Each of the 14 meeting participants completed a survey that listed each concern, problem, solution, and goal from the previous plan. Participants indicated whether each concern was still relevant and provided comments, when applicable. (The same handout was provided to the Steuben County SWCD Board on April 10, 2013, which they completed and posted on the Steuben County website to garner additional input. Detailed results can be found in Appendix A.)

Table 4 lists the stakeholder responses, which indicate most of the concerns remain the same as in the 2006 plan. The highest and unanimous concerns related to water quality (pollution, bacteria) and soil erosion; the lowest concerns related to dying lakes and property values dropping because of retention ponds.

Overall, not much has changed since 2006. Table 4 lists stakeholder concerns compared with those noted in the 2006 plan.

Table 4 - Stakeholder Concerns

Concern (2006 Plan)	Still Concern (# yes)	Still Concern (# no)	New Concern
Little Long Lake Water Quality	7	1	Sedimentation
Water quality	4	0	*E. coli*, P, TSS
Water pollution	8	0	*E. coli*, P
Prevent West Otter Lake Flooding	3	1	
Unsewered areas / Nonpoint Source	6	1	*E. coli*
Pigeon Creek Dredging	4	3	
Flooding	7	1	
Angola bypass sewage to Pigeon	6	3	Still a concern but progress made
Opposition to maintaining regulated drains	2	3	
Broken Tile / Wetland	8	0	
Bacteria	9	0	Upper Pigeon
Soil erosion	8	0	
Common ground between humans and natural resources	3	4	
Nothing will be done	2	4	
Financial	7	1	
Less development	2	3	
Wildlife	6	1	
Hogback Lake Flooding	2	2	
Wetland enhancement	8	1	
Farm runoff	8	1	
Drainage – open ditch, highway, road	6	1	
Property values because of retention ponds	0	6	
Overextension of campgrounds	2	3	
Implement Plan	5	3	
Environmental Stewardship	4	1	
Dying lakes	0	6	
Spirit of cooperation	2	3	

During this same week in April, a small number of one-on-one meetings were held with willing landowners to identify and discuss additional concerns and potential project locations. The meetings included tours and evaluations of farming operations (such as row crops and pasture management for livestock), discussions of landowner concerns, and BMPs needed. Landowners expressed concerns related to runoff, drainage, and local regulations. Project ideas were discussed and potential implementation sites were noted using GPS. These project locations are further discussed in Section 9.

Just one month earlier (March 13), the 2013 SWCD Board conducted a separate survey at its annual meeting (Appendix A). It included questions about the watershed, individual farming operations, resource concerns, and the SWCD in general. Results from this survey indicate the concerns shared with other stakeholders from the Steering Committee meeting, as well as a number of differences in perceptions of watershed quality and management:

- SWCD annual meeting participants believe water quality is excellent.
- The knowledge of conservation in the watershed has increased.
- Drainage is the number one resource concern.
- SWCDs are held in high regard, and individuals are very happy with the service they provide.
- Water quality should be addressed by a combination of landowners and communities.
- Tradition is a barrier to change.
- Crop rotation and no-till are the primary practices used to control erosion.

Drainage, erosion, and the importance of cooperation among the stakeholders are key shared concerns. A notable difference, however, lies in the perception of water quality; one of the primary goals of the 2014 WMP. The Board's survey indicates water quality as excellent, and the Steering Committee survey unanimously identifies it as the highest concern.

This difference highlights another important role of the 2014 WMP update. This update provides the comprehensive data and assessments - across the entire watershed - to reconcile perceptions with the scientific data and analysis. From site visits to GIS satellite imagery, the WMP has been able to identify the areas where water quality and drainage are acceptable, as well as specific impaired areas in a subwatershed that the BMPs can treat once the plan is finalized. The 2014 WMP provides, therefore, a systematic, comprehensive, and balanced assessment to benefit all stakeholders.

Overall, this 2014 plan applied a greater effort than in 2006 to interact one-on-one with private landowners, which generated very positive results and benefits. Some benefits include the engagement of large landowners and individuals unlikely to participate through an open public meeting, the identification of site-specific BMP opportunities, and the direct education and outreach to landowners regarding the benefits of conservation and BMP programs.

3.0 Part I: Watershed Inventory

Part I of the watershed inventory includes a detailed characterization of the entire Pigeon Creek watershed, including its history and unique watershed features. This section includes watershed-wide geology, topography, hydrology, resource use, soils, landuse/landcover and critical species. Also discussed are the many watershed success stories and previous planning efforts within the watershed. Where applicable, data has been summarized by subwatershed, along with a brief explanation of the data. Parts II and III of the watershed inventory provide a more thorough analysis of the data as it relates to watershed problems and solutions.

3.1 Physical Description

The Pigeon Creek watershed is located in the Indiana and Ohio Till Plain, and is part of the Steuben Morainal Lake physiographic region, which generally consists of rolling and hummocky or pot-hole topography formed by the recession of the Wisconsin-aged glaciers. See Figure 1 for the location of Pigeon Creek within the State of Indiana. Bedrock is located approximately 120-500 feet below the surface and does not significantly affect local topography, drainage, and soil development. The watershed can be naturally divided into three major drainages. The Upper watershed stretches from Cedar Swamp to the inlet to Long Lake. The Lake Chain watershed consists of the area from the Long Lake inlet to the outlet of Hogback Lake. The Lower watershed consists of the area from the Hogback Lake outlet to the western boundary of Steuben County and into LaGrange County where Pigeon Creek becomes the Pigeon River at Mongo Millpond within the Pigeon River Fish and Wildlife Area. The lower watershed also includes the drainages of Turkey Lake and Turkey Creek, which originate in DeKalb County and enter Pigeon Creek at the watershed outlet.

3.1.2 Topography

Percent slope was calculated for the watershed using a 1.5-meter digital elevation model (DEM). Average percent slope for the entire watershed is 13%. Table 5 lists average slope by subwatershed and Figure 2 illustrates percent slope for the watershed. The basin is generally flatter in the headwaters, gaining slope through the middle sections and Turkey Lake/Turkey Creek before flattening out again as Pigeon Creek becomes Pigeon River in LaGrange County.

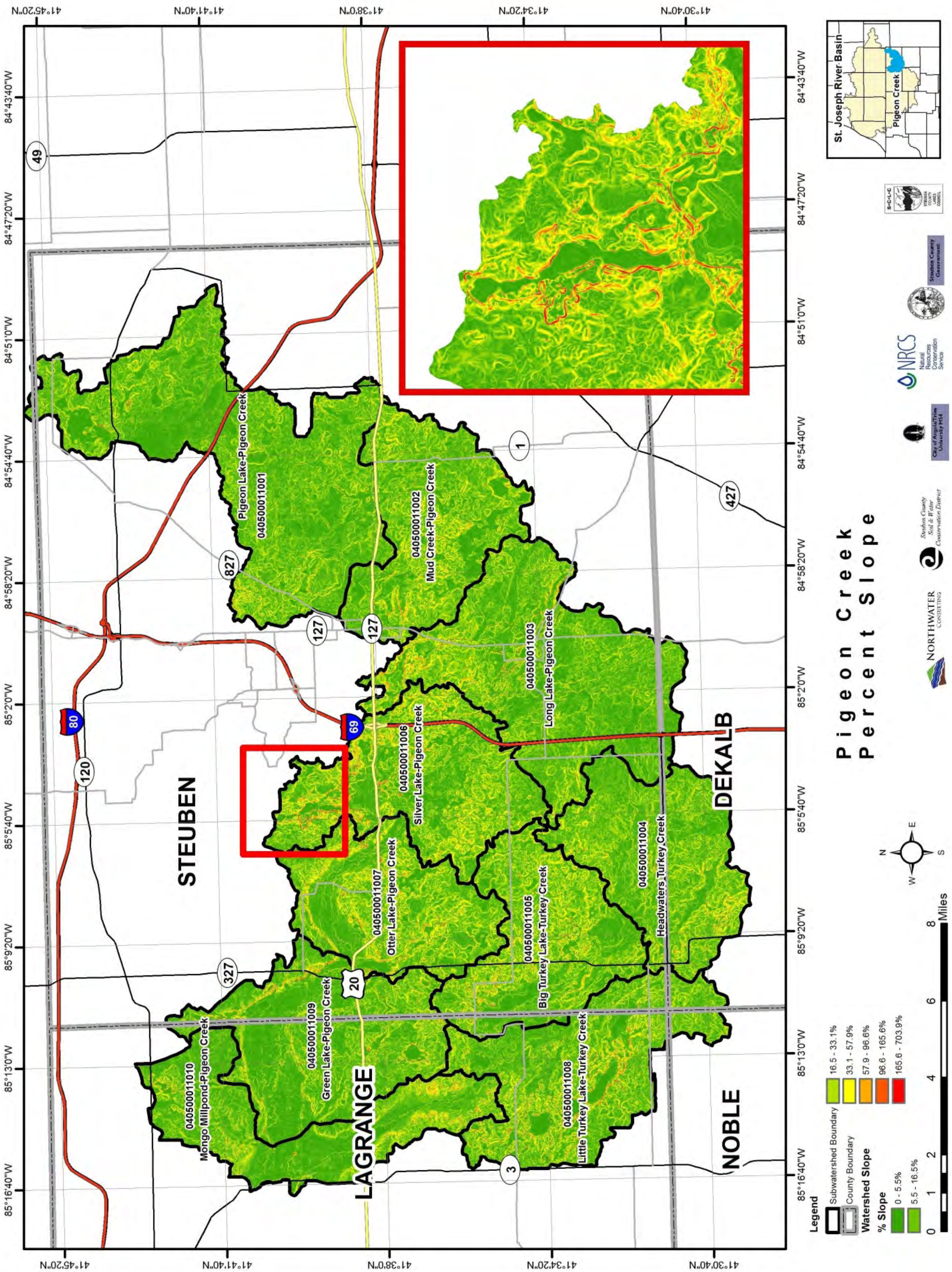
Table 5 - Subwatershed Percent Slope

HUC 12 Codes	HUC 12 Watersheds	Average Slope
40500011001	Pigeon Lake-Pigeon Creek	10.08%
40500011002	Mud Creek-Pigeon Creek	13.24%
40500011003	Long Lake-Pigeon Creek	11.75%
40500011004	Headwaters Turkey Creek	12.42%
40500011005	Big Turkey Lake-Turkey Creek	14.68%
40500011006	Silver Lake-Pigeon Creek	16.67%
40500011007	Otter Lake-Pigeon Creek	15.28%
40500011008	Little Turkey Lake-Turkey Creek	14.11%
40500011009	Green Lake-Pigeon Creek	10.61%
40500011010	Mongo Millpond-Pigeon Creek	10.97%

There is a range of 279 feet between the lowest and highest points in the watershed. The lowest and highest points are 893 and 1,172 feet above sea level, respectively.

No-till field; Pigeon Creek Watershed

Figure 2 - Watershed Slope



3.1.3 Geology

The watershed is primarily covered by a thick blanket of unconsolidated glacial drift resulting from the Wisconsin-age glaciation. Nearly 60% of the watershed consists of glacial tills with fine-grained materials including clay, silts and fine sands that were deposited at the edge or beneath glaciers. Approximately 30% of the watershed consists of glacial outwash sands and gravels. The outwash deposits resulted from glacial-melt and the glaciofluvial stream systems within and at the edges of the glaciers. Smaller areas of the watershed include organic muck (5%), aeolian dune sand (1%) and glacial lake sediment deposits (1%). The depth to bedrock in the watershed is documented to vary from 120 to nearly 500 feet.

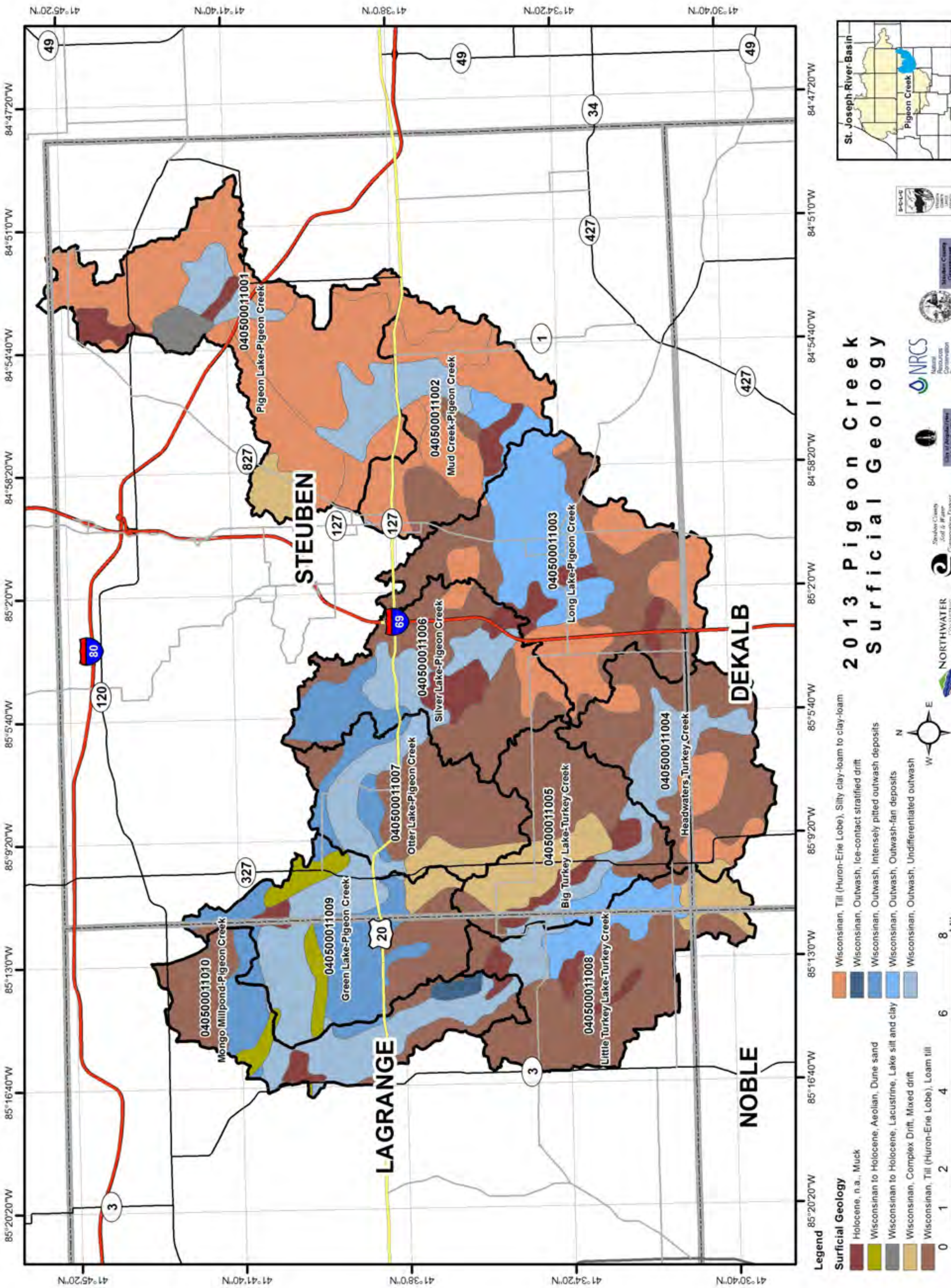
The bedrock geology beneath the glacial drift consists predominantly of Mississippian-aged Coldwater Shale, which can be greater than 500-feet thick. The Coldwater shale is a gray to greenish-gray silty shale. There are known to be lenses of brown dolomite and limestone throughout the unit. A distinctive red shale, up to 20-feet thickness, is at the base of the Coldwater.

The geology is important in the watershed, as the glacial drift topography created the lakes that dot the landscape. The unconsolidated and fine-grained nature of the surficial geology (Table 6 and Figure 3) is an important parent material for the productive soil development. However, the fine-grained nature of the geology also promotes a vulnerability to erosion and sedimentation in the watershed. The outwash deposits and other buried sands and gravels are important water supply sources for potable and non-potable needs throughout the watershed.

Table 6 - Watershed Surficial Geology

Age / Category	Description	Percent of watershed	Acres
Wisconsin Till	Loam till	34%	46,396
Wisconsin Till	Silty clay-loam to clay-loam	23%	31,221
Wisconsin Outwash	Undifferentiated outwash	16%	21,396
Wisconsin Outwash	Intensely pitted outwash deposits	8%	10,228
Wisconsin Outwash	Outwash-fan deposits	7%	9,676
Wisconsin Till and Outwash	Mixed drift	5%	7,152
Holocene-recent	Muck	5%	6,616
Wisconsin to Holocene, Aeolian	Dune sand	1%	1,901
Wisconsin Lacustrine	Lake silt and clay	1%	842
Wisconsin Till	Ice-contact stratified drift	0.3%	389

Figure 3 - Watershed Geology



3.2 Watershed Hydrology

This section provides an overview of lakes, streams, wetlands, groundwater, and flooding. Sections 3 and 4 (Part II and III of the Watershed Inventory) include detailed information and analysis of lake and river data. Watershed flooding is not directly addressed in subsequent sections as water quality is the primary focus of this plan, and any strategies aimed at addressing water quality will also have positive benefits that mitigate flooding.

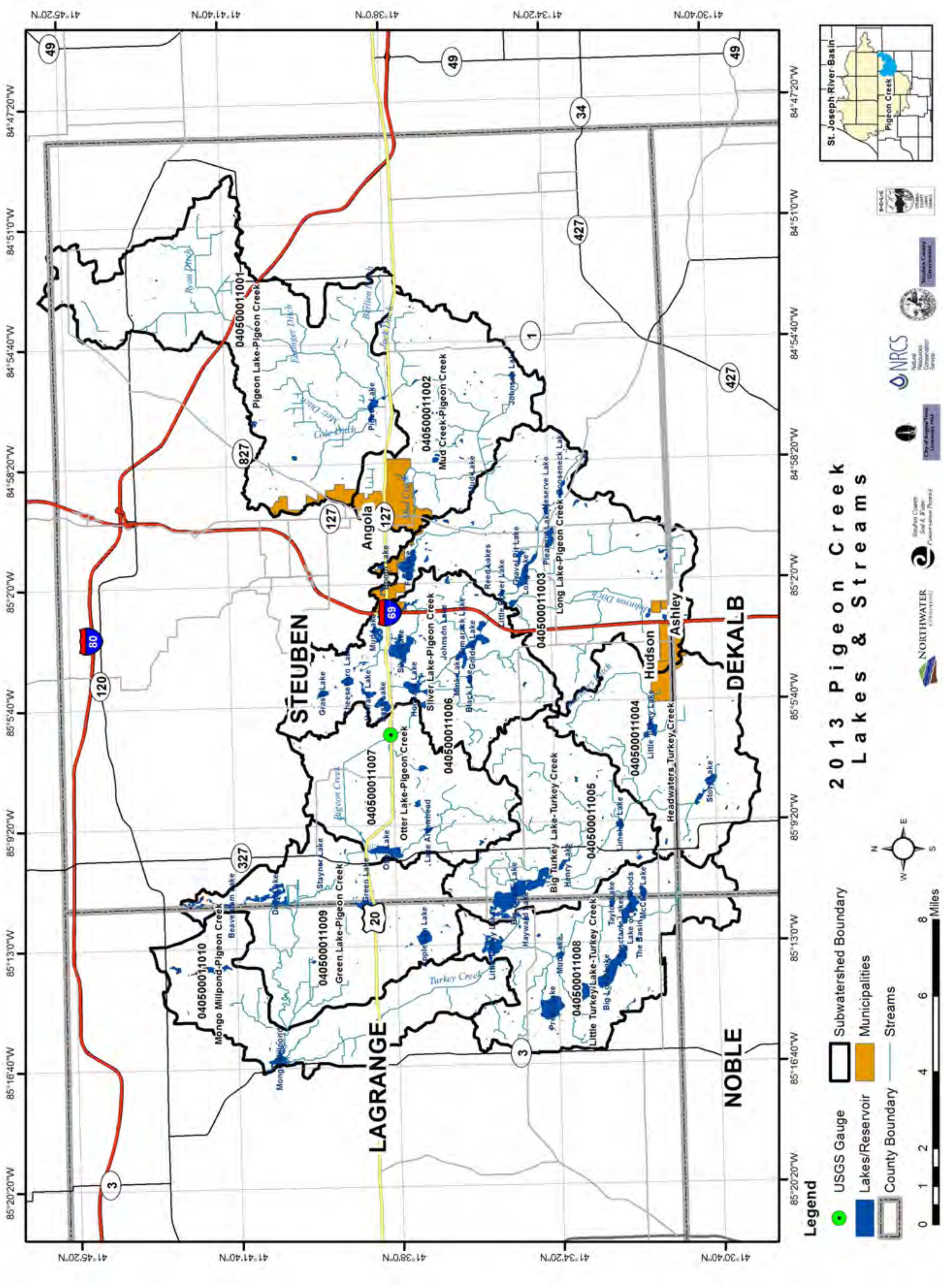
3.2.1 Streams & Rivers

According to the National Hydrography Dataset (NHD), the Pigeon Creek watershed includes 257 stream miles (1,357,047 feet.) Pigeon Creek is 37.5 miles (198,113 feet) in length and represents 15% of the entire stream length in the watershed. Table 7 shows stream length and drainage density by subwatershed and Figure 4 shows the spatial extent of streams and lakes in the watershed. As noted in Section 4.2.1, there are 179 miles (945,120 feet) of impaired streams; 70% of all stream miles in the watershed are considered to be impaired.

Table 7 - Watershed Streams

Subwatershed Name	HUC 12 Subwatershed Codes	Total Stream Feet	Stream Miles	Drainage Density
Pigeon Lake-Pigeon Creek	040500011001	228,433	43.3	10.4
Mud Creek-Pigeon Creek	040500011002	112,627	21.3	9.7
Long Lake-Pigeon Creek	040500011003	175,258	33.2	9.4l
Headwaters Turkey Creek	040500011004	95,415	18.1	8.1
Big Turkey Lake-Turkey Creek	040500011005	144,085	27.3	13.1
Silver Lake-Pigeon Creek	040500011006	152,758	28.9	11.8
Otter Lake-Pigeon Creek	040500011007	94,165	17.8	9.0
Little Turkey Lake-Turkey Creek	040500011008	145,242	27.5	11.0
Green Lake-Pigeon Creek	040500011009	122,094	23.1	9.0
Mongo Millpond-Pigeon Creek	040500011010	86,958	16.5	8.3
Grand Total		**1,357,047**	**257**	**10.0 (average)**

Figure 4 - Pigeon Creek Lakes & Streams



3.2.2 Lakes & Reservoirs

According to the NHD, there are 734 lakes and reservoirs within the watershed including 44 'named' lakes. Lakes and reservoirs within the watershed account for 4,102 surface acres; 3,160 acres of 'named' lakes and 942 acres of unnamed lakes and reservoirs (Table 8 and Figure 5).

Table 8 - Watershed Lakes & Reservoirs

Watershed/Lake	Qty	Area (acres)	Watershed/Lake	Qty	Area (acres)
Pigeon Lake-Pigeon Creek (040500011001)			**Otter Lake - Pigeon Creek (040500011007)**		
Named Lake/Reservoir			*Named Lake/Reservoir*		
Pigeon Lake		58	Otter Lake		119
Unnamed Lake/Reservoir	58	54	Lake Arrowhead		18
Mud Creek-Pigeon Creek (040500011002)			*Unnamed Lake/Reservoir*	83	68
Named Lake/Reservoir			**Little Turkey Lake-Turkey Creek (040500011008)**		
Johnson Lake		18	*Named Lake/Reservoir*		
Mud Lake		3.7	Big Long Lake		370
Unnamed Lake/Reservoir	64	90	Goose Pond		3.2
Long Lake-Pigeon Creek (040500011003)			Hayward Lake		8
Named Lake/Reservoir			Lake of the Woods		117
Booth Lake		9.1	Little Turkey Lake		134
Crockett Lake		4.7	McClish Lake		33
Fox Lake		141	Mud Lake		18
Gooseneck Lake		23	Pretty Lake		181
Gravel Pit Lake		27	Spectacle Lakes		2.3
Little Bower Lake		14	Taylor Lake		15
Long Lake		92	The Basin		5.4
Meserve Lake		18	*Unnamed Lake/Reservoir*	83	68
Pleasant Lake		51	**Green Lake-Pigeon Creek (040500011009)**		
Reed Lakes		4.8	*Named Lake/Reservoir*		
Unnamed Lake/Reservoir	123	180	Appleman Lake		79
Headwaters Turkey Creek (040500011004)			Beaverdam Lake		8.4
Named Lake/Reservoir			Deep Lake		110
Little Turkey Lake		61	Green Lake		67
Story Lake		72	Stayner Lake		2.6
Unnamed Lake/Reservoir	34	35	*Unnamed Lake/Reservoir*	66	116
Big Turkey Lake-Turkey Creek (040500011005)			**Mongo Millpond-Pigeon Creek (040500011010)**		
Named Lake/Reservoir			*Named Lake/Reservoir*		
Big Turkey Lake		442	Mongo Millpond		80
Henry Lake		22	*Unnamed Lake/Reservoir*	53	128
Limekiln Lake		25			
Unnamed Lake/Reservoir	64	63			
Silver Lake-Pigeon Creek (040500011006) - continued on next page					
Named Lake/Reservoir					
Bass Lake		59			
Black Lake		19			

Watershed/Lake	Qty	Area (acres)	Watershed/Lake	Qty	Area (acres)
Silver Lake-Pigeon Creek (040500011006) continued					
Cheeseboro Lake		35	Golden Lake		152
Hogback Lake		145	Grass Lake		28
Howard Lake		30	Johnson Lake		2.2
Mink Lake		5.3	Mud Lake		53
Silver Lake		183	Tamarack Lake		7.4
Unnamed Lake/Reservoir	97	137			

3.2.3 Hydrologic Modifications

Like most agricultural watersheds throughout the Midwest, the hydrology of Pigeon Creek has been altered to accommodate for urban development and agricultural production. Natural waterways have been modified or channelized, extensive underground tile systems installed and natural wetlands converted or impacted to improve drainage. Recent drought conditions and local soil conditions have also led to an increase in irrigation systems on agricultural land. Table 9 lists the extent of hydrologic modifications by subwatershed, length of channelized streams, length of known drainage tile lines, area of legal ditches, and the area of irrigated crop ground. It should be noted that legal ditches were available in a rough format and were modified or adjusted for the creation of a custom watershed landuse/landcover layer. As a result, only the total area is provided and the locations presented in Figures 5 and 6 may not represent the true extent of all legal ditches in the watershed. Figures provided for length of drainage tiles include only known/mapped lines, which greatly underestimates the total length of drainage tiles in the watershed.

The Pigeon Creek watershed has 177 miles of channelized ditches, 222 miles of mapped drainage tiles, 929 acres of legal ditches, and over 6,000 acres of irrigated agricultural ground. The length of channelized ditches in the watershed is roughly half of the total stream length within the watershed, indicating that channelization is extensive within the watershed and confirming stakeholder concerns over drainage of farm ground. Only 8.6 percent of the watershed's row crop acreage is irrigated, and the extent of area classified as a legal ditch is less than 1 percent of the entire watershed area.

Table 9 - Hydrologic Modifications

Subwatershed Names	HUC 12 Subwatershed Codes	Watershed Acres	Channelized (miles)	Drainage Tile (miles)	Legal Ditch (acres)	Irrigated Crop Ground (acres)
Pigeon Lake-Pigeon Creek	040500011001	22,036	39	64	303	1,185
Mud Creek-Pigeon Creek	040500011002	11,641	17	32	116	322
Long Lake-Pigeon Creek	040500011003	18,620	34	47	179	2,182
Headwaters Turkey Creek	040500011004	11,798	31	21	107	162
Big Turkey Lake-Turkey Creek	040500011005	11,015	13	19	75	0
Silver Lake-Pigeon Creek	040500011006	12,954	6	16	24	165
Otter Lake-Pigeon Creek	040500011007	10,491	6	10	13	504
Little Turkey Lake-Turkey Creek	040500011008	13,255	17	4.4	97	299
Green Lake-Pigeon Creek	040500011009	13,581	5	7.2	3.2	640
Mongo Millpond-Pigeon Creek	040500011010	10,520	9	1.6	10	731
Grand Total		**135,911**	**177**	**222**	**929**	**6,190**

Drainage Ditch; Upper Pigeon Creek Watershed

Figure 5 – Upper Pigeon Creek Hydrologic Modifications

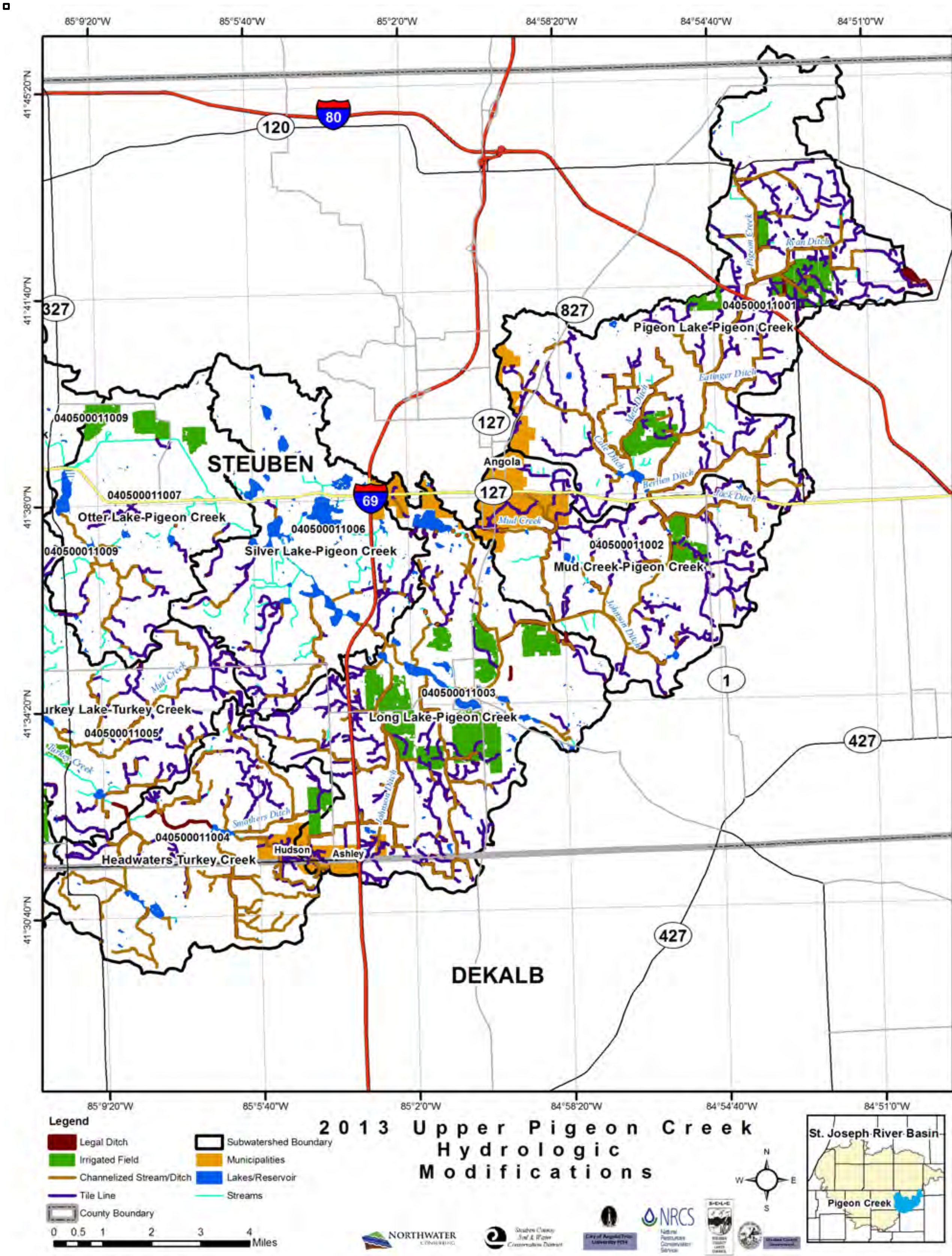
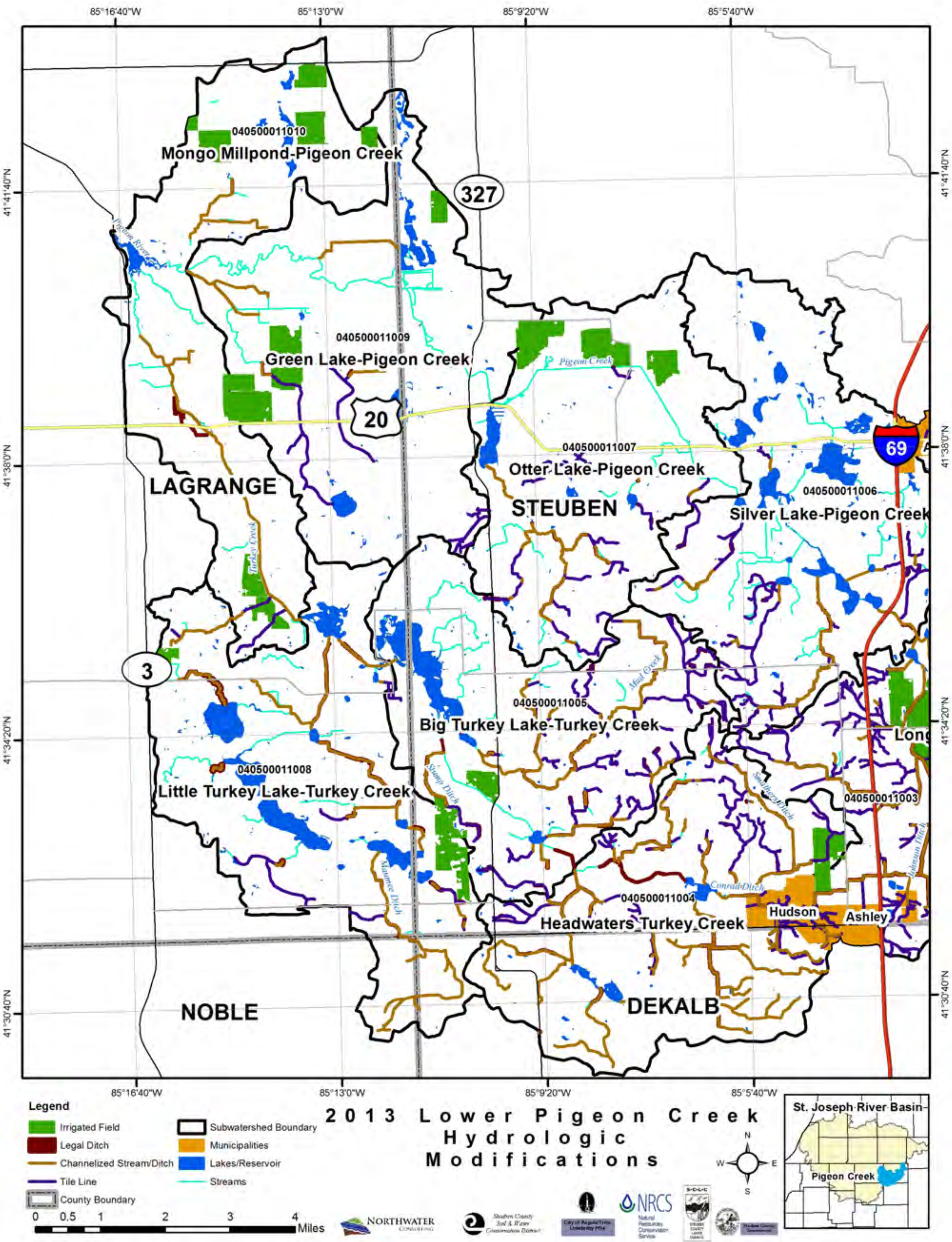


Figure 6 - Lower Pigeon Creek Hydrologic Modifications



3.2.4 Wetlands

Wetlands are scattered throughout the watershed, primarily at locations of hydric soils or low lying depressional areas. Wetlands reduce stormwater runoff and filter sediment and nutrients before reaching waterways. The vegetative communities within the wetlands bind excess nutrients within the living plant tissue while providing additional wildlife habitat. Wetlands should be protected and enhanced to provide both water quality, flooding and wildlife habitat benefits to the watershed.

In this section, wetlands are evaluated using a hybrid National Wetland Inventory (NWI) data set developed and provided by the Friends of the St. Joe River Association. This data set includes two distinct layers:

1. Current/PreSettlement Wetlands - current NWI wetlands along with the approximate location of wetlands prior to European settlement, including wetlands that are classified as lakes and rivers.
2. Current/Restoration Wetland Areas – wetlands classified as a priority for protection or restoration.

As noted in Table 10, there are currently 17,999 acres of wetlands in the watershed, or 13% of the total watershed area. Pre-settlement wetlands were estimated at 38,728 acres, or 28% of the watershed, indicating that total wetland area has been reduced by over 50% since pre-settlement times. Additionally, 13,262 acres of existing wetlands require protection and 23,939 acres of existing wetlands require restoration (Figures 7 and 8).

Table 10 - Pigeon Creek Wetlands

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Current Wetlands	% of Watershed	Acres Pre-settlement Wetlands	% of Watershed	Acres Wetlands Needing Protection	% of Watershed	Acres Wetlands Needing Restoration	% of Watershed
Pigeon Lake-Pigeon Creek	040500011001	2,396	11%	7,174	33%	2,220	10%	5,108	23%
Mud Creek-Pigeon Creek	040500011002	1,552	13%	3,374	29%	1,345	12%	2,049	18%
Long Lake-Pigeon Creek	040500011003	1,759	9%	5,442	29%	1,176	6%	3,990	21%
Headwaters Turkey Creek	040500011004	813	7%	3,310	28%	637	5%	2,630	22%
Big Turkey Lake-Turkey Creek	040500011005	1,682	15%	3,498	32%	1,112	10%	1,982	18%
Silver Lake-Pigeon Creek	040500011006	2,497	19%	4,031	31%	1,417	11%	2,096	16%
Otter Lake-Pigeon Creek	040500011007	1,180	11%	2,200	21%	938	9%	1,276	12%
Little Turkey Lake-Turkey Creek	040500011008	2,312	17%	4,073	31%	1,282	10%	2,150	16%
Green Lake-Pigeon Creek	040500011009	2,568	19%	3,381	25%	2,085	15%	1,367	10%
Mongo Millpond-Pigeon Creek	040500011010	1,243	12%	2,245	21%	1,050	10%	1,289	12%
Grand Total		**17,999**	**13%**	**38,728**	**28%**	**13,262**	**10%**	**23,939**	**18%**

Figure 7 – Upper Pigeon Creek Wetlands

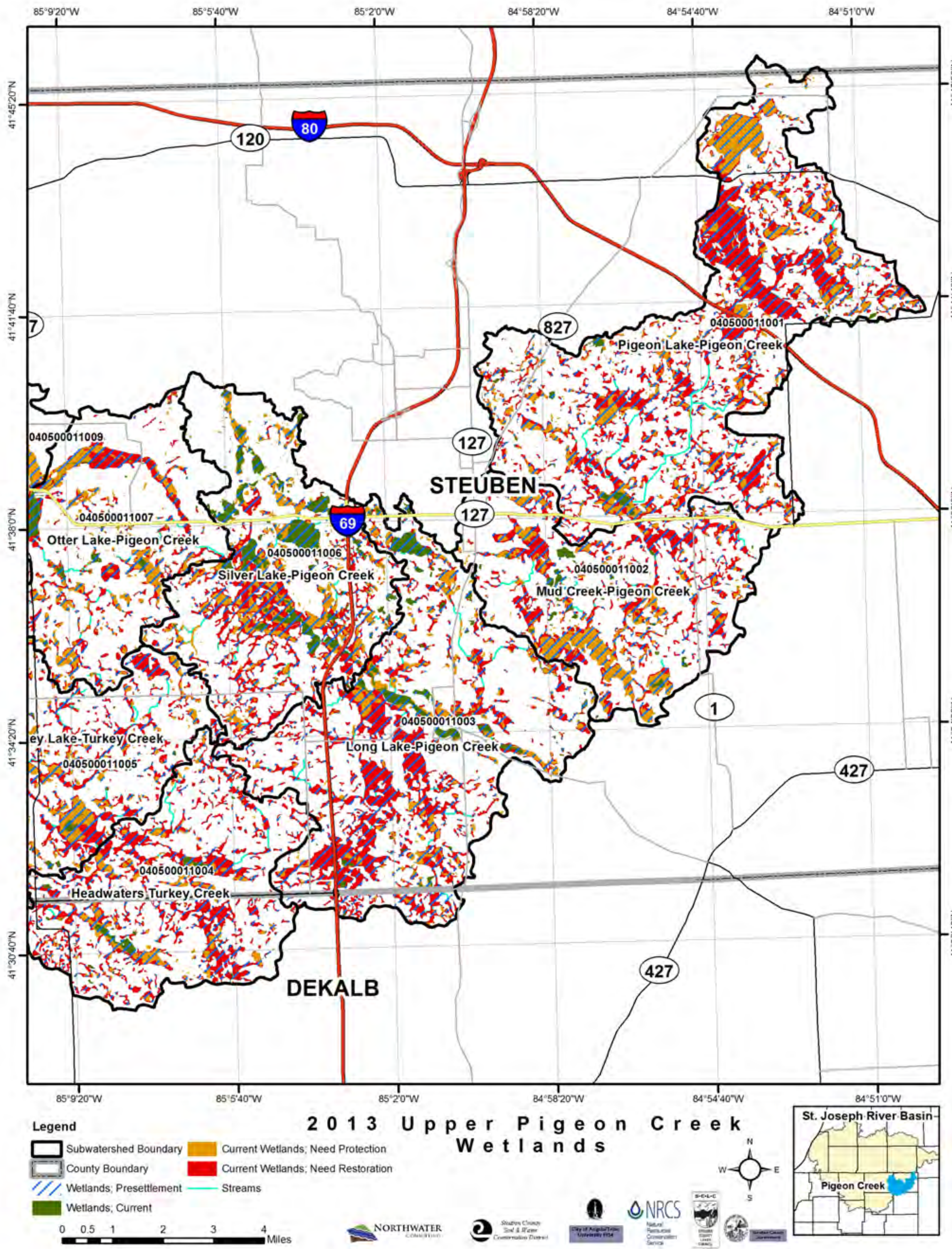
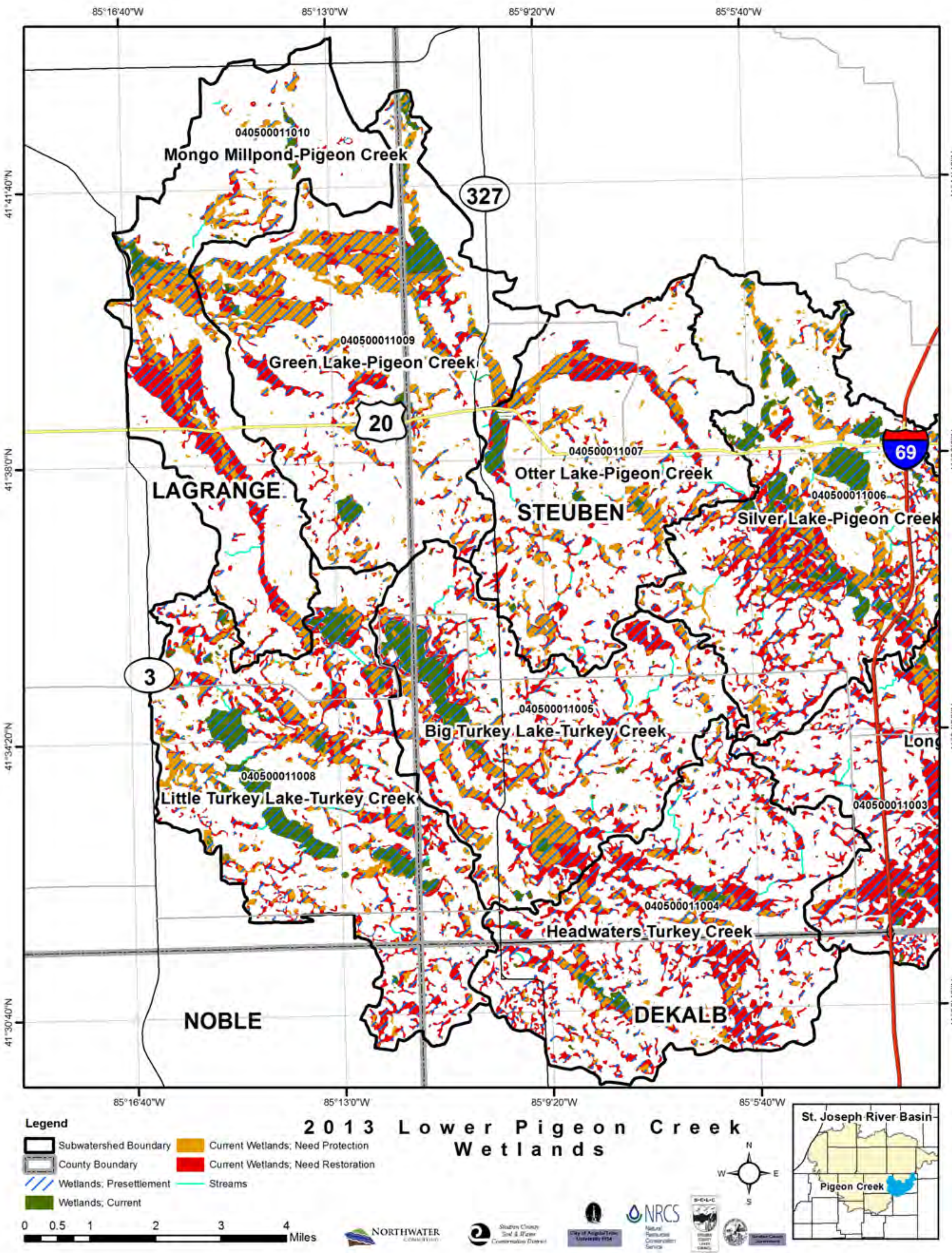


Figure 8 - Lower Pigeon Creek Wetlands



3.2.5 Flooding & Floodplain

The watershed has a continental climate, with cold winters and hot summers. The mean annual temperature at Angola is 48° F, but varies from a mean of 22° F in January to 72° F in July. Steuben County receives a mean annual precipitation of 35 inches. Frequent, short, but intense, rainfall events are common in spring and summer months, which produces high runoff volumes and flow rates. A significant amount of runoff is also generated during the annual spring snowmelt. Flooding has been a long-documented issue in the Pigeon Creek watershed. Originally, Pigeon Creek consisted of a series of meandering drainage ways but, in 1904, George Shrimplin Ditch was dredged to straighten the creek in order to provide greater conveyance capacity.

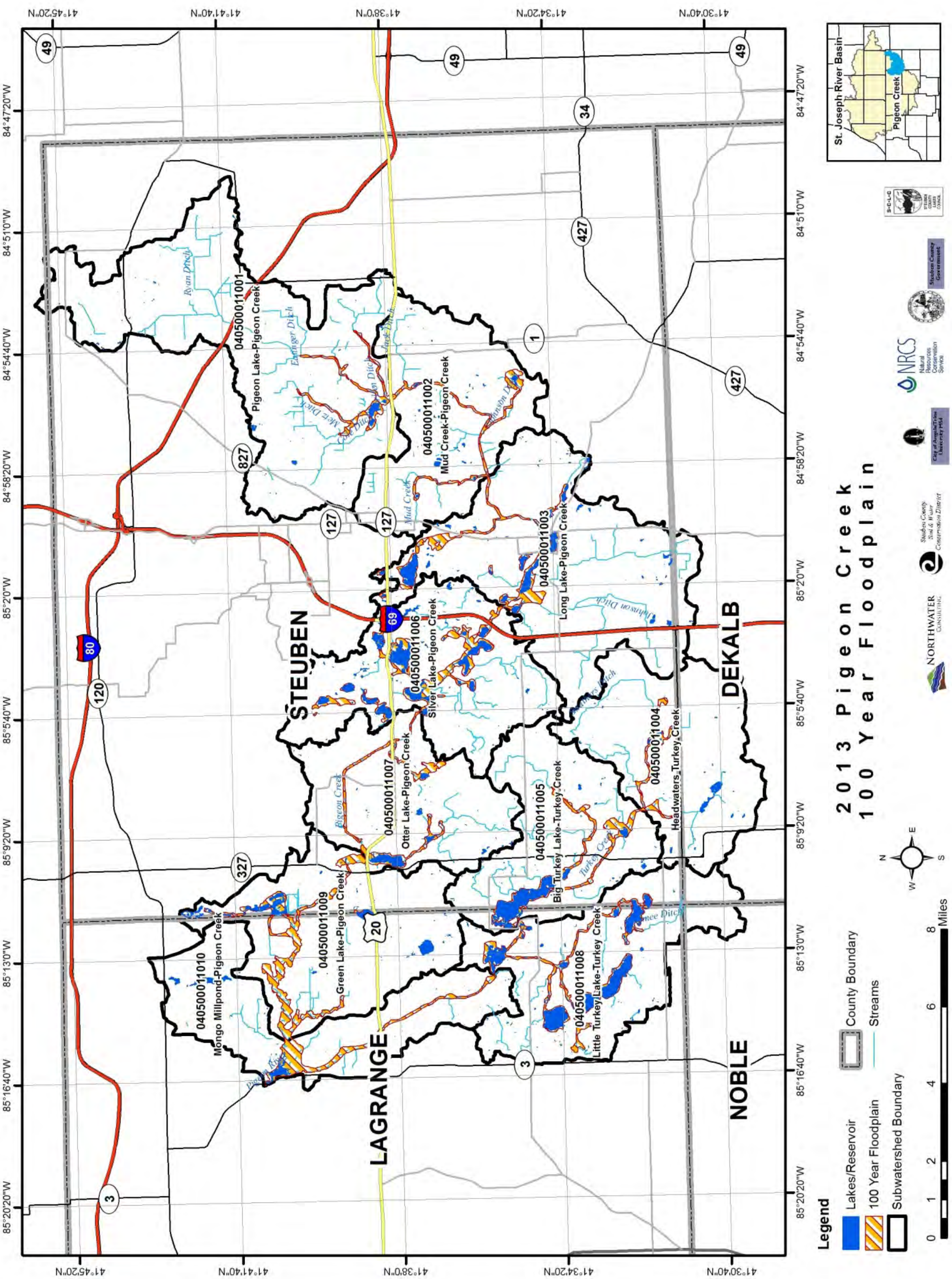
The chain of lakes along Pigeon Creek is heavily affected by extreme rainfall events. The 1967 *"Preliminary Investigation Report"* acknowledges the extreme fluctuation in lake levels after heavy rain events, which flooded cottages along Bower, Golden, Hogback, and Long Lakes. The report notes that the lake water level fluctuates at least five feet annually, where a rise of six feet is expected by a two-year rainfall event, and a rise of over seven feet is expected for a ten-year rainfall event. It is important to note that additional storage volume provided upstream in the watershed can have a substantial impact on decreasing flooding from frequent rainfall events.

The largest flood on record occurred March 22, 1982, due to extreme snowmelt. The winter of 1981-1982 generated 66 inches of snow, approximately 26 inches above average. As the snow melted, approximately 7 inches of runoff was created across the Pigeon Creek watershed. This resulted in lake levels 8.5 feet above normal stage with damage to 380 lakeside homes, however, minimal out-of-channel flood damage was reported. The total damage in the watershed was estimated at approximately $800,000 (1982 Dollars). If a similar flood were to occur today, the damage would be significantly higher due to both inflation and additional development along the lake chain. Figure 9 indicates the approximate areas of regulatory floodplain within the watershed that would be inundated by the 100-year flood. According to floodplain maps generated in 2004, there is a total of 8,643 acres of 100-year floodplain within the watershed. Floodplain areas are detailed by subwatershed in Table 11.

Table 11 - 100-Year Floodplain by Subwatershed

Subwatershed Name	HUC 12 Subwatershed Codes	Acres in 100 Year Floodplain	% of Watershed
Pigeon Lake-Pigeon Creek	040500011001	431	2%
Mud Creek-Pigeon Creek	040500011002	421	4%
Long Lake-Pigeon Creek	040500011003	1,038	6%
Headwaters Turkey Creek	040500011004	291	2%
Big Turkey Lake-Turkey Creek	040500011005	956	9%
Silver Lake-Pigeon Creek	040500011006	1,582	12%
Otter Lake-Pigeon Creek	040500011007	602	6%
Little Turkey Lake-Turkey Creek	040500011008	1,500	11%
Green Lake-Pigeon Creek	040500011009	1,152	8%
Mongo Millpond-Pigeon Creek	040500011010	670	6%
Grand Total		**8,643**	**6%**

Figure 9 - Pigeon Creek 100-Year Floodplain



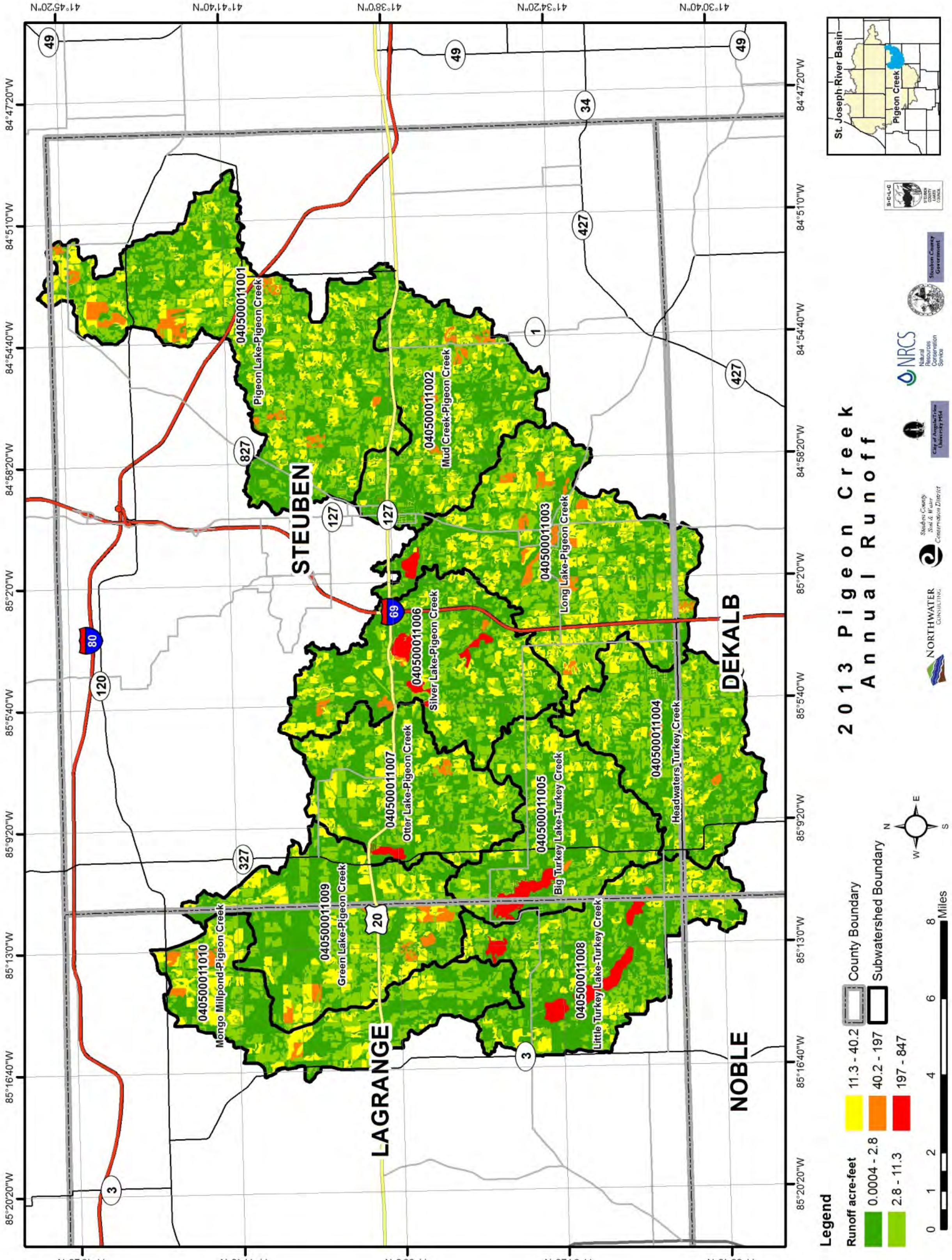
3.2.6 Annual Runoff

Watershed average annual runoff is estimated to be 97,419 acre-feet (Figure 10), or one foot of water covering over 97,000 acres (72%) of the entire watershed. Table 12 illustrates per-acre runoff is higher in urban areas with greater densities of impervious surface and on agricultural ground with hydrologic group C and D soils. The runoff was modeled using the SWAMM model outlined in Chapter 7. It is important to note that annual runoff values for each watershed are presented in total acre-feet and should be compared against subwatershed size. Although Mud Creek, for example, has a lower annual runoff total, it is also a relatively small watershed; Mud Creek has the highest percentage of impervious surface.

Table 12 - Modeled Runoff

Subwatershed Name	2012 HUC 12 Subwatershed Codes	Watershed Acres	Percent Impervious Surface	Percent C & D Soils	Annual Runoff (ac-ft)
Pigeon Lake-Pigeon Creek	40500011001	22,036	1.28	65.4	17,588
Mud Creek-Pigeon Creek	40500011002	11,641	3.83	68.9	9,741
Long Lake-Pigeon Creek	40500011003	18,620	2.64	48.4	15,491
Headwaters Turkey Creek	40500011004	11,798	1.62	37.9	8,794
Big Turkey Lake-Turkey Creek	40500011005	11,015	1.27	13.2	7,900
Silver Lake-Pigeon Creek	40500011006	12,954	1.76	31.9	9,331
Otter Lake-Pigeon Creek	40500011007	10,491	1.04	4.04	6,345
Little Turkey Lake-Turkey Creek	40500011008	13,256	1.06	19.7	9,905
Green Lake-Pigeon Creek	40500011009	13,581	0.89	3.4	6,635
Mongo Millpond-Pigeon Creek	40500011010	10,520	0.73	6.8	5,688
Total Watershed		**135,911**	**1.61**	**33.6%**	**97,419**

Figure 10 - Pigeon Creek Annual Runoff



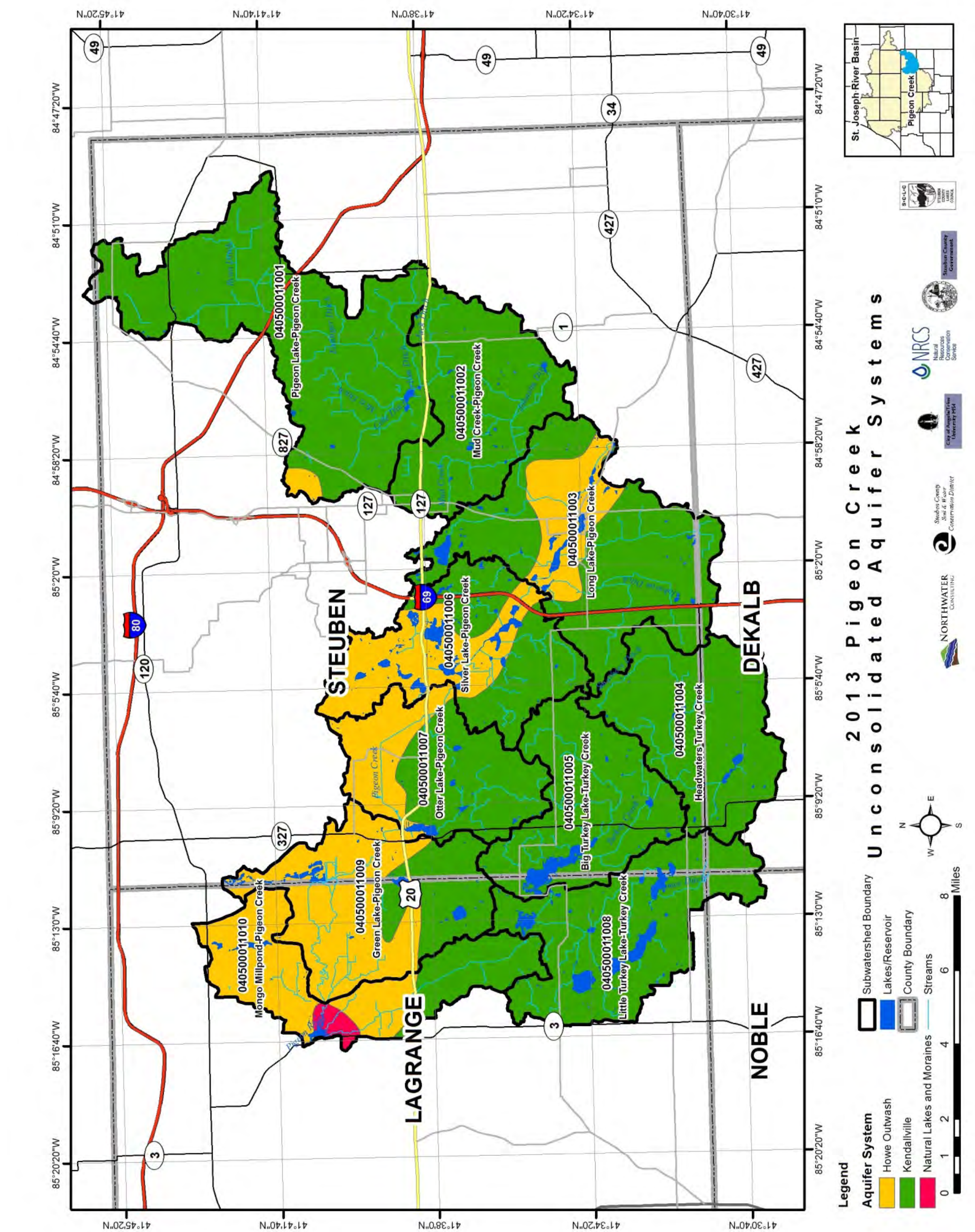
3.2.6 Aquifer Depth & Groundwater

In 2011, the IDNR, Office of Water published maps showing unconsolidated aquifer systems throughout the state. The maps, with accompanying text and tables, describe characteristics such as geologic materials, thickness of confining units, aquifer thickness, static water levels, well yield, typical well depths, and depth to the aquifer resource. According to the maps, there are three unique unconsolidated aquifer systems in the watershed: the Howe Outwash, Kendallville, and Natural Lakes and Moraines system. The Kendallville system covers 104,115 acres, or 76% of the watershed; the Howe Outwash system includes 31,079 acres, or 23%; and Natural Lakes and Moraines covers the remaining 1%, or 622 acres. Figure 11 shows the location on these unconsolidated aquifers in Pigeon Creek.

The Howe Outwash System consists of surficial outwash sand and gravel up to 145 feet thick overlying till with interbeds of sand and gravel. Aquifer thickness in the Howe Outwash system sand and gravel ranges from 15 – 50 feet; interbed sand and gravel typically 5 – 25 feet thick. Water yield can range from 10 gallons per minute to 1,200 gallons per minute in high-capacity wells. The Kendallville system consists of isolated near-surface sand and gravel, but mostly deeper interbed sand and gravel at various depths. In this system, aquifer depth ranges from 3 – 95 feet and commonly 5 – 20 feet. Aquifer yield ranges from 10 to 1400 gallons per minute for high-capacity wells. The Natural Lakes and Moraines system includes near surface sand and gravel, and deeper interbed sand and gravel. Near- surface depths range from 10 – 50 feet with deeper interbed depths of 10 – 30 feet. Aquifer yield ranges from 25 to 2000 gallons per minute for high-capacity wells.

Pigeon Creek

Figure 11 - Pigeon Creek Unconsolidated Aquifers



3.3 Watershed Soils

Soils in the Pigeon Creek watershed are mainly composed of sandy silts to silty clays resulting from the last glacial episode. In low-lying wetlands, organic soils are common due to decomposition of plant remains in a high water table environment. The dominant upland soils include well-drained Miami, Morley, and Kendallville, somewhat poorly drained Blount; and very poorly drained Pewamo. Well-drained Fox terrace soils are common in large areas in the lower reaches of the main watershed. Watershed soils primarily consist of muck, including the Houghton and Carlisle types, and sandy outwash soils of the Oshtemo, Brady, and Griffen varieties.

3.3.1 Soils; Hydrologic Groupings

The Natural Resource Conservation Service (NRCS) has classified soils into four hydrologic soil groups based on the infiltration capacity and runoff potential of the soil. The soil groups are identified as A, B, C, and D. Group A has the greatest infiltration capacity and least runoff potential, while group D has the least infiltration capacity and greatest runoff potential. Table 13 provides a breakdown of hydrologic groupings and Figures 12 and 13 indicate the distribution of hydrologic soil groups within the watershed. The Upper watershed primarily consists of group C and D soils; this portion of the watershed has a lower infiltration capacity and a greater runoff potential. The Lake Chain and lower half of the watershed primarily consist of group A and B soils, which are better at infiltration and less susceptible to runoff damage. Hydrologic group B and C soils make up the majority of the watershed.

Table 13 - Soil Hydrologic Groups

Subwatershed Name	HUC 12 Subwatershed Codes	A	B	C	D	Unclassified
Pigeon Lake-Pigeon Creek	040500011001	3,105	4,233	13,853	555	193
Mud Creek-Pigeon Creek	040500011002	1,612	1,645	7,549	481	354
Long Lake-Pigeon Creek	040500011003	2,931	5,983	8,520	483	703
Headwaters Turkey Creek	040500011004	2,326	4,804	3,942	534	191
Big Turkey Lake-Turkey Creek	040500011005	2,536	6,449	1,435	14	596
Silver Lake-Pigeon Creek	040500011006	3,563	4,298	3,589	544	960
Otter Lake-Pigeon Creek	040500011007	4,056	5,756	424	0	255
Little Turkey Lake-Turkey Creek	040500011008	2,981	6,629	2,606	0	1,038
Green Lake-Pigeon Creek	040500011009	9,251	3,588	456	0	286
Mongo Millpond-Pigeon Creek	040500011010	5,885	3,830	716	0	88
Grand Total		**38,245**	**47,216**	**43,091**	**2,612**	**4,664**
Percentage of Watershed		**28%**	**35%**	**32%**	**2%**	**3%**

Soils with high runoff potential have an influence on both flooding and the export of pollutants as a greater percentage of the precipitation that falls on these soils produces runoff. Stakeholder concerns related to flooding and pollution loading can be supported in areas of the watershed where C and D soils are more prevalent.

Figure 12 – Upper Pigeon Creek Soil Hydrologic Groups

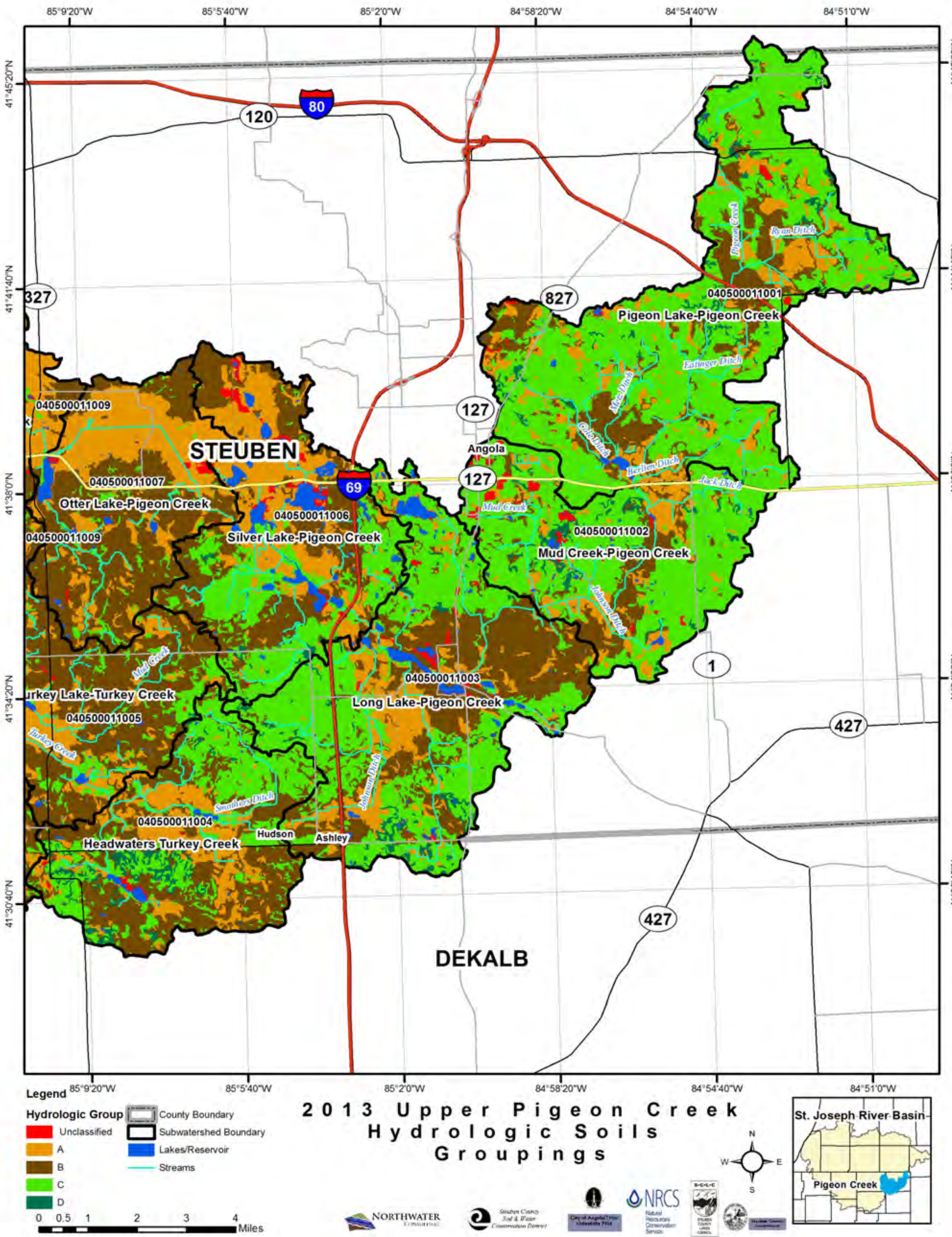
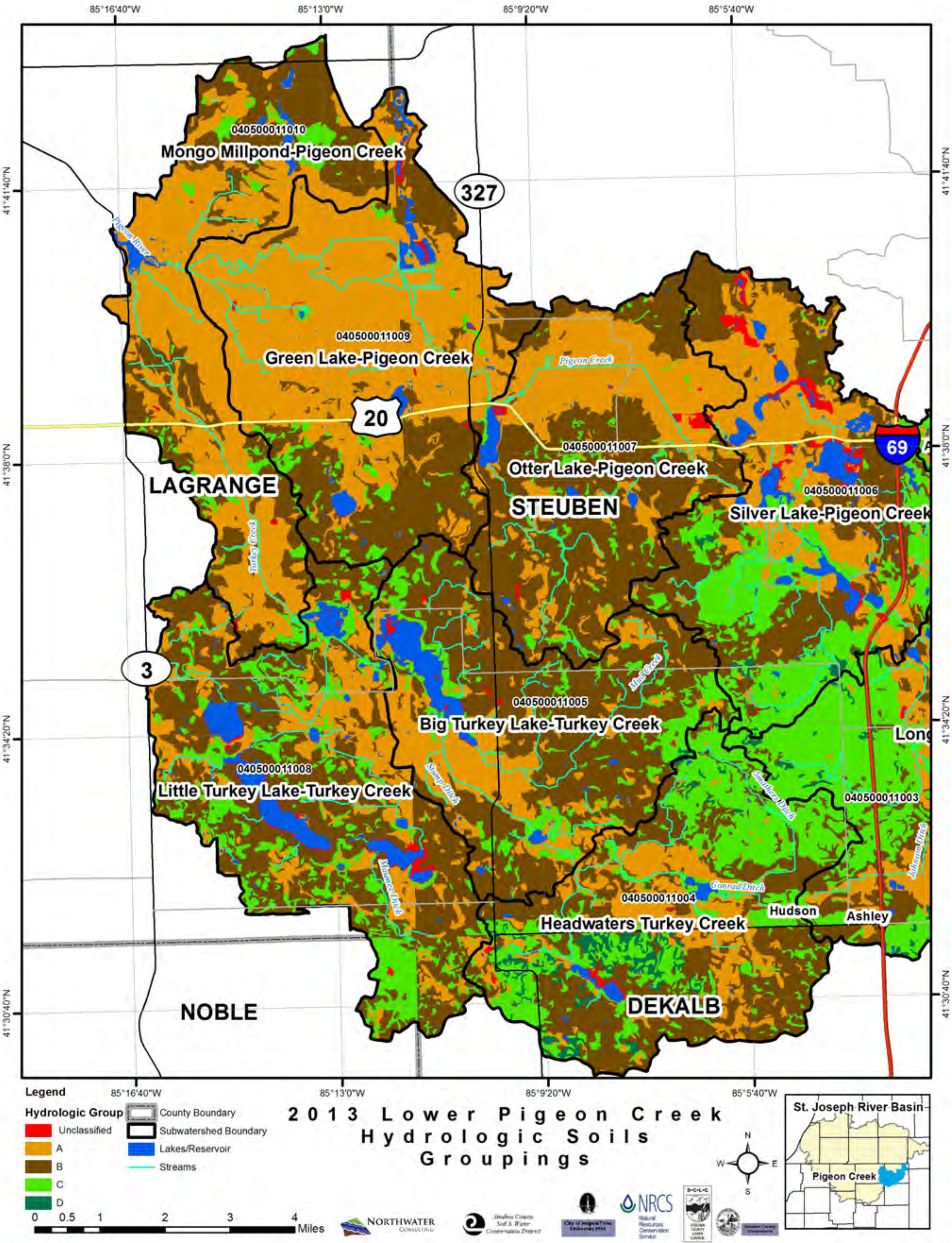


Figure 13 - Lower Pigeon Creek Soil Hydrologic Groups



3.3.2 Highly Erodible Soils

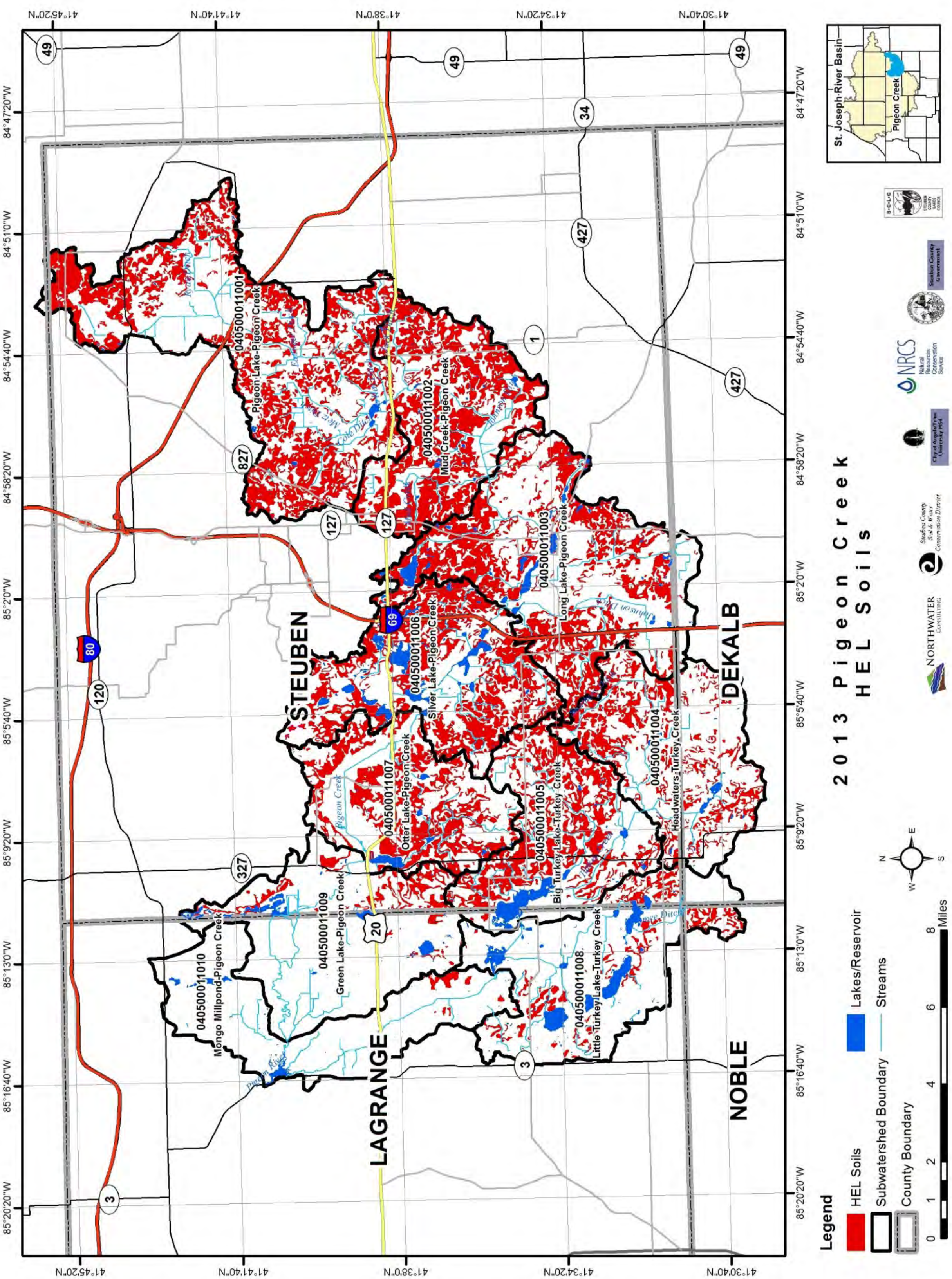
According to the NRCS, Highly Erodible Land (HEL) is cropland, hayland or pasture that can erode at excessive rates, containing soils that have an erodibility index of eight (8) or higher. If a producer has a field identified as highly erodible land and wishes to participate in a voluntary NRCS cost-share program, that producer is required to maintain a conservation system of practices that keeps erosion rates at a substantial reduction of soil loss. Fields that are determined not to be highly erodible land are not required to maintain a conservation system to reduce erosion. The Pigeon Creek watershed has 42,110 acres of such soils with the highest percentage occurring in the Mud Creek subwatershed (Table 14 and Figure 14). Along the Steuben County line and LaGrange County line and on into LaGrange, the extent of HEL soils drops off dramatically.

A more thorough analysis of HEL soils is presented in Section 7.1.3, which describes HEL soils on agricultural land. Of the 42,110 acres of HEL soils throughout the watershed, 22,767 (17% of the watershed) are located on crop ground. The amount of HEL soils in the watershed can also be tied back to stakeholder concerns relating to erosion and sedimentation.

Table 14 - HEL Soils

Subwatershed Name	HUC 12 Subwatershed Codes	Acres HEL Soils	Percent of Subwatershed
Pigeon Lake-Pigeon Creek	040500011001	9,185	42%
Mud Creek-Pigeon Creek	040500011002	6,368	55%
Long Lake-Pigeon Creek	040500011003	7,051	38%
Headwaters Turkey Creek	040500011004	3,059	26%
Big Turkey Lake-Turkey Creek	040500011005	4,097	37%
Silver Lake-Pigeon Creek	040500011006	5,768	45%
Otter Lake-Pigeon Creek	040500011007	3,847	37%
Little Turkey Lake-Turkey Creek	040500011008	1,458	11%
Green Lake-Pigeon Creek	040500011009	1,101	8%
Mongo Millpond-Pigeon Creek	040500011010	176	2%
Grand Total/Percent Entire Watershed		**42,110**	**31%**

Figure 14 - Pigeon Creek HEL Soils



3.3.3 Hydric Soils

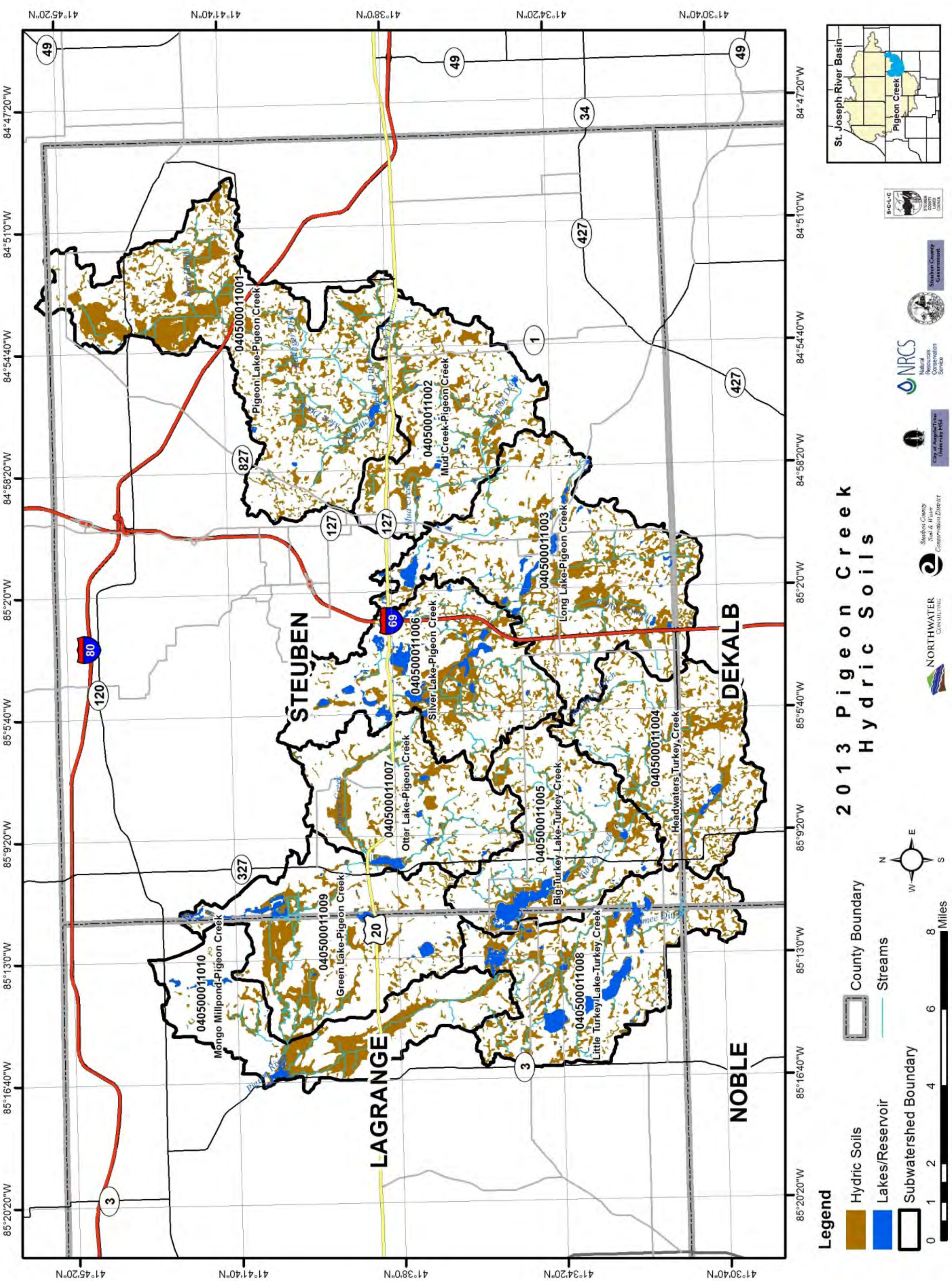
Hydric soils are scattered throughout the watershed and are an indicator of former wetlands and potential areas for wetland development. The greatest concentration of hydric soils are found along Pigeon Creek, at Cedar Swamp, along Long Lake and Hogback Lake, east of the crossing of Bill Deller Road and Pigeon Creek, and into the Pigeon River Fish and Wildlife Area in LaGrange County. Hydric soils are typically wet and will flood if proper drainage, overland or through field tiles, is not available. There are over 14 different hydric soils within the watershed totaling 34,993 acres. Table 15 provides a breakdown of the area of hydric soils by subwatershed and Figure 15 indicates the location of hydric soils within the watershed. Downstream in the watershed there is a decrease in hydric soils. The Pigeon Lake subwatershed has the highest overall percentage of hydric soils (32%) compared to 26% average for the entire watershed.

Table 15 - Hydric Soils

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Hydric Soils	Percentage of Subwatershed
Pigeon Lake-Pigeon Creek	040500011001	7,075	32%
Mud Creek-Pigeon Creek	040500011002	3,244	28%
Long Lake-Pigeon Creek	040500011003	4,932	26%
Headwaters Turkey Creek	040500011004	3,176	27%
Big Turkey Lake-Turkey Creek	040500011005	2,931	27%
Silver Lake-Pigeon Creek	040500011006	3,261	25%
Otter Lake-Pigeon Creek	040500011007	2,008	19%
Little Turkey Lake-Turkey Creek	040500011008	3,103	23%
Green Lake-Pigeon Creek	040500011009	3,095	23%
Mongo Millpond-Pigeon Creek	040500011010	2,169	21%
Grand Total/Percent Entire Watershed		**34,993**	**26%**

As an indicator of the potential for wetland development, understanding where hydric soils are located can inform wetland restoration and creation activities. Local stakeholders are concerned about the loss of wetland habitat in the watershed and support projects focused on wetland restoration and creation.

Figure 15 - Pigeon Creek Hydric Soils



3.3.4 Septic System Suitability

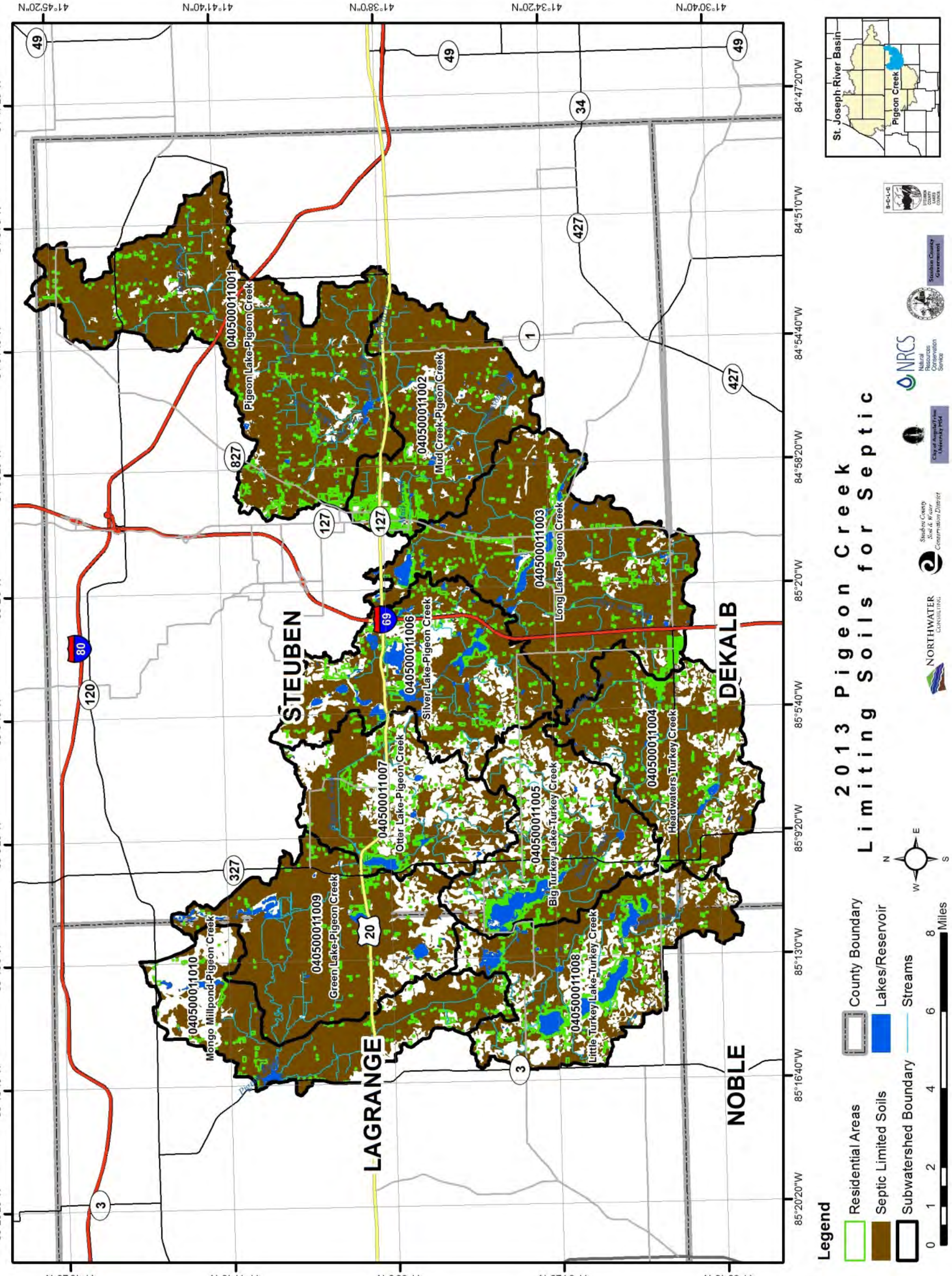
Outside of regional and municipal wastewater districts, residents within the Pigeon Creek watershed use septic systems to manage and treat wastewater. Over 95% of the watershed (129,934 acres) is outside of a wastewater district; a map of areas in the watershed that are served by a Wastewater Treatment Plant can be found in Section 7.1.2. Not all soil types support septic systems; improperly constructed systems can lead to failure and allow leaching of wastewater into groundwater and surrounding waterways. An analysis of the USDA national soils dataset indicates that 78%, or 105,488 acres (Table 16) of soils within the watershed, are classified as "very limited" with respect to septic suitability. The highest percentage falls within the Pigeon Lake subwatershed. This does not necessarily mean that all of these soils are unsuitable for septic but caution should be taken when establishing systems within most of the watershed. Figure 16 illustrates the extent of limiting soils for septic fields along with the location of residential areas within the watershed.

A more detailed analysis of potential septic problem areas can be found in Section 7.1.2, which notes that of an estimated 9,108 septic systems in the watershed, 1,365 are failing. Over 3,600 acres (2.68%) of all residential septic systems are on limiting soils and, of this acreage, 2,667 (73%) are within 500 feet of a stream. Considering that bacteria is the number one stakeholder concern, it is important to understand the relationship between water quality, soils suitable for septic systems, and improperly maintained or failing systems in the watershed.

Table 16 - Septic Suitability Soils

Subwatershed Name	HUC 12 Subwatershed Codes	Very Limited Soils	Percent of Subwatershed
Pigeon Lake-Pigeon Creek	040500011001	20,626	94%
Mud Creek-Pigeon Creek	040500011002	10,744	92%
Long Lake-Pigeon Creek	040500011003	16,893	91%
Headwaters Turkey Creek	040500011004	8,883	75%
Big Turkey Lake-Turkey Creek	040500011005	6,458	59%
Silver Lake-Pigeon Creek	040500011006	8,809	68%
Otter Lake-Pigeon Creek	040500011007	6,171	59%
Little Turkey Lake-Turkey Creek	040500011008	8,051	61%
Green Lake-Pigeon Creek	040500011009	11,302	83%
Mongo Millpond-Pigeon Creek	040500011010	7,552	72%
Grand Total/Percent Entire Watershed		**105,488**	**78%**

Figure 16 - Pigeon Creek Septic System Limiting Soils



3.3.5 Tillage Transect Survey Data

The Steuben County SWCD, along with the other counties in the watershed, performs annual transect surveys as part of the Indiana T by 2000, Watershed Soil Loss Transects Project. The most recent survey data from 2011 and 2012 included a total of 306 fields in the watershed. No survey sites fell within the Noble County portion of the watershed and LaGrange County was limited to 2011 data only. Compared to results presented in the previous plan, no-till remains the dominant tillage practice. Results also show a slight reduction in conventional tillage and a nominal increase in mulch-till. It should be noted that these results only represent those fields assessed and may not represent the watershed as a whole. Observations made during an April 2013 watershed windshield survey indicated a higher number of fields with conventional tillage, likely a result of the recent dry weather conditions, however, the majority of cropped HEL soils in the watershed are in no-till. Table 17 summarizes the data from the 2011 and 2012 surveys. Figures 17 and 18 show the distribution of tillage practices throughout the watershed.

Table 17 - 2011/2012 Transect Survey Data

Present Crop	Number of Fields	No-Till (>30% Residue) Total	Mulch-Till (30-75% Residue) Total	Reduced-Till (16-30% Residue) Total	Conventional (0-15% Residue) Total	Unknown Total
Corn	147	58	36	36	17	0
Soybeans	106	75	23	6	2	0
Small Grains	9	3	0	0	0	9
Hay	35	0	0	0	0	35
Specialty	3	0	0	0	3	0
CRP/Fallow	17	0	0	0	0	17

Pigeon Creek

Figure 17 – Upper Pigeon Creek Tillage

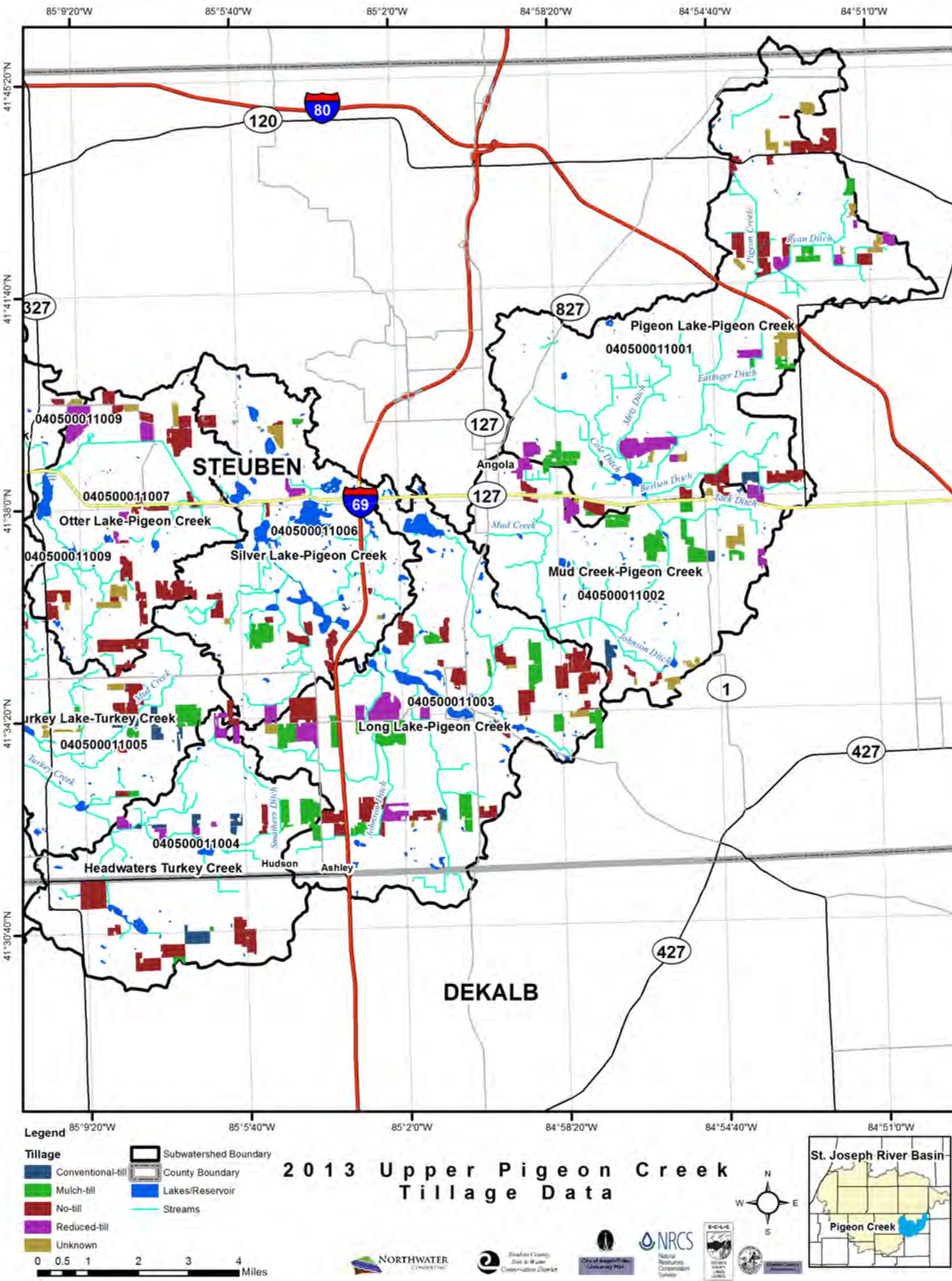
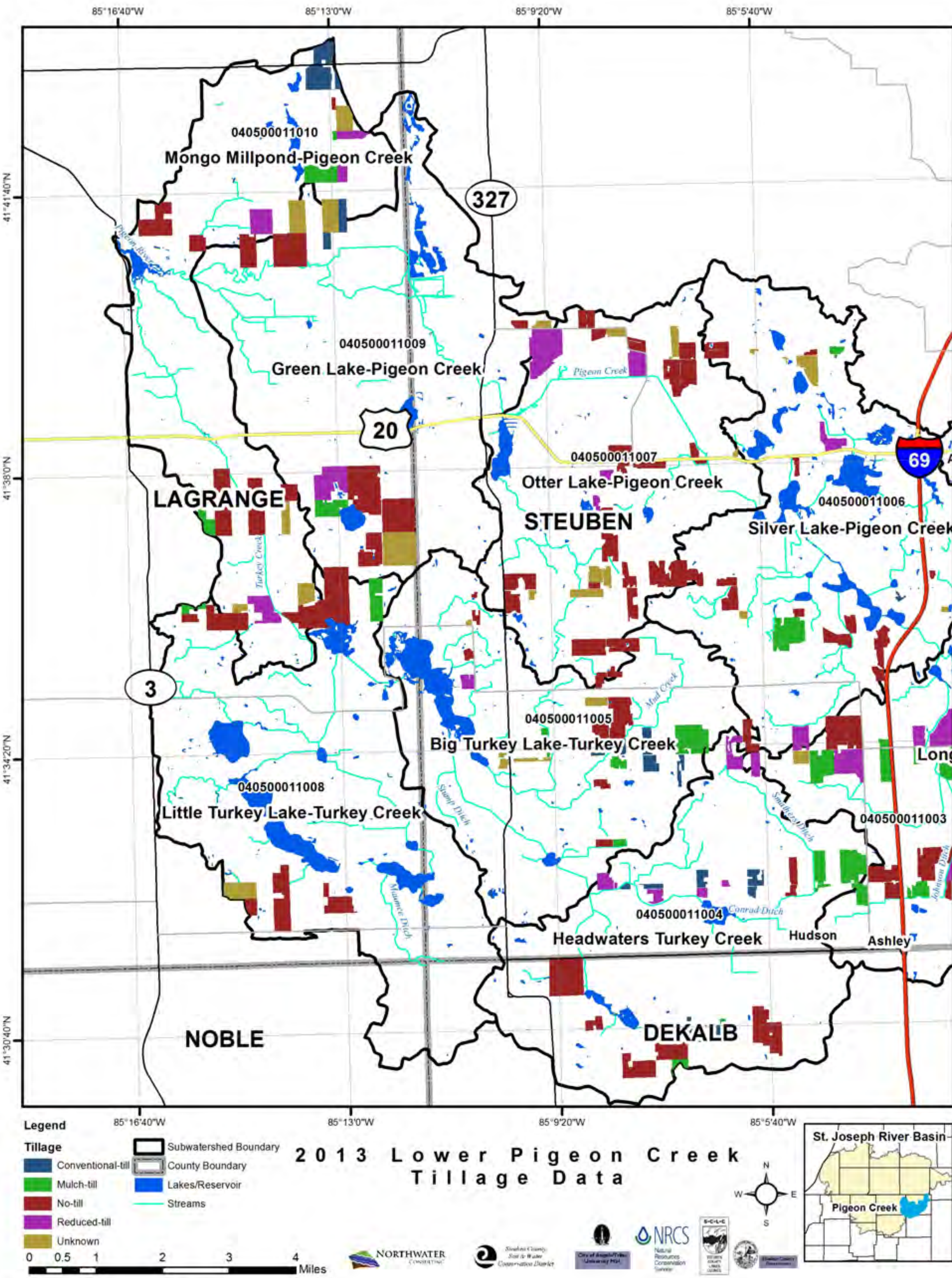


Figure 18 - Lower Pigeon Creek Tillage



3.4 Watershed Landuse/Landcover

A hybrid landuse/landcover GIS layer was created for the watershed using existing data provided by each county, analysis of recent aerial imagery and information collected during the windshield survey. This newly created layer represents a current snapshot of landuse and landcover in the watershed and is significantly more detailed than other national landcover datasets. Watershed-wide landuse statistics are provided in Table 18 and in Figures 19 and 20. Part II of the watershed inventory provides a more detailed explanation of landuse by subwatershed. Agricultural row crops encompass over 50% of the watershed and woodland and open space cover 25%. Wetlands, pasture, residential farm areas and open water are also of importance and account for 16% of the watershed area.

Table 18 - Watershed Landuse/Landcover

Landuse/Landcover Category	Acres	Percent of Watershed
Row Crop	69,396	51.05%
Woodland	22,120	16.27%
Open Space (grass or shrubs)	12,111	8.91%
Pasture	7,471	5.50%
Wetland	5,783	4.25%
Residential Farm	4,513	3.32%
Open Water Lake/Pond	3,752	2.76%
Road	3,236	2.38%
Residential (urban)	2,466	1.81%
Legal Ditch	929	0.68%
Primary Commercial/Industrial/Institutional	741	0.55%
Classified Wildlife Habitat	682	0.50%
Public Open Space (recreation)	651	0.48%
Classified Forest	523	0.38%
Farm Buildings and Barn Lots	378	0.28%
Railroad Right-of-Way	243	0.18%
Quarry	204	0.15%
Golf Course	149	0.11%
Open Water Stream/River	117	0.09%
Secondary Commercial/Industrial/Institutional	104	0.08%
Cemeteries	69	0.05%
Confinement	66	0.05%
Feed Area (non-barn)	60	0.04%
Agricultural Excess Area	47	0.03%
Feed Area Hogs	33	0.02%
Nursery	26	0.02%
Undeveloped Unusable Commercial/Industrial	23	0.02%
Undeveloped Usable Commercial/Industrial	17	0.01%
Vacant	13	0.01%
Cell Tower	4	0.003%
Public Utility Tower	0.12	0.0001%

Figure 19 – Upper Pigeon Creek Landuse/Landcover

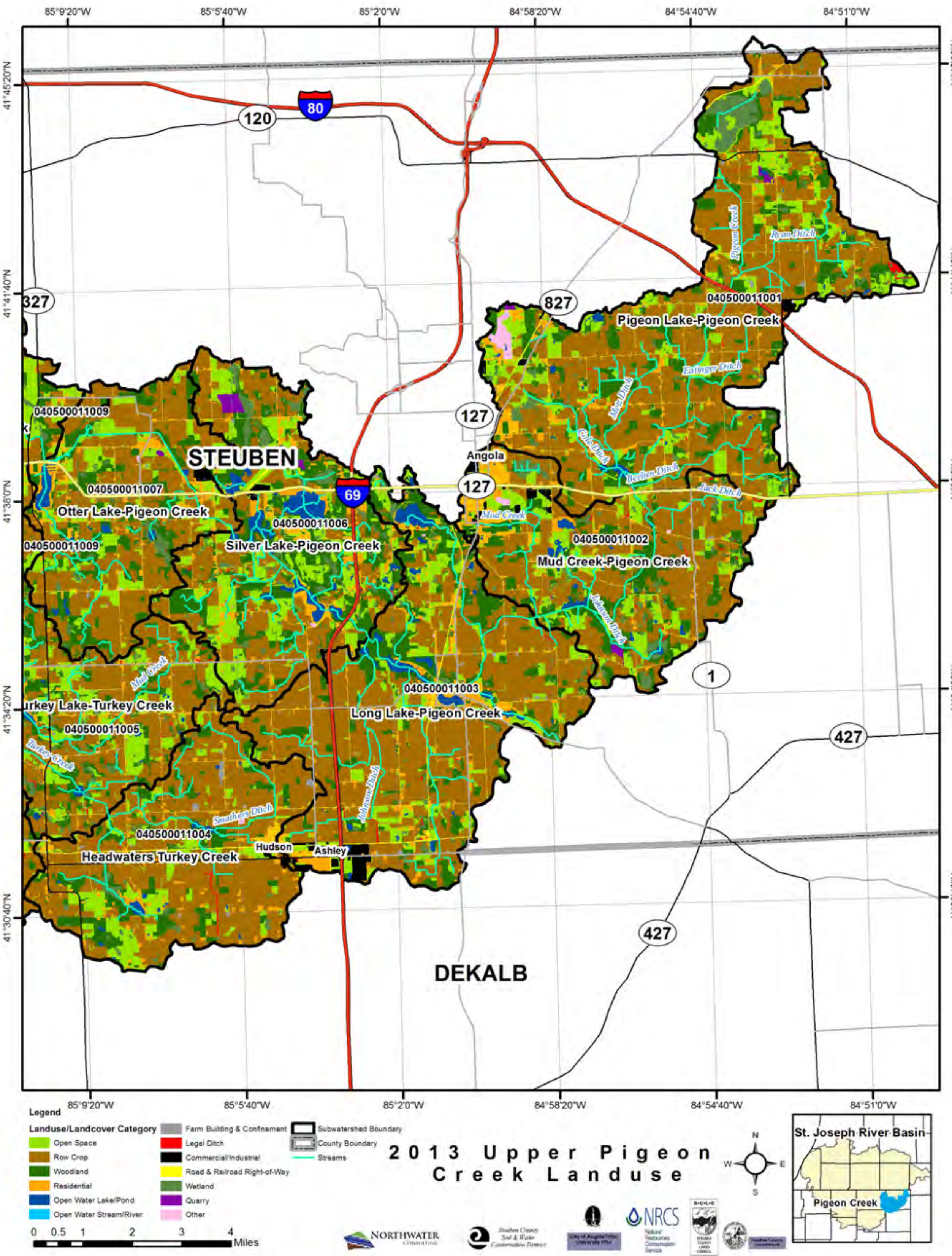
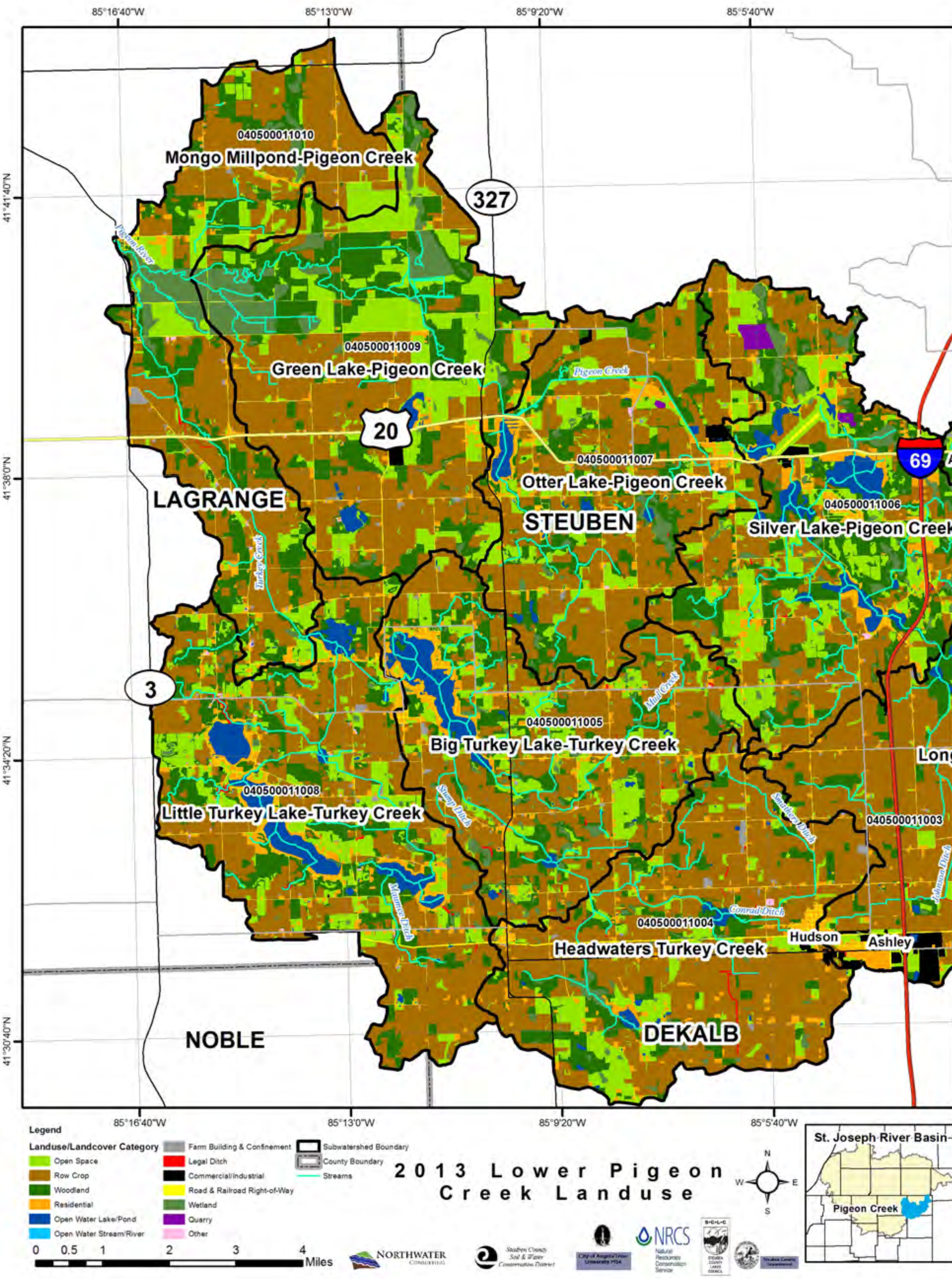


Figure 20 - Lower Pigeon Creek Landuse/Landcover



As noted in the 2006 plan:

> *"Steuben County economic income has long been based on agriculture with farming the primary historical land use. In 1995, approximately 70% of the watershed was classified as farmland (row crops and pasture.) The remainder of the watershed consists of small clusters of development primarily on the outskirts of Angola, forests, lakes, and other undeveloped land. Although the majority of Angola is outside of the Pigeon Creek watershed, the Angola Wastewater Treatment Plant discharges to a tributary of Pigeon Creek. Therefore, land use changes in the Angola vicinity will have an effect on the watershed."*

It is difficult to compare historical with current landuse using the 2006 plan as the dataset was from a national scale of lower resolution and the watershed planning areas are different between 2006 and 2014. Landuse/landcover from the 2006 plan is provided in Table 19; however, comparisons were not made due to the major difference in scale.

Table 19 - 1999 National Landcover Database Landuse/landcover

Land Use	Total Acres	Percent of Watershed
Row Crops	51,072	57.25
Pasture/Hay	12,450	13.95
Unclassified/Other	9,598	10.76
Deciduous Forest	9,152	10.26
Forested Wetlands	2,737	3.07
Open Water	1,991	2.23
Emergent Wetlands	883	0.99
Low Intensity Residential	694	0.78
Commercial/Industrial/Transportation	427	0.48
Evergreen Forest	95	0.11
4 remaining categories, each less than 0.1%	118	0.14
Totals	**89,216**	**100**

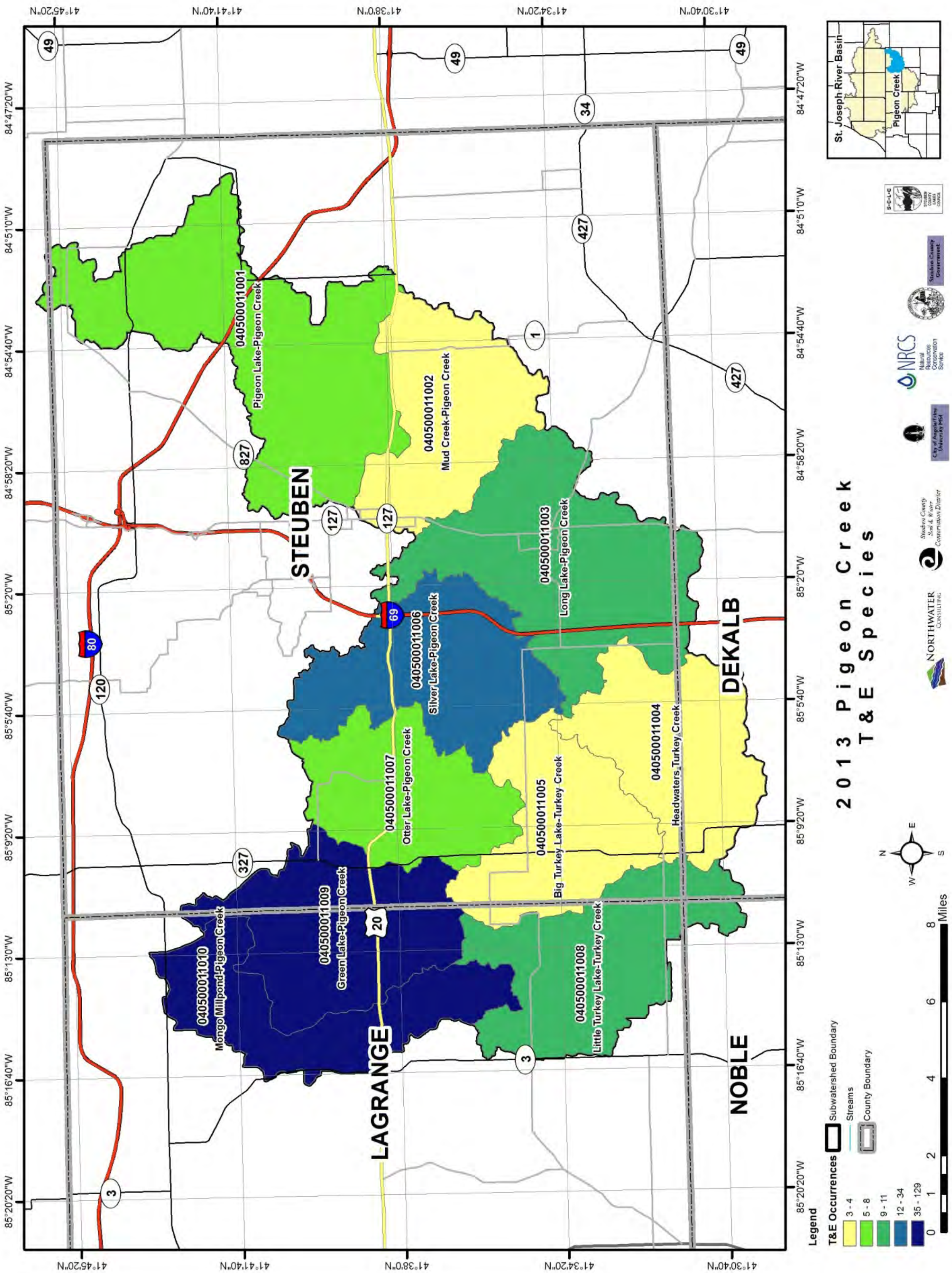
Landuse relating to confinement operations, small animal feeding operations, pasture, row crop agriculture, urban, and residential areas are further detailed in Sections 7.1.2 and 7.1.3. The Pigeon Creek watershed contains eight (8) regulated confinement operations that house 12,654 animals. There are eighty-five (85) small animal feeding locations totaling 161 acres and located an average of 577 feet from a stream or lake, and 7,471 acres of pasture of varying quality. Urban residential areas total 2,466 acres, residential farm sites make up 4,516 acres, commercial, industrial, and institutional landuses total 845 acres and farm buildings and barn lots are located on 370 acres throughout the watershed.

3.5 Threatened & Endangered Species

The 1987 *"Watershed Protection Plan"* indicated that the Indiana bat (*Myotis sodalist*) could be the only identified threatened or endangered species that may be present in the watershed. As part of the efforts to update the 2006 plan, a request was made to IDNR requesting information on the Threatened and Endangered (T&E) or rare species, high quality natural communities, and natural areas within the Pigeon Creek watershed. Table 20 and Figure 21 show the number of T&E species occurrences within each subwatershed. A detailed list by species is included in Appendix C; a list of T&E species is also available in the 2006 PCWMP (pages 47-50). As watershed improvement projects are designed and implemented, it is important to incorporate protective measures or avoidance of the species and areas that are listed. BMPs implementation and watershed improvement measures should consider the habitat requirements of T&E species.

Indiana Bat (photo credit: US Fish & Wildlife Survey)

Figure 21 - Pigeon Creek T&E Species Occurrences



There are 313 known occurrences of T&E species within the watershed that include 156 different species (Appendix C). The list includes 71 plants, 39 insects, 18 birds, 12 high quality natural communities, 5 mammals, 4 reptiles, 3 amphibians, 2 fish, and 2 mollusks. Amphibian species include the Northern Leopard Frog, Four-toed Salamander and the Blue-spotted Salamander. Fish species include the Cisco and the Greater Redhorse. The Cisco is a coldwater species found in lakes, and sometimes large rivers, and is a member of the trout/salmon family, resembling the lake whitefish. The Greater Redhorse is typically found in clear, relatively fast-moving rivers and in both shallow and deep waters in some lakes. Listed mollusks include the Snuffbox and the Ellipse. Both the Ellipse and the Snuffbox live in small to medium streams in gravel or mixed sand and gravel.

Table 20 - Threatened & Endangered Species

Subwatershed Name	HUC 12 Subwatershed Codes	Number of T&E Species Occurrences
Pigeon Lake-Pigeon Creek	040500011001	8
Mud Creek-Pigeon Creek	040500011002	3
Long Lake-Pigeon Creek	040500011003	11
Headwaters Turkey Creek	040500011004	3
Big Turkey Lake-Turkey Creek	040500011005	4
Silver Lake-Pigeon Creek	040500011006	34
Otter Lake-Pigeon Creek	040500011007	6
Little Turkey Lake-Turkey Creek	040500011008	10
Green Lake-Pigeon Creek	040500011009	129
Mongo Millpond-Pigeon Creek	040500011010	105
Grand Total		**313**

3.5.1 Indicator Species

The Cisco (*Coregonus artedi*) is a slender silver-colored fish that is a member of the salmon/trout family and is primarily found in glacial lakes. The southernmost range of the Cisco extends into northern Indiana. Cisco populations in Indiana have been declining and, in some cases, have disappeared completely. A layer of cold, well-oxygenated water is required by Cisco for survival. Lake eutrophication is caused by increased nutrient loading which results in the loss of oxygen from the deeper, cold water utilized by Cisco. Eutrophication is thought to be a cause for the decline in the Cisco populations of Indiana's lakes.

Gooseneck Lake and Meserve Lake are the only two lakes that had a Cisco population during the IDNR survey from 1990 to 1993, both within Steuben County and the Pigeon Creek watershed. There were four other lakes within Steuben County, not within the watershed, that had a Cisco population during the survey, including Failing Lake, McClish Lake, Lake Gage, and Seven Sisters Lakes.

The IDNR Division of Fish and Wildlife has stocked Cisco in Green Lake, which is within Steuben County and the watershed, but Green Lake does not have a direct surface water connection with Pigeon Creek.

The Cisco and other rare species can be used as an indicator of high-quality water bodies, thus populations should be closely monitored to forewarn of declining water quality.

3.6 Watershed Successes & Progress Made

After the 2006 plan was completed, Phase I Implementation of the plan commenced under funding from an IDEM Section 319 Nonpoint Source Management Program Grant. Phase I implementation was completed in 2008, and the Steuben County SWCD applied for the next phase of funding. The Phase II Implementation Grant was awarded from the IDEM Section 319 program in 2009 with grant work commenced on September 22, 2009. The goal of the Phase II project was to continue to improve the water quality of the watershed by working in critical areas identified in the 2006 plan, and to build on the success of Phase I. Goals and objectives of Phase II implementation included: increased adoption of agricultural and urban BMPs, greater public awareness of the importance of water quality, demonstration of the benefits of agricultural and urban BMPs, improved water quality and biotic communities from BMP implementation, and wetland/habitat restorations. In addition to Phases I and II, the Steuben County SWCD received complementary funding through the Indiana Lake and River Enhancement Program (LARE) to implement additional BMPs between 2007 and 2012.

Overall, substantial progress has been made to address goals identified during the 2006 plan, which include improved water quality, improved drainage, and regulated development. Specific progress included:

- A reduction in localized bacteria loads through the implementation of livestock BMPs (Sections 3.6.2 and 3.6.3 and Section 9).
- Reductions in sedimentation and nutrients have occurred through the implementation of agricultural and urban BMPs. Load reductions from these practices are summarized in Section 9.
- The number of Combined Sewer Overflow (CSO) events has been reduced in the City of Angola.
- Complaints and concerns at Steering Committee meetings related to flooding have been reduced.
- Development in Angola continues to be regulated and numerous urban BMPs have been implemented, such as rain gardens, porous pavement, rain barrels, and a large stormwater wetland restoration project.

3.6.1 PCWMP Phase I Implementation

After completion of the 2006 plan, the Phase I grant was applied for and awarded to the Steuben County Commissioners/GIS and administered through the County Surveyor's Department. The project included the hiring of a resource specialist to promote the installation of BMPs within the watershed. The role of the Steuben County SWCD was to assist the resource conservationist with project identification and planning, conservation planning, field checks, and education.

Phase I highlights included:

- Candidate sites identified within critical subwatersheds.

- An education campaign and materials covering: best lawn fertilizer practices, best crop and livestock practices, septic maintenance, car washing, pet waste, and urban construction practices.
- BMP implementation including: filter strips (28,150 ft), grassed waterways (3,350 ft), and water and sediment control basins (20 structures).

3.6.2 PCWMP Phase II Implementation

Phase II PCWMP implementation included the following:

- Development and promotion of a cost-share program to implement BMPs such as, but not limited to, conservation buffers, a constructed wetland, rain gardens, and green roofs all of which address the water quality concerns outlined in the 2006 plan.
- BMPs were implemented in critical areas as described in the 2006 plan.
    - 307 feet of streambank stabilization
    - 4,295 feet of exclusion fencing and rotational grazing
    - 15 acres of hay planting
    - 30 acres of tree planting
    - Commons Park/John Leach Drain 2.66-acre wetland restoration project
    - 43 rain barrels
    - 324 square feet of pervious concrete
    - 4,100 square feet bio-swale
    - 3 rain gardens in Angola
- Implementation of a water monitoring program to determine the source and fate of pollutants in the watershed and to guide future sampling and/or remediation of point and nonpoint source pollution. The monitoring program included:
    - Sampling for: Total Phosphorus, Total Suspended Solids, pH, Dissolved Oxygen, temperature, specific conductance, stream flow, and *E. coli*.
    - A minimum of ten (10) sites within the Pigeon, Hogback, Long, Center, Pleasant, Big Bower, and Golden Lakes for the aforementioned parameters and was to take place at least three (3) times between May and September of each year.
    - No less than four (4) sites within the Pigeon Creek for the aforementioned parameters at least three (3) times between May and September of each year.
    - The development of Quality Assurance Project Plan (QAPP) for the monitoring activities.
- An education and outreach program designed to bring about behavioral changes and encourage BMP implementation that would lead to reduced nonpoint source pollution in the watershed. Projects included:
    - a presentation educating the attendees on water quality issues at schools within the watershed each year
    - five (5) presentations educating the attendants on water quality issues
    - twelve (12) quarterly Steering Committee meetings
    - one (1) public meeting each year
    - three (3) project-related press releases to local media each year

- updates on the Steuben County SWCD website
- project promotion at city and county meetings
- signage at highly visible BMP sites throughout the watershed
- three (3) workshops on water quality issues
- development and dissemination of a brochure regarding septic maintenance to stakeholders throughout the watershed

3.6.3 PCWMP Supplemental Implementation

The Steuben County SWCD received two LARE grants to install additional agricultural BMPs in the watershed between 2007 and 2012. Completed practices installed (2007-2012) through this funding included:

- 683 acres of hay planting
- 20.6 acres of filter strips
- 36,832 feet of livestock fencing
- 4 livestock watering facilities
- 86 acres of tree planting
- 878 acres of cover crops
- 3,200 acres of grassed waterways
- 8.35 acres of critical area seeding

3.7 Previous Planning Efforts

It is important to understand the historical planning and assessment efforts conducted within the watershed (Table 21) to inform current planning efforts, avoid duplication of efforts, and to ensure a linkage with any higher level plans. Numerous planning projects, plans, and reports have been completed for the watershed in the last thirty years, including local watershed and city plans and numerous assessment reports. Each document represents a different snapshot in time, which provides insight into the current plan. Some of these plans are outdated but offer a historical perspective, and several existing watershed-wide plans, including the recent TMDL document, provide guidance that will drive components of the current planning effort.

Table 21 - Summary of Previous Planning Efforts

Plan Title	Plan Year	Plan Purpose	Notes/Relevance
Preliminary Investigation Report; Pigeon River Watershed	1967	Identify solutions to flooding	Includes watershed inventory and recommends land treatment and structural solutions
Feasibility Report; Pigeon Creek watershed	1983	To identify feasibility of a PL-566 flood control project	Updates, summarizes and reiterates recommendations in the 1967 report
Preauthorization Report; Pigeon Creek watershed	1984	To investigate solutions to upstream erosion issues and to justify funding through the PL-566 program	The report identifies watershed problems, specifically focusing on erosion and compares several treatment alternatives. Desired recommendations included a combination of land treatment practices.
Watershed Protection Plan – Environmental Assessment for Pigeon Creek watershed	1987	To justify land treatment in the watershed using Department of Agriculture programs	Locally led planning effort. Quantifies erosion problems and recommends a 10-year plan for land treatment and structural practices aimed at reducing soil erosion and flooding.
Northeast Indiana Erosion Study Report for Steuben County, Indiana	1987	Response to concerns over excessive soil erosion	Only for Steuben County. Average 17.7 tons/acre/year erosion. The document recommends land treatments
Pigeon River Flooding Study Phase I	1994	To Identify solutions to flooding	Similar to previous studies; recommends land treatment and some structural measures including using or enhancing existing recreational areas. Notes septic leachate as a problem during flood events
Lake Engineering Feasibility Studies	1991 & 2002	LARE Studies for evaluating the feasibility or alternatives for enhancing and protecting lake quality	Two plans exist for Big and Little Turkey Lakes, including a watershed feasibility study and an enhancement study. These studies outline strategies for enhancing and protecting lake quality and, although specific to those lakes, plan recommendations are similar to those outlined in the PCWMP. These documents can be used to further justify and seek funding for the Big and Little Turkey Lake Watersheds and should be consulted if work is planned in these areas.
St. Joseph River Basin Management Plan	2005	To address water quality issues and natural resource protection across jurisdictional boundaries	High level plan covering Pigeon Creek as a tributary to the St. Joseph River. Provides general implementation guidance; no specifics for Pigeon Creek. The plan goals are generally in line with the goals for Pigeon Creek. The plan should be used to justify funding requests.
City of Angola/Trine University; Storm Water Quality Management Plan; Municipal Separate Storm Sewer System (MS4)	2010	To reduce the discharge of pollutants to the "Maximum Extent Practicable" (MEP); To protect water quality; and; To satisfy the appropriate water quality requirements of the Clean Water Act.	The plan provides a framework for improving stormwater quality within MS4 boundaries. The document is relevant to the watershed planning process in that it establishes the need and guidance for practice implementation and action within city limits. It addresses public participation and education, illicit discharges, runoff and control measures. This document can be used to justify funding for implementation and further strengthens the Watershed Management Plan.

Plan Title	Plan Year	Plan Purpose	Notes/Relevance
Pigeon River Watershed Total Maximum Daily Load (TMDL) Study for *E. coli* and Impaired Biotic Community (IBC)	2012	To establish percentage load reductions for *E. coli* and Phosphorus needed to meet state standards and improve the impaired biotic community	This report establishes a baseline number from which to measure and reduce bacteria and nutrient/sediment loading to Pigeon Creek. The most important thing about a TMDL is that once in place, the assessed waterbody will receive priority for funding. A TMDL study is a mechanism to secure watershed improvement project funding. Often, once a TMDL study is completed, additional planning is required to identify specific implementation projects.
Pigeon Creek Watershed Management Plan Phase Two Implementation; Final Report	2012	To describe EPA Clean Water Act funding in the watershed from 2009-2012	The report provides details on specific watershed restoration practices installed using federal funds from 2009-2012. This document can be used to understand implementation efforts prior to the PCWMP update and is a testament to the many watershed accomplishments since 2006.
Various Aquatic Vegetation Management Plans	2006-2013	Plans that describe the condition of lake vegetation species and the treatment of aquatic invasive species	Over 25 plans (including plan updates) have been completed for lakes in the watershed. These documents are lake-specific and address vegetation management. These plans complement the PCWMP as vegetation management is not specifically addressed in this plan.
Lake Diagnostic Studies	1991-2013	Similar to Lake Engineering Feasibility Studies, LARE Lake Diagnostic Studies outline options and alternatives for addressing lake quality	Plans exist for Pretty Lake, McClish Lake, Lake of the Woods, and Fox Lake. These studies include a watershed evaluation and data collection and outline strategies for enhancing and protecting lake quality. Although specific to those lakes, plan recommendations are similar to those outlined in the PCWMP. These documents can be used to further justify and seek funding for the above-listed lake watersheds and should be consulted if work is planned in these areas.
City and County Comprehensive Plans	N/A	Comprehensive plans guide the type, location and timing of development	The Steuben County Comprehensive Plan covers unincorporated areas of Steuben County; this plan is implemented through the County Zoning Ordinance, the Subdivision Control Ordinance, and various policies and practices. Angola has adopted a Comprehensive Pan. This plan specifically addresses water and environmental quality; no other known comprehensive plans exist in the watershed. A town master plan does exist for Ashley. City and county planning generally occurs through zoning ordinances. These ordinances and other initiatives can support sound water quality management and, in the case of Angola, local efforts to control stormwater runoff are directly incorporated into the PCWMP. Other communities within the watersheds should be approached; similar work being implemented in Angola can occur in other urban areas.
Pigeon River Watershed Management Plan	2013	To address water quality issues in the Pigeon River watershed and expand implementation efforts.	The Pigeon Creek flows southwesterly through Steuben County and enters the east side of LaGrange County. Pigeon Creek turns into the Pigeon River once the creek meets the Mongo Millpond. The Pigeon River WMP, produced through the LaGrange County SWCD, also includes three subwatersheds within the extent of the

Plan Title	Plan Year	Plan Purpose	Notes/Relevance
Pigeon River Watershed Management Plan (Continued)	2013	To address water quality issues in the Pigeon River watershed and expand implementation efforts.	Pigeon Creek WMP; Little Turkey Lake – Turkey Creek (HUC 040500011008), Green Lake – Pigeon Creek (HUC 04050001009), and Mongo Millpond – Pigeon Creek (HUC 040500011010). Many of the water quality issues and solutions are similar between the Pigeon River and Pigeon Creek WMPs and, despite some overlap in watershed area, each plan addresses a different geographic area. Any work completed in the Pigeon Creek watershed will have positive benefits to Pigeon River. With both of these plans completed, significant opportunities now exist for Steuben and LaGrange Counties to coordinate on projects that are mutually beneficial to both watersheds, especially where subwatersheds and plan recommendations overlap. Relevant overlapping recommendations include the installation of buffer strips, limiting livestock access to streams, and management of livestock waste from small feed areas. Additional funds and technical resources could be leveraged through coordination.

Based on a review of historical planning projects, the Pigeon Creek watershed has received interest as early as 1967 when the first watershed assessment/investigation report was commissioned. Early reports and plans followed a similar structure as today's plan, focusing on identifying solutions to watershed and water quality problems. Most of the historical documents and plans focused on flooding and sedimentation of lakes. In each situation, planners identified watershed issues and made either site-specific or generalized recommendations to alleviate quantifiable problems. Similar to today, many of the recommendations to address both flooding and erosion focused on a combination of land treatment and structural practices. What is interesting about the planning history for the watershed is that, over the years, little has changed in terms of what conditions residents perceived as problems and what conditions the 'data' suggested were problems: flooding, erosion/sedimentation, and water quality.

After beginning these early land treatment projects, many of the watershed issues remain and many of the solutions are still very relevant. Regardless of the progress made to date in addressing watershed issues, these issues still do persist. This 2014 plan identifies where and which solutions are needed, along with the water quality benefits achieved as a result.

Lakes in the Pigeon Creek watershed have received significant attention in terms of historical planning and studies, especially through the Indiana LARE program. As noted in Table 21 above, numerous Aquatic Vegetation Management Plans, Lake Engineering Feasibility Studies, and Lake Diagnostic Studies have been completed. Big and Little Turkey Lakes have received the most attention as both lakes have all three of these documents in place. Similar to this watershed plan, diagnostic and feasibility studies include a watershed area assessment and evaluation, data collection, public participation and general project recommendations. These documents do not replace the PCWMP; rather, they enhance the plan by reinforcing similar water quality issues at a more focused and local scale. Applicable LARE plans and studies should be consulted prior to initiating any work in those areas. This PCWMP acts as an overarching document, focused primarily on water quality at the basin scale; it supports these smaller, more localized efforts. The PCWMP also includes a set of unique and site-specific project recommendations, not found in previous studies. Stakeholders responsible for implementing existing LARE studies and plans can refer to the PCWMP for additional direction.

Planning has also been completed from the Pigeon Creek Watershed to the Pigeon River Watershed and into the St. Joseph River basin. These hydrologically connected systems share common water quality issues and each plan describes similar solutions. Goals outlined in the large-scale St. Joseph River Basin Plan are in line with those of Pigeon Creek. The recently completed Pigeon River Watershed Management Plan overlaps in both geography and water quality concerns. Progress made towards improving water quality in Pigeon Creek will have numerous benefits to the Pigeon River and significant opportunities now exist to coordinate implementation activities in both watersheds.

Furthermore, the existing Pigeon Creek/River TMDL plan and the City of Angola MS4 Storm Water Quality Management Plan are two very relevant documents that provide additional justification for improving water quality in the watershed. The TMDL plan establishes numerical load reduction targets required to address stream impairments. The PCWMP is directly tied to these targets in that it establishes site-specific treatment practices required to reasonably achieve the needed load reductions within the watershed. The simple fact that a TMDL plan exists will allow local watershed stakeholders to take advantage of water quality improvement funds and receive a much higher priority. The City of Angola's MS4 plan establishes the regulatory framework for addressing stormwater quality within the City's MS4 permitted area, and provides the continuity with urban water quality issues and solutions. The MS4 plan ensures that there is a willingness from Angola to make measurable efforts to address stormwater and water quality issues from the city. As in the case of the TMDL plan, it enhances access to water quality improvement funds as well as addressing project needs within the city.

3.7 Other Relevant Watershed Characteristics

The Pigeon Creek watershed includes a variety of unique features and a combination of both urban and rural areas. This section of the plan describes other relevant watershed characteristics, including public owned and protected land, watershed demographics, and urban areas.

3.7.1 Public Owned & Protected Land

There are 7,198 acres (5%) of the watershed that are owned by the State of Indiana, the largest area is the Pigeon River Fish and Wildlife Area which is 6,126 acres and located at the watershed's outlet. The entire Pigeon River Fish & Wildlife Area extends outside the watershed and includes 11,605 acres of land, 529 acres of lakes and impoundments and 17 miles of free-flowing river. It was established in 1956 when three impoundments in the Pigeon River Valley were transferred to state ownership. These included Mongo, Nasby and Ontario reservoirs. The state has continued to acquire additional land along the river valley.

Cedar Lake Wetland Conservation Area is 883 acres within the watershed, and an additional 51 acres outside the watershed. It is located in the headwaters of Pigeon Creek in the Northeast of the watershed. The Nature Conservancy (TNC) owns 118 acres in the Silver Lake subwatershed (HUC 040500011006). Figure 22 depicts the location of protected and public owned areas throughout the watershed and Table 22 breaks down acreage by subwatershed.

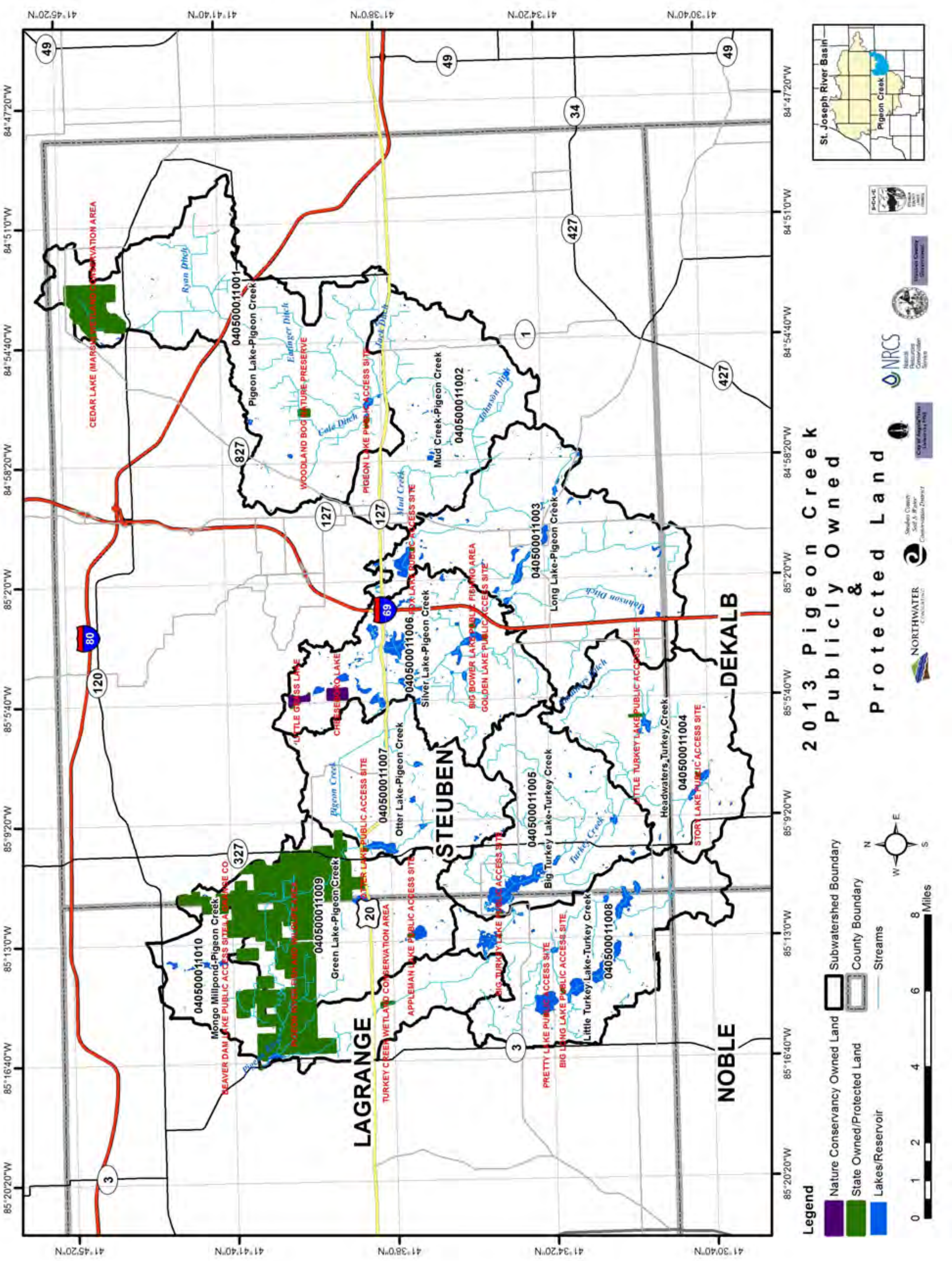
Table 22 - Public Owned Land

Subwatershed/Site Names	HUC 12 Subwatershed Codes	Area in Acres	Percent of Watershed
Pigeon Lake-Pigeon Creek	**040500011001**	**22,036**	
Cedar Lake (Marsh) Wetland Conservation Area		883	4.01%
Pigeon Lake Public Access Site		4	0.02%
Woodland Bog Nature Preserve		25	0.11%
Total		**912**	**4.14%**
Mud Creek-Pigeon Creek	**040500011002**	**11,641**	0
Long Lake-Pigeon Creek	**040500011003**	**18,620**	
Fox Lake Public Access Site		1	0.01%
Headwaters Turkey Creek	**040500011004**	**11,798**	
Little Turkey Lake Public Access Site		3	0.02%
Story Lake Public Access Site		2	0.01%
Total		**5**	**0.04%**
Big Turkey Lake-Turkey Creek	**040500011005**	**11,015**	
Big Turkey Lake Public Access Site		3	0.03%
Silver Lake-Pigeon Creek	**040500011006**	**12,954**	
Big Bower Lake Public Fishing Area		3	0.03%
Cheeseboro Lake		80	0.62%
Golden Lake Public Access Site		1	0.01%
Little Grass Lake		46	0.36%
Grass Lake Complex (TNC)		118	0.91%

Subwatershed/Site Names	HUC 12 Subwatershed Codes	Area in Acres	Percent of Watershed
Total		**249**	**1.92%**
Otter Lake-Pigeon Creek	**040500011007**	**10,491**	
Otter Lake Public Access Site		5	0.05%
Pigeon River Fish And Wildlife Area		3	0.03%
Total		**8**	**0.08%**
Little Turkey Lake-Turkey Creek	**040500011008**	**13,255**	
Big Long Lake Public Access Site		2	0.01%
Little Turkey Lake Public Access Site		1	0.004%
Pretty Lake Public Access Site		1	0.01%
Total		**4**	**0.03%**
Green Lake-Pigeon Creek	**040500011009**	**13,581**	
Appleman Lake Public Access Site		1	0.01%
Beaver Dam Lake Public Access Site/La Grange Co		1	0.01%
Pigeon River Fish And Wildlife Area		4,694	34.57%
Total		**4,697**	**34.58%**
Mongo Millpond-Pigeon Creek	**040500011010**	**10,520**	
Pigeon River Fish And Wildlife Area		1,429	13.59%
Turkey Creek Wetland Conservation Area		8	0.07%
Total		**1,437**	**13.66%**
Grand Total		7,316	5.4%

Pigeon Creek

Figure 22 - Pigeon Creek Publicly Owned & Protected Land



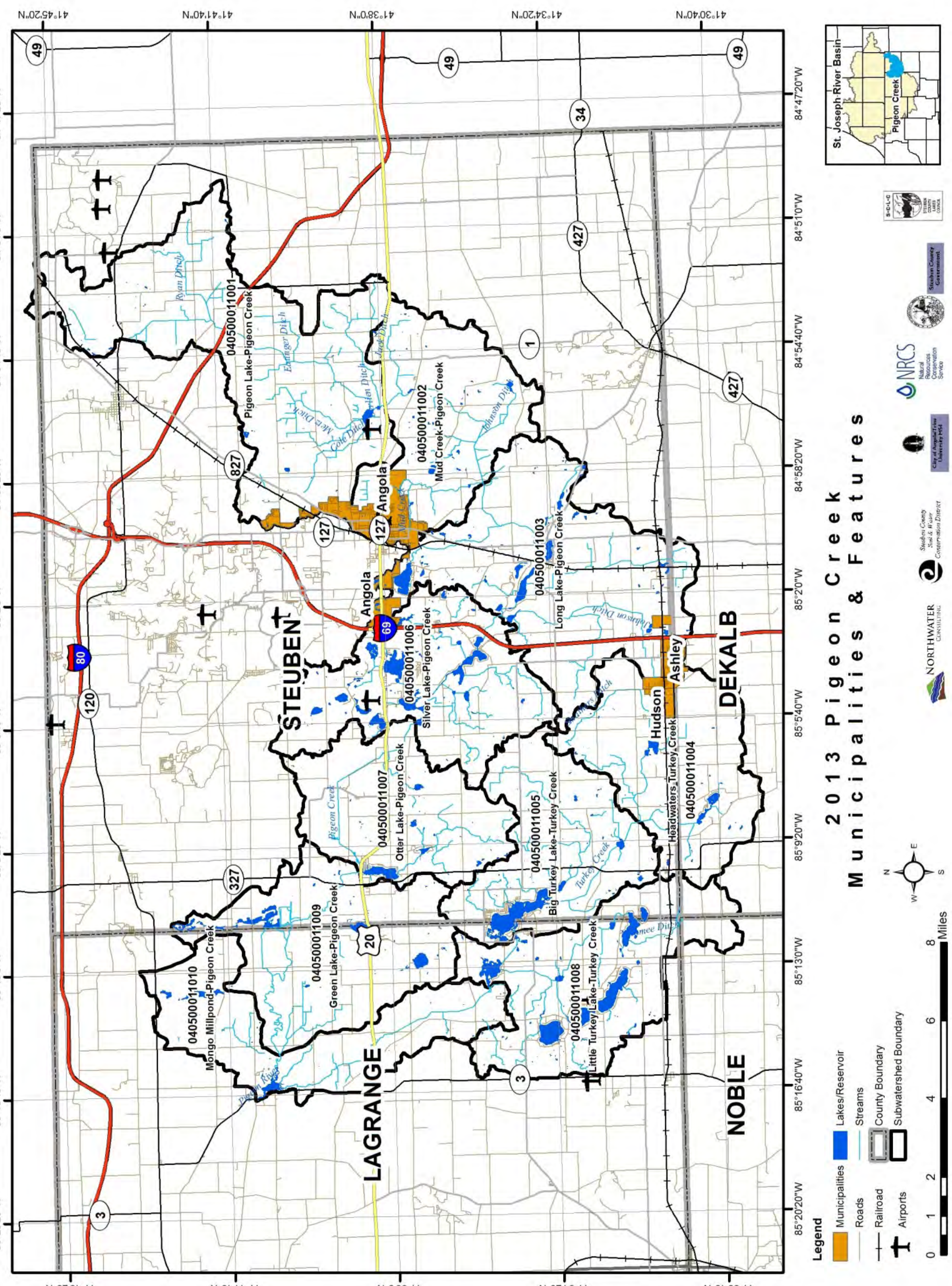
3.7.2 Watershed Demographics & Urban Areas

The Pigeon Creek watershed is primarily rural and includes three municipalities (Figure 23); Angola and Hudson (located in Steuben County) and Ashley (located in both Steuben and DeKalb Counties.) The City of Angola covers 4,002 acres, Ashley covers 686 acres and Hudson covers 858 acres within the watershed.

Angola has a 2012 population of 8,604, an increase of seventeen percent (17%) since 2000. Ashley has a current population of 985 and Hudson has 516 residents. An analysis of 2000 map-based Census data (2010 Census data is not currently available in map format) shows the watershed has a total population of approximately 27,528, with 10,249 households and an average median age of 35.4. Average watershed population density in 1890 was 16 persons per square kilometer compared to 36 in 2000, an increase of over one hundred percent (100%.) Despite consistent, small increases in population, the watershed has maintained its rural character. Local reports indicate that the population of Steuben County doubles during the summer due to lake-related recreation and seasonal housing.

2011 Volunteer Stream Clean-Up Day

Figure 23 - Pigeon Creek Municipalities & Features



4.0 Part II: Watershed Inventory

Part II of the watershed inventory includes detailed water quality and hydrology, landuse and biological information by subwatershed, applicable data sources, methodologies and targets. Part II provides specific information and a thorough scientific analysis of watershed data.

The Pigeon Creek watershed is mostly rural with three small municipalities; a total watershed area of over 135,000 acres. The gently sloping watershed has an average slope of 13% and landuse is primarily agriculture (row crops) and forest land. There are 257 miles of stream, 177 miles of which are considered channelized and 734 lakes and reservoirs. There are just over 6,000 acres of irrigated crop ground and 17,999 acres of wetland. Six percent of the watershed is in the 100-year floodplain and there are 3 unique, unconsolidated aquifer systems. Hydrologic group B and C soils make up over 60% of the watershed's soils and 34,993 acres are classified as hydric. Just over 31% of the watershed is considered highly erodible and almost 80% of the entire watershed is comprised of soils unsuitable for septic systems. Conventional tillage and no-till are the primary tillage practices in Pigeon Creek. There have been over 300 occurrences of T&E species and 5% of the watershed is in publicly owned and protected land.

To date, substantial implementation and planning has occurred, including a watershed plan completed in 2006, numerous flood studies and a TMDL. The Steuben County SWCD has worked to install numerous urban and agricultural BMPs and educate watershed stakeholders. An active watershed committee meets regularly and frequent water quality monitoring occurs at various sites throughout Pigeon Creek.

To support Part II of the watershed inventory, Pigeon Creek was evaluated in detail utilizing existing datasets, GIS information compiled by county and state sources, a watershed windshield survey, and site assessments on properties where willing landowners allowed access. Existing and historical water quality information was collected and assessed and followed by a detailed review of the 2012 Pigeon Creek TMDL.

4.1 Watershed Data & Sources

Data was compiled from existing databases and reports and analyzed spatially using GIS. Field assessments were conducted during a 2013 windshield survey that evaluated the watershed as well as individual land parcels. Almost every road within the watershed was covered and observations recorded using GPS. Individual property assessments were conducted on six properties where willing landowners participated. Water quality was analyzed by accessing data from existing surface water quality monitoring programs managed by IDEM and the Steuben County SWCD. Habitat and biological data was compiled from IDEM and IDNR databases and a wetland inventory was provided by the Friends of the St. Joe River Association. Parcel-specific watershed pollution loading was evaluated by building a GIS-based pollution load model, calibrated with existing water quality data.

Table 23 - Data Sources/Methodology

Data Set	Methodology/Source	Notes
Water Quality & Quantity	1. IDEM surface water quality data & TMDL 2. Steuben County SWCD, Lakes Council, and Surveyors office; chemistry and flow 3. 2012 TMDL - Emmons & Olivier Resources Inc. 4. Lake Trophic Status – Indiana University; Indiana Clean Lake Program 5. USGS Stream Gauge 6. NPDES permits	• Steuben Co. has implemented a stream monitoring program through a Phase II IDEM grant. Extensive water quality and flow data has been collected. Additional monitoring sites are funded through the Steuben County Lakes Council, COA, MS4, and the County Surveyor's office. • TMDL loading data were utilized for model calibration and point source loadings.
Habitat &Biological	1. Fish and Bugs - IDEM Assessment Information Management System 2. Wetlands – Friends of the St. Joe River Association 3. Threatened & Endangered Species – IDNR Natural Heritage Database	• Friends of the St. Joe River Association wetland layer; see layer description in section 3.2.3.
Landuse	1. GIS data – County and state GIS data centers 2. Previous projects and relevant planning documents - County SWCD offices and the City of Angola 3. Tillage Transect Data – County SWCD Offices 4. Landuse/Landcover – Northwater Consulting 5. Windshield Survey and BMPs – Northwater Consulting	• All existing GIS data obtained from state and county sources. • Previous implementation project locations provided by the Steuben SWCD. • Transect survey data obtained from the Steuben Co. SWCD and modified by Northwater Consulting. • A hybrid landuse/landcover layer was created by Northwater Consulting by interpreting the most recent aerial imagery and digitizing existing watershed features. • A windshield and individual landowner site survey was conducted by Northwater Consulting; data was collected using GPS: BMP type, gully dimensions (if applicable), condition of pasture, priority, severity and any relevant notes.
Pollution Loading	1. Spatial Watershed Assessment and Management Model (SWAMM) – Northwater Consulting 2. 2012 TMDL - Emmons & Olivier Resources Inc.	• SWAMM based on custom landuse layer, soils and precipitation. Results calibrated based on a watershed inventory and existing water quality data. • TMDL plan used for estimating septic system loading.

4.2 Water Quality & Stream Flow

Section 4.2 describes all relevant water quality and stream flow for the Pigeon Creek watershed. This section includes state-impaired streams and lakes, results of monitored water quality and flow data, and lake trophic status.

4.2.1 Impaired Lakes & Streams

Understanding the extent streams and lakes are impaired requires an understanding of state procedures. Waterbodies, such as streams and lakes, are monitored by the state to determine if they exceed state water quality standards and support what are called "designated uses." The federal Clean Water Act provides the underpinning for Indiana's Water Quality Standards (WQS), which are designed to ensure all waters of the state, unless specifically exempted, are safe for full body contact recreation and are protective of aquatic life, wildlife, and human health. These beneficial uses are described in the state's WQS as "designated" uses. IDEM monitors and assesses Indiana's surface waters to determine the extent to which they meet WQS. These surface waters must support designated uses and IDEM must identify, where possible, the sources of impairment for those waters that do not support one or more of these uses. The federal Environmental Protection Agency (EPA) describes designated uses as:

> *"The water quality standards regulation requires that States and authorized Indian Tribes specify appropriate water uses to be achieved and protected. Appropriate uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes. In designating uses for a water body, States and Tribes examine the suitability of a water body for the uses based on the physical, chemical, and biological characteristics of the water body, its geographical setting and scenic qualities, and economic considerations. Each water body does not necessarily require a unique set of uses. Instead, the characteristics necessary to support a use can be identified so that water bodies having those characteristics can be grouped together as supporting particular uses.*
>
> *Where water quality standards specify designated uses less than those which are presently being attained, the State or Tribe is required to revise its standards to reflect the uses actually being attained. A use attainability analysis must be conducted for any water body with designated uses that do not include the "fishable/swimmable" goal uses identified in section 101(a)(2) of the Act. Such water bodies must be reexamined every three years to determine if new information has become available that would warrant a revision of the standard. If new information indicates that "fishable/swimmable" uses can be attained, such uses must be designated."*

Indiana regulations list four designated uses and they include:

- Aquatic Life Use
- Fish Consumption Use
- Recreational Use
- Drinking Water Use

The designated uses outlined in Indiana's WQS with the narrative and numeric criteria to protect them provide the foundation for IDEM's 305(b) assessment process and 303(d) listing decisions. Water quality assessments are made by compiling existing and readily available data from site-specific chemical (water, sediment, and fish tissue), physical (habitat, flow data), and biological (fish community, macroinvertebrates, and *E. coli*) monitoring of Indiana's rivers, streams, and lakes by evaluating those data against Indiana's WQS. Waters identified as not meeting one or more of their designated uses are then placed on the Indiana's 303(d) List of Impaired Waters.

Interpretation of the data through the stream and lake assessment process and the subsequent 303(d) listing decisions are based in large part on U.S. EPA guidance. U.S. EPA's guidance calls for a comprehensive listing of all monitored or assessed waterbodies in the state. Prior to 2006, U.S. EPA required that states place each waterbody into only one category. U.S. EPA now encourages states to place waterbodies in additional categories, as appropriate, in order to more clearly illustrate where progress has been made in TMDL development and other restoration efforts. IDEM places each waterbody into one of five categories of the Consolidated List depending on the degree to which it supports the designated beneficial use in question. Since IDEM makes use of support assessments for three to four of the beneficial uses designated for each waterbody, a single waterbody may appear in one or more categories of the Consolidated List for different uses. Table 24 includes a listing of waterbody impairments by category:

Table 24 - Waterbody Impairment Categories

Category	Impairment Listing Description
1	Attaining the water quality standard for all designated uses and no use is threatened. Waters should be listed in this category if there are data and information that meet the requirements of the state's assessment and listing methodology and support a determination that all WQS are attained and no designated use is threatened.
2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information are available to determine if the remaining uses are attained or threatened. Waters should be listed in this category if there are data and information that meet the requirements of the state's assessment and listing methodology to support a determination that some, but not all, designated uses are attained and none are threatened.
3	Insufficient data and information to determine if any designated use is attained. Little or no information is available with which to make an assessment. Waters should be listed in this category where the data or information to support an attainment determination for any designated use are not available or are not consistent with the requirements of the state's assessment and listing methodology. States should schedule monitoring on a priority basis to obtain data and information necessary to classify these waters as Category 1, Category 2, Category 4, or Category 5.
4	Impaired or threatened for one or more designated uses but does not require the development of a TMDL.
4A	A TMDL has been completed that results in attainment of all applicable WQS, and has been approved by the U.S. EPA. Monitoring should be scheduled for these waters to verify that the WQS are met when the water quality management actions needed to achieve all TMDLs are implemented.
4B	Other pollution control requirements are reasonably expected to result in the attainment of the WQS in a reasonable period of time. Consistent with the regulation under 130.7(b)(i),(ii), and (iii), waters should be listed in this subcategory where other pollution control requirements required by

Category	Impairment Listing Description
	local, state, or federal authority are stringent enough to achieve any water quality standard (WQS) applicable to such waters. Monitoring should be scheduled for these waters to verify that the WQS are attained, as expected.
4C	Impairment is not caused by a pollutant. Waters should be listed in this subcategory if the impairment is not caused by a pollutant but is attributed to other types of pollution for which a total maximum daily load cannot be calculated.
5	The water quality standard is not attained. Waters may be listed in both 5A and 5B depending on the parameters causing the impairment.
5A	The waters are impaired or threatened for one or more designated uses by a pollutant(s) and require a TMDL. This category constitutes the Section 303(d) list of waters impaired or threatened by a pollutant(s) for which one or more TMDL(s) are needed. Waters should be listed in this category if it is determined, in accordance with the state's assessment and listing methodology, that a pollutant has caused, is suspected of causing, or is projected to cause impairment. Where more than one pollutant is associated with the impairment of a single waterbody, the waterbody will remain in Category 5 until TMDLs for all pollutants have been completed and approved by the U.S. EPA.
5B	The waterbodies are impaired due to the presence of mercury or PCBs, or both, in the edible tissue of fish collected from them at levels exceeding Indiana's human health criteria for these contaminants. This category also composes a portion of the Section 303(d) list of impaired waters, but the state believes that a conventional TMDL is not the appropriate approach. The state will continue to work with the general public and the U.S. EPA on actual steps needed ultimately to address these impairments.

Only category 4 and 5 waterbodies make it on the 303(d) impaired waters list. In Indiana, a category 5 waterbody is reclassified as category 4 upon completion of a TMDL plan. These waterbodies will remain impaired under category 4 and 5 until such time that monitoring data warrants a delisting. Attention should be paid to those waterbodies on the 303(d) list, as well as any impaired waterbodies identified as part of a TMDL plan; these waterbodies will receive state and federal funding priority.

According to the State of Indiana's 2012 303(d) impaired streams list, the Pigeon River watershed contains 38 streams (179 miles) of category 4 and 5 impaired waterbodies. These waterbodies are impaired or threatened for the designated uses of aquatic life, fish consumption and recreation. Impairments are due to low Dissolved Oxygen (DO) concentrations (aquatic life), chloride (aquatic life), and high concentrations of *E.coli* (recreation). Additional impairments listed include Impaired Biotic Community (IBC). Table 25 summarizes the 2012 stream impairments.

In 2010, the impaired list included waterbodies impaired for *E. coli*, chloride, IBC and a waterbody impaired for total nitrogen and total phosphorus. Nitrogen and phosphorus are no longer impairments and DO is on the list in 2012 and was not in 2010. The 2012 impaired waters list includes all 2010 listed waterbodies plus nine additional impaired streams and eleven 2010 listed segments that include newly added impairments. Mud Creek (INJ01A5_T1001) is the only waterbody, which was delisted for IBC, nitrogen and phosphorus, but continues to be listed for *E. coli*.

Lakes in the Pigeon Creek watershed are also considered impaired. According to the 2012 impaired list, nine lakes (783 acres) are listed as impaired. These lakes are listed for IBC, mercury, PCBs, and phosphorus. No changes in lake impairments have occurred since publication of the 2010 impaired list. Table 25 lists all 2012 impaired stream segments and Table 26 lists all 2012 impaired lakes. Red highlighted waterbodies and impairments are additions from 2010; an "X" denotes waterbodies within the 2012 TMDL and all impairments are listed by year. Figure 24 shows impaired lakes and streams in Pigeon Creek.

Table 25 - 2012 Pigeon River Watershed 303(d) listed Impaired Streams

2012 AUID	2012 AUNAME	SIZE (MILES)	TMDL	*E. coli*	IBC[1]	Chloride	DO[2]	Nitrogen
INJ01A1_01	Pigeon Creek	13.95	X	2010				
INJ01A1_T1001	Ryan Ditch	7.60	X	2010				
INJ01A1_T1002	Metz Ditch	8.51	X	2010				
INJ01A1_T1003	Cole Ditch	3.07		2012				
INJ01A1_T1004	Berlien Ditch	5.44	X	2010				
INJ01A2_01	Pigeon Creek	6.92	X	2010				
INJ01A2_T1001	Jack Ditch	3.16	X	2010				
INJ01A2_T1002	Johnson Ditch	2.85		2012				
INJ01A2_T1003	Pigeon Creek - Unnamed Tributary	2.68	X	2010				
INJ01A2_T1004*	Mud Creek	5.06	X	2010	2010	2012		2010
INJ01A3_01**	Pigeon Creek	7.15	X	2010	2012			
INJ01A3_T1001	Pigeon Creek - Unnamed Tributary	3.18	X	2010				
INJ01A3_T1002	Pigeon Creek - Unnamed Tributary	2.39		2012	2012			
INJ01A3_T1003	Pigeon Creek - Unnamed Tributary	7.86	X	2010	2012			
INJ01A3_T1004	Johnson Ditch	5.56	X	2010	2012			
INJ01A3_T1005	Johnson Ditch - Unnamed Tributary	3.87	X	2010	2012			
INJ01A4_01	Smathers Ditch	4.15		2012	2012		2012	
INJ01A4_02	Turkey Creek	2.47	X	2010	2012		2012	
INJ01A4_T1001	Conrad Ditch	1.04		2012	2012		2012	
INJ01A4_T1002	Inlet To Little Turkey Lake	1.38		2012	2012		2012	
INJ01A4_T1003	Turkey Creek - Unnamed Tributary	3.05	X	2010	2012		2012	
INJ01A4_T1005	Deetz Ditch	3.23	X	2010	2012		2012	
INJ01A5_01	Turkey Creek	6.71	X	2010				
INJ01A5_T1001	Mud Creek	6.53	X	2010				
INJ01A5_T1002	Mud Creek - Unnamed Tributary	2.89	X	2010				
INJ01A6_T1002	Inlet To Golden Lake	4.78	X	2010				
INJ01A7_01	Pigeon Creek	3.08	X	2010				
INJ01A7_T1001	Inlet To Otter Lake	8.21	X	2010	2012			

2012 AUID	2012 AUNAME	SIZE (MILES)	TMDL	*E. coli*	IBC[1]	Chloride	DO[2]	Nitrogen
INJ01A8_T1001	Maumee Ditch	2.29	X	2010				
INJ01A8_T1002	Inlet To Mud Lake	2.16	X	2010	2012			
INJ01A8_T1002A	Inlet To Taylor Lake	0.55	X	2010				
INJ01A8_T1008	Inlet To Little Turkey Lake	1.65	X	2010				
INJ01A9_01*	Pigeon Creek	14.71	X	2010	2012			
INJ01A9_T1001**	Pigeon Creek - Unnamed Tributary	6.95		2012				
INJ01A9_T1001A	Pigeon Creek - Unnamed Tributary	0.55		2012				
INJ01AA_01**	Pigeon Creek	1.78		2012				
INJ01AA_02	Turkey Creek	3.71	X	2010				
INJ01AA_03	Turkey Creek	7.40	X	2010				

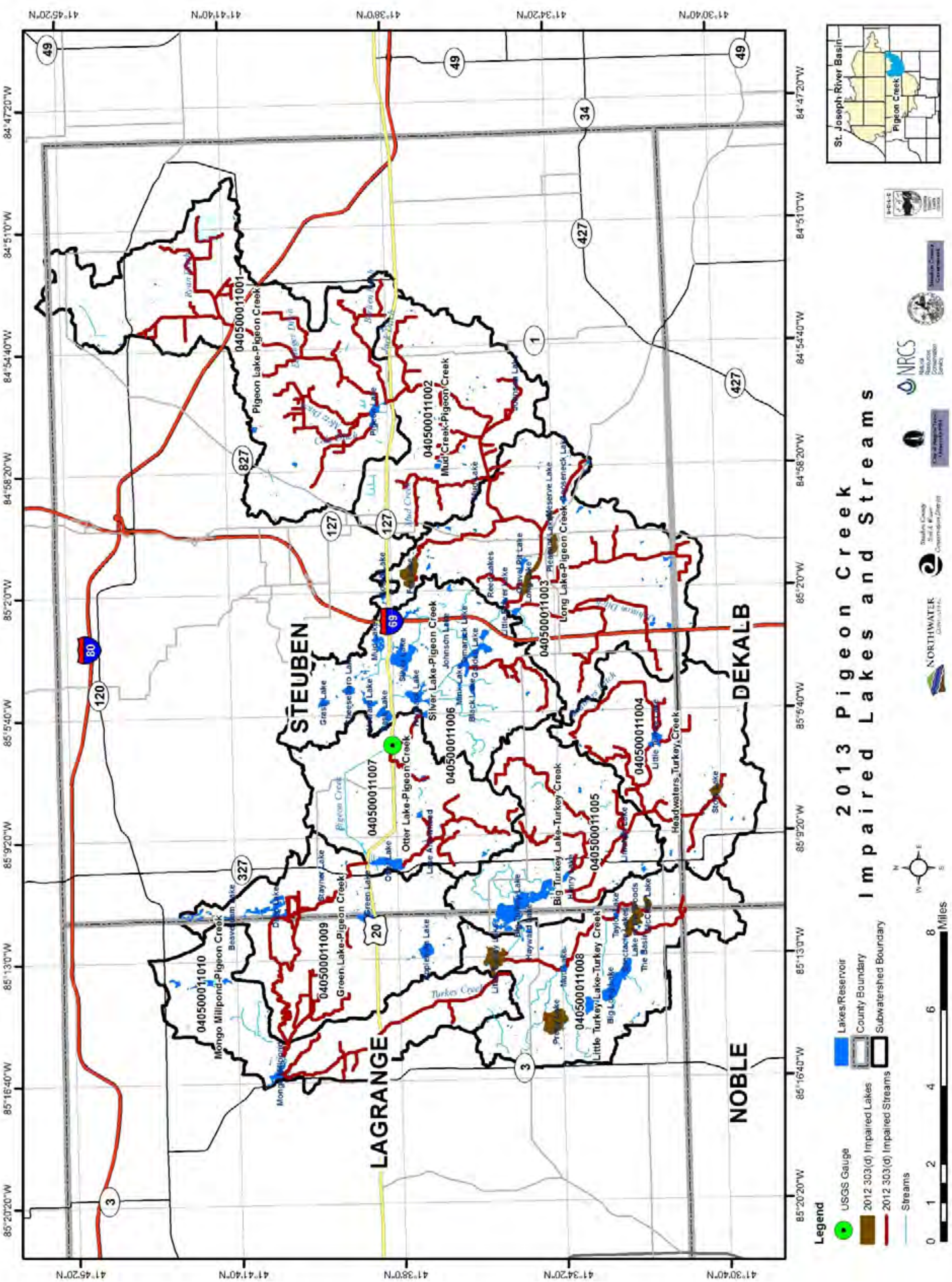
1IBC – Impaired Biotic Community
2DO – Dissolved Oxygen
*This reach was listed for IBC in 2010 under its original AUID but was not included in the TMDL.
**This reach was listed for *E. coli* in 2010 under its original AUID but was not included in the TMDL.

Table 26 - 2012 Pigeon River Watershed Impaired Lakes

Waterbody	2010 AUID	Impairments			
		Hg[1]	IBC[2]	Total P	PCB
Fox Lake	INJ01P1075_00	X			X
Upper Story Lake	INJ01P1088_00				X
Pretty Lake	INJ01P1098_00	X			
Meserve Lake	INJ01P1083_00		X		
Long Lake	INJ01P1080_00			X	
McClish Lake	INJ01P1091_00	X			
Pleasant Lake	INJ01P1082_00				X
Little Turkey Lake	INJ01P1101_00			X	
Lake of the Woods	INJ01P1093_00	X	X		

1Hg – Mercury
2IBC – Impaired Biotic Community

Figure 24 - Pigeon Creek Impaired Lakes & Streams



4.2.2 Water Quality Data

An analysis of existing water quality data was conducted for the Pigeon Creek watershed. Water quality data and trends are used as one of many tools to identify problems, causes and potential sources of pollution throughout the watershed. Results were also used in pollution load model calibration.

4.2.2.1 Water Quality Monitoring

Originally initiated by the Steuben County Lakes Council, the Steuben County SWCD implemented a 16-station monitoring program. Between 2009 and 2013, the Steuben County Lakes Council managed the monitoring effort with contributions from the SWCD. Data was used to provide general insight into water quality and trends in the Pigeon Creek watershed. Five sites were located at or near the outlet of each HUC 12 to allow for subwatershed-based diagnostics. Stations were also selected to include the confluence point and exit point of Pigeon Creek within each lake of the Pigeon Creek chain. Stations selected had a prior history of water quality issues, and were located immediately downstream of the confluence of major tributaries to the Pigeon. Fourteen of the stations were funded through the IDEM 319 Phase II project and the City of Angola/Trine University MS4 Program funded two stations.

In addition to the 16 Phase II monitoring sites, 14 additional monitoring sites were established through funding by the Steuben County Lakes Council and the Steuben County Surveyor's Office. Water quality data collected as part of the 2012 TMDL and by IDEM at the numerous sample sites throughout the watershed were also evaluated and are included in the overall water quality analysis.

Figures 25 and 26 show monitoring stations throughout the watershed. The 91 IDEM locations shown on the map include current and historical sites sampled for biological and water quality parameters, of which only a small selection provided biological data. Very little of the water quality data included flow measurements and, therefore, it was difficult to utilize the information in generating loading estimates, however, all available data was used and is included in Section 4.2.2.2.

4.2.2.2 Water Quality Data Analysis

Stream and river water quality sampling and monitoring has been ongoing throughout the watershed under several programs as outlined in section 4.2.2.1. Analysis was performed on a large water quality dataset provided by Steuben County SWCD and Emmons & Oliver Resources, Inc. The dataset is inclusive of monitoring programs funded by the City of Angola/Trine University, IDEM 319, the Steuben County Lakes Council (SCLC), and the 2012 TMDL process. It is important to note that sampling data illustrated is only intended to be a simple summary of a very large set of data.

Overall, 2,020 water quality samples were collected from 62 stations between the dates of 10/31/2001 and 10/29/2013. The data analysis is summarized by subwatershed in Table 28 through Table 33 and Figure 27 through Figure 30. The data was compared against water quality targets, which are outlined in Table 27.

Table 27 - Water Quality Targets

Parameter	Target	Source	Primary Impacts
E. coli Bacteria	Max: 235 CFU/ 100ml in a single sample	Indiana Administrative Code (327 IAC 2-1.5-8)	Human and ecological health risks from fecal bacteria from warm-blooded mammals
Total Phosphorus	Max: 0.3 mg/L	IDEM draft TMDL target	Algal blooms, aquatic health, recreational value of lakes and streams
Total Nitrogen	Max: 10.0 mg/L	IDEM draft TMDL target based on drinking water targets	Human health risk, potentially fatal risk to infants, if consumed. Aquatic health of lakes and streams
Total Suspended Solids	Max: 30 mg/L	IDEM draft TMDL target from NPDES rule 327 IAC 5-10-4	Aquatic and ecological health and recreational value of lakes and streams
Total Suspended Solids cont.	Range: 25.0-80.0 mg/L	Concentrations within this range reduce fish concentrations (Waters, T.F., 1995).	Aquatic and ecological health and recreational value of lakes and streams
Dissolved Oxygen	Min: 6.0 mg/L in coldwater fishery streams	Indiana Administrative Code (327 IAC 2-1.5-8)	Aquatic and ecological health and recreational value of lakes and streams
Dissolved Oxygen	Min: 4.0 mg/L Max: 12.0 mg/L in non coldwater fishery streams	Indiana Administrative Code (327 IAC 2-1.6)	Aquatic and ecological health and recreational value of lakes and streams
pH	6.0 – 9.0	Indiana Administrative Code (327 IAC 2-1.6(a))	Aquatic and ecological health and recreational value of lakes and streams
Specific Conductance	1,200 µs/cm at 25°C	Indiana Administrative Code (327 IAC 2-1.6)	Aquatic and ecological health and recreational value of lakes and streams

Figure 25 – Upper Pigeon Creek Monitoring Sites

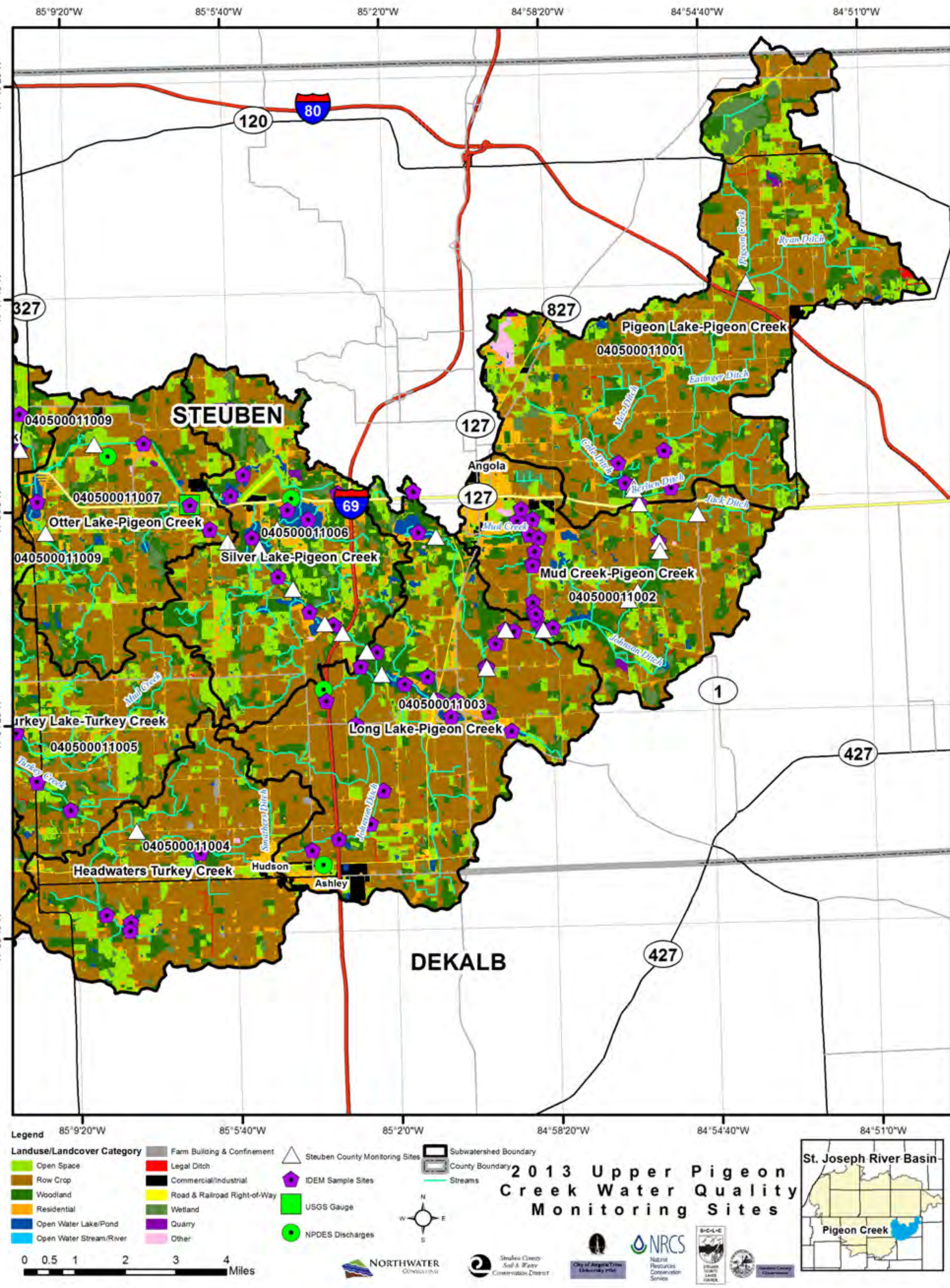


Figure 26 - Lower Pigeon Creek Monitoring Sites

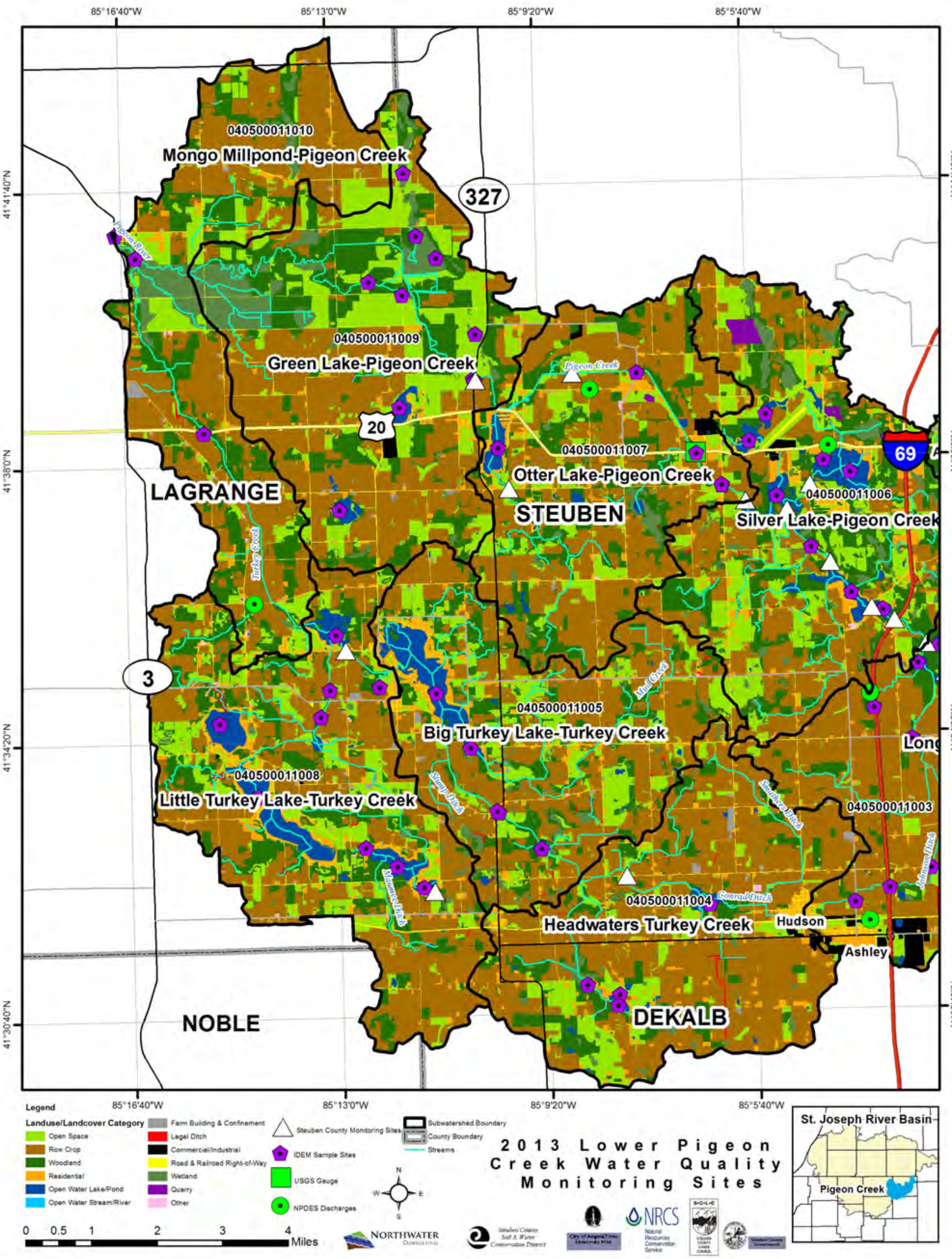


Table 28 - *E. coli* Bacteria Water Quality Data Summary

HUC 12 ID	HUC 12 Name	# Sampling Events	*E. coli* Bacteria - CFU/100 ml				Exceedences of 235 CFU/100 ml	
			Median	GeoMean	Max	Min	QTY	%
40500011001	Pigeon Lake-Pigeon Creek	77	29	263	27,500	1	42	55
40500011002	Mud Creek-Pigeon Creek	111	388	427	22,000	13	67	60
40500011003	Long Lake-Pigeon Creek	120	277	219	10,900	5	59	49
40500011004	Headwaters Turkey Creek	19	274	305	1,720	45	12	63
40500011005	Big Turkey Lake-Turkey Creek	65	178	167	2,733	18	27	42
40500011006	Silver Lake-Pigeon Creek	139	46	46	28,400	0	21	15
40500011007	Otter Lake-Pigeon Creek	29	158	160	8,700	1	12	41
40500011008	Little Turkey Lake-Turkey Creek	19	530	457	13,600	10	15	79
40500011009	Green Lake-Pigeon Creek	36	150	163	740	77	11	31
40500011010	Mongo Millpond-Pigeon Creek	12	155	124	290	27	3	25

Table 29 - Phosphorus Water Quality Data Summary

HUC 12 ID	HUC 12 Name	# Sampling Events	Phosphorus (mg/l)				Exceedences of 0.30 mg/l	
			Median	GeoMean	Max	Min	QTY	%
40500011001	Pigeon Lake-Pigeon Creek	71	0.03	0.04	0.60	0.01	25	35
40500011002	Mud Creek-Pigeon Creek	99	0.07	0.08	1.00	0.01	6	6
40500011003	Long Lake-Pigeon Creek	111	0.07	0.06	0.70	0.01	7	6
40500011004	Headwaters Turkey Creek	17	0.06	0.04	0.13	0.01	--	--
40500011005	Big Turkey Lake-Turkey Creek	60	0.03	0.03	0.18	0.01	--	--
40500011006	Silver Lake-Pigeon Creek	134	0.04	0.04	0.32	0.01	2	1
40500011007	Otter Lake-Pigeon Creek	26	0.07	0.07	0.80	0.01	4	15
40500011008	Little Turkey Lake-Turkey Creek	17	0.03	0.03	0.39	0.01	1	6
40500011009	Green Lake-Pigeon Creek	33	0.03	0.03	0.14	0.01	--	--
40500011010	Mongo Millpond-Pigeon Creek	9	0.01	0.01	0.08	0.01	--	--

Samples collected between 10/31/2007 - 10/29/2013

Table 30 - Nitrogen Water Quality Data Summary

HUC 12 ID	HUC 12 Name	# Sampling Events	Total Nitrogen (mg/l)				Exceedences of 10 mg/l	
			Median	GeoMean	Max	Min	QTY	%
40500011001	Pigeon Lake-Pigeon Creek	31	4.7	4.9	25.4	0.9	9	29
40500011002	Mud Creek-Pigeon Creek	49	5.4	4.9	18.9	0.8	11	22
40500011003	Long Lake-Pigeon Creek	44	5.4	5.0	19.2	0.9	4	9
40500011004	Headwaters Turkey Creek	6	3.6	4.6	25.1	1.4	2	33
40500011005	Big Turkey Lake-Turkey Creek	23	4.1	4.5	25.1	1.2	4	17
40500011006	Silver Lake-Pigeon Creek	45	4.8	4.6	10.6	1.3	6	13
40500011007	Otter Lake-Pigeon Creek	9	2.2	2.2	3.6	1.3	--	--
40500011008	Little Turkey Lake-Turkey Creek	6	1.7	2.4	7.4	1.2	--	--
40500011009	Green Lake-Pigeon Creek	17	2.6	2.8	8.1	1.3	--	--
40500011010	Mongo Millpond-Pigeon Creek	9	1.9	2.7	13.6	1.0	3	33

Samples collected between 6/16/2010 - 10/29/2013

Table 31 - Total Suspended Sediment Water Quality Data Summary

HUC 12 ID	HUC 12 Name	# Sampling Events	Total Suspended Sediment (mg/l)				Exceedences of 30 mg/l	
			Median	GeoMean	Max	Min	QTY	%
40500011001	Pigeon Lake-Pigeon Creek	72	9.0	10	212	0.5	11	15
40500011002	Mud Creek-Pigeon Creek	98	11	11.5	188	0.5	13	13
40500011003	Long Lake-Pigeon Creek	111	13	11.4	187	0.5	17	15
40500011004	Headwaters Turkey Creek	17	5.0	3.3	20	0.5	--	--
40500011005	Big Turkey Lake-Turkey Creek	58	3.9	3.1	20	0.5	--	--
40500011006	Silver Lake-Pigeon Creek	134	6.5	6.1	108	1.0	5	4
40500011007	Otter Lake-Pigeon Creek	26	4.0	2.7	15	0.5	--	--
40500011008	Little Turkey Lake-Turkey Creek	17	4.0	3.8	45	0.5	1	6
40500011009	Green Lake-Pigeon Creek	32	4.5	3.2	26	0.5	--	--
40500011010	Mongo Millpond-Pigeon Creek	9	0.5	1.1	7.0	0.5	--	--

Samples collected between 10/31/2007 - 10/29/2013

Table 32 - Dissolved Oxygen & pH Water Quality Summary

HUC 12 ID	HUC 12 Name	Dissolved Oxygen (DO)				pH			
		Median	Geomean	Max	Min	Median	Geomean	Max	Min
40500011001	Pigeon Lake-Pigeon Creek	7.93	7.77	15.	5.1	7.82	7.43	8.35	7.09
40500011002	Mud Creek-Pigeon Creek	6.59	6.20	8.97	4.1	7.74	7.42	8.13	7.02
40500011003	Long Lake-Pigeon Creek	7.16	7.12	12.3	4.0	7.87	7.68	8.93	7.35
40500011004	Headwaters Turkey Creek	6.26	5.10	9.2	2.94	7.49	6.11	7.85	6.83
40500011005	Big Turkey Lake-Turkey Creek	7.26	6.91	12.1	4.29	7.85	7.46	8.39	7.10
40500011006	Silver Lake-Pigeon Creek	7.69	7.64	16.2	4.12	8.04	7.88	10.3	7.31
40500011007	Otter Lake-Pigeon Creek	6.45	6.03	11.3	5.34	7.77	6.76	8.14	7.32
40500011008	Little Turkey Lake-Turkey Creek	6.77	6.01	7.5	5.82	7.48	6.12	7.85	7.06
40500011009	Green Lake-Pigeon Creek	7.67	6.92	9.96	6.12	7.78	7.03	8.18	7.45
40500011010	Mongo Millpond-Pigeon Creek	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 33 - Temperature & Specific Conductance Water Quality Summary

HUC 12 ID	HUC 12 Name	Temp - C				Specific Conductance (µs/cm)			
		Median	Geomean	Max	Min	Median	Geomean	Max	Min
40500011001	Pigeon Lake-Pigeon Creek	19.5	19.8	28.1	12.2	658	640	794	384
40500011002	Mud Creek-Pigeon Creek	21.5	20.9	24.8	11.6	675	645	830	358
40500011003	Long Lake-Pigeon Creek	21.6	20.2	30.6	11.4	731	626	976	449
40500011004	Headwaters Turkey Creek	20.8	15.9	28.2	18.5	590	297	659	359
40500011005	Big Turkey Lake-Turkey Creek	22.4	20.82	29.8	15.1	572	481	670	461
40500011006	Silver Lake-Pigeon Creek	23.6	21.6	30.3	8.5	646	549	781	44
40500011007	Otter Lake-Pigeon Creek	21	17.3	27.1	15.1	521	505	596	427
40500011008	Little Turkey Lake-Turkey Creek	17.9	14.2	23.8	16.6	724	362	745	526
40500011009	Green Lake-Pigeon Creek	21.2	16.9	25.6	11.2	644	417	677	521
40500011010	Mongo Millpond-Pigeon Creek	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Figure 27 - Pigeon Creek Water Quality Exceedences Bacteria

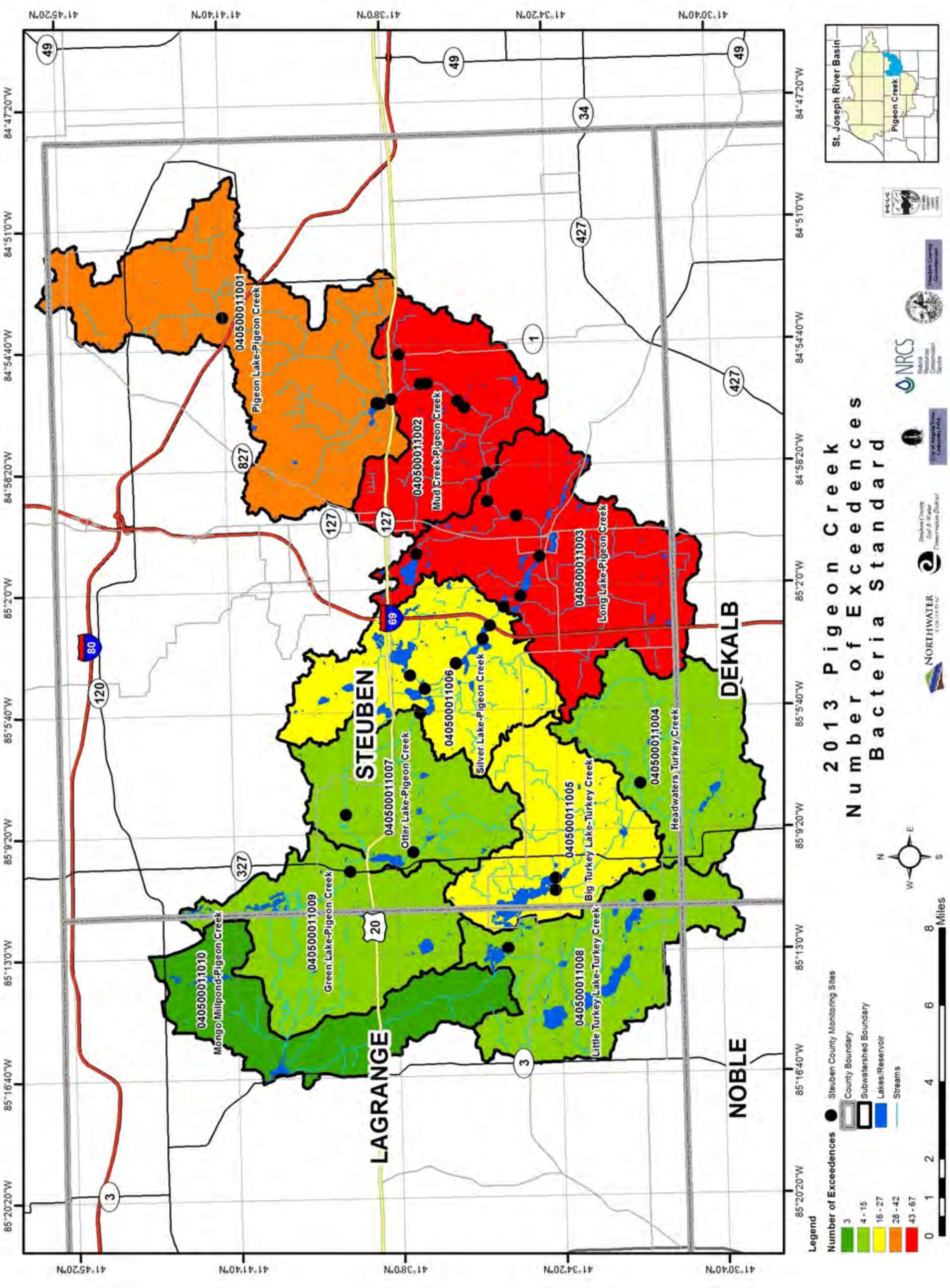


Figure 28 - Pigeon Creek Water Quality Exceedences Phosphorus

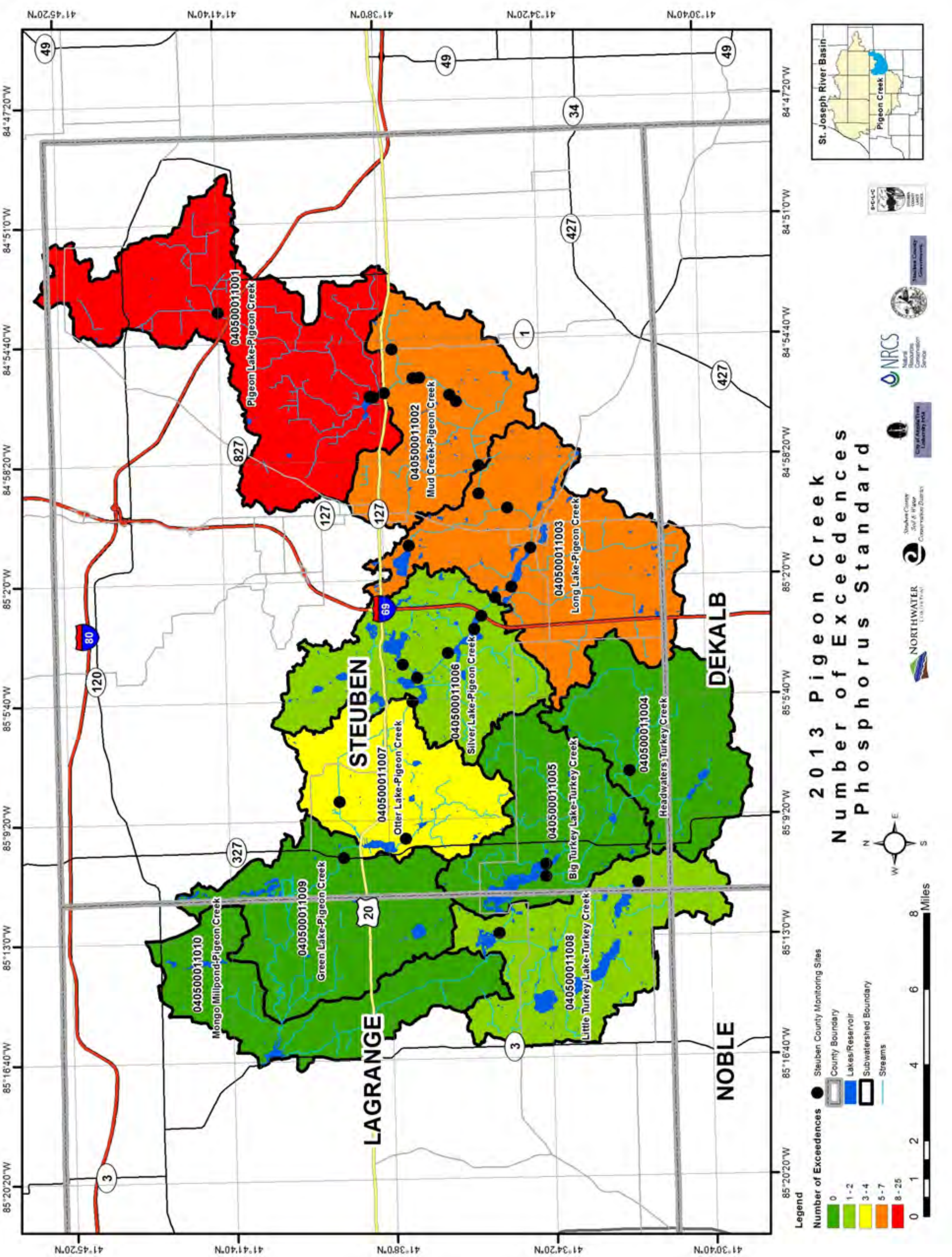


Figure 29 - Pigeon Creek Water Quality Exceedences Nitrogen

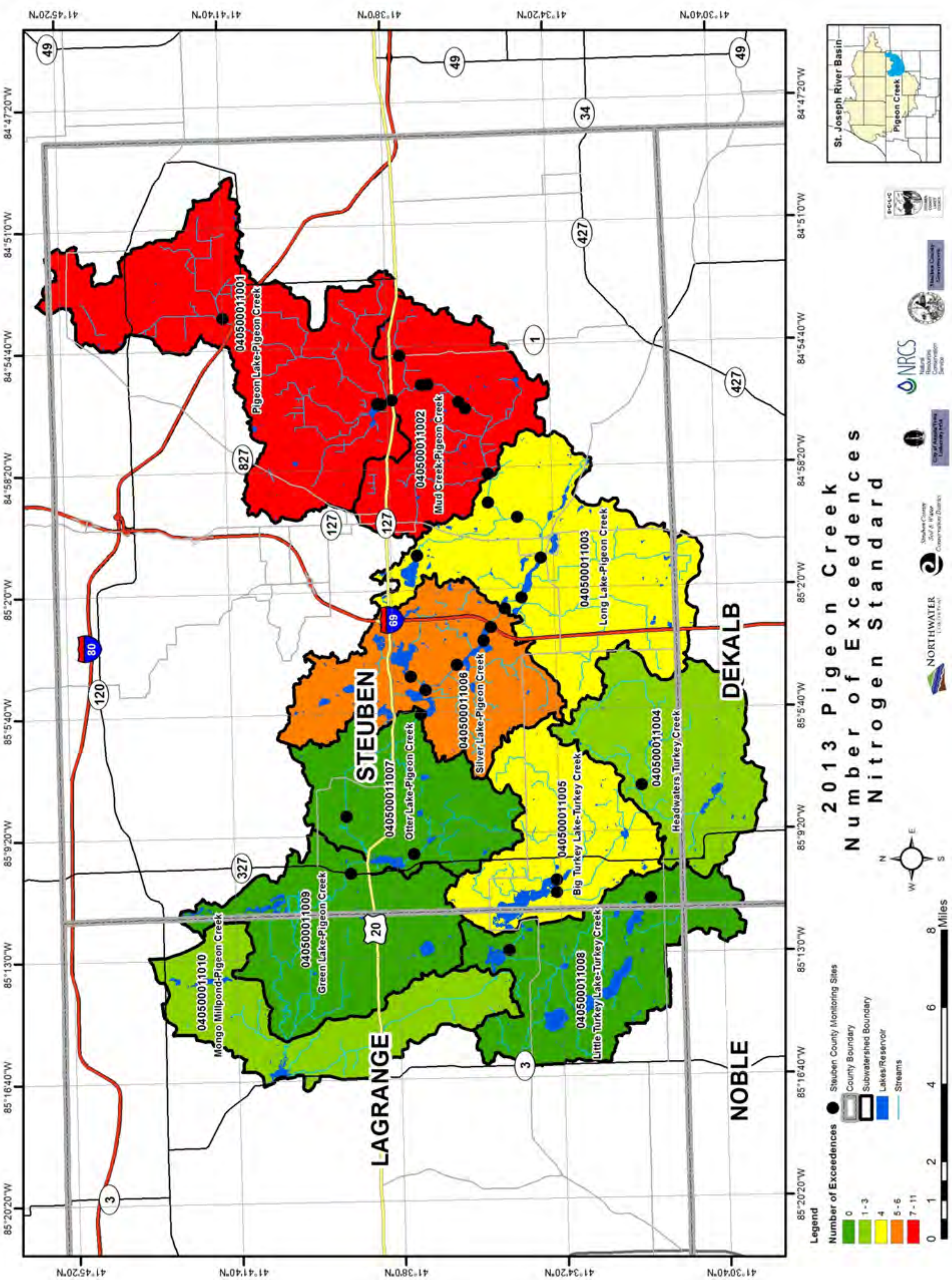
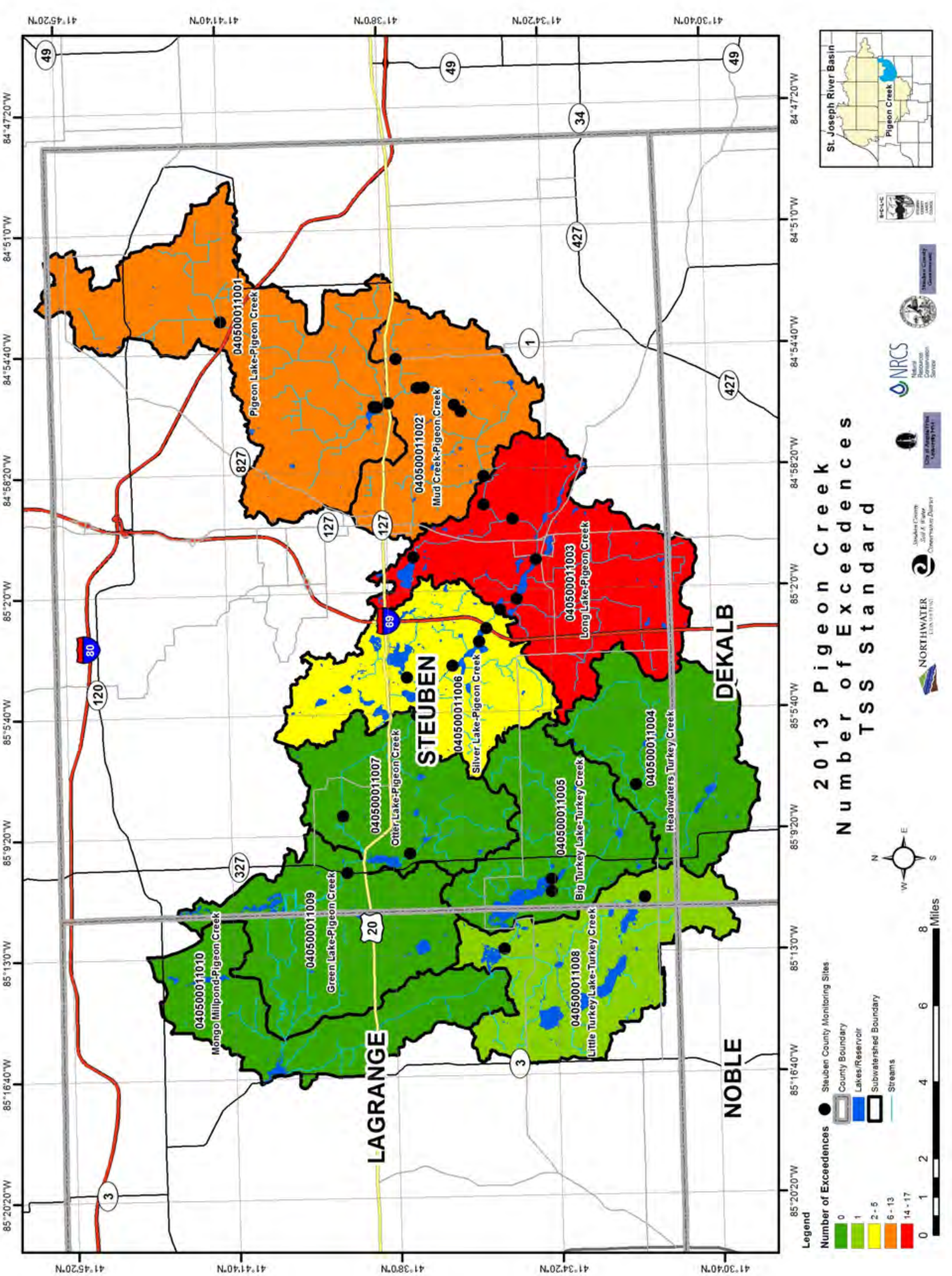


Figure 30 - Pigeon Creek Water Quality Exceedences Sediment



4.2.2.3 Water Quality Data Discussion

Table 34 summarizes the water quality parameters that are of concern in the each of the ten subwatersheds based on the analysis of water quality data. The only constituent that appears to be a watershed-wide issue is *E. coli* bacteria. Total phosphorus, total nitrogen and total suspended solids are issues that are primarily focused in a select 6 to 7 subwatersheds. The water quality data did not illustrate any issues in the watershed with total dissolved solids (specific conductance) and ph. Only one subwatershed is a potential concern regarding dissolved oxygen (Headwaters- Turkey Creek), however, this is based only on a few sampling events and additional monitoring is required to properly assess the condition.

Approximately 70% of the sampling events occurred during base flow conditions, so the data as analyzed holds a bias towards baseflow conditions and, in our opinion, did not represent a wide enough range of flows. Sediment, nitrogen and phosphorus concentrations are largely affected by flow rates in streams and river systems, and concentrations are generally higher following storm events. *E. coli* bacteria concentrations, on the other hand, are more diluted during higher flow events and have lower concentrations. These factors should be considered in applying this analysis and it is important to derive water quality conclusions not only from this data, but also the pollutant load modeling (Section 7.2) and other components of the watershed inventory.

Table 34 - Subwatersheds with Water Quality Problems Based on Monitoring Data

HUC 12 ID	HUC 12 Name	Water Quality Problems Based on Monitoring Data
40500011001	Pigeon Lake-Pigeon Creek	*E.Coli* bacteria, phosphorus, nitrogen, sediment
40500011002	Mud Creek-Pigeon Creek	*E.Coli* bacteria, phosphorus, nitrogen, sediment
40500011003	Long Lake-Pigeon Creek	*E.Coli* bacteria, phosphorus, nitrogen, sediment
40500011004	Headwaters Turkey Creek	*E.Coli* bacteria, nitrogen, dissolved oxygen
40500011005	Big Turkey Lake-Turkey Creek	*E.Coli* bacteria, nitrogen
40500011006	Silver Lake-Pigeon Creek	*E.Coli* bacteria, phosphorus, nitrogen, sediment
40500011007	Otter Lake-Pigeon Creek	*E.Coli* bacteria, phosphorus
40500011008	Little Turkey Lake-Turkey Creek	*E.Coli* bacteria, phosphorus, sediment
40500011009	Green Lake-Pigeon Creek	*E.Coli* bacteria
40500011010	Mongo Millpond-Pigeon Creek	*E.Coli* bacteria, nitrogen

***E. coli* Bacteria** - Samples collected ranged from non-detect to a maximum of 28,400 CFU/100 mL. The geometric mean for the entire watershed was 202 CFU/100 mL. The three subwatersheds with the highest geometric mean were Mud Creek-Pigeon Creek (427), Little Turkey Lake-Turkey Creek (457), and Headwaters Turkey Creek (305). There were 269 of 627 (43%) total samples that exceeded the reference limit of 235 CFU/100 mL. The three subwatersheds with the greatest proportion of samples above the reference limit were Mud Creek-Pigeon Creek (60%), Long Lake-Pigeon Creek (49%), and Pigeon Lake-Pigeon Creek (55%).

It is important to note that only 3% of the sampling events were outside the recreational season of April 1 – October 31, and these sampling events did not adversely skew the statistical results for *E. coli*. This is significant because the wastewater treatment plants do not have *E. coli* permit limits or reporting requirements outside of this period. The data analyzed is reflective of the periods when the treatment plants are operating as permitted.

Phosphorus - Samples collected ranged from 0.01 mg/L to a maximum of 1.00 mg/L. The geometric mean for the entire watershed was 0.04 mg/L. The three subwatersheds with the highest geometric mean were Mud Creek-Pigeon Creek (0.08), Otter Lake-Pigeon Creek (0.07), and Long Lake-Pigeon Creek (0.06). There were 40 of 577 (7%) total samples that exceeded the reference limit of 0.30 mg/L. The three subwatersheds with the greatest proportion of samples above the reference limit were Pigeon Lake-Pigeon Creek (39%), Long Lake-Pigeon Creek (6%), and Mud Creek-Pigeon Creek (6%).

Nitrogen - Samples collected ranged from 0.77 mg/L to a maximum of 25.44 mg/L. The geometric mean for the entire watershed was 3.8 mg/L. The three subwatersheds with the highest geometric mean were Silver Lake-Pigeon Creek (5.68), Pigeon Lake-Pigeon Creek (4.9), and Mud Creek-Pigeon Creek (4.9). There were 39 of 239 (16%) total samples that exceeded the reference limit of 10 mg/L. The two subwatersheds with the greatest proportion of samples above the reference limit were Mud Creek-Pigeon Creek (22%), and Pigeon Lake-Pigeon Creek (29%).

Nitrogen is a serious public health concern, and many of the results far exceed the 10 mg/L target. This target is a drinking water standard primarily because elevated concentrations of nitrates can lead to methemoglobinemia, or blue baby syndrome and cause death to infants. Depending upon the interactions between surface water and groundwater in the watershed, this could potentially affect private drinking water wells; this would be potentially most relevant in shallow alluvial aquifers.

Total Suspended Solids (TSS) - Samples ranged from 0.5 mg/L to a maximum of 212 mg/L. The geometric mean for the entire watershed is 7.5 mg/L. The three subwatersheds with the highest geometric means were Mud Creek-Pigeon Creek (11.5), Long Lake-Pigeon Creek (11.4), and Pigeon Lake-Pigeon Creek (10). There were 46 of 574 (8%) total samples that exceeded the reference limit of 30 mg/L limit. The three subwatersheds with the greatest proportion of samples above the reference limit were Long Lake-Pigeon Creek (15%), Mud Creek-Pigeon Creek (13%), and Pigeon Lake-Pigeon Creek (15%).

Dissolved Oxygen (DO) – The geometric mean and median values of dissolved oxygen only fell below the reference minimum of 6.0 mg/L for one subwatershed (Headwaters-Turkey Creek). However, each watershed resulted in sampling events that reported DO below the 6.0 mg/L reference limit. Headwaters-Turkey Creek exhibits the worst DO conditions in the watershed with a minimum reported value of 2.94 and a geometric mean of 5.10. Headwaters-Turkey Creek was the only subwatershed that resulted in any results below the alternate 4.0 mg/L minimum reference. Low dissolved oxygen can lead to kills of fish and aquatic organisms and habitat degradation.

pH - No subwatershed had a geometric mean or even minimum pH level falling below 6.0. No geometric mean was above the maximum limit of 10; Silver Lake-Pigeon Creek had a maximum recording of 10.25. According to the Indiana Administrative Code (327 IAC 2-1.6(a)), pH levels can exceed 9.0 if it is correlated with photosynthetic activity; however, this was not verified for the sample results that exceeded 10. Levels of pH this high have been known to stress the physiological symptoms of aquatic organisms and can lead to lower levels of reproduction which, in turn, could lower stream diversity.

Specific Conductance – There were no statistics that exceeded the reference limit for specific conductance, also indicative of total dissolved solids. The geomean for the three subwatersheds with the highest specific conductance were Otter Lake-Pigeon Creek (683.92 µs/cm), Mud Creek-Pigeon Creek (645.0 µs/cm, and Pigeon Lake-Pigeon Creek (640.3 µs/cm). The highest specific conductance sample collected was from the Long Lake-Pigeon Creek subwatershed (976 µs/cm).

4.2.3 Stream Flow Data

To measure stream flow on Pigeon Creek, the USGS installed a stream gauge downstream of Hogback Lake in 1946 that continuously records depth and flow measurements in the channel. The gauge has a tributary drainage area of approximately 106 square miles. The Pigeon Creek station is located about five miles west of the City of Angola and has average daily flow of 87 cubic feet per second (1946-2012). The low flow recorded at this station for the period of record is 3.4 cubic feet per second (cfs) on October 25th, 1964, and the high flow was 996 cfs recorded on May 21st, 1996.

The overbank flood stage of the gauge is 11 feet, or an estimated 525 cfs. Figure 32 illustrates the annual peak streamflow from 1946 through 2012. During the past 36 years, peak streamflow has exceeded the flood stage in 17 (48%) of those years. Between 1946 and 1975, it was exceeded in only three years (10%). Figure 32 clearly illustrates that annual peak streamflow events have increased since 1976, indicating that flooding is a problem in the watershed, especially when compared to historical conditions.

Figure 31 - Mean Monthly Flow at USGS Angola Station (2002 - 2012)

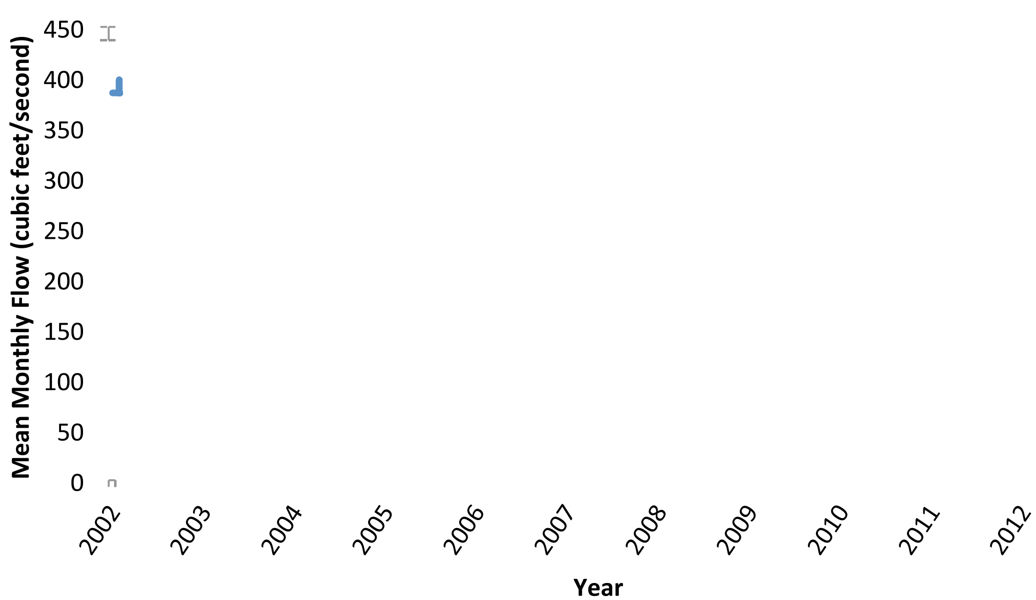
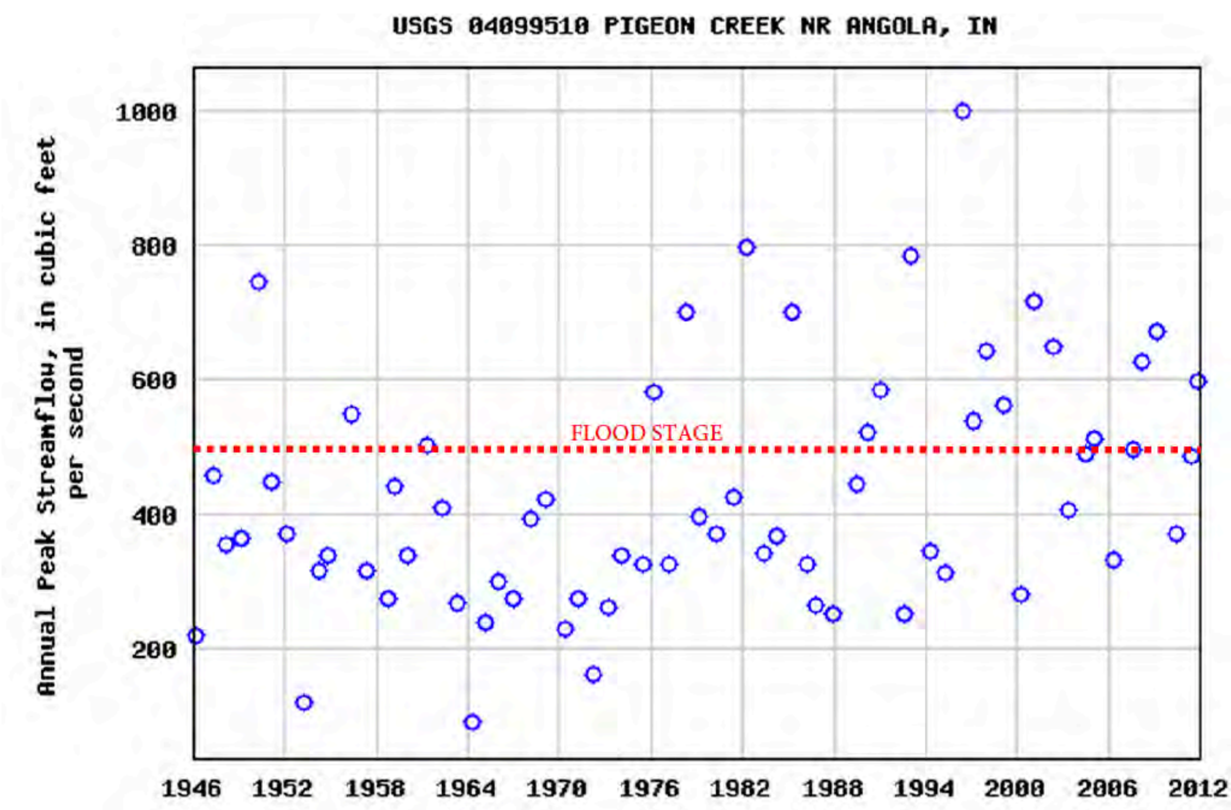


Figure 32 – Annual Peak Streamflow at USGS Angola Station (1946 – 2012)



4.2.4 Lake Trophic Status

Through IDEM, the Indiana Clean Lakes Program and Indiana University track lake trophic status of lakes in the state as an indicator of biologic activity, oxygen content and overall lake health. Indiana uses a "trophic state index" (TSI) to help identify the status of lakes. Indiana's TSI uses a set of parameters to which an index, or eutrophy number, is assigned. The TSI results in the sum of the individual eutrophy points and varies from 0 to 75. TSI ranges from oligotrophic (low nutrients – low plants and fish) to hypereutrophic (high in nutrients – support large amounts of plants and fish). Eutrophy points are evaluated for the following parameters: total phosphorus, soluble phosphorus, organic nitrogen, nitrate, ammonia, DO (both % saturation at 5 feet and % through water column >1.0 mg/L), light penetration, light transmission and total plankton.

High levels of phosphorus and nitrogen contribute to the eutrophic and hypereutrophic conditions within Big Bower Lake, Golden Lake, Hogback Lake, Little Bower Lake, Long Lake, Little Turkey Lake (Steuben and LaGrange Counties) and Pigeon Lake. It is important to note that Big Bower, Golden Lake, Hogback, and Long Lake have seen eutrophic or hypereutrophic conditions consistently since 2002 and should be focused on for reductions in nutrients. Table 35 presents a list of lake trophic status (for those lakes assessed) and trends for years 2002 through 2011; the highlighted waterbodies indicate a negative trend.

Table 35 - Lake Trophic Levels

Waterbody Name	2002 Trophic Status	2004 Trophic Status	2010-2011 Trophic Status
Appleman	N/A	N/A	Oligotrophic
Bass Lake	Oligotrophic	N/A	N/A
Beaver Dam Lake	Oligotrophic	Oligotrophic	N/A
Big Bower Lake	Eutrophic	Eutrophic	N/A
Booth Lake	Mesotrophic	Mesotrophic	N/A
Fox Lake	Mesotrophic	Mesotrophic	N/A
Golden Lake	Eutrophic	Hypereuthrophic	Eutrophic
Green Lake	Mesotrophic	Oligotrophic	Mesotrophic
Hogback Lake	Hypereuthrophic	Hypereuthrophic	Eutrophic
Little Bower Lake	Eutrophic	N/A	N/A
Little Turkey (Steuben)	N/A	N/A	Eutrophic
Little Turkey (LaGrange)	N/A	N/A	Eutrophic
Long Lake	Eutrophic	Hypereuthrophic	Eutrophic
Mud Lake	Mesotrophic	N/A	N/A
Pigeon Lake	Eutrophic	Mesotrophic	N/A
Pretty Lake	N/A	N/A	Mesotrophic
Silver Lake	Oligotrophic	Mesotrophic	N/A
Stayner Lake	Oligotrophic	Oligotrophic	N/A
West Otter Lake	Mesotrophic	Mesotrophic	N/A

4.3 Habitat & Biological Information

The Pigeon Creek watershed is rich in wildlife habitat and biological resources. There are large, contiguous blocks of protected wildlife habitat and many existing wetlands. Data exist on the quality of aquatic species, including fish and aquatic macroinvertebrates or insects. Section 4.3 evaluates the quality and extent of terrestrial wildlife habitat and aquatic species in the watershed.

4.3.1 Habitat

The amount of habitat within the watershed can be expressed by evaluating the acreage and quality of protected areas and/or natural habitat, wetlands and T&E species occurrences. As noted in Section 3.2.4, current wetlands cover 17,999 acres (13%) compared to 38,728 acres of wetlands (28%) prior to human settlement, a reduction of 20,729 acres (50%) of wetland habitat. An analysis of wetland data provided by Friends of the St. Joe River Association indicates that 13,262 acres of existing high-quality wetlands require protection and an additional 24,939 acres of degraded or converted wetlands require some form of restoration.

There are 7,316 acres (5.4%) of the total watershed area in state-owned and protected land. Green Lake, Mongo Millpond, and Pigeon Lake subwatersheds house the largest total acreage of protected land in the watershed. There are 313 occurrences and 156 known T&E species within the watershed, well over half being in the Mongo Millpond and Green Lake subwatersheds.

Efforts to protect, restore or create wildlife habitat will provide multiple benefits to the watershed and have a positive effect on water quality. Focus should be on expanding and improving existing habitat areas and then identifying strategic opportunities to add additional acreage and restore isolated remnants. Table 36 provides some guidance for targeting habitat restoration/protection activities within the watershed. Results are based on an analysis of existing protected habitat, wetland restoration and protection needs, and T&E species occurrences using the following assumptions:

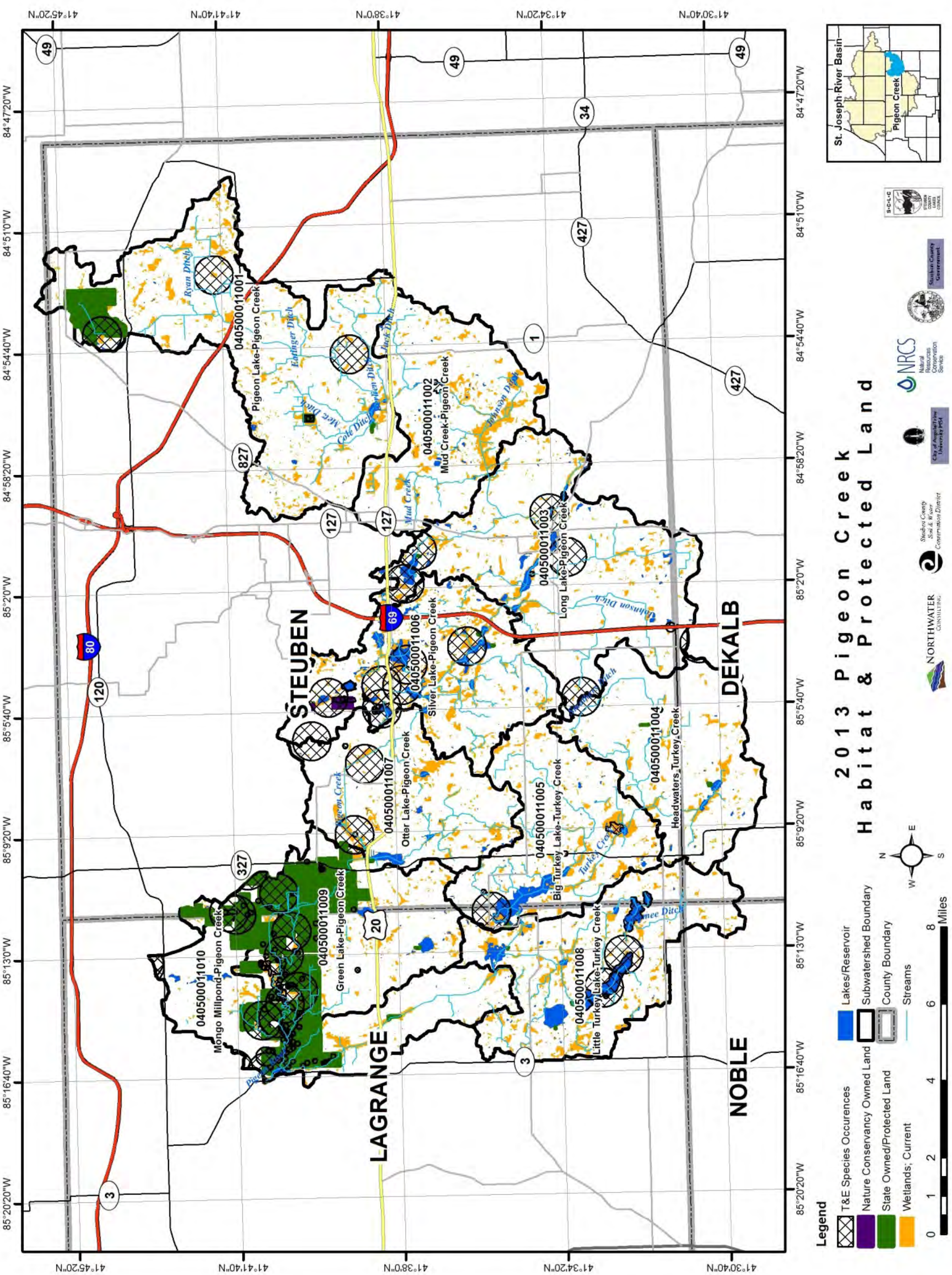
- Expanding existing protected areas may be more feasible and realistic to attain.
- Restoring or improving existing protected habitat is more economical.
- Wetland restoration efforts should be targeted to areas with the greatest percentage decline in pre-settlement wetland area.
- T&E species occurrences are indicators of habitat availability and restoration potential.
- Existing, high-quality wetlands should be protected.

Table 36 - Habitat Restoration & Protection Options

Subwatershed Name	HUC 12 Subwatershed Codes	Improve/Expand Existing State Owned/Protected Habitat	Add Additional Protected Habitat Acreage	Target Wetland Protection	Target Wetland Restoration
Pigeon Lake-Pigeon Creek	040500011001	X			X
Mud Creek-Pigeon Creek	040500011002			X	
Long Lake-Pigeon Creek	040500011003				X
Headwaters Turkey Creek	040500011004				X
Big Turkey Lake-Turkey Creek	040500011005				
Silver Lake-Pigeon Creek	040500011006		X		
Otter Lake-Pigeon Creek	040500011007				
Little Turkey Lake-Turkey Creek	040500011008				
Green Lake-Pigeon Creek	040500011009	X		X	
Mongo Millpond-Pigeon Creek	040500011010	X			

The subwatersheds of Pigeon Lake, Mud Creek, Long Lake, Headwaters of Turkey Creek, Green Lake, and Mongo Millpond may offer the most potential for habitat restoration and protection. Silver Lake may provide more opportunities to add additional protected habitat corridors or areas; TNC-owned Grass Lake complex (Silver Lake-Pigeon Creek subwatershed) could be expanded through the purchase of adjacent ground. Figure 33 shows the location of protected land, existing habitat areas and T&E occurrences.

Figure 33 - Pigeon Creek Habitat



4.3.2 Biological

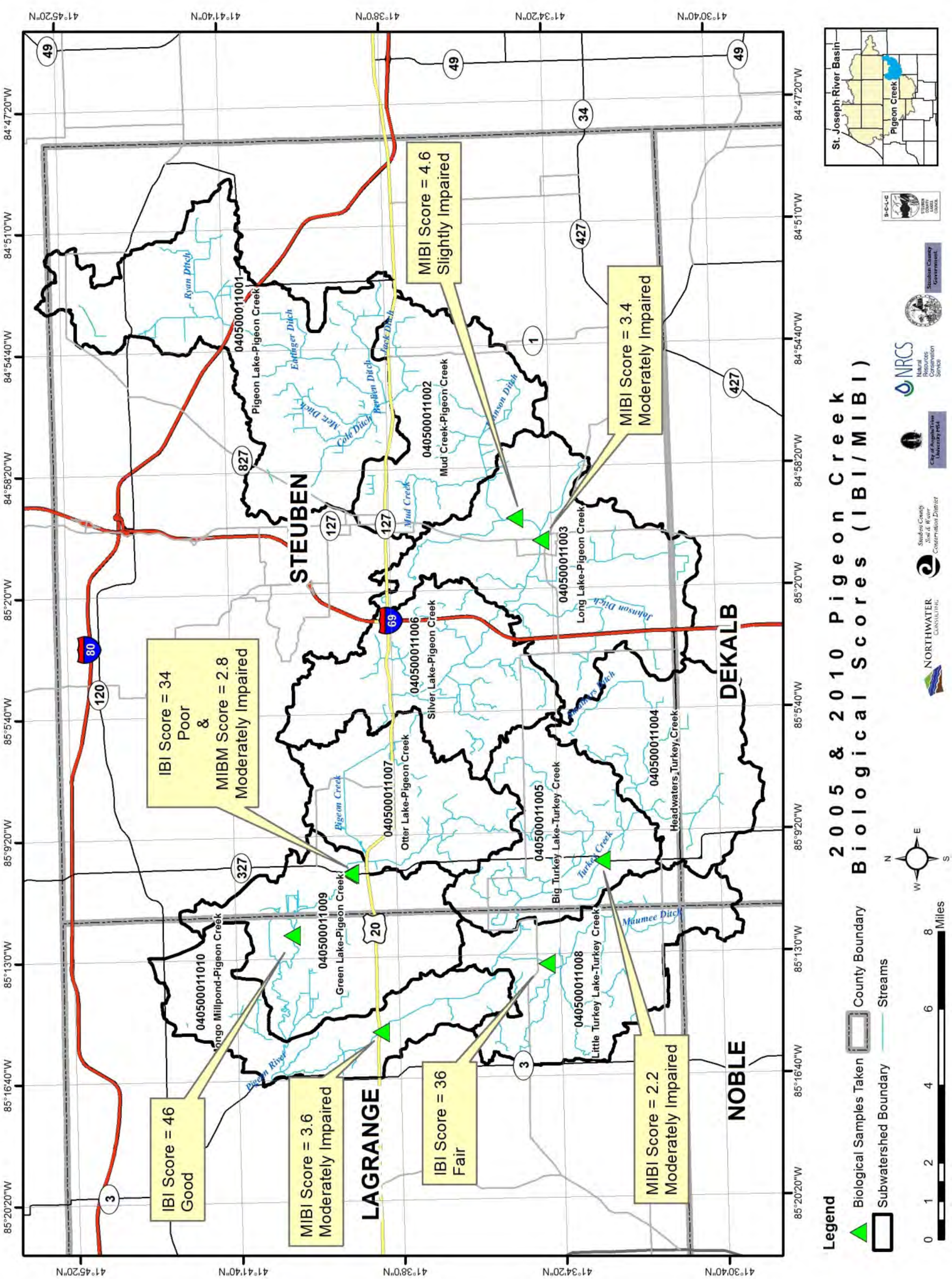
Water quality can be evaluated using biological indicators such as fish and macroinvertebrates. IDEM completed biological sampling in 2005 for Turkey Creek, and in 2010 for Pigeon Creek. A total of 3 sites were sampled for fish and 5 for macroinvertebrates. Table 37 lists the results of these samples in terms of their Index of Biological Integrity (IBI) and macroinvertebrate Index of Biological Integrity (mIBI) scores. Fish quality scores range from poor to good and macroinvertebrate scores from slight to moderately impaired. Figure 34 shows biological sample sites and the corresponding index scores.

Table 37 - IBI & mIBI Scores

Stream Name	Station Code	IBI	mIBI	Rating
Turkey Creek	LMJ110-0080	36	N/A	Fair (35-44)
Pigeon Creek	LMJ110-0003	34	N/A	Poor (23-34)
Pigeon Creek	LMJ110-0128	46	N/A	Good (45-52)
Pigeon Creek	LMJ110-0001	N/A	4.6	Slightly Impaired (4-6)
Pigeon Creek	LMJ110-0026	N/A	3.4	Moderately Impaired (2-4)
Turkey Creek	LMJ110-0027	N/A	3.6	Moderately Impaired (2-4)
Pigeon Creek	LMJ110-0028	N/A	2.8	Moderately Impaired (2-4)
Turkey Creek	LMJ110-0025	N/A	2.2	Moderately Impaired (2-4)

Pigeon Creek

Figure 34 - Pigeon Creek IBI/mIBI Scores



4.4 Landuse Information

Before settlement, Steuben County was primarily a hunting ground for the Potawatomi Indians. Originally a part of LaGrange County, Steuben County was settled in 1834 in the current town of Orland. The town was settled as the "Vermont Settlement," as many of the first settlers originated from Vermont. In the early 1900s, the county gained prominence for its 101 lakes. In addition to full-time residents, several thousand part-time residents and tourists reside in the watershed during the summer months.

Row crop agriculture makes up the largest percentage area in the watershed at approximately 50%. Woodland and open space (grassland) make up 25% of the watershed. Agricultural products are primarily corn and soybean, with livestock grazing operations throughout. Landuse information is important because many stakeholder concerns that relate to sediment, nutrient, and bacteria loading are tied to contributions from row crop agriculture, pasture, and residential areas. Table 38 lists the top five landuses by subwatershed. The headwaters of Turkey Creek has the highest percentage of row crops; Silver Lake, the highest percentage of woodland; Green Lake, the highest percentage of open space (grassland); Big Turkey Lake, the highest percentage of pasture; and Green Lake, the highest percentage of wetlands.

Although not listed in the table below, the Little Turkey Lake subwatershed has the highest percentage of open water at 936 acres (7%). Silver Lake has the second most open water with 811 acres (6%). Residential landuse is highest in Mud Creek with 590 acres (5%) and residential farm areas are highest in Otter Lake and Silver Lake with 472 acres (4.5%) and 568 acres (4.3%), respectively. Also notable, Silver Lake has the greatest area of roads at 454 acres (3.51%). It is important to note when referencing Table 38, that the percentage landuse type listed represents the percentage of that individual subwatershed and not the Pigeon Creek watershed as a whole.

Table 38 - Top Five Landuses by Subwatershed

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Row Crop	% Row Crop	Acres Woodland	% Woodland	Acres Open Space	% Open Space	Acres Pasture	% Pasture	Acres Wetland	% Wetland
Pigeon Lake-Pigeon Creek	040500011001	12,721	57.73%	3,043	13.81%	1,888	8.57%	874	3.97%	960	4.36%
Mud Creek-Pigeon Creek	040500011002	5,642	48.47%	1,770	15.21%	958	8.23%	533	4.58%	587	5.04%
Long Lake-Pigeon Creek	040500011003	10,783	57.91%	2,377	12.76%	1,271	6.82%	558	3.00%	397	2.13%
Headwaters Turkey Creek	040500011004	**7,643**	**64.78%**	1,397	11.84%	683	5.79%	608	5.16%	276	2.34%
Big Turkey Lake-Turkey Creek	040500011005	5,472	49.68%	1,661	15.08%	855	7.76%	**954**	**8.66%**	431	3.92%
Silver Lake-Pigeon Creek	040500011006	4,209	32.49%	**2,745**	**21.19%**	1,508	11.64%	1,007	7.77%	747	5.76%
Otter Lake-Pigeon Creek	040500011007	5,618	53.55%	1,882	17.94%	794	7.57%	615	5.86%	274	2.61%
Little Turkey Lake-Turkey Creek	040500011008	6,303	47.55%	2,285	17.24%	922	6.95%	1,142	8.62%	167	1.26%
Green Lake-Pigeon Creek	040500011009	5,371	39.55%	2,869	21.12%	**2,214**	**16.30%**	774	5.70%	**1,287**	**9.48%**
Mongo Millpond-Pigeon Creek	040500011010	5,635	53.56%	2,090	19.87%	1,020	9.69%	406	3.86%	657	6.25%

5.0 Part III; Watershed Inventory

Part three of the watershed inventory describes data collected and observations made during the watershed planning process, including information from a watershed windshield survey and key recommendations, as well as a detailed analysis of stakeholder concerns.

5.1 Watershed Inventory Summary

In addition to a detailed analysis of existing GIS and water quality data, a watershed-wide windshield survey and five (5) individual landowner site visits were conducted in early April of 2013. The windshield survey was conducted by traveling most of the roads within the watershed and recording observations using GPS. Data recorded included potential BMP location and details, cropping practices and landuse, pasture and confinement operations, and any other relevant information.

Landowner site visits included a discussion of the watershed planning process, resource concerns, evaluation property, and a discussion about implementing recommended BMPs. Several potential projects were identified on private ground, and are detailed along with other site-specific BMPs in Section 9.2. Section 9.1 details basin-wide BMPs.

The detailed watershed inventory yielded the following watershed-wide observations and key recommendations for addressing water quality issues:

1. Wetlands are critical features within the watershed, especially where field and pasture areas drain. These wetlands have been impacted, and may no longer be efficient at treating runoff. In many cases, field tiles bypass these wetlands and drain directly to ditches and streams. Recommendations include:
    - Restoration of wetlands adjacent to crop fields and pastures will increase sediment storage and nutrient uptake.
2. Many crop fields drain to a central depressional zone within the field where tile drains runoff under existing wetlands and into streams. Tile discharges observed after a rain event showed very turbid water, indicating that much of the eroded sediment may also be transported through these tiles and directly into nearby waterways. Recommendations include:
    - Installing tile restrictor plates or blind inlets at tile riser locations in depressional areas or at field edges where tile systems direct runoff around wetlands. This will force runoff to exit the system at a slower rate, allowing eroded sediment to drop out and remain in the field. Secondary benefits will include a reduced flood pulse as water is stored in the fields for a longer period.
3. Pasture operations are somewhat limited within the watershed and, for the most part, are in good condition without evidence of overgrazing. Pasture operations that have been overgrazed or too densely stocked may be contributing to high levels of bacteria and nutrients in streams. Recommendations include:
    - Focusing pasture improvement practices and landowner outreach to these high-impact pasture operations. BMPs should include stream fencing and buffer zones, rotational grazing, and alternative water systems and on-site runoff control/detention.

4. There is only a handful of permitted Concentrated Animal Feeding Operations (CAFO) within the watershed, and these operations were observed to be utilizing best practices with respect to waste management. There are, however, numerous small livestock feeding operations within the basin that are not permitted, and are not managing onsite waste control. Many of these sites have small, bare feed areas and barns, located on the top of a hill, or a side slope, where pollution is running off the site directly into a stream or ditch. Recommendations that focus on reducing or minimizing runoff and treating contaminants include:
    - Gutter systems on farm buildings and barn areas, water diversions around feed areas, detention basins, and small treatment ponds/wetlands.
5. Flat, productive fields within the watershed are difficult to drain, resulting in the construction of ditches and channelized streams to move more water faster. The challenge is to maintain productivity and drainage while reducing nutrient loss and the impacts of flooding. Recommendations include:
    - Installing two-stage ditches in headwater areas where streams have been channelized, providing additional capacity for floodwaters and increase nutrient removal.
    - Install water control structures at the outlets of small drainage ditches to temporarily store runoff.
6. Certain tillable sections of the watershed are on very long, steep slopes. Although crop residue is maintained on these fields, sheet and rill erosion is still occurring. Recommendations include:
    - Installing terrace systems on HEL fields, focusing on fields with the longest slopes.
7. Several areas surrounding lakes in the watershed are not currently serviced by a wastewater treatment plant. These areas are generally much older developments, likely on septic systems. It is possible these older developments are contributing contamination through failing septic systems. Recommendations include:
    - Conducting outreach on septic system maintenance to areas not served by a treatment plant.
    - Certify septic pumpers to inspect septic tanks.
    - Recommend homeowners get their septic tanks pumped and inspected every 3 years.
    - Septic pumpers file an inspection report with the County Health Department.
    - Define a "sensitive area" boundary in the watershed close to creeks and waterways. Base boundary on soil types and slopes – where seepage from a drain field could reasonably be expected to reach a watercourse before being adequately treated.

5.2 Analysis of Stakeholder Concerns

This section, as described in section 2.3, provides a condensed list of stakeholder concerns gathered during public and one-on-one meetings. These concerns may or may not be supported by data, and may not be quantifiable, but are important to the relevance of the watershed plan.

An effort was made to "poll" watershed stakeholders for the purposes of identifying concerns. Stakeholder input was solicited by conducting surveys at scheduled public meetings, speaking directly with watershed landowners and SWCD board members. Overall, stakeholder concerns identified at public meetings can be focused on water quality, while individual landowners expressed concerns with flooding and drainage. Practices implemented to reduce flooding and improve drainage can also improve water quality. An example would be the two-stage ditch; a BMP that reduces local flooding by maintaining or improving drainage, while improving water quality by filtering pollution. Table 39 lists the most important stakeholder concerns relevant to the watershed plan. During the first public meeting, a handout was provided to participants listing problems and concerns from the previous plan. Participants were then asked to list whether or not these were still a concern or not. The results or votes were then tallied; a total of 135 votes were received indicating the 2006 plan concerns were still valid and 53 total votes indicating the concerns were no longer valid. For example, concerns related to dying lakes and property values, both concerns in 2006, are no longer concerns today.

Concerns are listed in order from most to least important and are based on number of votes as detailed in Section 2.3. In order to improve implementation efficiency and reduce complexity, only those concerns that received seven or more votes are included. Also, some concerns were deliberately left out due their relevance to this plan and their ability to be addressed such as property values and overextending campgrounds. Several of the concerns listed in Table 39 include a lumping of issues identified by stakeholders. For example, any lake-specific concerns with respect to bacteria or the Angola WWTP were lumped into bacteria and concerns with drainage and wetlands, as well as wildlife, were lumped into degraded wetlands and ecological habitat. Concerns related to nonpoint source pollution, road and farm runoff were lumped into urban and rural runoff. Finally, concerns related to environmental stewardship, outreach and cooperation are not listed in Table 39 as they received only a few votes and are solutions rather than problems; outreach is listed as an implementation strategy and stewardship and cooperation is already being promoted in the watershed.

Table 39 – Primary Stakeholder Concerns

	Concern	Supported by Data (yes/no)	Notes/Analysis
1.	**Bacteria**	yes	Bacteria concentrations in watershed lakes and streams continue to be a major concern. Exceedences in water quality standards are numerous and a TMDL plan was completed in 2012 for bacteria.
2.	**Water Pollution, Phosphorus and Sediment**	Yes & No	Results from water quality sampling do not necessarily indicate a major issue with sediment; more sampling of high flow events is needed. Modeled results and observations indicate that sedimentation is an issue during high-flow events and is impacting wetlands that drain adjacent crop ground. A TMDL was completed for phosphorus, and sampled water quality indicates exceedences in state standards. Modeled phosphorus results indicate reductions are needed. Nitrogen was not noted as a concern by stakeholders, however, water quality results indicate numerous exceedences in the 10mg/L threshold.
3.	**Drainage**	Yes	Drainage is the number one concern for farmers in the watershed. Watershed soils, the extent of tiling and topography support the fact that drainage is difficult to manage for production agriculture.
4.	**Degraded Wetlands and Ecological Habitat**	Yes	Extensive data and observations support the fact that the acreage of historical wetlands has been significantly reduced. Wetlands are degraded and under stress; wetland restoration and enhancement is a recommended strategy.
5.	**Flooding**	Yes	Data exists that supports the idea that flooding frequency and severity in the watershed has been increasing. As noted in Section

Concern	Supported by Data (yes/no)	Notes/Analysis
		4.2.3, peak flood stage in the last 36 years has been exceeded in 17 of those years. There is also anecdotal evidence from landowners that flooding does occur and it is still a concern for many.
6. Urban and Rural Runoff	Yes	Modeled results and an assessment of watershed data indicate that both urban and rural runoff is contributing to water quality impairments.
7. Financial Concerns	No	Relating to the availability of funding, a review of past watershed success and an understanding of current funding programs, there is no indication that financial concerns are an issue. Various state and federal programs exist and the SWCD has been extremely successful in receiving funds to date. Particular "un-fundable" projects may be limited in funding. The limited ability for individuals to fund projects (matching funds), combined with landowner interest, or lack thereof, to implement specific practices, are likely why there are concerns with financing. Flexibility in state and federal cost-sharing could increase participation.

Water Quality Brochure Distributed in the Watershed

6.0 Problems & Causes

Based on the data and information presented in the watershed inventory and analysis of the data, problems and causes are correlated to the seven individual stakeholder concerns as identified in Section 5.2 and previously in the plan. Four major problem areas are identified based on the stakeholder concerns:

1. Water Quality, Bacteria
2. Water Quality, Nutrients and Sediment
3. Flooding & Drainage
4. Degraded Wetland and Ecological Habitat

Chapter 7 further details and characterizes major sources of pollution in the watershed.

Table 40 - Categories of Key Problems

Key Categories	Major Causes/Sources	Supporting Information
1. Water Quality, Bacteria	Urban and rural land runoff, point source pollution, septic systems, pasture and small animal feed areas, wildlife, and legacy sediment.	Water quality data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, and local reports and data.
2. Water Quality, Nutrients & Sediment	Agricultural runoff, sheet, rill, and gully erosion, urban and residential farm runoff, small animal feeding operations and pasture, hydrologic modifications and tiling, and wastewater treatment plants and CSOs (to a lesser degree)	Water quality data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, local reports and data, water quality from permitted dischargers, and GIS analysis of landuse.
3. Flooding & Drainage	Urban runoff and impervious surfaces, soil types, hydrologic modifications, channelization, and tiling.	Windshield survey, water flow data, runoff modeling, and GIS analysis.
4. Degraded Wetlands & Ecological Habitat	Agricultural and urban runoff, urban development, and drainage.	Windshield survey, runoff and pollution load modeling, GIS analysis of existing and degraded wetlands and of hydrologic modifications.

6.1 Water Quality, Bacteria

As noted in the previous sections, high concentrations of fecal coliform and *E. coli* bacteria have been consistently recorded in the watershed, confirming bacteria as a water quality problem. Bacteria can have a negative impact on both human and biological health.

The State of Indiana has water quality standards only for *E. coli* bacteria, and *E. coli* values are presented and discussed throughout the plan. *E. coli* represents a portion or subset of fecal coliform bacteria. The pollution load modeling performed for this plan represents fecal coliform bacteria, of which *E. coli* typically represents up to 90% of the total fecal coliform count.

Based on the watershed inventory and assessment, *E. coli* bacteria-related problems exist watershed-wide in all 10 subwatersheds. Table 41 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 41 – Bacteria-Related Problems & Causes

Problem	Causes/Sources	Subwatershed (s)	Supporting Information
A majority of the streams and waterways in the watershed are at sometimes unsafe for full contact recreational uses due to elevated levels of bacteria.	Urban and rural land runoff, and confinement operations, septic systems, pasture and small animal feed areas, wildlife, legacy sediment and, to a lesser extent, point source pollution from wastewater treatment plants (CSOs).	All Subwatersheds	Water quality data, impairment data, wastewater discharge data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, local reports and data, and GIS analysis of landuse.
Three subwatersheds are considered high priority for bacterial contamination and are degraded.	Rural farm runoff, pasture and small feed areas, confinement operations, and septic systems.	1. Little Turkey Lake – Turkey Creek 2. Long Lake – Pigeon Creek 3. Silver Lake – Pigeon Creek	Water quality data, pollutant load modeling, critical areas analysis, septic analysis, windshield survey, distance of pasture and feed areas to a stream, and GIS analysis of landuse.

6.2 Water Quality, Nutrients & Sediment

Based on the watershed inventory and assessment, sediment and nutrient problems exist watershed-wide, however, there are areas where the problems are more focused than others. Table 42 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

The quality of water within the watershed has a direct impact on several resources, including lakes and wildlife habitat. It can be expected that as the water quality in the watershed decreases, so will the quality of recreational resources and wildlife. This section of the plan attempts to link the most commonly identified stakeholder concerns to actual problems and causes identified in the watershed through an analysis of water quality data, GIS information, and modeled pollution loading results.

Table 42 - Sediment & Nutrient-Related Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Excessive sedimentation is degrading fish habitat and affecting recreational and aesthetic value.	Sheet and rill erosion, gully erosion and, to a lesser degree, streambank erosion, cropped HEL soils, and overgrazed pasture.	1. Mud Creek – Pigeon Creek 2. Long Lake – Pigeon Creek 3. Pigeon Lake – Pigeon Creek 4. Headwaters Turkey Creek	Water quality data, pollutant load modeling, HEL soils analysis, windshield survey, and critical area analysis.
Eutrophic conditions are known to exist in Golden Lake,	Excess nutrients from agricultural runoff, livestock	1. Long Lake – Pigeon Creek	Long Lake and Little Turkey Lake are impaired for total

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Hogback Lake, Little Turkey Lake, and Long Lake have degrading water quality, affecting recreational and aesthetic value.	Operations, septic systems, hydrologic modifications and drainage tiles, and urban runoff.	2. Headwaters Turkey Creek 3. Little Turkey Lake – Turkey Creek 4. Mongo Millpond – Pigeon Creek	phosphorus, 2010-2011 trophic index data, pollutant load modeling, GIS analysis of landuse, and hydrologic modifications.
Phosphorus and nitrogen are too high in some streams and are impacting aquatic life.	Hydrologic modifications and drain tiles, excess nutrients from agricultural runoff and erosion, pasture and small feed areas, and septic systems.	1. Long Lake – Pigeon Creek 2. Headwaters Turkey Creek 3. Pigeon Lake – Pigeon Creek 4. Mud Creek – Pigeon Creek	2010 impairment data, water quality data, pollutant load modeling, GIS analysis of landuse and hydrologic modifications, septic analysis, windshield survey, critical areas analysis.

6.3 Flooding & Drainage

Flooding continues to be a problem in the watershed. Although there are many causes for flood occurrences, the primary reason for flooding in the Pigeon Creek watershed is the lack of storage in upstream areas and, as a result, the lack of drainage capacity in the waterways to drain flood events. The watershed often experiences overbank flooding in agricultural areas, as the runoff peaks exceed the capacity of the channels. Most flooding, and likewise the most damage, is reported near the lake chain due to development within the floodplain along the lakeshore, and a flow restriction at the Hogback Lake outlet. In addition to property damage, flooding also impacts water quality in the watershed, as residential septic units can be impacted by the floodwaters. Table 43 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 43 - Flooding & Drainage-Related Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Overall peak floods in the watershed have increased significantly since 1976.	Increase in impervious surface, historical loss of wetlands, hydrologic modifications and drainage tiles, and soil characteristics.	1. Long Lake – Pigeon Creek 2. Headwaters Turkey Creek 3. Mud Creek – Pigeon Creek	Stream gage data analysis, GIS analysis of soil types, landuse, current and historical wetlands, impervious surfaces, and hydrologic modifications, and annual runoff volume modeling.

6.4 Degraded Wetlands & Ecological Habitat

Degraded wetlands and ecological habitat is a key concern of stakeholders and, based on the inventory and assessments, there are problems throughout the watershed. Table 44 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 44 - Degraded Wetlands & Ecological Habitat Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Presettlement wetlands have been reduced by 50% and this is impacting water quality and available wildlife habitat.	Increase in impervious surface, historical loss of wetlands, drainage tiles.	1. Pigeon Lake – Pigeon Creek 2. Mud Creek – Pigeon Creek 3. Long Lake – Pigeon Creek 4. Headwaters Turkey Creek	Stream impairments for IBC, GIS analysis of landuse, current and historical wetlands, and existing and protected habitat.
Stream habitat and biological integrity is low overall, indicating a stressed biological community.	Excessive nutrients, sediment, and bacteria from both point and nonpoint source pollution, and hydrologic modifications.	1. Green Lake – Pigeon Creek 2. Little Turkey Lake – Turkey Creek 3. Big Turkey Lake – Turkey Creek 4. Long Lake – Pigeon Creek	Biological stream data (IBI & mIBI) and GIS analysis of existing and protected habitat and landuse.

7.0 Pollution Sources & Loading

Like many Midwestern watersheds, water pollution can originate from both point and nonpoint sources. Point-source pollution is any single identifiable source of pollution from which pollutants are discharged, such as a pipe. Nonpoint-source (NPS) pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, and even groundwater. This section will describe, in detail, pollution sources, as well as quantities or total loading.

7.1 Pollution Sources

In order to limit the impact of stressors on critical characteristics of the watershed, the sources of the stressors should be examined and addressed. Pollution sources can be broken down into point-source and nonpoint-source pollution. This section will examine specific watershed point and nonpoint pollution sources for the treatable problems and causes listed in the previous sections.

7.1.1 Point-Source Discharges

Potential sources of bacteria, phosphorus, nitrogen, and sediment in the watershed include both permitted and non-permitted point sources. As of 2012, there are seven National Pollutant Discharge Elimination System (NPDES) permitted point sources in the Pigeon Creek watershed, which include wastewater treatment plants, combined sewer overflows, and stormwater runoff from IDEM stormwater Phase II communities. Other NPDES point sources include a state rest area and a local business. As of 2012, there are two (2) CAFOs and six (6) CFOs also considered permitted point sources and exist within the watershed. According to their general permits, these CFOs are considered to be no-discharging. Septic systems can also be considered point-source pollution and are discussed below.

Septic Systems

Septic systems provide treatment of wastewater from individual properties. Failing septic systems are typically an active source of pollutants. Faulty or leaking septic systems are sources of bacteria, nitrogen, and phosphorus. According to the 2012 TMDL, there is an estimated total of 9,108 septic systems (Table 45) and, of these, 1,365 (15%) are estimated to be failing. In the TMDL plan, the number of septic systems was estimated based on landuse, and was not tied to a specific location. Areas identified as developed open space, low intensity development, and medium intensity development were assumed to be served by onsite septic systems at a rate of: one system per four acres of open space, one system per acre of low intensity, and five systems per acre of medium intensity. The TMDL plan applied a 15% failure rate.

Table 45 - 2012 TMDL Septic System Estimates

Subwatershed Name	HUC 12 Subwatershed Codes	Total Estimated Number of Septic Systems	Total Estimated Number of Failing Septic Systems
Pigeon Lake-Pigeon Creek	040500011001	1,134	170
Mud Creek-Pigeon Creek	040500011002	1,780	267
Long Lake-Pigeon Creek	040500011003	2,101	315
Headwaters Turkey Creek	040500011004	765	115
Big Turkey Lake-Turkey Creek	040500011005	530	79
Silver Lake-Pigeon Creek	040500011006	1,154	173
Otter Lake-Pigeon Creek	040500011007	366	55
Little Turkey Lake-Turkey Creek	040500011008	547	82
Green Lake-Pigeon Creek	040500011009	442	66
Mongo Millpond-Pigeon Creek	040500011010	289	43
Grand Total		**9,108**	**1,365**

Actual locations of failing systems are unknown so an analysis of available GIS data was conducted to identify the potential for water quality impacts from septic systems. Data layers used included: residential (urban and farm) boundaries, areas within a waste treatment district, areas connected to a municipal waste treatment facility, and soils limited for septic fields. These layers were combined to determine the location and acreage of those residential areas with the highest likelihood of failing septic systems. Out of a total of 4,936 acres of residential area believed to be on septic, 3,647 acres (74%) are located on limiting soils. Out of these 3,647 acres, 2,667 residential acres (73%) are within 500 feet of a stream or lake and should be targeted for the application of septic system BMPs. The highest percentage of residential area on septic, on limiting soils, and within proximity to a stream or lake is in the Long Lake and Silver Lake subwatersheds (Table 46 and Figures 35 and 36); priority should be given to these subwatersheds. Pollution load estimates and specific treatment recommendations for septic systems can be found in Sections 7 and 9.

Table 46 - Septic Systems

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Residential Septic Systems on Limiting Soils	% Area (acres) Residential Septic Systems on Limiting Soils	Area (acres) Residential Septic Systems on Limiting Soils and within 500ft of a Stream or Lake	% Area (acres) Residential Septic Systems on Limiting Soils and within 500ft of a Stream or Lake
Pigeon Lake-Pigeon Creek	040500011001	22,036	646	2.93%	435	67%
Mud Creek-Pigeon Creek	040500011002	11,641	330	2.84%	221	67%
Long Lake-Pigeon Creek	040500011003	18,620	786	4.22%	623	79%
Headwaters Turkey Creek	040500011004	11,798	237	2.01%	85	79%
Big Turkey Lake-Turkey Creek	040500011005	11,015	174	1.58%	135	78%
Silver Lake-Pigeon Creek	040500011006	12,954	514	3.97%	468	91%
Otter Lake-Pigeon Creek	040500011007	10,491	275	2.62%	212	77%
Little Turkey Lake-Turkey Creek	040500011008	13,255	208	1.57%	161	77%
Green Lake-Pigeon Creek	040500011009	13,581	253	1.86%	173	68%
Mongo Millpond-Pigeon Creek	040500011010	10,520	224	2.13%	153	68%
Grand Total		**135,911**	**3,647**	**2.68%**	**2,667**	**73%**

Steuben Lakes RWD Waste Water Treatment Plant

Figure 35 – Upper Pigeon Creek Septic Systems

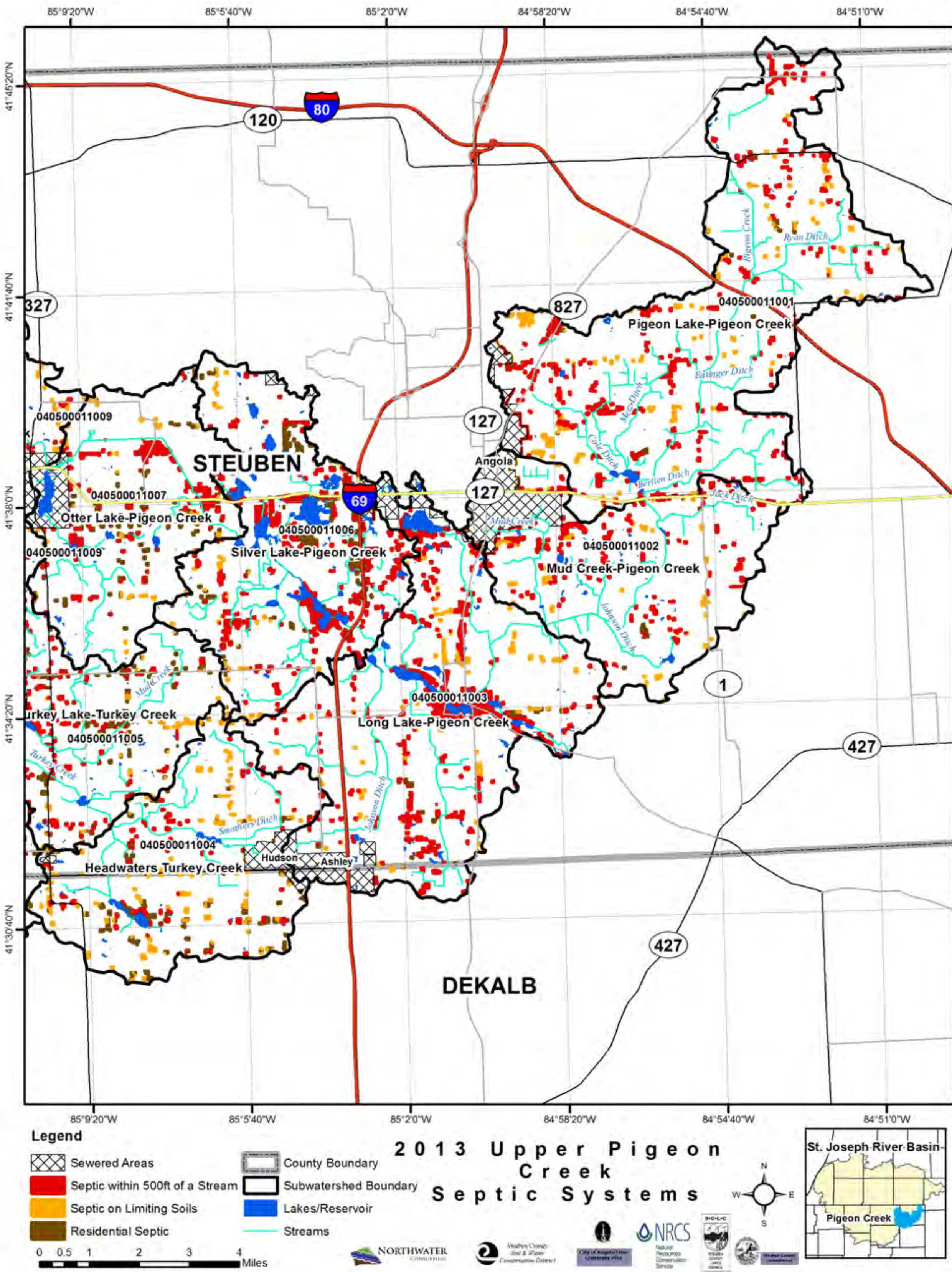
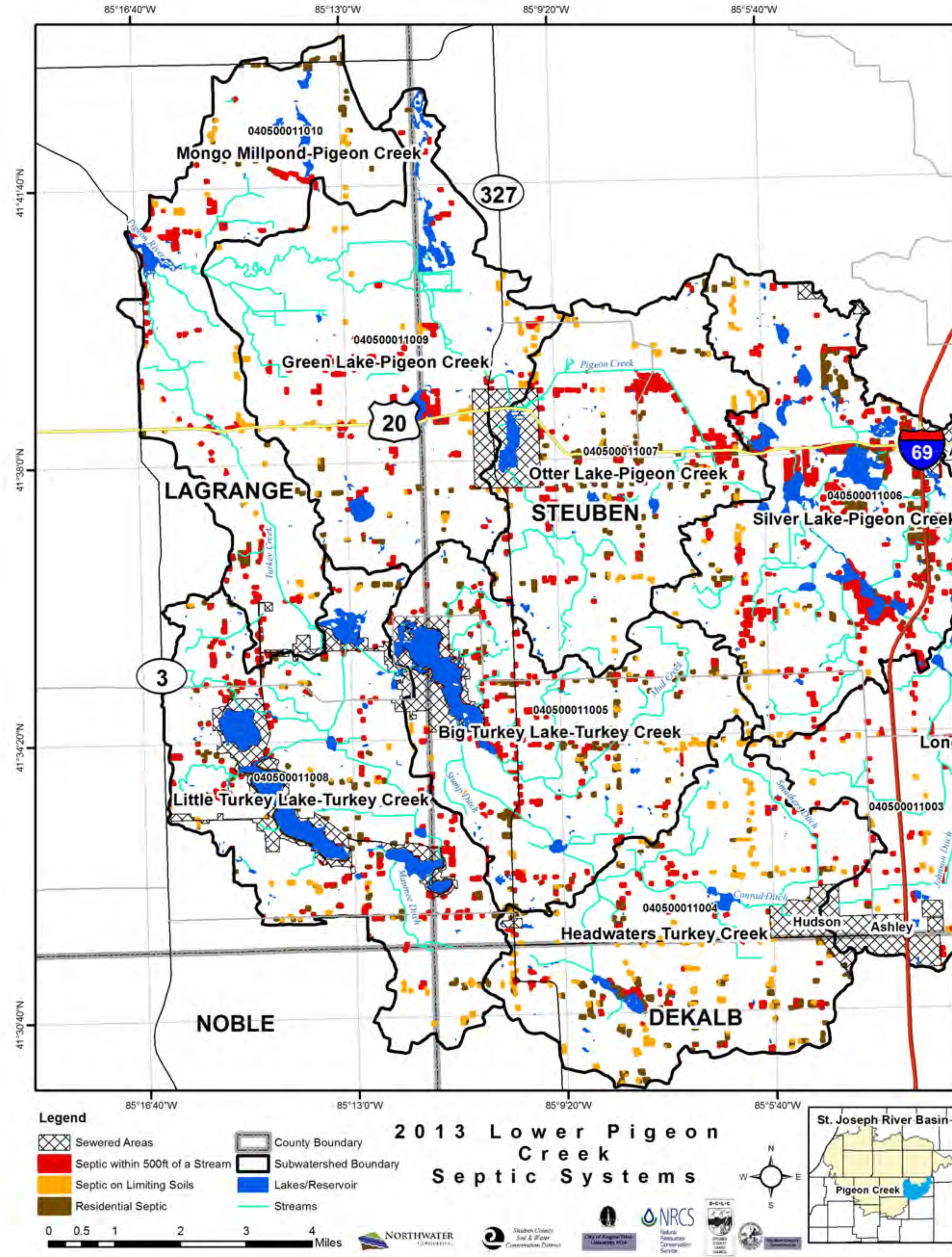


Figure 36 - Lower Pigeon Creek Septic Systems



Wastewater Treatment Plants & Permitted Discharges

Wastewater Treatment Plants (WWTPs) and industrial facilities are permitted dischargers authorized to discharge specific pollutants up to regulated thresholds, and are a source of bacteria, phosphorus, and nitrogen. Wastewater treatment plants and industrial facilities can contribute both pollutants and flow volume to the system. The regulated parameters and thresholds are specified in each permit. Municipal separate storm sewer systems (MS4s) dischargers are authorized to discharge stormwater and are regulated through Best Management Practices and not Water Quality-Based Effluent Limits. Only one MS4 (permit INR040005), with co-permittees of the City of Angola and Trine University (formerly Tri-State University), is located within the Pigeon River Watershed. This is a Phase II MS4 that includes land area within three HUC12s: 040500011001 (398 acres), 040500011002 (1308 acres), and 040500011003 (192 acres).

Seven existing WWTPs that are regulated for *E. coli*, total suspended solids, total phosphorus, and other constituents, such as ammonia and chloride, were identified in the Pigeon Creek watershed. Table 47 lists the existing WWTPs and permitted discharges and Figure 37 shows the location of all NPDES permit pipes and the areas served by WWTPs; all other areas of the watershed are assumed to be on septic. Only 4% (5,977 acres) of the watershed is serviced by a WWTP.

Table 47 - NPDES Permitted Discharges

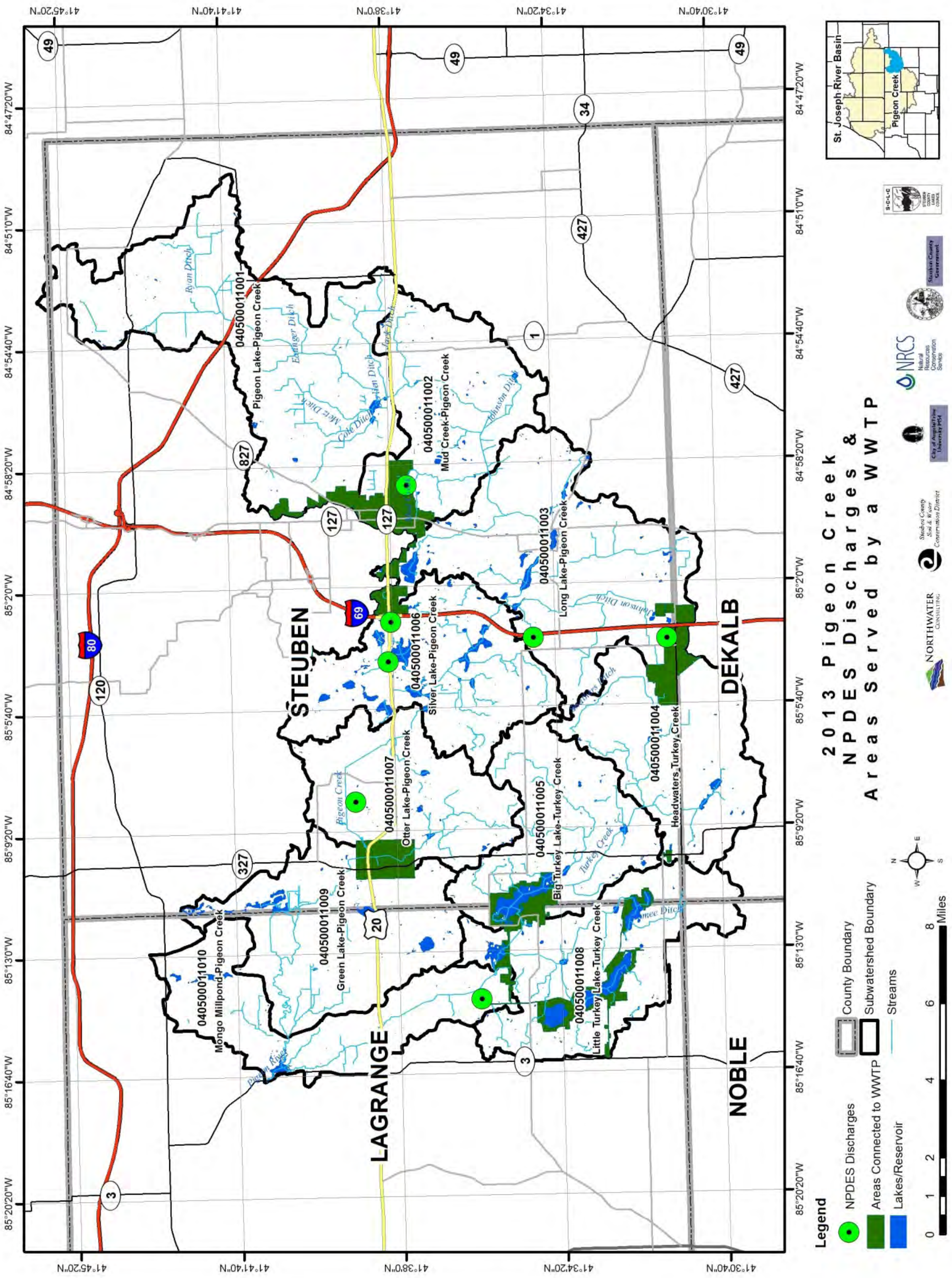
Site Name	Type	Permit Number	HUC 12	Design Flow (MGD)	Average Daily Flow (MGD)[1]
Angola Municipal STP	WWTP	IN0021296	Mud Creek-Pigeon Creek - 040500011002	1.70	1.190 (2005-2006)
Ashley Municipal STP	WWTP	IN0022292	Long Lake-Pigeon Creek - 040500011003	0.40	0.197 (2005-2007)
LaGrange Region B	WWTP	IN0060097	Mongo Millpond-Pigeon Creek - 040500011010	0.75	0.201 (2004-2009)
Pigeon Creek Rest Area I-69 SB	WWTP	IN0052043	Long Lake-Pigeon Creek - 040500011003	0.01	N/A
Silver Lake Group of Angola	WWTP	IN0039543	Silver Lake-Pigeon Creek - 040500011006	0.03	0.024 (2003-2004)
Steuben Lakes RWD	WWTP	IN0061557	Otter Lake-Pigeon Creek - 040500011007	1.00	0.390 (2005-2006, 2008-2010)
Best Western[2] Angola Inn	WWTP	IN0042196	Otter Lake-Pigeon Creek - 040500011007	N/A	N/A

[1] From 2012 TMDL

2 Although this permit is still active according to current state records, it is not known to be actively discharging; the Best Western is no longer located at this site.

An assessment of the Angola Wastewater Treatment Plant and other treatment facilities in the watershed has also confirmed that plant discharge is not the sole or primary source of bacteria, sediment, nitrogen or phosphorus. Other sources are present in the watershed, as well as bacteria that are naturally occurring such as from wildlife and biological processes. A detailed assessment of four permitted WWTPs is provided below. Permitted discharges and areas of the watershed served by a WWTP are shown on Figure 37.

Figure 37 - Pigeon Creek Permitted Discharges & Areas Served by a WWTP



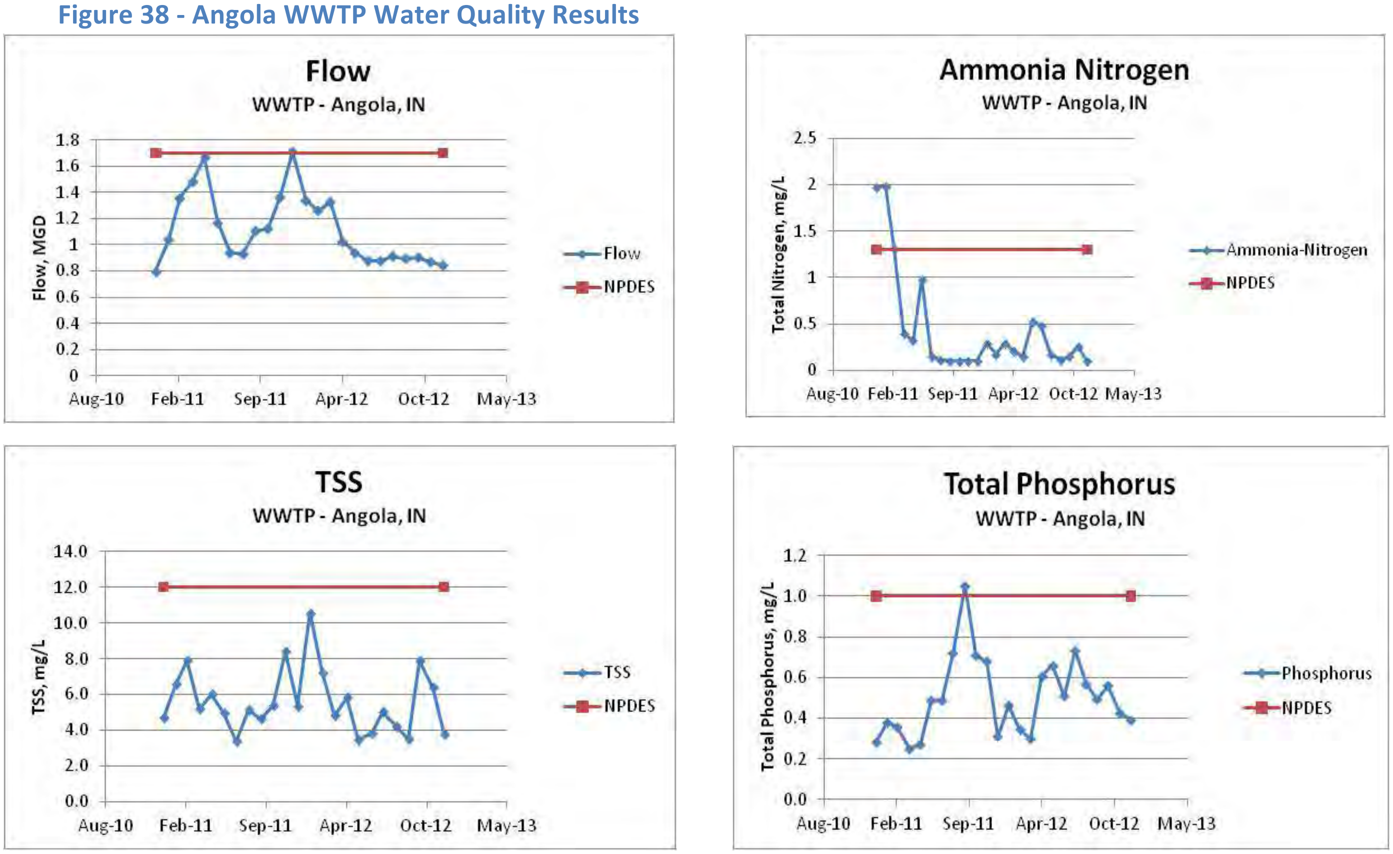
Angola Waste Water Treatment Plant

Angola operates a Class III conventional activated sludge treatment facility. The capacity is 1.7 Million Gallons per Day (MGD). The facility consists of a bar screen, degritter, two (2) flow equalization basins, three (3) primary clarifiers, three (3) aeration tanks, three (3) secondary clarifiers, ultraviolet light disinfection and an effluent flow meter. Class B biosolids are aerobically digested and belt filter pressed, stored, and land-applied by a licensed hauler. The collection system is comprised of combined sanitary and storm sewers with two (2) CSO locations. The CSO locations have been identified and are permitted. The long-term plan is to minimize/eliminate these two CSO discharges through sewer separation projects and removal of illicit connections

The facility discharges to Outfall 001, which is located at latitude: 41° 37’ 38” N, Longitude: 84° 58’ 59” W. The receiving water is Wood Ditch, which empties to Mud Creek and, eventually, Pigeon Creek. The CSOs also discharge to Wood Ditch.

A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have been plotted for the period between January 2011 and December 2012. The results of the analysis are shown in Figure 38.

Figure 38 - Angola WWTP Water Quality Results



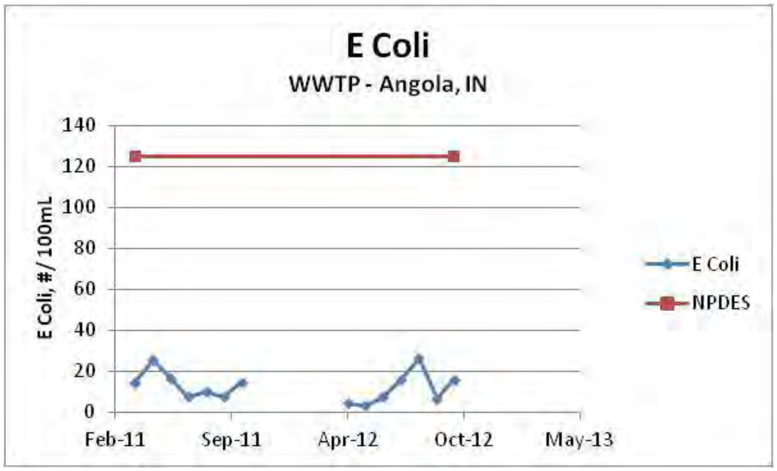


Table 48 shows permit limit exceedances (by monthly average) between January 2011 and December 2012. The results show that permit limits were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 48 - Angola WWTP Permit Exceedances

Parameter	Monthly Average exceeded NPDES Permit	Remarks
Flow	December 2012	The NPDES permit does not necessarily limit flow. Flow is a reported value only.
Ammonia Nitrogen	January 2011 February 2011	The winter limit is 1.6 mg/L. The reported monthly average for these two months was 1.99 and 1.99 mg/L.
Total Phosphorus	September 2011	The limit is 1.0 mg/L. The reported monthly average for this month was 1.05 mg/L. There is an exception to the limit when the influent raw wastewater phosphorus is less than 5 mg/L, in which case, a degree of reduction is prescribed and calculated based on monthly average raw and final concentrations. However, influent phosphorus was 7.15 mg/L for the month in question.
TSS	None	
E. Coli	None	

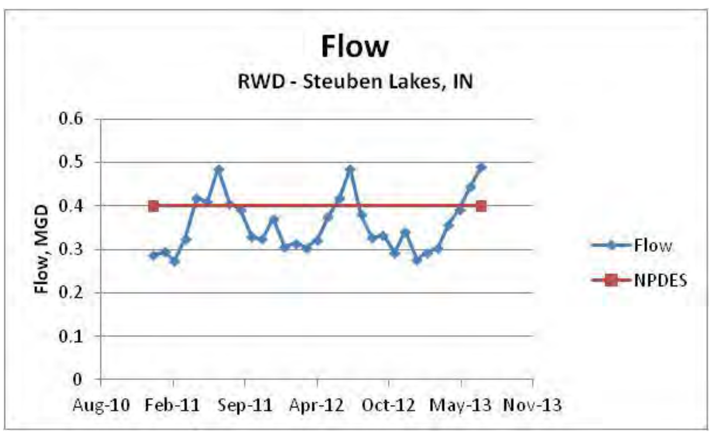
Steuben Lakes Waste Water Treatment Plant

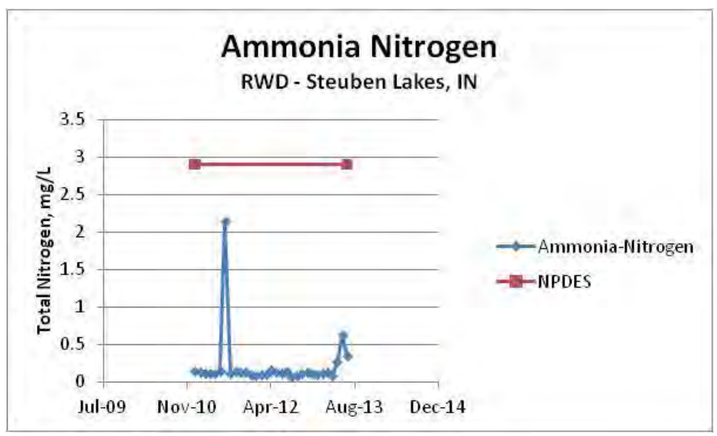
The Steuben Lakes Regional Waste District currently operates a Class III, 1.0 MGD treatment facility consisting of three sequencing batch reactors (SBR), a two-day polishing pond, cascade aeration, and an ultraviolet light disinfection unit. Solids handling includes a sludge holding tank, a two-day polishing pond, an alkaline treatment system, and a sludge storage pad. The supernatant from the sludge storage tank is pumped back to the headworks of the plant.

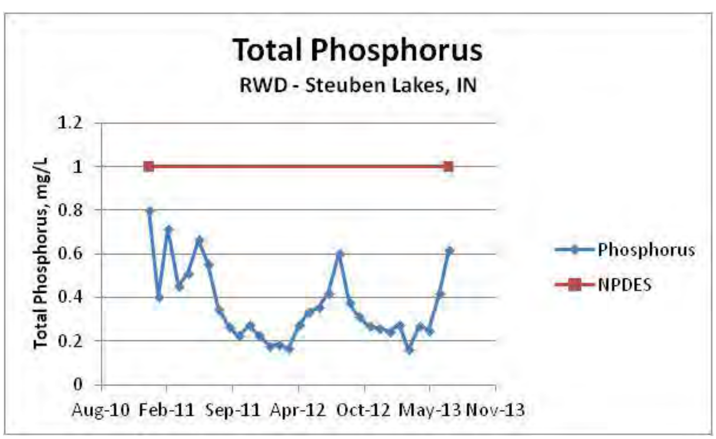
The collection system is comprised of 100% separate sanitary sewers by design with no overflow points. There is one bypass point around the two-day polishing pond following the SBR units.

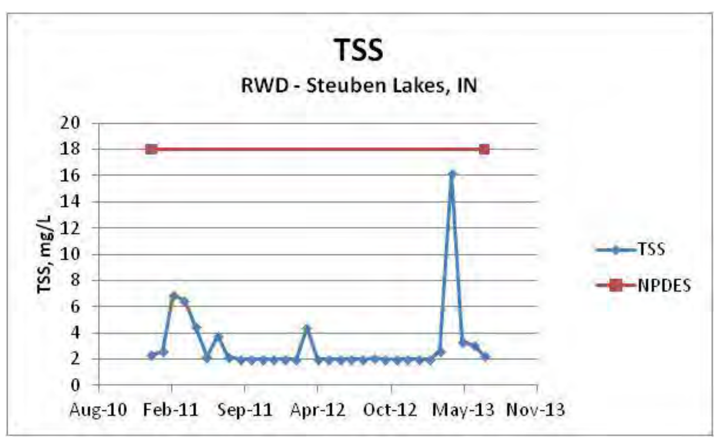
A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have been plotted for the period between January 2011 and July 2013. The results of the analysis are shown in Figure 39.

Figure 39 - Steuben Lakes RWD Water Quality Results









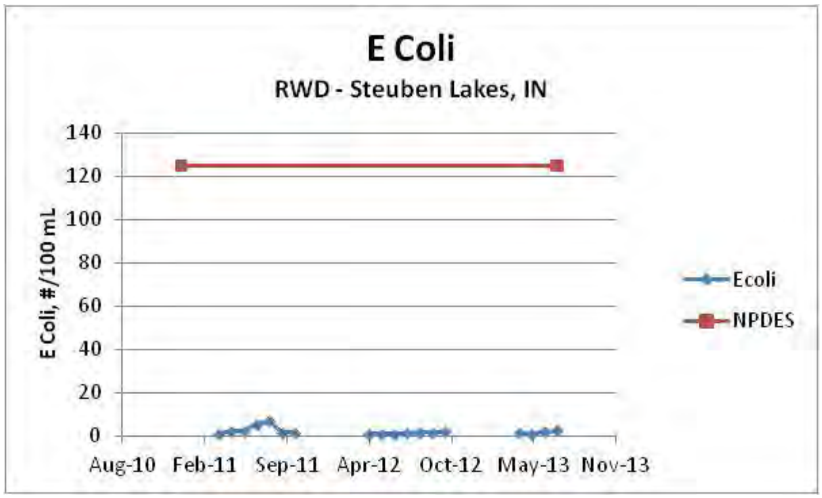


Table 49 shows permit limit exceedances (by monthly average) between January 2011 and July 2013. The results show that only permit limits for flow were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 49 - Steuben Lakes WWTP Permit Exceedances

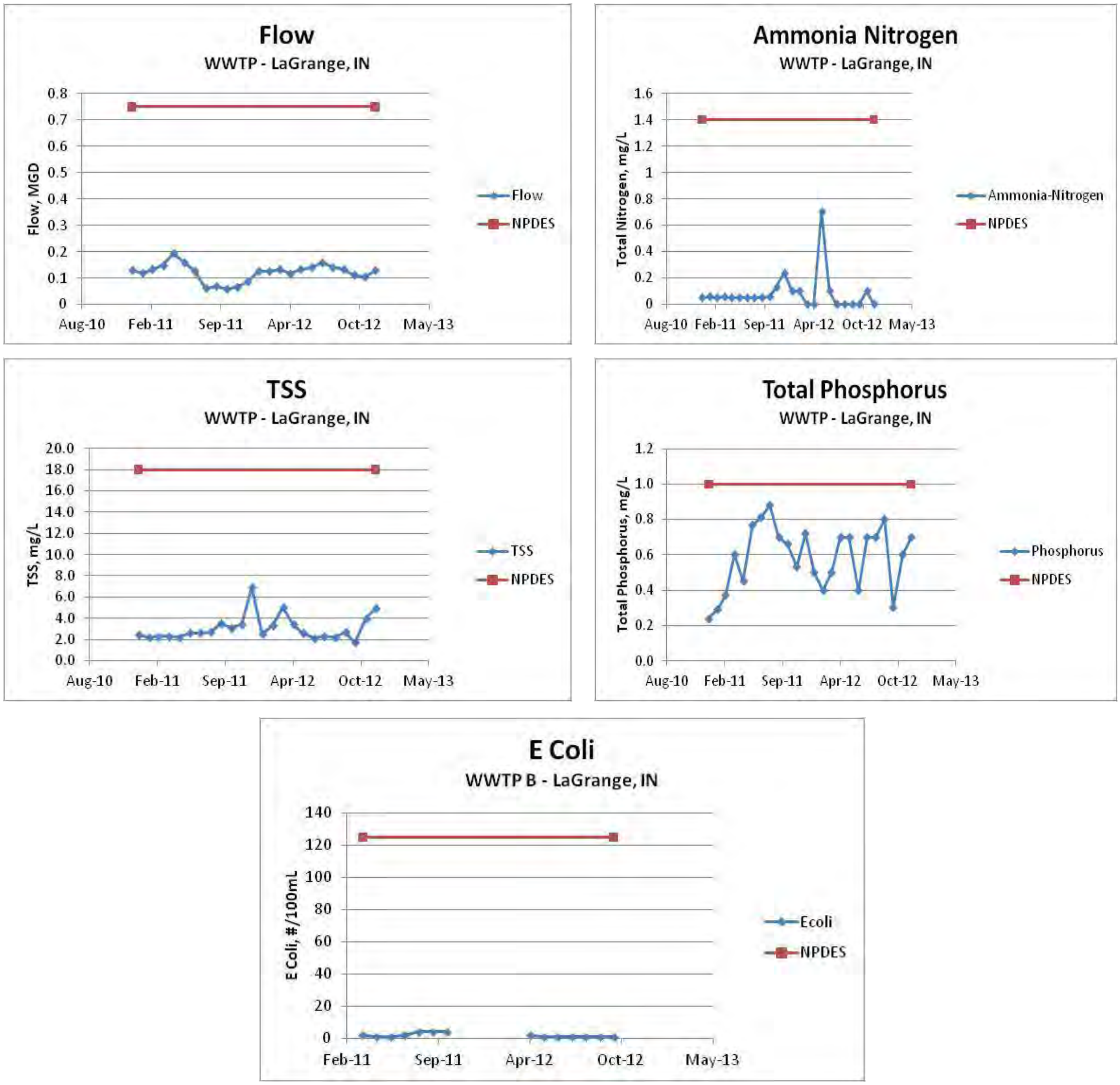
Parameter	Monthly Average exceeded NPDES Permit Limit	Remarks
Flow	May, June, July, August, 2011 June, July 2012 June, July 2013	The NPDES permit does not necessarily limit flow. Flow is a reported value only.
Ammonia Nitrogen	None	
Total Phosphorus	None	
TSS	None	
E. Coli	None	

LaGrange County Regional Waste Water Treatment Plant

The LaGrange County Regional Utility District currently operates a Class II treatment facility with a maximum rated flow of 750,000 gallons per day. The treatment facility consists of an equalization tank, an influent flowmeter, a ferric chloride tank with injection, an oxidation ditch, two secondary clarifiers, an aerobic digester, post cascade aeration, an ultraviolet light disinfection unit, and an effluent flowmeter. Biosolids are stored in a 277,000-gallon storage tank for land application by a licensed hauler. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The discharge point, Outfall 001, is located at Latitude: 41° 36’ 11” N, Longitude: 85° 14’ 05” W. The receiving waterbody is Turkey Creek. A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have been plotted for the period between January 2011 and December 2012. The results of the analysis are shown in Figure 40.

Figure 40 - LaGrange WWTP Water Quality Results



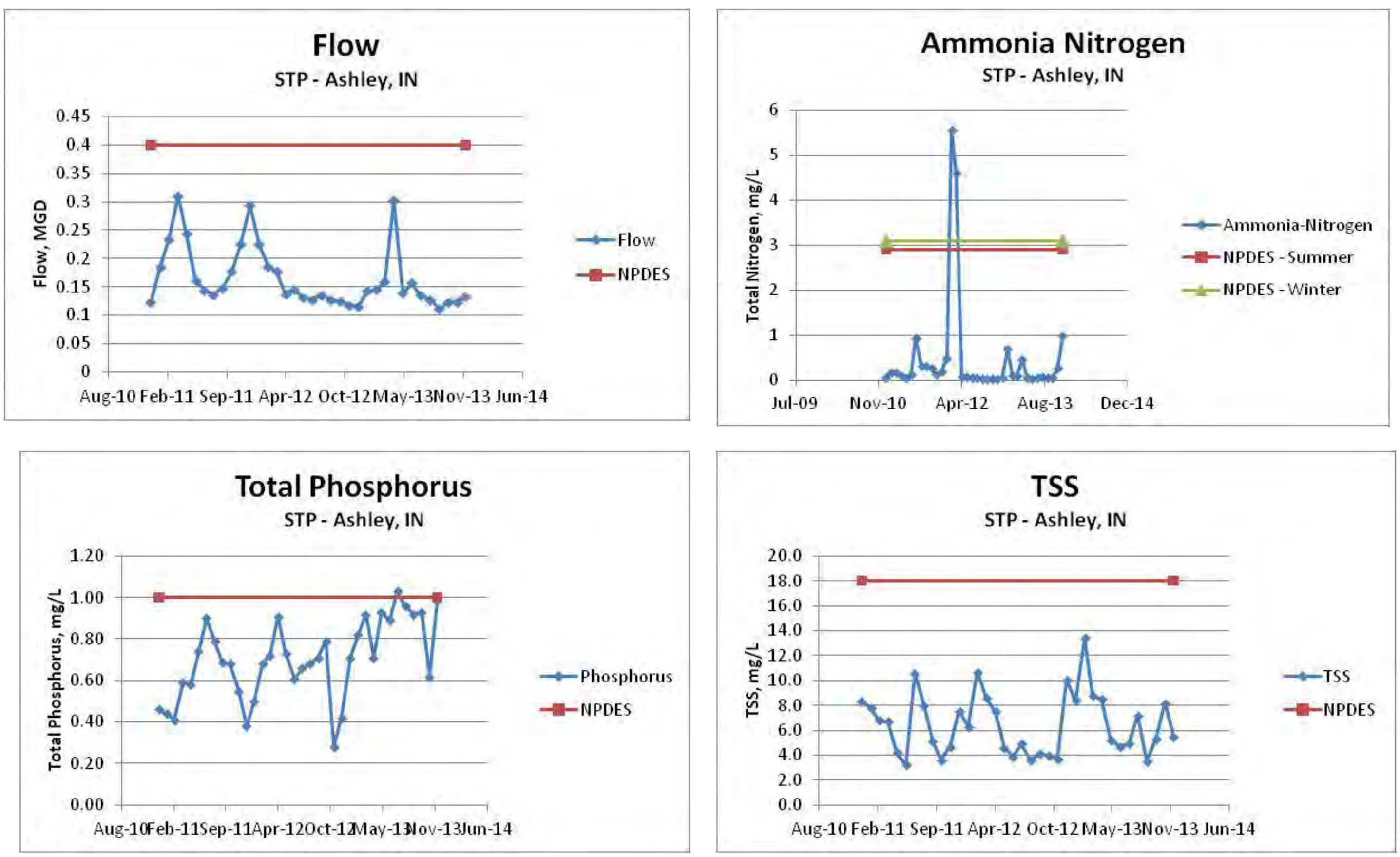
There were no permit limit exceedances (by monthly average) between January 2011 and December 2012. Results also show that effluent is well below permitted limits all of the time.

Ashley Waste Water Treatment Plant

The Town of Ashley maintains a Sequencing Batch Reactor (SBR) style wastewater treatment facility for the Towns of Ashley and Hudson. The capacity is 400,000 gallons per day. The new wastewater facility was completed in the fall of 2006. The facility consists of an influent flowmeter, a comminutor, a manually cleaned bar screen, two sequential batch reactors, phosphorus removal via liquid alum injection, ultraviolet light disinfection, post cascade aeration, and an effluent flowmeter. Sludge handling includes two aerobic digesters and five sludge drying beds. Final solids are sent to a landfill for disposal. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The discharge point, Outfall 001, is located at latitude: 41° 36' 11" N, Longitude: 85° 14' 05" W. The receiving waterbody is Johnson Ditch. The water quality analysis compared effluent flow, ammonia-nitrogen, *E. coli*, TSS and Phosphorus to NPDES permit limits for the wastewater treatment facility. Monthly averages for each data set have been plotted for the period between January 2011 and December 2013. The results show that permit limits were exceeded, by monthly average. The results of the analysis are shown in Figure 41.

Figure 41 – Ashley WWTP Water Quality Results



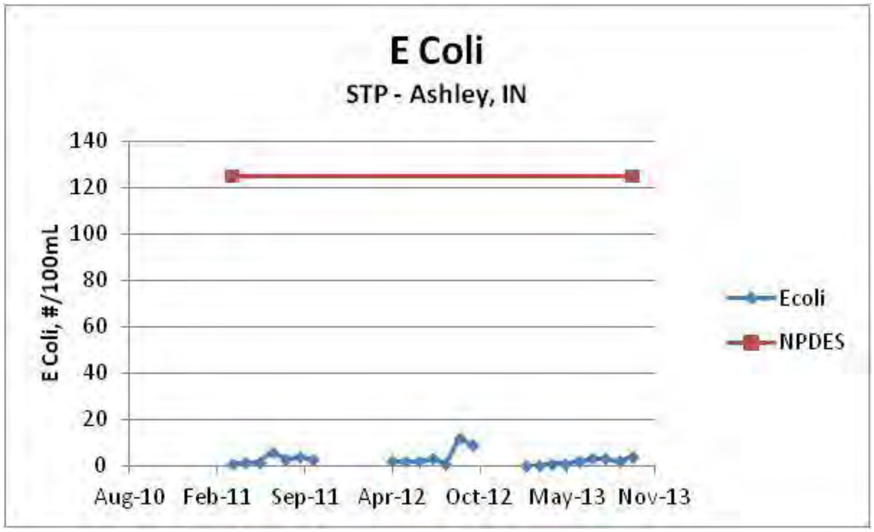


Table 50 shows permit limit exceedances (by monthly average) between January 2011 and December 2013. The results show that only permit limits for nitrogen and phosphorus were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 50 - Ashley WWTP Permit Exceedances

Parameter	Monthly Average exceeded NPDES Permit Limit	Remarks
Flow	None	
Ammonia Nitrogen	February 2012, March 2012	The winter limit is 3.1 mg/L. The reported monthly average for these two months was 5.56 and 4.6 mg/L.
Total Phosphorus	July 2013	The limit is 1.0 mg/L. The reported monthly average for this month was 1.03 mg/L. There is an exception to the limit when the influent raw wastewater phosphorus is less than 5 mg/L in which case, a degree of reduction is prescribed and calculated based on monthly average raw and final concentrations. However, influent phosphorus was 6.49 mg/L for the month in question.
TSS	None	
E. Coli	None	

Confinement Operations

Animal feeding operations can be sources of nutrients and bacteria to downstream waterbodies through the mobilization and transportation of phosphorus and bacteria-laden materials from feeding, holding, and manure storage areas.

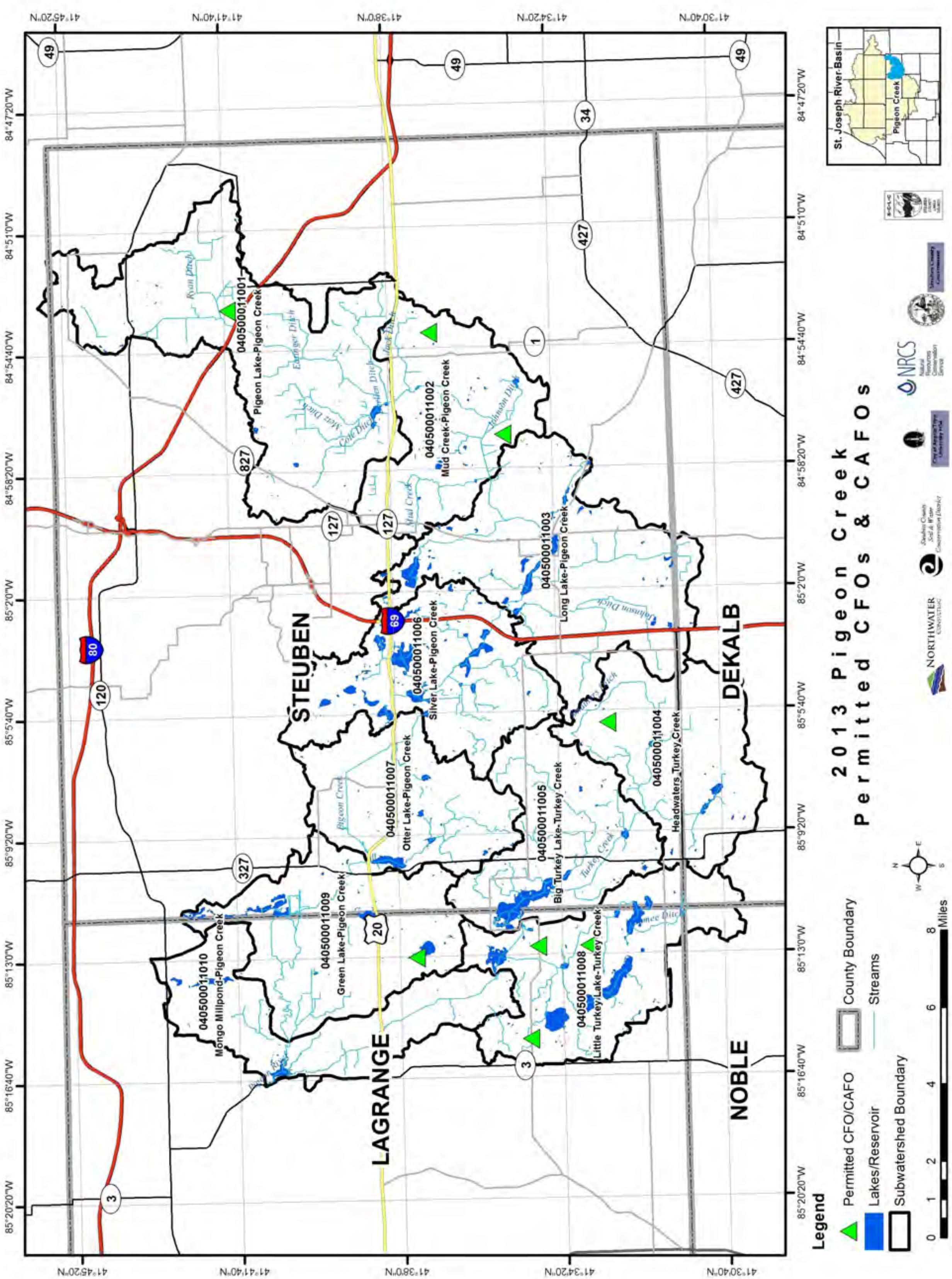
IDEM's Office of Land Quality regulates CFOs and has established and enforced standards that prohibit discharge from CFOs. Confined Feeding Operations are any animal feeding operations engaged in the confined feeding of at least 300 cattle, or 600 swine or sheep, or 30,000 fowl, such as chickens, turkeys, or other poultry. Compliance issues may occur that result in discharges, and land application of collected manure is common. Eight CFOs were identified in the Pigeon Creek watershed. Little Turkey Lake-Turkey Creek has the highest density of CFOs in the basin. The animals permitted for each site are listed in Table 51 and locations are shown in Figure 42. None of these sites are identified as having boars, beef calves, veal calves, layers, pullets, broilers, turkeys, ducks, sheep, or horses.

There are two (2) CAFOs within the watershed. The removal and disposal of manure, litter, or processed wastewater that is generated as a result of confined feeding operations falls under the regulations for CFOs and CAFOs. The CFO and CAFO regulations require that operations "not cause or contribute to an impairment of surface waters of the state." IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. Due to size, some confined feeding operations are defined as CAFOs, although all CAFOs are confined feeding operations. The CAFO regulation, however, contains more stringent operational requirements and slightly different application requirements.

Table 51 - Confined Feeding Operations

CFO/CAFO	Type	Farm ID #	HUC 12	Nursery Pigs	Finishers (pigs or hogs)	Sows	Beef Cattle	Dairy Cattle	Dairy Calves	Dairy Heifers
Twin Pines Farm Incorporated	CFO	291	Little Turkey Lake-Turkey Creek - 04050001108	0	1,300	0	0	0	0	0
Hilltop Dairy LLC	CFO	1005	Little Turkey Lake-Turkey Creek - 04050001108	0	0	0	0	220	15	0
Springfield Swine	CFO	4004	Green Lake-Pigeon Creek - 040500011009	920	2,376	288	0	0	0	0
Perkins Twin Creek Farm	CFO/CAFO	6390	Little Turkey Lake-Turkey Creek - 04050001108	0	0	0	0	400	74	0
John D Smith & Sons Inc.	CFO	1082	Mud Creek-Pigeon Creek - 040500011002	2,880	0	0	0	0	0	0
John D Smith & Sons Inc.	CFO	1108	Mud Creek-Pigeon Creek - 040500011002	2,880	0	0	0	0	0	0
Stockwell Acres Inc.	CFO	6650	Headwaters Turkey Creek - 040500011004	0	0	0	0	451	85	315
NEI Dairy LLC	CFO/CAFO	6067	Pigeon Lake -Pigeon Creek - 040500011002	0	0	0	0	1,620	0	0

Figure 42 - Pigeon Creek Confinement Operations



7.1.2 Nonpoint Source Pollution

Nonpoint-source pollution in the Pigeon Creek watershed makes up a considerable percentage of the overall pollution load. The majority of bacteria, phosphorus, sediment, and nitrogen impacting water quality in the watershed are the direct result of nonpoint-source pollution and runoff. Despite the fact that significant progress has already been made to address nonpoint-source pollution through on-the-ground project implementation and education, more work is needed to achieve any substantial reductions in the overall watershed pollutant load.

Agricultural Runoff; Row Crops

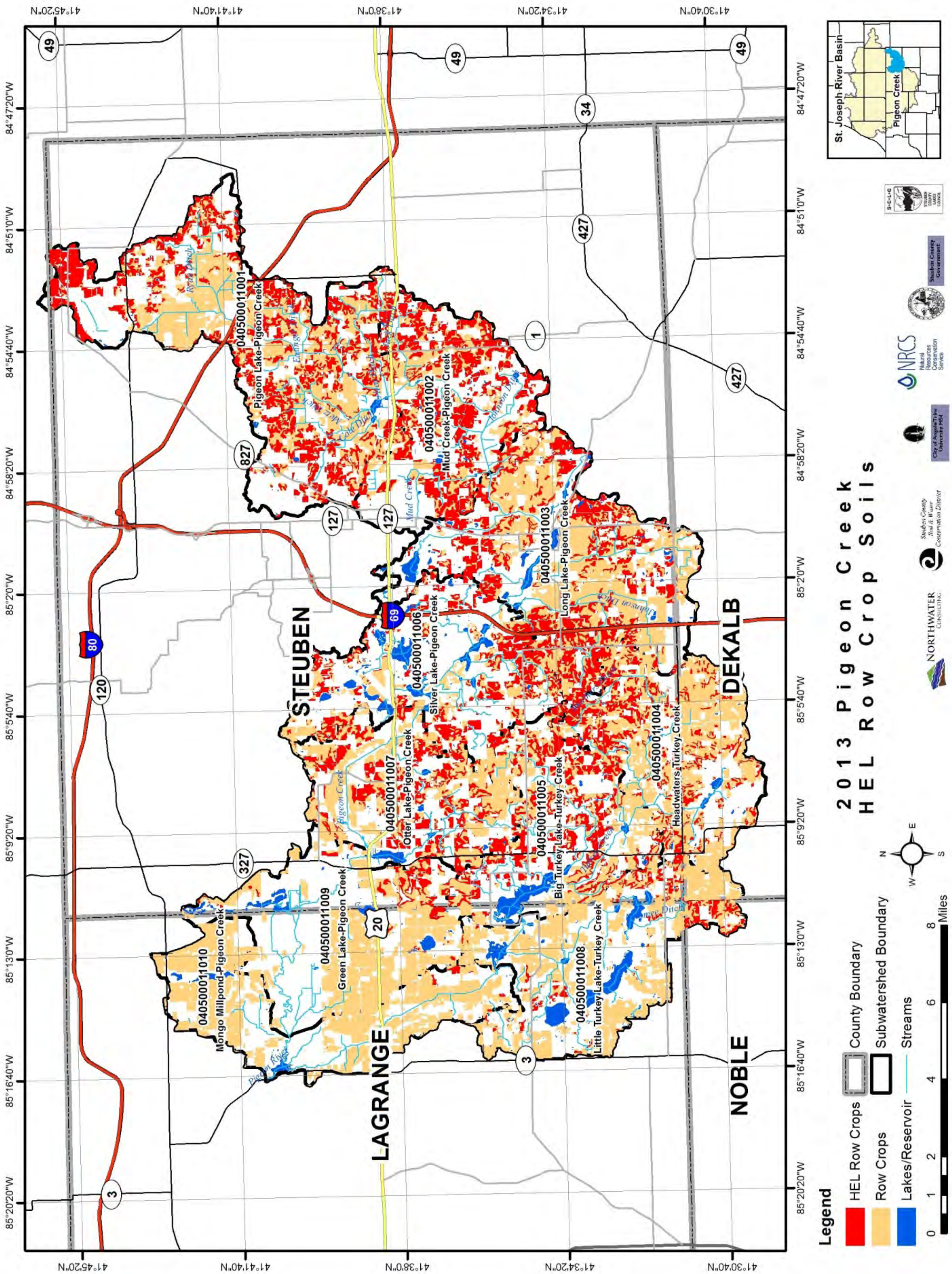
Cropland is a source of sediment, phosphorus and nitrogen due to fertilizer use and disturbed soils. Rainfall events can cause soils and nutrients to run off the land and be transported to waterbodies. Additionally, cropland can be a source of bacteria, if manure is applied to the field. Soil erosion from crop ground is not only a watershed problem or concern by itself, but is a source of particulate phosphorus as well. Highly Erodible Land in close proximity to a waterbody or unrestricted tile inlet, where conventional or traditional tillage is occurring, produces higher sediment and nutrient loads per acre. A custom landuse GIS layer identifies the location and extent of row crops within the Pigeon Creek watershed indicating a total land area of 69,396 acres (51%) of the watershed. There are currently 22,767 acres of row crop ground also considered to be HEL representing 33% of all row crops in the watershed. Table 52 breaks down the area of HEL soils in each subwatershed; Figure 43 shows the extent of these areas and the potential sources of sediment, nutrients and bacteria from row crops in the watershed.

Table 52 - Highly Erodible Row Crop Soils

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) HEL Row Crop Soils	Percent Subwatershed Area (acres)
Pigeon Lake-Pigeon Creek	040500011001	22,036	5,508	25%
Mud Creek-Pigeon Creek	040500011002	11,641	3,455	30%
Long Lake-Pigeon Creek	040500011003	18,620	4,134	22%
Headwaters Turkey Creek	040500011004	11,798	1,965	17%
Big Turkey Lake-Turkey Creek	040500011005	11,015	2,278	21%
Silver Lake-Pigeon Creek	040500011006	12,954	2,111	16%
Otter Lake-Pigeon Creek	040500011007	10,491	2,103	20%
Little Turkey Lake-Turkey Creek	040500011008	13,255	683	5%
Green Lake-Pigeon Creek	040500011009	13,581	474	3%
Mongo Millpond-Pigeon Creek	040500011010	10,520	56	0.5%
Grand Total		**135,911**	**22,767**	**17%**

Information gathered from the Steuben County SWCD indicates that agricultural producers in the county have implemented conservation practices throughout the watershed. The majority of producers use some type of conservation tillage practice (no-till, mulch-till, or reduced-till). Many producers also have erosion control BMPs in place on HEL ground and are actively managing for erosion. Croplands with effective conservation practices have lower rates of nutrient, sediment, and bacteria runoff than similar ground without these practices.

Figure 43 - Pigeon Creek HEL Row Crop Soils



Agricultural Runoff; Small Animal Feeding Operations

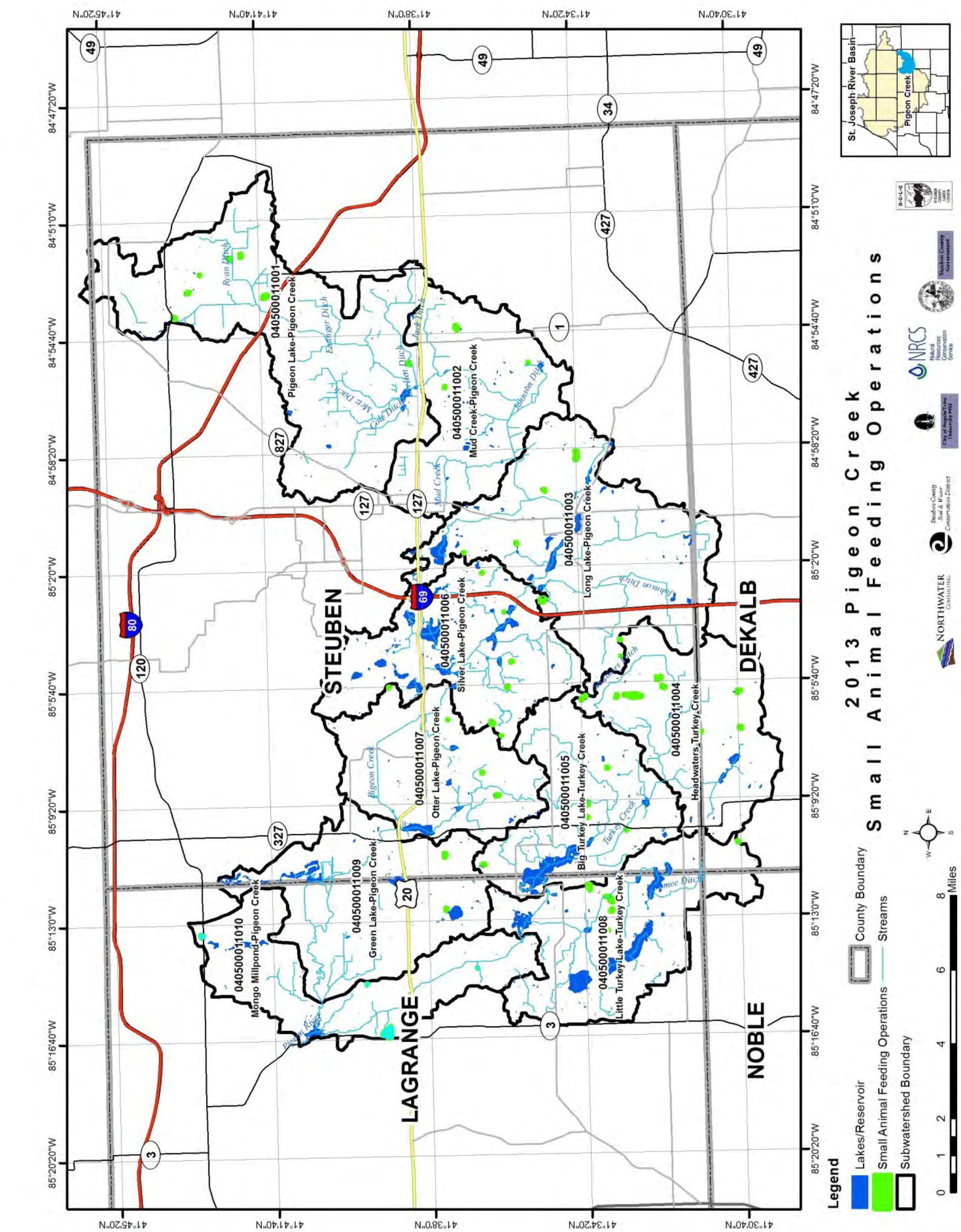
Small animal feeding operations can also be a source of bacteria and nutrients to waterbodies. Operations raising a smaller number of animals are not regulated as a CFO or CAFO, but still result in production of manure. Smaller animal facilities may add bacteria to surface waters via wastewater from these facilities or stormwater runoff from near-stream pastures. Livestock management practices for small operations may include manure storage and application at rates needed for crop growth; collection and treatment of runoff from feeding pens; grazing plans, fencing, and buffers to limit animal access to wetlands, streams, and other waterbodies; along with other practices. These types of livestock management practices are expected to reduce the rate of nutrient and bacteria runoff from agricultural properties when compared to similar ground without these practices.

An analysis of existing landuse information gathered during a watershed survey helped to locate many of these small feed operations. During the survey, an attempt was made to rank each feed area in terms of potential impact to water quality. A ranking of high indicates evidence of substantial waste runoff, close proximity to a receiving waterbody, and a relatively high number of animals. A ranking of low indicates minimal runoff with controls such as buffers or lagoons in place, a substantial distance from a receiving waterbody, and a small number of animals. Table 53 lists the breakdown in acres for each subwatershed, a summary of potential water quality impacts, and the average distance of all operations to the closest watercourse. The summary of potential water quality impacts represents an average by subwatershed based on visual observations and a ranking of each individual feeding operation. Figure 44 shows the location of these operations in the watershed. There are a total of 85 (161 acres) known small animal feeding operations in the Pigeon Creek watershed; these operations are located an average of 577 feet from the nearest watercourse. It is important to note that several small feed areas in the watershed are very well managed and have extensive best management practices in place to control runoff. Information on pollution loading and specific BMPs for these areas are listed in subsequent sections.

Table 53 - Small Animal Feeding Operations

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Small Animal Feed Areas	Average Distance to Watercourse (feet)	Potential Impact on Water Quality
Pigeon Lake-Pigeon Creek	040500011001	22,036	21	518	Medium
Mud Creek-Pigeon Creek	040500011002	11,641	6	433	High
Long Lake-Pigeon Creek	040500011003	18,620	15	594	Medium-High
Headwaters Turkey Creek	040500011004	11,798	37	1,293	Medium-High
Big Turkey Lake-Turkey Creek	040500011005	11,015	5	558	High
Silver Lake-Pigeon Creek	040500011006	12,954	10	440	Medium
Otter Lake-Pigeon Creek	040500011007	10,491	6	607	Medium-High
Little Turkey Lake-Turkey Creek	040500011008	13,255	17	456	High
Green Lake-Pigeon Creek	040500011009	13,581	6	354	High
Mongo Millpond-Pigeon Creek	040500011010	10,520	38	535	High
Grand Total		**135,911**	**161**	**577 (avg)**	

Figure 44 - Pigeon Creek Small Animal Feed Areas



Agricultural Runoff; Pastured Animals

Pastured animals are a potential source of bacteria and nutrients to nearby waterbodies, especially if animals have access to the waterbodies. Livestock with direct access to stream environments may add bacteria directly to surface waters or re-suspend particles that had settled on the stream bottom. Direct deposit of animal wastes can result in high bacteria counts and can also contribute to downstream impairments. Observations made during a windshield survey noted numerous instances of livestock access to adjacent streams or ponds. Stormwater runoff from near-stream pastures may add bacteria and nutrients to nearby waterbodies. The landuse of the Pigeon Creek watershed includes hay or pasture land on 7,471 acres (5%) of the land area, all with varying levels of pasture quality and proximity to receiving waterbodies. Table 54 breaks out pasture area by subwatershed and Figure 45 shows the distribution throughout Pigeon Creek.

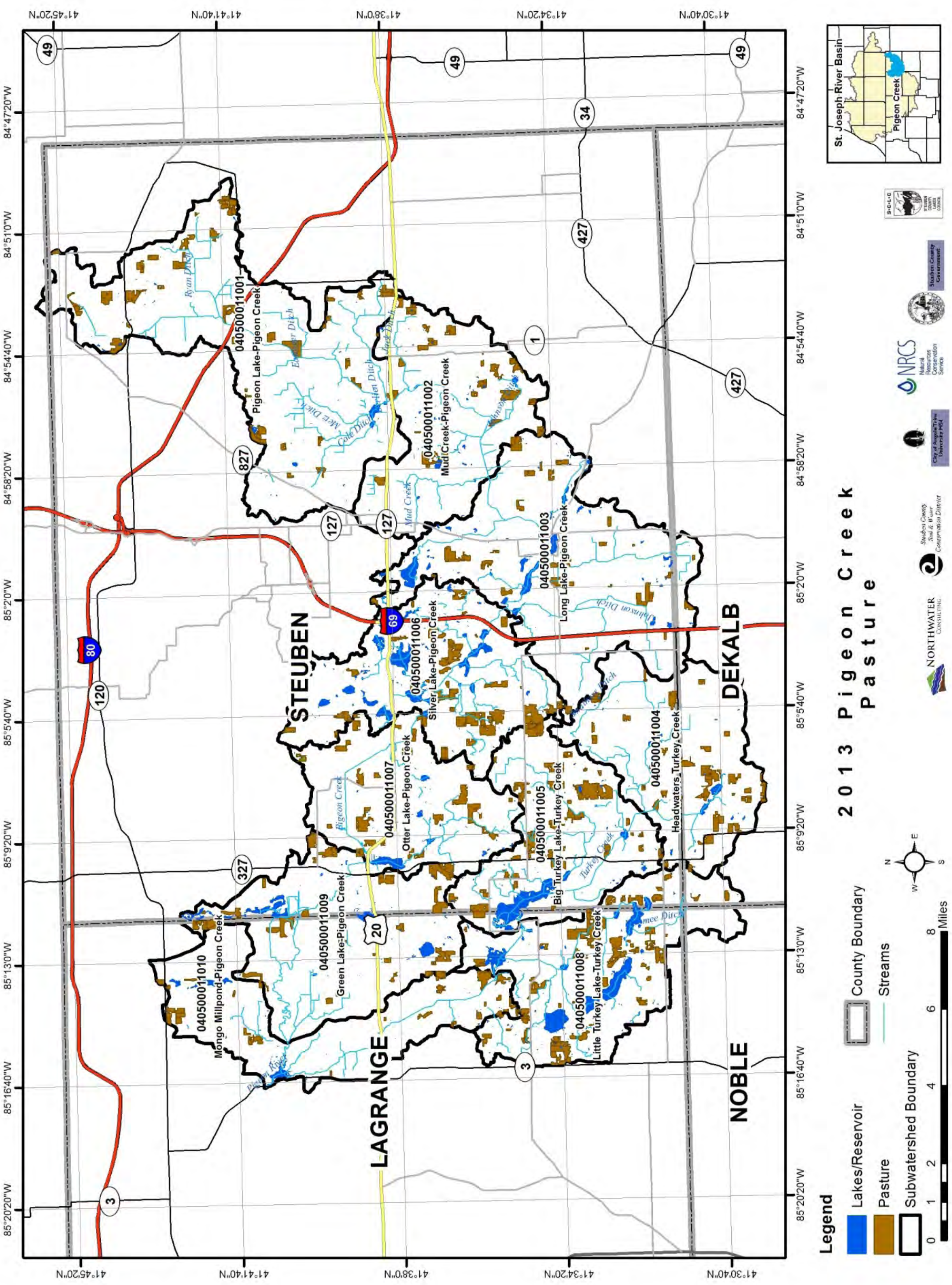
Table 54 - Pasture

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Pasture	Percent Subwatershed Area (acres)
Pigeon Lake-Pigeon Creek	040500011001	22,036	874	4%
Mud Creek-Pigeon Creek	040500011002	11,641	533	5%
Long Lake-Pigeon Creek	040500011003	18,620	558	3%
Headwaters Turkey Creek	040500011004	11,798	608	5%
Big Turkey Lake-Turkey Creek	040500011005	11,015	954	9%
Silver Lake-Pigeon Creek	040500011006	12,954	1,007	8%
Otter Lake-Pigeon Creek	040500011007	10,491	615	6%
Little Turkey Lake-Turkey Creek	040500011008	13,255	1,142	9%
Green Lake-Pigeon Creek	040500011009	13,581	774	6%
Mongo Millpond-Pigeon Creek	040500011010	10,520	406	4%
Grand Total		**135,911**	**7,471**	**5%**

Agricultural Runoff; Land Application of Manure

Improper land application of manure from animal feeding operations is an additional source of nutrients and bacteria to downstream waterbodies. There are no existing records regarding location, volume, and frequency of land application of manure. IDEM assumes that land application of manure occurs within five miles of animal feeding operations. The Pigeon Creek watershed contains two regulated CAFOs and eight (8) CFOs, two of which are also considered CAFOs. These operations contain a total of 12,654 animals. There are also 85 unregulated small animal feeding operations in the watershed where land application of manure may be occurring.

Figure 45 - Pigeon Creek Pasture



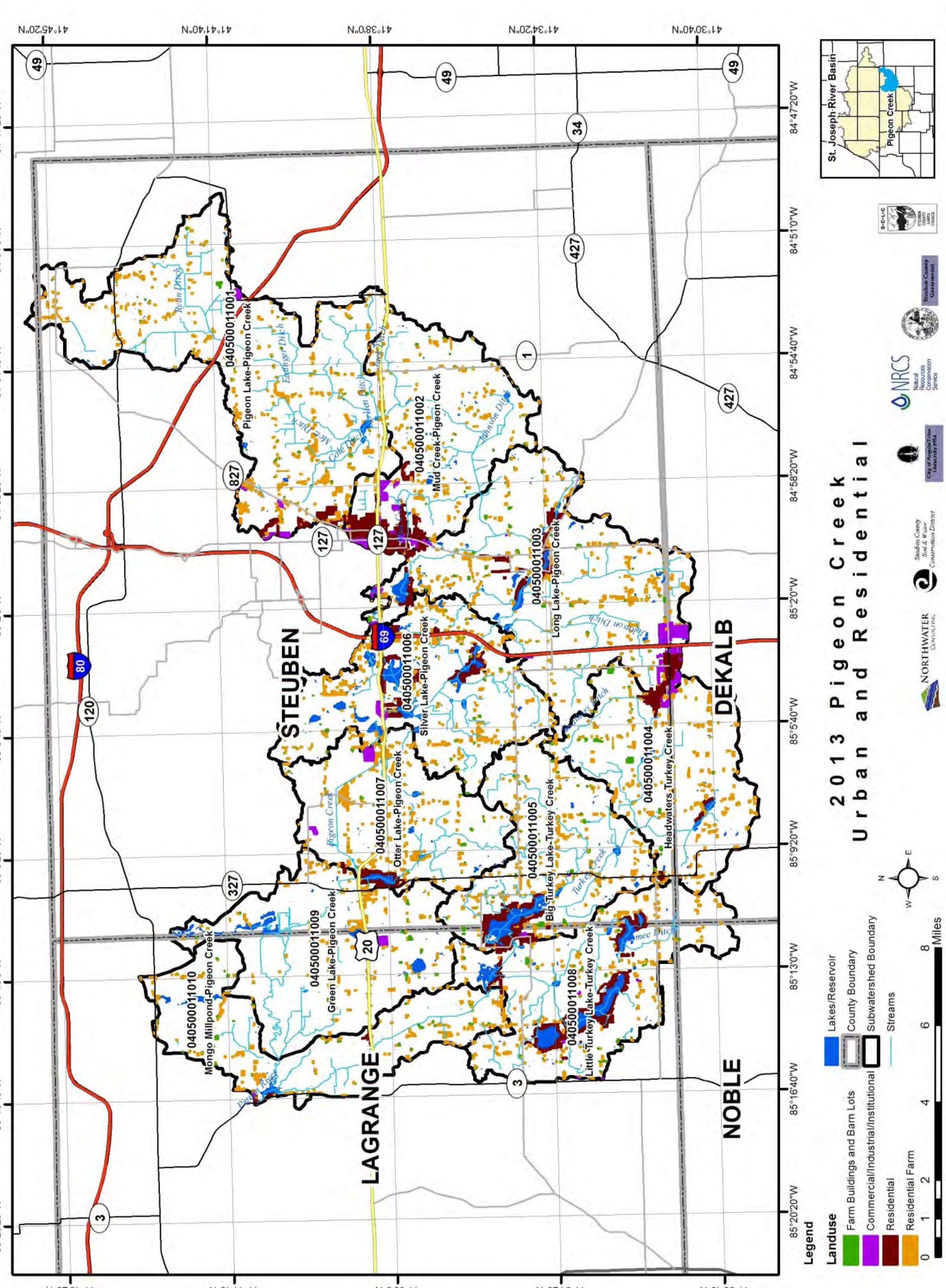
Urban & Residential Farm Runoff

Surface runoff from urban and residential areas in the watershed is also a potential source of phosphorus, nitrogen, sediment, and bacteria. An analysis of current landuse indicates that the watershed contains 371 acres (0.3%) farm buildings and barn lots; 845 acres, or 0.6%, commercial, industrial and institutional landuse; 2,466 acres (1.8%) urban or urban residential areas; and 4,516 acres (3.3%) residential farm homes. Table 55 provides a breakdown by subwatershed and Figure 46 shows the distribution throughout the watershed.

Table 55 - Urban & Residential Landuse

Subwatershed Names	HUC 12 Subwatershed Codes	Area (acres) Farm Buildings & Barn Lots	Percent Area	Area (acres) Commercial, Industrial and Institutional	Percent Area	Area (acres) Urban Residential	Percent Area	Area (acres) Residential Farm	Percent Area
Pigeon Lake-Pigeon Creek	040500011001	39	0.2%	80	0.4%	148	0.7%	740	3.36%
Mud Creek-Pigeon Creek	040500011002	15	0.1%	181	1.5%	590	5.1%	283	2.43%
Long Lake-Pigeon Creek	040500011003	60	0.3%	302	1.6%	486	2.6%	608	3.27%
Headwaters Turkey Creek	040500011004	53	0.4%	43	0.4%	91	0.8%	463	3.93%
Big Turkey Lake-Turkey Creek	040500011005	46	0.4%	14	0.1%	262	2.4%	386	3.50%
Silver Lake-Pigeon Creek	040500011006	19	0.1%	82	0.6%	298	2.3%	568	4.39%
Otter Lake-Pigeon Creek	040500011007	18	0.2%	60	0.6%	98	0.9%	472	4.50%
Little Turkey Lake-Turkey Creek	040500011008	52	0.4%	17	0.1%	449	3.4%	360	2.72%
Green Lake-Pigeon Creek	040500011009	26	0.2%	66	0.5%	14	0.1%	326	2.40%
Mongo Millpond-Pigeon Creek	040500011010	43	0.4%	1	0.01%	30	0.3%	309	2.94%
Grand Total		**371**	**0.3%**	**845**	**0.6%**	**2,466**	**1.8%**	**4,516**	**3.3%**

Figure 46 - Pigeon Creek Urban & Residential Areas



Legacy Stream Sediment

On December 4th, 2013, two samples of water were taken at sample site 1A (Ray Clarke Rd.), one under normal conditions and one after stirring up sediment in the stream. Under normal conditions, results showed *E. coli* levels of 52 cfu/100ml and, after stirring up sediment, *E. coli* concentrations jumped to 300 cfu/100ml. Although this is only a single sample event, results indicate that a source of bacteria could be originating from deposited or legacy streambed sediment. This sediment is likely re-suspended during high flow or storm events, resulting in higher bacteria concentrations in the water column. To support this theory, two reports (listed below) relevant to Indiana can be referenced. Both reports covering the same study looked at riparian sediment as a source of bacteria in the Dunes Creek Watershed in Indiana Dunes State Park and concluded that Dunes Creek is a source of bacteria. Results showed that bacteria from nonpoint sources are common in shallow, submerged sections of the creek and are held and subsequently released by soil and sediment erosion.

1. *Distribution and Characterization of E. coli within the Dunes Creek Watershed, Indiana Dunes State Park*
2. *Ubiquity and Persistence of Escherichia coli in a Midwestern Coastal Stream*

Wildlife

According to the 2012 TMDL plan, wildlife waste is a source of bacteria in the watershed. The statewide population of Greater Canada geese in Indiana was estimated to be 84,215 in 2009. Steuben and LaGrange counties are expected to have large deer populations as these counties have a high deer harvest. Also noted in the 2012 TMDL document, while wildlife waste is a source of bacteria to waterbodies, it appears to be a minor source in this watershed compared to other sources. Management of wildlife to reduce the delivery of feces to waterbodies is not a priority in the Pigeon Creek watershed. Large tracts of high quality wildlife habitat exist in the lower reaches and headwaters of the watershed, as well as isolated patches or Conservation Reserve Program (CRP) ground. These areas, in addition to existing forest and grassland, are home to both resident and migrating wildlife and a source of bacteria.

Field Tiles & Hydrologic Modifications

Drainage tiles in agricultural fields create direct conduits to downstream waterbodies through which nutrients and bacteria may be discharged. Data on the specific location of all field tiles is unavailable for the watershed but observations made during a watershed survey indicate tiling is used extensively. Regulated drainage systems and open ditches are also present throughout the Pigeon Creek watershed; these systems capture and subsequently drain much of the existing tile flow. Cultivated cropland covers about 51% of the Pigeon Creek watershed and many producers rely on tile drainage for production. As a result of local geology and topography, many farm fields drain to a central location or depressional zone such as a wetland. Tiles are installed in these areas and through adjacent wetlands to ensure standing water does not damage crops. As noted previously in Section 3.2.3 (hydrologic modifications), the Pigeon Creek watershed has 177 miles of channelized ditches, 222 miles of known tile, 929 acres of legal ditches and over 6,000 acres of irrigated ground.

7.2 Pollution Loads

A spatial, event-based pollution load model was used as a tool to predict and quantify soil erosion, phosphorus, nitrogen, and bacteria loading in the watershed. The Spatial Watershed Assessment and Management Model (SWAMM) accounts for slope, soil type, precipitation and land use to estimate annual and storm-event sediment, phosphorus, nitrogen, and bacteria loading. SWAMM is customized to the watershed, is map-based, and can be used to target high loading areas. Another strength of SWAMM is that it can aid in estimating site-specific load reductions based on the placement of BMPs. It is calibrated to local in-stream water quality and can provide estimates of watershed pollutant yields. It is important to note that a model's output is only as good as the data provided to it.

The SWAMM prepared for Pigeon Creek includes high-resolution input data unique to the watershed and is calibrated to analytical water quality data. The Pigeon Creek SWAMM was not built to include groundwater flow and, due to the lack of information on the location of gully and streambank erosion, it does not directly estimate loading from these sources. To address this, observed estimates of gully erosion, and general estimates of septic system loading, are presented separately in this section. Gullies that were measured in the field during the windshield survey are also included in this section (Table 57) and factored into the overall watershed loading. Total watershed pollution loading is presented in Table 56 and includes all modeled nonpoint source totals, all wastewater loading, observed gully erosion loading, and failing septic system loading. Due to the fact that septic loading totals are calculated for the watershed as a whole, they have been divided up equally among subwatersheds in Table 56.

Table 56 - Pigeon Creek Watershed Total Pollution Load

Subwatershed Name	2012 HUC12 Subwatershed Codes	Watershed Acres	Phosphorus Load (lbs/yr)	Nitrogen Load (lbs/yr)	Sediment Load (tons/ yr)	Fecal Coliform (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	22,036	28,745	190,871	23,581	53,337
Mud Creek-Pigeon Creek	40500011002	11,641	19,351	99,877	14,485	38,933
Long Lake-Pigeon Creek	40500011003	18,620	25,186	159,298	20,213	49,853
Headwaters Turkey Creek	40500011004	11,798	15,721	100,827	14,045	34,690
Big Turkey Lake-Turkey Creek	40500011005	11,015	11,296	73,206	9,685	32,204
Silver Lake-Pigeon Creek	40500011006	12,954	11,236	73,461	9,904	36,608
Otter Lake-Pigeon Creek	40500011007	10,491	12,896	63,731	8,920	30,109
Little Turkey Lake-Turkey Creek	40500011008	13,256	13,980	93,259	12,455	38,507
Green Lake-Pigeon Creek	40500011009	13,581	9,038	57,312	8,275	28,189
Mongo Millpond-Pigeon Creek	40500011010	10,520	11,107	57,500	6,448	27,053
Total		**135,911**	**158,556**	**969,341**	**128,012**	**369,481**

7.2.1 Nonpoint-Source Pollution Loading

The Pigeon Creek nonpoint-source SWAMM incorporates landuse data, soils and precipitation to calculate annual runoff using the Curve Number approach; literature-based Event Mean Concentrations (EMCs) and the Universal Soil Loss Equation (USLE) are incorporated to calculate loading. The model assumes uniform rainfall over the study area and uses a distance-based delivery ratio. The Pigeon Creek SWAMM was calibrated using data obtained during a windshield survey and an analysis of existing water quality data. Calibrated model values are within acceptable ranges. Appendix F includes a complete SWAMM methodology.

Due to project limitations and property access concerns, streambank erosion estimates are excluded from the overall loading totals. General watershed observations of streambanks during the windshield survey and discussions with local agency staff indicate that although streambank erosion is occurring in the watershed, it is not a major source of sediment or nutrients.

Gully erosion was assessed during a watershed-wide windshield survey where active gullies were visible. A total of twenty-one (21) actively eroding gullies were observed. Using formulas derived from Region 5 EPA's spreadsheet tool for "Estimating Pollutant Load Reductions for Nonpoint Source Pollution Control BMPs," sediment and nutrient loads are assessed. Results indicate that observed active gully erosion is contibuting 508 tons/year of sediment, 1,017 lbs/year of nitrogen and 610 lbs/year of phosphorus. Table 57 provides a breakdown of gully erosion by subwatershed.

Table 57 - Gully Erosion Pollution Loading

Subwatershed Name	2012 HUC12 Subwatershed Codes	Number of Gullies	Phosphorus Loading (lbs/yr)	Nitrogen Loading (lbs/yr)	Sediment Loading (tons/ yr)
Pigeon Lake-Pigeon Creek	40500011001	1	2.8	4.7	2.3
Mud Creek-Pigeon Creek	40500011002	2	199	331	166
Long Lake-Pigeon Creek	40500011003	4	152	253	126
Headwaters Turkey Creek	40500011004	3	58	97	48
Big Turkey Lake-Turkey Creek	40500011005	1	27	46	23
Silver Lake-Pigeon Creek	40500011006	8	164	273	137
Otter Lake-Pigeon Creek	40500011007	0	0	0	0
Little Turkey Lake-Turkey Creek	40500011008	2	7.6	13	6.3
Green Lake-Pigeon Creek	40500011009	0	0	0	0
Mongo Millpond-Pigeon Creek	40500011010	0	0	0	0
Grand Total		**21**	**610**	**1,017**	**508**

Table 58 lists total and per-acre modeled pollution loading results by subwatershed and Figures 47 through 50 show the spatial distribution of loading in the watershed. Results show that annual loading in the watershed is 0.98 lbs/ac for phosphorus, 6.75 lbs/ac for nitrogen, 0.94 tons/ac for sediment, and 1.57 billion CFU/ac. The Pigeon Lake subwatershed contributes the higest total and per- acre loads of phosphorus and nitrogen and the highest total sediment and bacteria load. Mud Creek contributes the highest per-acre sediment load and Long Lake contributes the highest per-acre bacteria load.

Table 58 - Modeled Pollution Loading Results

Subwatershed Name	2012 HUC12 Subwatershed Codes	Acres	Annual Runoff (ac-ft)	P (lbs/yr)	Per Acre P (lbs/yr)	N (lbs/yr)	Per Acre N (lbs/yr)	TSS (tons/ yr)	Per Acre TSS (tons/yr)	Fecal Coliform (billion colony-forming units/yr)	Per Acre Fecal Coliform (billion colony-forming units/yr)
Pigeon Lake-Pigeon Creek	40500011001	22,036	17,588	27,374	**1.24**	187,374	**8.50**	23,579	1.07	38,390	1.74
Mud Creek-Pigeon Creek	40500011002	11,641	9,741	12,674	1.09	87,773	7.54	14,242	**1.22**	21,066	**1.81**
Long Lake-Pigeon Creek	40500011003	18,620	15,491	22,449	**1.21**	153,970	**8.27**	20,072	**1.08**	34,212	**1.84**
Headwaters Turkey Creek	40500011004	11,798	8,794	14,295	**1.21**	97,237	**8.24**	13,997	**1.19**	19,743	1.67
Big Turkey Lake-Turkey Creek	40500011005	11,015	7,900	9,901	0.90	69,668	6.32	9,662	0.88	17,257	1.57
Silver Lake-Pigeon Creek	40500011006	12,954	9,331	9,704	0.75	69,695	5.38	9,767	0.75	21,661	1.67
Otter Lake-Pigeon Creek	40500011007	10,491	6,345	8,484	0.81	57,711	5.50	8,897	0.85	13,446	1.28
Little Turkey Lake-Turkey Creek	40500011008	13,256	9,905	12,605	0.95	89,754	6.77	12,449	0.94	23,560	**1.78**
Green Lake-Pigeon Creek	40500011009	13,581	6,635	7,670	0.56	53,819	3.96	8,275	0.61	13,242	0.98
Mongo Millpond-Pigeon Creek	40500011010	10,520	5,688	7,456	0.71	50,582	4.81	6,421	0.61	10,828	1.03
Total		**135,911**	**97,419**	**132,611**	**0.98**	**917,585**	**6.75**	**127,361**	**0.94**	**213,405**	**1.57**

Pigeon Creek; Streambank Erosion

Figure 47 - Annual Per Acre Phosphorus Loading

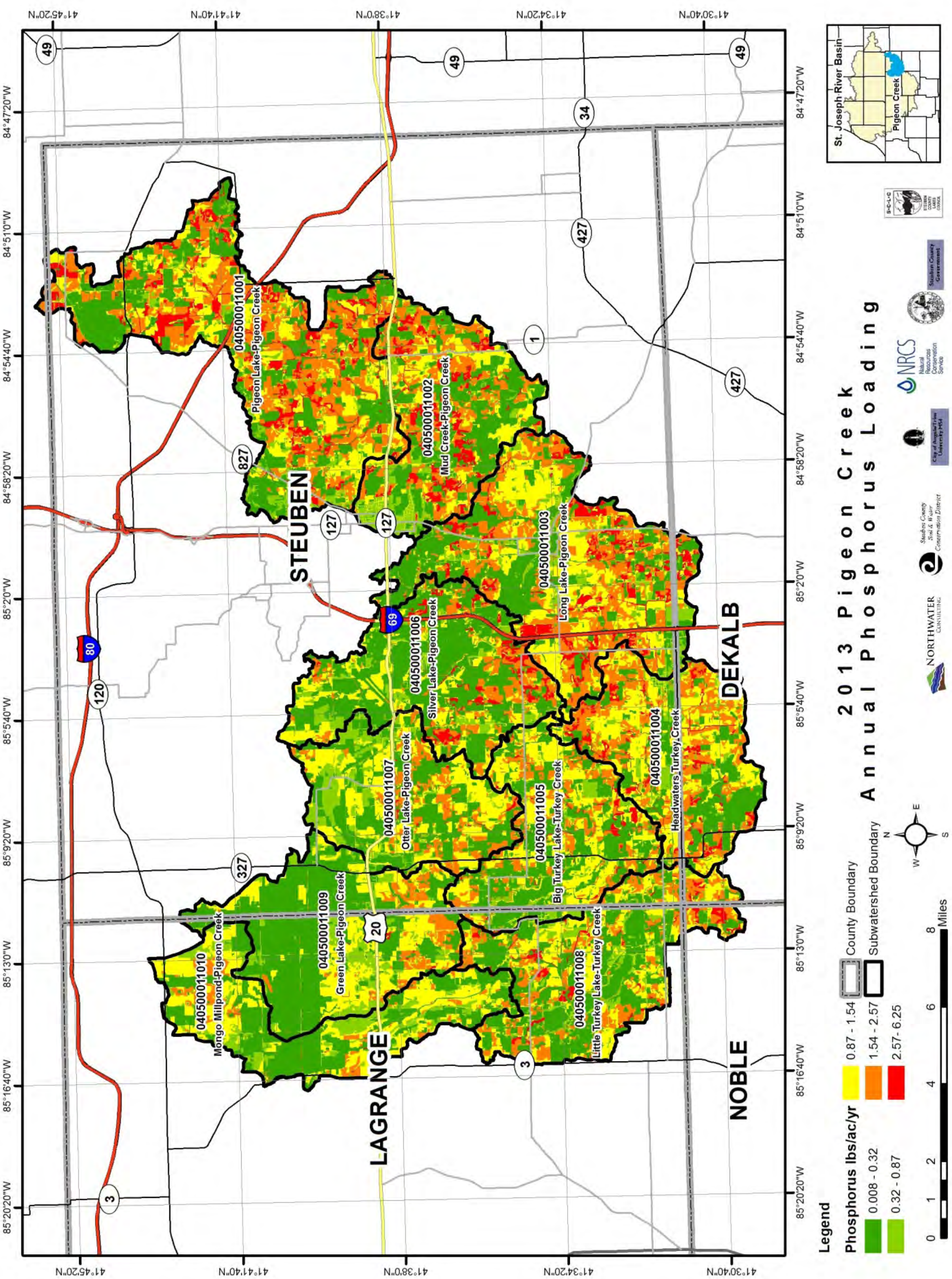


Figure 48 - Annual Per Acre Nitrogen Loading

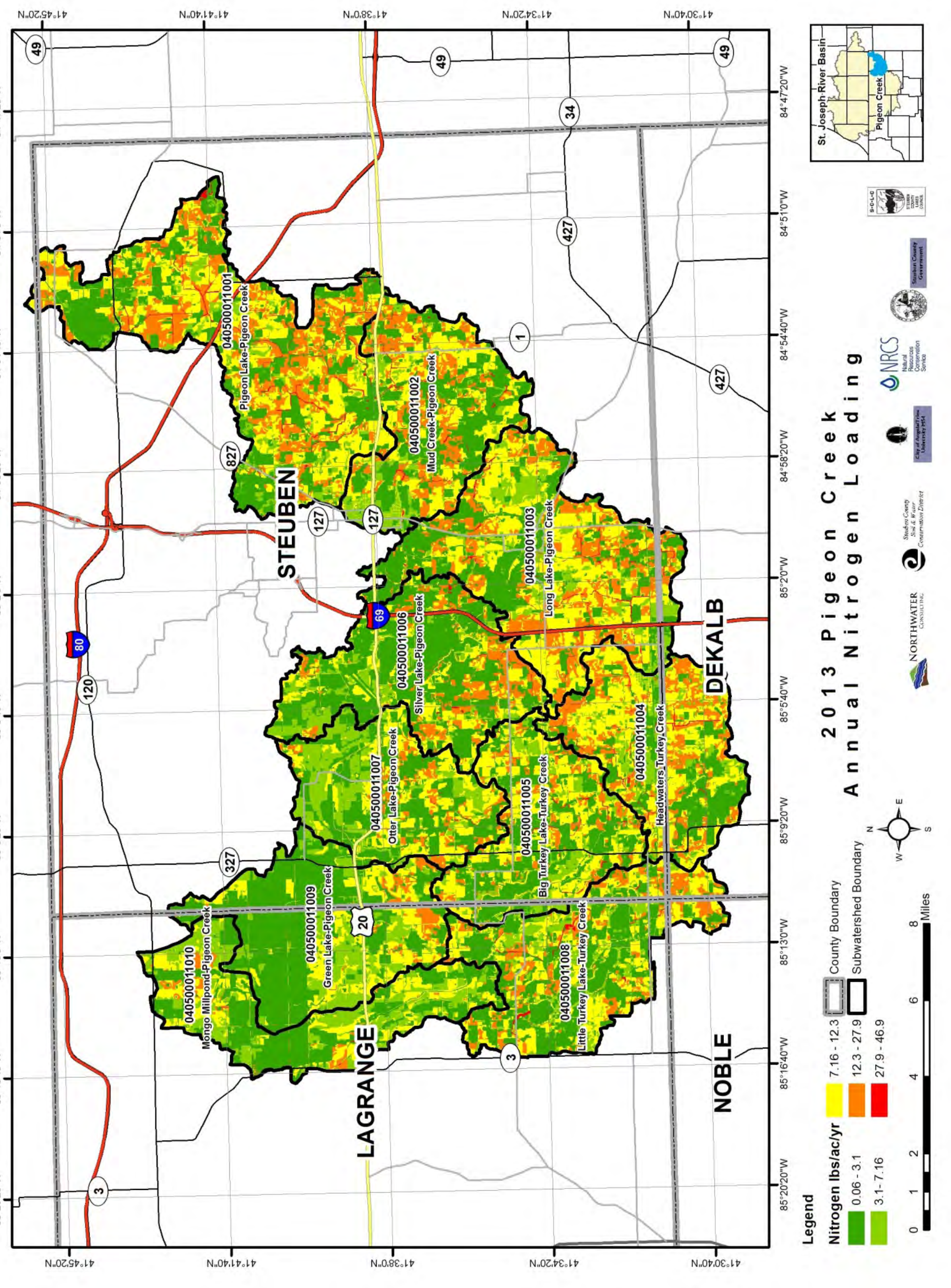


Figure 49 - Annual Per Acre Bacteria Loading

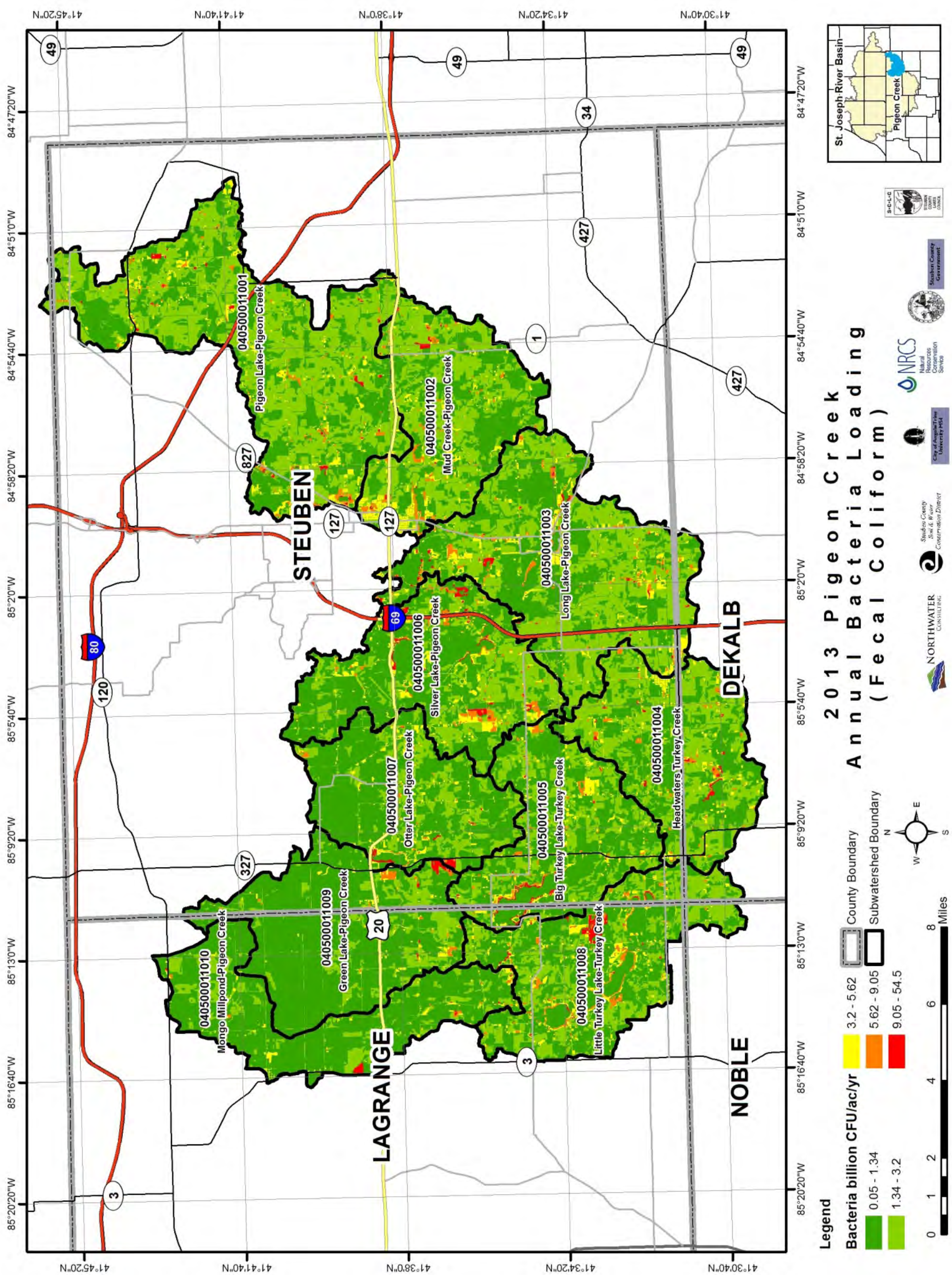
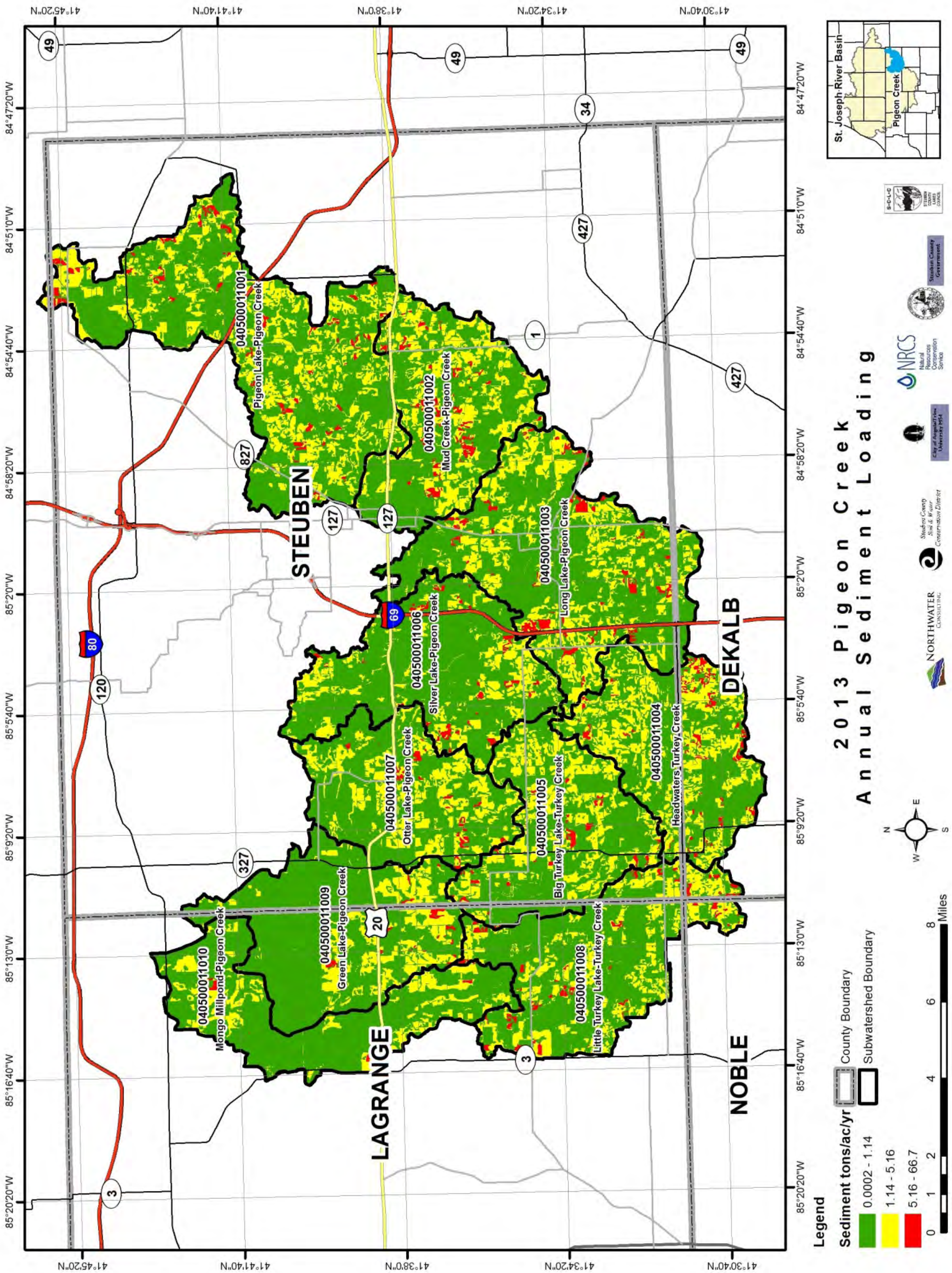


Figure 50 - Annual Per Acre Sediment Loading



7.2.2 Point-Source Pollution Loading

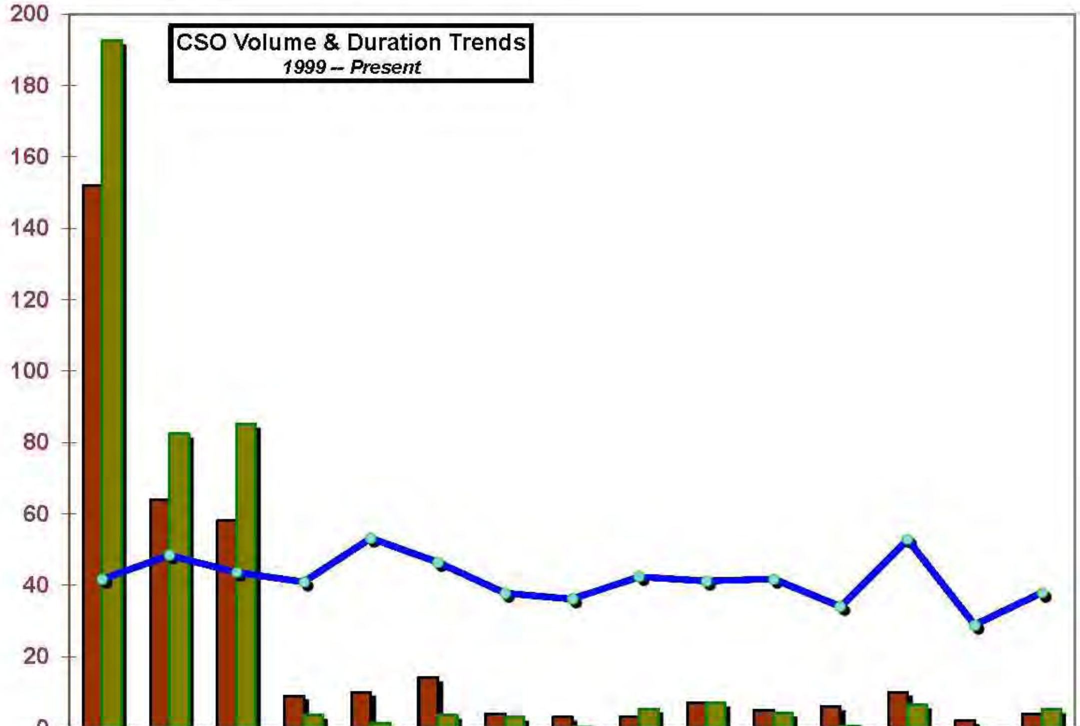
Taken directly from the 2012 Pigeon Creek TMDL plan, there are four (4) regulated point sources for which Waste Load Allocations (WLAs) have been calculated. The TMDL defines WLAs as an allocation of loads to these regulated discharges. WLAs were calculated based on each facility's design flow and permit limits. The permit limits used to calculate annual point source loading are as follows:

- *E. coli* permit limit of 125 cfu/100 mL for all facilities.
- Phosphorus permit limit of 1.0 mg/l for all facilities.
- TSS permit limit of 30 mg/l for Angola, 24 mg/l for LaGrange and Ashley and 15 mg/l for Steuben Lakes.
- Nitrogen using an ammonia-nitrogen standard of 1.6 mg/l for Angola, 1.5 mg/l for LaGrange, 1.3 mg/l for Ashley and 0.83 mg/l for Steuben Lakes.

The Angola Municipal WWTP also discharges to streams impaired due to nitrogen and phosphorus and, therefore, the TMDL plan calculated WLAs for these pollutants based on design flow and permit limits. Point-source pollution loading estimates presented in Table 59 are calculated from the TMDL WLA for phosphorus, nitrogen (only Angola WWTP) and *E. coli*. Sediment and nitrogen loads not included in the TMDL are calculated based on annual design flow and limits gathered from NPDES permits.

There are two CSOs within the project area, and they each have the potential to discharge to surface waters impaired for bacteria, nitrogen, and phosphorus. Both CSOs are in the watershed and are associated with the Angola Municipal WWTP. Figure 51 shows trends in CSO volume and duration from 1999-2013. Results indicate a sharp drop-off in CSO events starting in 2002 and remaining relatively steady though 2013, with a higher number of events during wet years. The two CSO events listed in 2012 occurred on July 18th and August 18th. The July event resulted in 12,520 gallons from Outfall 002 during a 1.12-inch rain. In August, a 0.7-inch rain resulted in a CSO volume from Outfall 003 of 969 gallons. In 2013, four CSO events were recorded including: two continuous events on April 23rd through April 24th, one on June 1st, one on June 25th, and one on July 10th. The first continuous event recorded April 23rd through April 24th occurred from Outfalls 002 and 003 and resulted in a combined 1.29 million gallons over three days under 1.57 inches of rain and saturated conditions where the WWTP was already at capacity. The June 1st event occurred at Outfalls 002 (0.045 million gallons) and 003 (0.031 million gallons) under 1.63 inches of rain. The third CSO event of 2013 on June 25th occurred at Outfalls 002 (0.06 million gallons) and 003 (0.07 million gallons), from 1.57 inches of rain. The fourth CSO event of 2013 occurred at Outfall 002 and resulted in 0.31 million gallons from 0.47 inches of rain.

Figure 51 - Angola CSO Volume & Duration Trends



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of CSO Events	152	64	58	9	10	14	4	3	3	7	5	6	10	2	4
Volume (MG)	192.5	82.4	85.1	3.5	1.3	3.5	3.0	0.163	5.299	6.911	4.097	0.527	6.484	0.011	5.081
Annual Rain (Inches)	41.6	48.4	43.6	40.9	53.1	46.4	37.7	36.1	42.3	41.1	41.7	34.0	52.7	28.8	37.8

There is one MS4 permit in the watershed, which is a joint permit between the City of Angola and Trine University (formerly Tri-State University). These communities discharge to waters impaired for *E. coli* and, therefore, received WLAs in the 2012 TMDL. Within the HUC 12 watershed 040500011002, the MS4 discharges to waters impaired for nitrogen and phosphorus, therefore, for these areas, the MS4 received WLAs for total nitrogen and total phosphorus in the TMDL.

Annual flow from WWTPs in the watershed is 3.85 million gallons per day, annual phosphorus load is 11,655 pounds, annual nitrogen load is 15,815 pounds, annual bacteria load totals approximately 6,608 billion colony-forming units, and annual sediment load is 142.4 tons. Table 59 provides detail regarding annual point source loads.

Table 59 – Annual Point Source Pollution Loading

HUC 12 Name	HUC 12 Code	Facility Name	Permit ID	Design Flow (million gallons/day)	Annual Phosphorus (lbs/yr)	Annual Nitrogen (lbs/yr)	Annual *E. coli* Load (billion CFU/yr)	Annual TSS Load (tons/yr)
Mud Creek-Pigeon Creek	040500011002	Angola Municipal WWTP	IN0021 296	1.7	5,110	8,280	2,920	77.6
Long Lake-Pigeon Creek	040500011003	Ashley Municipal STP	IN0022 292	0.4	1,218	1,583	694	14.6
Otter Lake-Pigeon Creek	040500011007	Steuben Lakes RWD	IN0061 557	1	3,044	2,527	1,716	22.8
Mongo Millpond-Pigeon Creek	040500011010	LaGrange Region B WWTP	IN0060 097	0.75	2,283	3,425	1,278	27.4
Grand Total				**3.85**	**11,655**	**15,815**	**6,608**	**142.4**

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Septic System Loading

Using an estimated 1,365 failing septic systems utilized by two people per system, bacteria and nutrient loading can be calculated for the watershed. Phosphorus and nitrogen loading was calculated using STEPL (Spreadsheet Tool for Estimating Pollution Loading) and bacteria loading was calculated using research done by the Water Environment Research Foundation (WERF) where, on average, bacteria loading from a failing septic system can equal 0.15 billion colony-forming units per person, per day. Table 60 lists loading totals from failing septic systems.

Table 60 - Nutrient & Bacteria Loading from Septic

Number of Failing Septic Systems	Number of People per structure	Annual Phosphorus Load (lbs/yr)	Annual Nitrogen Load (lbs/yr)	Annual bacteria Load (billion CFU/year)
1,365	2	13,679	34,926	149,468

7.3 Load Reductions

This section provides an overview of expected load reductions from recommended site-specific and basin-wide BMPs. These load reductions are compared against load-reduction targets presented in Section 8.1. A detailed description of BMPs and their individual load reductions are included in Section 9.0.

The implementation of BMPs detailed in Section 9 will have significant reductions in watershed pollution loading. Tables 61 and 62 list the total percent load reductions expected for both site-specific and basin-wide BMPs; percentages in red represent numerical load reduction goals for the watershed. Results indicate that widespread adoption of all basin-wide BMPs will meet, come close to meeting, or significantly exceed the percent reduction targets established by the 2012 TMDL and noted in Table 63 (Section 8.1). It should be noted that many basin-wide BMPs do overlap with each other and that total pollution loads do not account for streambank erosion or all gully erosion in the watershed. Also, modeled results are calibrated to sampled water quality data, which likely contributes to an underestimation of sediment load. As a result, percent reductions for sediment may be elevated. Site-specific BMPs will result in reductions; however, they alone are not sufficient enough to achieve the desired load reduction targets.

Table 61 - Expected Load Reduction Percentages from Basin-Wide BMPs

Subwatershed Name	2012 HUC12 Subwatershed Codes	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Sediment (tons/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	82%/49%	93%/94%	100%/43%	63%/76%
Mud Creek-Pigeon Creek	40500011002	62%/87%	87%/37%	100%/50%	62%/79%
Long Lake-Pigeon Creek	40500011003	80%/48%	95%/89%	100%/44%	63%/68%
Headwaters Turkey Creek	40500011004	74%/48%	87%/88%	93%/49%	68%/51%
Big Turkey Lake-Turkey Creek	40500011005	75%/29%	81%/44%	100%/31%	67%/50%
Silver Lake-Pigeon Creek	40500011006	67%/15%	69%/23%	90%/19%	59%/97%
Otter Lake-Pigeon Creek	40500011007	58%/22%	80%/25%	100%/28%	68%/52%
Little Turkey Lake-Turkey Creek	40500011008	54%/33%	64%/54%	70%/35%	54%/87%
Green Lake-Pigeon Creek	40500011009	48%/0%	52%/0%	51%/0%	62%/23%
Mongo Millpond-Pigeon Creek	40500011010	35%/11%	49%/10%	40%/0%	64%/18%
Total		67%	81%	96%	63%

Table 62 - Expected Load Reduction Percentages from Site-Specific BMPs

Subwatershed Name	2012 HUC12 Subwatershed Codes	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Sediment (tons/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	5%/49%	5%/94%	1%/43%	2%/76%
Mud Creek-Pigeon Creek	40500011002	5%//87%	5%/37%	9%/50%	6%/79%
Long Lake-Pigeon Creek	40500011003	5%/48%	5%/89%	4%/44%	2%/68%
Headwaters Turkey Creek	40500011004	3%/48%	4%/88%	2%/49%	2%/51%
Big Turkey Lake-Turkey Creek	40500011005	5%/29%	6%/44%	2%/31%	1%/50%
Silver Lake-Pigeon Creek	40500011006	3%/15%	2%/23%	4%/19%	1%/97%
Otter Lake-Pigeon Creek	40500011007	1%/22%	1%/25%	1%/28%	0.4%/52%
Little Turkey Lake-Turkey Creek	40500011008	2%/33%	3%/54%	1%/35%	5%/87%
Green Lake-Pigeon Creek	40500011009	0.5%/0%	1%/0%	0.1%/0%	1%/23%
Mongo Millpond-Pigeon Creek	40500011010	1%/11%	1%/10%	1%/0%	2%/18%
Total		**4%**	**4%**	**3%**	**2%**

8.0 Critical Areas, Goals & Measurement Indicators

The 2006 watershed plan determined critical areas based on project locations within the Upper Lake Chain and Lower reaches of the watershed; those project locations were determined to be "critical areas." A significantly different approach was taken with the current plan where "critical areas" are defined as those HUC 12 sub watersheds where implementation will have the greatest likelihood of reducing flooding and bacteria, phosphorus, nitrogen, and sediment loading. The intent is that implementation efforts targeted to these subwatersheds will maximize load reductions and achieve the "biggest bang-for-the-buck."

Water quality goals and targets typically represent a desired water quality endpoint. To determine if water quality goals are being met, measurement indicators are established. In the current Pigeon Creek Watershed Management Plan, watershed stakeholders established the water quality goals. Consideration was given to load reduction goals outlined in the 2012 Pigeon Creek TMDL along with past and current water quality impairments and data; narrative goals are directly supported by available water quality data.

Numerical reduction targets have been applied to the narrative goal statements identified by watershed stakeholders. These targets are based on TMDL pollutant reduction percentages, modeled pollutant loads and instream water quality data. Existing state water quality standards have been utilized to establish measurement indicators for each goal and goal target, which are discussed in more detail in Section 8.2.

Since flooding is still a major concern for watershed residents, narrative goals were also established for flooding. Specific flood reduction calculations are outside the scope of this watershed plan update and, therefore, only narrative flood reduction goals are provided. Narrative measurement indicators are also used for flooding. A comprehensive flood study and detailed hydrologic modeling is needed to truly evaluate the current impacts of flooding along with the most appropriate solutions. However, an effort was made in this plan to address watershed concerns for flooding by making the assumption that virtually any strategy proposed to improve water quality will also have a positive effect on flooding. For example, a wetland or pond constructed to trap nutrients will also detain stormwater and the construction of a two-stage drainage ditch will reduce both nutrient loads and increase the channel's ability to store and transport floodwaters; two-stage ditches do provide localized flood reduction benefits. Section 9.0 includes the location of proposed two-stage ditches, their pollutant load reductions and any relevant changes in stream capacity and hydraulics.

8.1 Water Quality Goals

The following three goals have been identified by watershed stakeholders and are supported through an analysis of existing watershed data. Reduction percentages noted for each goal represent an average for the watershed based on Table 63:

1. Reduce bacteria loading by 30% in ten years and 60% in twenty-five years.
    - includes numeric reduction target as presented in Table 63
2. Reduce sediment and nutrient loading (phosphorus and nitrogen) by 20% in ten years and 40% in twenty-five years.
    - Includes numeric reduction target as presented in Table 63
3. Reduce flooding by increasing flood storage areas by 500 acres in ten years and 1,000 acres in twenty-five years.
    - narrative goal only; no numeric target

To support these narrative goal statements, specific percent reduction targets for *E. coli* bacteria, phosphorus, nitrogen, and sediment are used and listed in Table 62. Similar to a TMDL plan, numeric goal targets represent percent load reductions and can be used to evaluate how well plan recommendations or implementation strategies reduce overall subwatershed pollutant loadings. The targets presented below are based on the 2012 TMDL, modeled pollution loads, and water quality data.

The 2012 TMDL for Pigeon Creek established percent reductions for bacteria and a percent reduction target for phosphorus and nitrogen in one subwatershed (Mud Creek). The TMDL does not provide any percent reduction targets for sediment. In order to establish phosphorus and nitrogen reduction targets for the remaining nine subwatersheds and sediment targets for all ten subwatersheds, the following method was used:

1. Select two reference subwatersheds representing desired phosphorus, nitrogen and sediment load. Referenced subwatersheds represent the lowest per-acre phosphorus, nitrogen and sediment loads from both modeled results and available water quality data.
2. Green Lake (HUC 040500011009) and Mongo Millpond (HUC 040500011010) were selected as reference watersheds. Green Lake has an annual per-acre phosphorus load of 0.56 lbs/ac and 3.96 lbs/ac for nitrogen, and Mongo Millpond has an annual per-acre phosphorus load of 0.71

lbs/ac and a nitrogen load of 4.81 lbs/ac. Both Green Lake and Mongo Millpond have an annual TSS load of 0.61 tons/ac.

3. Determine a baseline target value equal to the average annual per-acre load of 0.635 lbs/ac for phosphorus, 4.39 lbs/ac for nitrogen and 0.61 tons/ac for sediment.
4. Calculate the percentage reductions required for the remaining subwatersheds to meet the desired reference condition of 0.635 lbs/ac for phosphorus, 4.39 lbs/ac for nitrogen and 0.61 tons/ac for sediment.

Table 63 - Percentage Load Reduction Goals

Subwatershed Name	HUC 12 Subwatershed Codes	Bacteria Goal: 2012 TMDL Load Reduction Percentages; Bacteria*	Nutrient Goal: Load Reduction Percentages; Nitrogen	Nutrient Goal: Load Reduction Percentages; Phosphorus	Sediment Goal: Load Reduction Percentages; Sediment
Pigeon Lake-Pigeon Creek	040500011001	76%	94%	49%	43%
Mud Creek-Pigeon Creek	040500011002	79%	37%**	87%**	50%
Long Lake-Pigeon Creek	040500011003	68%	89%	48%	44%
Headwaters Turkey Creek	040500011004	51%	88%	48%	49%
Big Turkey Lake-Turkey Creek	040500011005	50%	44%	29%	31%
Silver Lake-Pigeon Creek	040500011006	97%	23%	15%	19%
Otter Lake-Pigeon Creek	040500011007	52%	25%	22%	28%
Little Turkey Lake-Turkey Creek	040500011008	87%	54%	33%	35%
Green Lake-Pigeon Creek	040500011009	23%	0%	0%	0%
Mongo Millpond-Pigeon Creek	040500011010	18%	10%	11%	0%

*Reduction percentages are established for multiple stream segments within the subwatershed. The percent reduction target represents an average of all the stream segments within that subwatershed.

**Represents TMDL target

8.2 Measurement Indicators

Indicators are used for measuring each goal in order to determine whether progress is being made toward achieving the goal. For the Pigeon Creek Watershed Management Plan, indicators are based on existing and future monitoring, state water quality standards and any exceedences in those standards. For bacteria, phosphorus, nitrogen and sediment reduction goals/targets, numerical indicators are simply the number of times a given water quality sample exceeds the state standard. Where state standards do not exist, such as in the case of sediment, a protective value is used. A protective value of 30 mg/L was established for sediment; this represents the highest HUC 12 subwatershed average based on sampled water quality data. The intent here was to limit future sediment loads from exceeding this threshold. The number of sample exceedences against state standards and the protective sediment value are, therefore, used as the primary numerical measurement indicators for water quality. In the absence of water quality results, or when local monitoring efforts are scaled down, secondary narrative indicators can be used. As with goals for flood reduction, primary measurement indicators are also narrative.

Often times, watershed plans will provide a large and detailed list of measurement indicators. This can become cumbersome and difficult to manage and track effectively. The approach taken with the PCWMP was to simplify this process by providing an easy-to-track list of indicators. Table 64 lists primary and secondary measurement indicators for each goal area. Implementation milestones for each indicator are provided in Section 10.2.

Table 64 - Measurement Indicators

Goal	Primary Indicator	Notes	Secondary Indicator	Notes
Reduce Bacteria Loading	Number of water quality samples exceeding 235 CFU/100 mL	1) Results should be tracked separately for each subwatershed at existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for *E. coli* (bacteria)	Currently, 34 streams are listed for *E. Coli* (bacteria). No Lakes are listed. The number of listed streams should be reduced and the number of listed lakes should be maintained
Reduce Phosphorus Loading	Number of water quality samples exceeding 0.3 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for phosphorus and Impaired Biotic Communities (IBC)	Currently, no streams are listed for phosphorus. Two lakes are listed for phosphorus. There are 12 streams and 2 lakes listed for IBC. The number of streams listed for phosphorus should be maintained and the number of lakes should be reduced. The number of IBC impairments should be reduced for streams and lakes

Goal	Primary Indicator	Notes	Secondary Indicator	Notes
Reduce Nitrogen Loading	Number of water quality samples exceeding 10 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for nitrogen and Impaired Biotic Communities (IBC)	Currently, no streams are listed for nitrogen. No lakes are listed for nitrogen. There are 12 streams and 2 lakes listed for IBC. The number of streams and lakes listed for nitrogen should be maintained. The number of IBC impairments should be reduced for streams and lakes.
Reduce Sediment	Number of water quality samples exceeding 30 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for TSS (sediment)	Currently, no streams or lakes are listed as impaired for TSS (sediment). Maintaining this is the target.
Reduce Flooding by increasing storage	1) Acres of restored wetland in headwaters 2) Feet of two-stage drainage ditches		That flooding is no longer a concern for watershed stakeholders	Although flooding is still a concern, it is less of a concern since the 2006 plan according to a recent poll of Steering Committee members.

8.3 Critical Areas

Five primary, secondary, and tertiary critical HUC 12 subwatersheds and one critical urban area have been identified for Pigeon Creek. Primary critical subwatersheds include Long Lake/Pigeon Creek (HUC 040500011003) and Little Turkey Creek/Turkey Lake (HUC 040500011008). Secondary critical subwatersheds include Pigeon Lake/Pigeon Creek (HUC040500011001) and Mud Creek/Pigeon Creek (HUC 040500011002). Tertiary subwatersheds include Silver Lake/Pigeon Creek (HUC 040500011006) and Headwaters Turkey Creek (HUC 040500011004). Summaries of subwatershed rankings are provided in Table 65 including the secondary and tertiary critical subwatersheds. Subwatersheds with a ranking of one are considered primary, two are secondary, and three are tertiary. Work should focus first on those subwatersheds with the highest ranking and those where a subwatershed is ranked high in multiple goal categories. An urban critical area is also delineated and includes the City of Angola. Figure 52 shows all critical subwatersheds and the urban critical area.

The process for the establishment of critical areas included:

- Defining three primary watershed goal areas: 1) reduce bacteria loads; 2) improve water quality by reducing phosphorus, nitrogen and sediment; 3) reduce flooding.
- Establishing a set of data-driven indicators that represent each goal statement. For example, to reduce bacteria loads, focus should be on those areas with the highest current bacteria loads

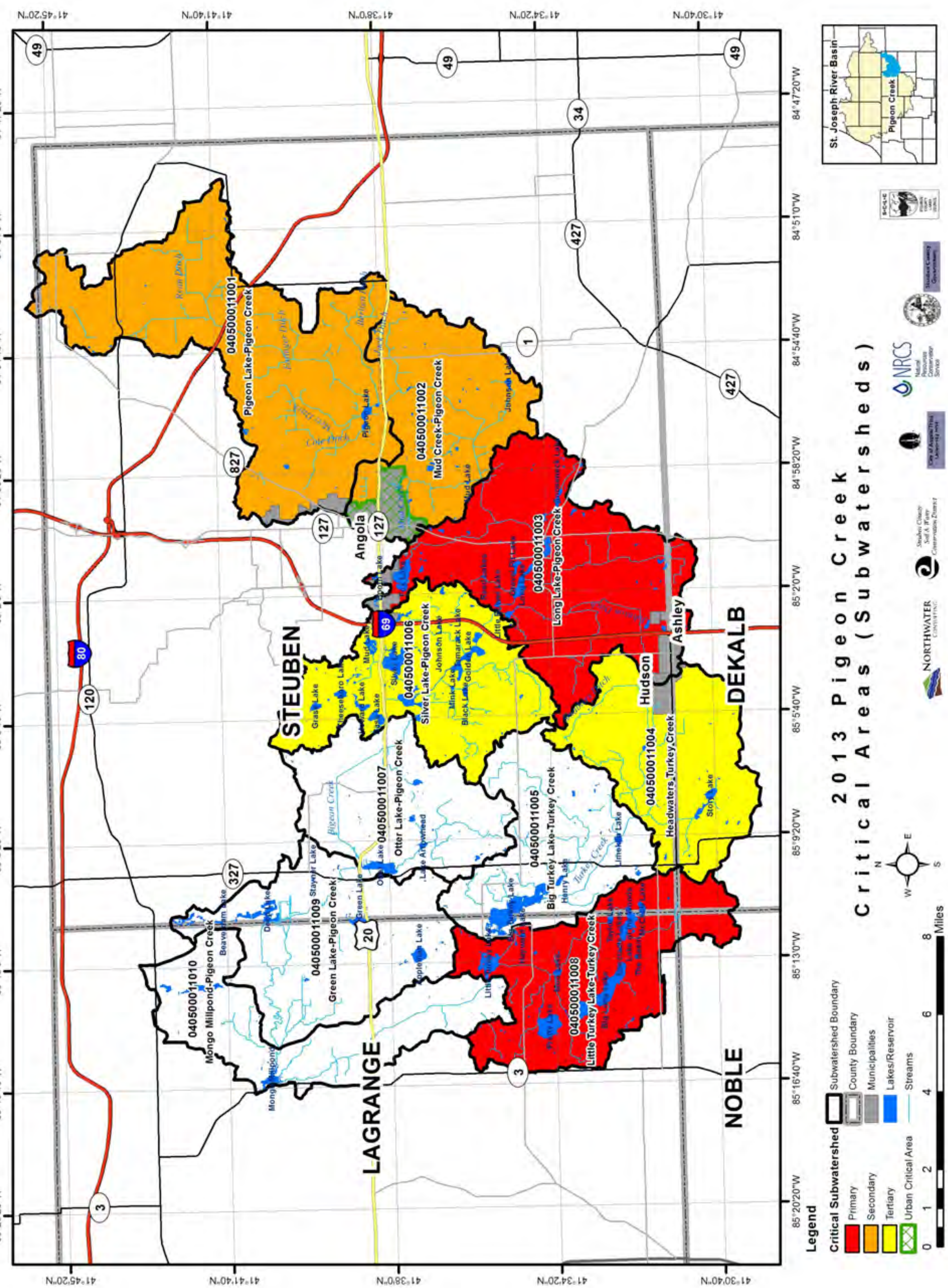
and greatest potential for bacteria load reductions. Here, indicators would include: per-acre modeled bacteria load, number of water quality standard violations, and total expected bacteria load reduction. To reduce sediment, focus should be on areas with the highest percentage of erodible soils and the least amount of protected soils. Here, indicators would include: percent area highly erodible soils and percent area grassland and woodland.

- A detailed GIS analysis of each indicator by HUC 12 subwatershed.
- The application of weighting factors for each indicator based on overall importance.
- Normalization of indicator results by subwatershed.
- A subwatershed ranking.

Table 65 - Critical Subwatershed Ranking Summary

Subwatershed Names	HUC 12 Subwatershed Codes	Rank; Goal of Reducing Bacteria	Rank; Goal of Reducing Sediment and Nutrients	Rank; Goal of Reducing Flooding
Pigeon Lake-Pigeon Creek	040500011001	6	*2*	4
Mud Creek-Pigeon Creek	040500011002	4	*3*	*2*
Long Lake-Pigeon Creek	040500011003	*2*	*1*	*1*
Headwaters Turkey Creek	040500011004	8	4	*3*
Big Turkey Lake-Turkey Creek	040500011005	5	5	5
Silver Lake-Pigeon Creek	040500011006	*3*	7	7
Otter Lake-Pigeon Creek	040500011007	7	8	8
Little Turkey Lake-Turkey Creek	040500011008	*1*	6	6
Green Lake-Pigeon Creek	040500011009	10	10	10
Mongo Millpond-Pigeon Creek	040500011010	9	9	9

Figure 52 - Pigeon Creek Critical Areas



As previously noted, critical areas are defined based on three major goals areas; two subwatersheds are ranked high in multiple goal areas; Mud Creek in two of the three goal areas and Long Lake in all of the goal areas. Pigeon Lake, Silver Lake and Little Turkey Lake are ranked high in only one goal area. Table 66 summarizes the data or criteria used to generate the critical subwatershed rankings.

Table 66 - Critical Area Criteria

Critical Area Criteria	Reduce Bacteria Loads	+ or -*	Improve Water Quality; Reduce Sediment, Nitrogen and Phosphorus	+ or -*	Reduce Flooding	+ or -*
Per-Acre Bacteria Load	X	+				
% Area on Septic and on Limited Soils within 500 ft of a Stream	X	+				
# Water Wells	X	+				
% Area Wetlands Needing Restoration	X	-	X	-		
% Area Pasture	X	+				
Average Distance of Feed Operations & Confinements to a Watercourse	X	-				
# Water Quality Samples Exceeding Standard for Bacteria	X	+				
% Area of Wetlands	X	-				
# NPDES Permits	X	+				
Total Number of Past Projects	X	-	X	-		
Total Per-Acre Bacteria Load Reductions from Needed Projects	X	+				
% Area Open Space	X	-	X	-	X	-
% Area Public Land	X	-	X	-	X	-
# T&E Occurrences	X	-	X	-		
% Area Hydrologic Group C & D Soils	X	+	X	+	X	+
Per-Acre P and N Load			X	+		
Per-Acre TSS Load			X	+		
% Area Residential			X	+	X	+
# Water Quality Samples Exceeding Standard for P and N			X	+		
# Water Quality Samples Exceeding 30mg/L Threshold For TSS			X	+		
% Urban Area			X	+	X	+
% Area HEL Soils			X	+		
% Area Non-Hel Soils					X	+
% Area HEL Agricultural Soils			X	+		
Acres of Filter Strips Needed			X	+		
% Area Wetland	X	-	X	-	X	-
Per Acre Runoff (Ac-Ft)			X	+	X	+
Length Tiled Ditches			X	+		
% Area Row Crops			X	+	X	+
% Area Lakes/Open Water			X	+		
Acres Irrigated Fields			X	+		
Total Per Acre P, N and TSS Load Reductions from Needed Projects			X	+		
Length Two-Stage Ditch Recommended					X	+
% Area Hydric Soils					X	+
Length Channelized Ditch					X	+
% Area Legal Ditch					X	+
% Area 100-Year Floodplain					X	-

*+ represents high score for a high number; - represents a high score for a low number

9.0 Best Management Practices

Best Management Practices can be described as a practice or procedure to prevent or reduce water pollution and address stakeholder concerns. BMPs typically include treatment requirements, operating procedures, and practices to control runoff and abate the discharge of pollutants. This section of the plan will describe both site-specific BMPs, as well as those that can be applied basin-wide to achieve measurable load reductions in phosphorus, nitrogen, sediment, and bacteria. A watershed-wide survey was conducted to evaluate point-source discharges, document watershed features, and the location of potential BMPs. Basin-wide BMPs were identified using GIS and other locally available information.

Recommended practices focus on both point source and NPS pollution. Estimates of the expected pollution load reductions associated with recommended practices are included in this section. Load reductions are calculated using pollutant removal efficiency percentages based on existing literature and local expertise. Pollutant removal efficiencies can be found in Table 67.

Table 67 - Pigeon Creek BMP Pollutant Removal Effeciencies

Best Management Practice	Nitrogen Reduction Percentage	Phosphorus Reduction Percentage	Sediment Reduction Percentage	Bacteria Reduction Percentage
Rain Garden/barrel (together)	50%-70%	60%-75%	65%-80%	35%-45%
Rain Barrel	30%	30%	30%	30%
Wetland Restoration	25%-55%	30%-50%	50%-70%	40%-65%
Detention Basin	20%-55%	25%-60%	40%-75%	30%-65%
Waste Basin Treatment System	65%	70%	75%	90%
Cover crop/Hay/Critical Area Seeding	35%-40%	40%-45%	35%-40%	35%-40%
Terrace/WASCOB	25%-30%	30%-40%	50%-65%	25%-35%
Restrictor/Blind Inlet/Drop Inlet Structure	30%	50%	70%	35%
Livestock Fence	15%-25%	20%-30%	20%-30%	25%-35%
Filter Strip/Riparian Buffer	25%-50%	30%-55%	35%-70%	25%-50%
Grass Waterway	55%	45%	80%	50%
Porous Pavement	60%	55%	70%	40%
Tree Planting	45%	50%	55%	45%
Combined Pasture BMPs (can include fence, diversion, crossings, water system, detention)	35%-65%	40%-70%	45%-80%	35%-80%
Grade Control Structure*	30%	40%	60%	20%
Denitrifying Bioreactor	50%	0%	0%	0%

* treats 100% of sediment from gully erosion

9.1 – Basin-Wide Best Management Practices

Basin-wide BMPs are those practices or procedures that can be applied throughout the watershed where exact project locations may be unknown or where locations may not have been verified through a site visit. Basin-wide BMPs include practices such as cover crops, blind inlets or tile restrictor plates, septic inspections and monitoring, or field terraces. Basin-wide BMP recommendations cover 135,750 acres in the watershed. It is important to note that many of these practices overlap with each other, such as cover crops and blind inlets and, therefore, these BMPs result in coverage of over 99% of the basin.

Many standard BMPs exist that will reduce pollution loading. Basin-wide BMPs specifically recommended for the Pigeon Creek watershed include:

1. Cover Crops: a cover crop is a temporary vegetative cover that is grown to provide protection for the soil and improve soil conditions.
2. Terraces/Water and Sediment Control Basin (WASCOB): earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
3. Blind Inlet: a blind inlet is defined as an excavated earthen box with perforated collector tubing placed in the bottom and filled to the surface with rock or gravel. The rock is the inlet for surface water.
4. Denitrifying Bioreactor: a structure containing a carbon source, installed to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification.
5. Wetland Restoration: Using a hybrid NWI data set developed and provided by the Friends of the St. Joe River Association, a selection of existing wetlands are identified for restoration. These sites received a combined water quality score of greater than 100. Wetland restoration activities include restoring natural hydrology and the habitat diversity of existing wetlands.
6. Septic system recommendations to evaluate/mitigate the effects of septic systems:
    a. Certify septic pumpers to inspect septic tanks.
    b. Recommend homeowners have their septic tanks pumped and inspected every 3 years.
    c. Septic pumpers file an inspection report with the SWCD.
    d. Define a "sensitive area" boundary in the watershed close to creeks and waterways. Base boundary on soil types and slopes – where seepage from a drain field could reasonably be expected to reach a watercourse before being adequately treated. Septic systems within this boundary would receive additional attention and/or regulation.
7. Rain Barrel: a barrel used as a cistern to hold rainwater from residential roof runoff.
8. Rain Garden: a planted depression that allows rainwater runoff from impervious urban areas, including roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.
9. Porous/Permeable Pavement: permeable or porous pavement is a method of paving that allows stormwater to seep into the ground as it falls rather than running off into storm drains and waterways. Permeable pavements function similarly to sand filters, in that they filter the water by forcing it to pass through different aggregate sizes and typically some sort of filter fabric.

Therefore, most of the treatment is through physical (or mechanical) processes. As precipitation falls on the pavement, it infiltrates down into the storage basin where it is slowly released into the surrounding soil.

10. Education and Outreach Programs: an effective strategy for improving water quality and promoting conservation is through targeted education and outreach. Education and outreach programs can be designed to promote particular conservation practices or educate stakeholders on the importance of water quality in general.

Absent from recommendations above are no-till, mulch-till, and reduced-tillage practices. These tillage practices are currently in good use throughout the watershed and, therefore, have not been addressed in this plan. Although not specifically recommended, no-till, mulch-till, and reduced-tillage practices should continue to be promoted in Pigeon Creek.

Priority should be given to those BMPs with the greatest load reductions and/or that fall within a designated critical area (highlighted red in the table below). Table 68 provides a summary of all basin-wide BMPs by subwatershed, their treated area, and expected load reductions. Comparing the anticipated load reduction results of site-specific and basin-wide BMPs to water quality targets indicate that in order to achieve significant reductions in the watershed, there must be widespread adoption of BMPs.

Cover crop adoption is a logical strategy for reducing sediment and nutrients due to their relatively low cost and high anticipated per acre and overall load reductions. Blind inlets will achieve the highest overall reductions in sediment and nutrients, although, the cost of these practices may be prohibitive and recent work has shown reluctance on the part of landowners to install blind inlets. Addressing leaking septic tanks will result in the highest overall reduction in bacteria loading and, although urban BMPs such as rain barrels, rain gardens, and porous pavement are high in cost, they are relatively efficient at reducing pollutant loads (with the exception of sediment) and, more importantly, will help to reduce urban runoff volumes. Denitrifying bioreactors will significantly reduce overall nitrogen loads and should be considered, at least as demonstration projects, to gauge landowner willingness to adopt. Terraces and water and sediment control basins are very efficient at reducing sediment and phosphorus loads and are already popular practices in the watershed and, therefore, should be considered a high priority for implementation. Despite the fact that wetland restoration ranks the lowest in terms of overall sediment, phosphorus and bacteria reductions, this practice will result in high nitrogen reductions; additional considerations with respect to wetland restoration include flood control, wildlife habitat and biodiversity.

Table 68 - Basin-Wide BMP Load Reduction Totals

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Benefited by BMP	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	29,581	23,560	178,320	33,512	26,434
Mud Creek-Pigeon Creek	040500011002	13,889	12,010	87,267	24,156	17,024
Long Lake-Pigeon Creek	040500011003	27,130	20,182	151,327	31,199	23,163
Headwaters Turkey Creek	040500011004	14,395	11,646	88,059	23,487	13,004
Big Turkey Lake-Turkey Creek	040500011005	11,896	8,519	59,335	21,520	9,954
Silver Lake-Pigeon Creek	040500011006	9,257	7,523	50,910	21,469	8,939
Otter Lake-Pigeon Creek	040500011007	11,060	7,513	50,872	20,393	9,194
Little Turkey Lake-Turkey Creek	040500011008	8,784	7,611	59,305	20,921	8,728
Green Lake-Pigeon Creek	040500011009	5,208	4,315	29,746	17,596	4,215
Mongo Millpond-Pigeon Creek	040500011010	4,550	3,914	28,352	17,231	2,585
Total		**135,750**	**106,792**	**783,491**	**231,484**	**123,239**

Pigeon Creek; Streambank Stabilization

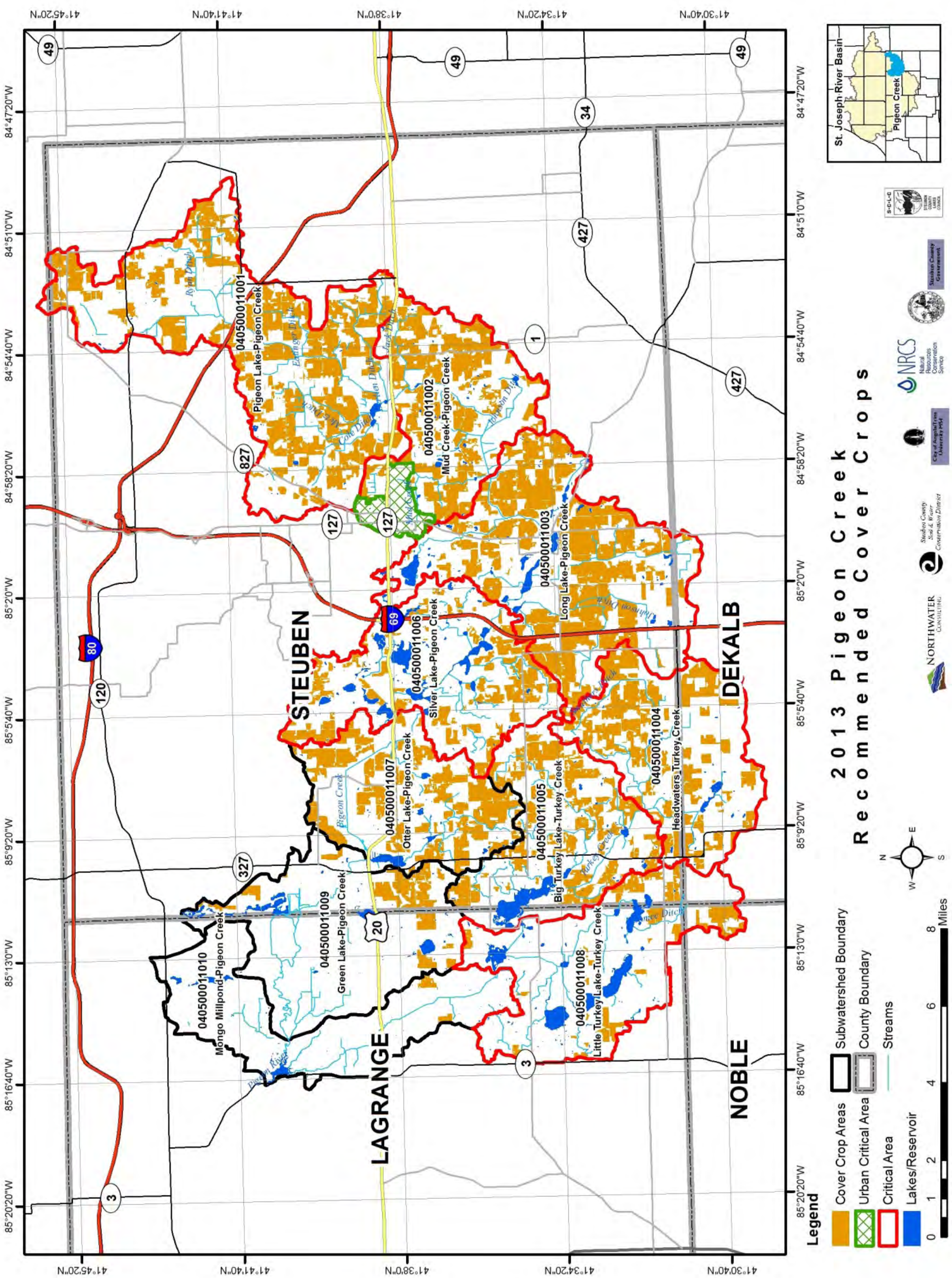
9.1.1 – Cover Crops

Cover Crops are recommended on 39,186 (29%) acres throughout the watershed. Areas targeted for cover crops include primarily flat to gently sloping crop ground. Table 69 lists acreage and load reductions by subwatershed and Figure 53 shows the distribution throughout the watershed. The implementation of cover crops in the watershed will achieve significant reductions in phosphorus (0.7 lbs/ac/yr), nitrogen (3.9 lbs/ac/yr), and sediment (0.7 tons/ac/yr) and, to a lesser extent, bacteria (0.57 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below) and on fields currently practicing no-till. For those fields not currently in no-till, a no-till system should be promoted prior to implementing cover crops.

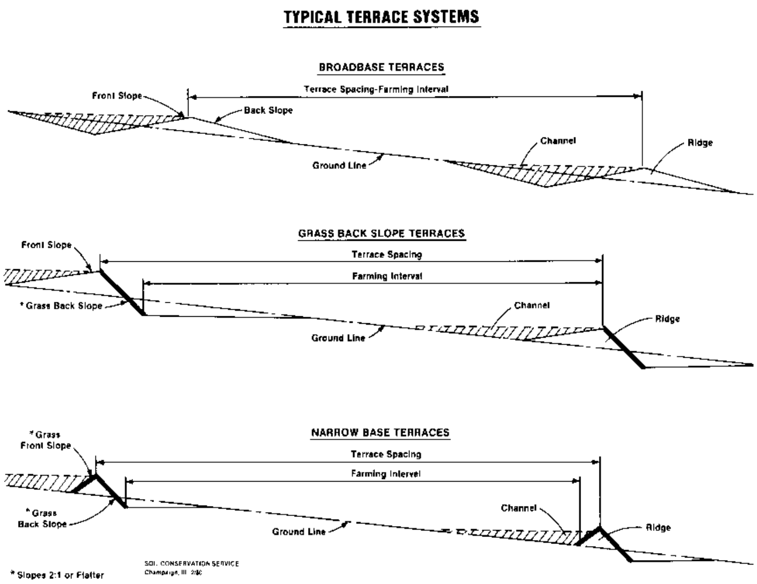
Table 69 - Cover Crop Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Cover Crop	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	**040500011001**	8,696	6,590	37,221	5,418	6,027
Mud Creek-Pigeon Creek	**040500011002**	4,524	3,516	19,859	2,891	4,128
Long Lake-Pigeon Creek	**040500011003**	8,105	5,723	32,321	4,705	5,310
Headwaters Turkey Creek	040500011004	4,436	3,032	17,125	2,493	2,958
Big Turkey Lake-Turkey Creek	040500011005	3,515	2,139	12,081	1,759	2,241
Silver Lake-Pigeon Creek	040500011006	2,960	2,062	11,647	1,696	2,431
Otter Lake-Pigeon Creek	040500011007	3,950	2,111	11,925	1,736	2,343
Little Turkey Lake-Turkey Creek	040500011008	1,578	1,080	6,099	888	1,091
Green Lake-Pigeon Creek	040500011009	1,291	761	4,297	626	887
Mongo Millpond-Pigeon Creek	040500011010	130	59	333	48	85
Grand Total		**39,186**	**27,074**	**152,909**	**22,258**	**27,502**

Figure 53 - Pigeon Creek Recommended Cover Crops



9.1.2 – Terraces & Water & Sediment Control Basins

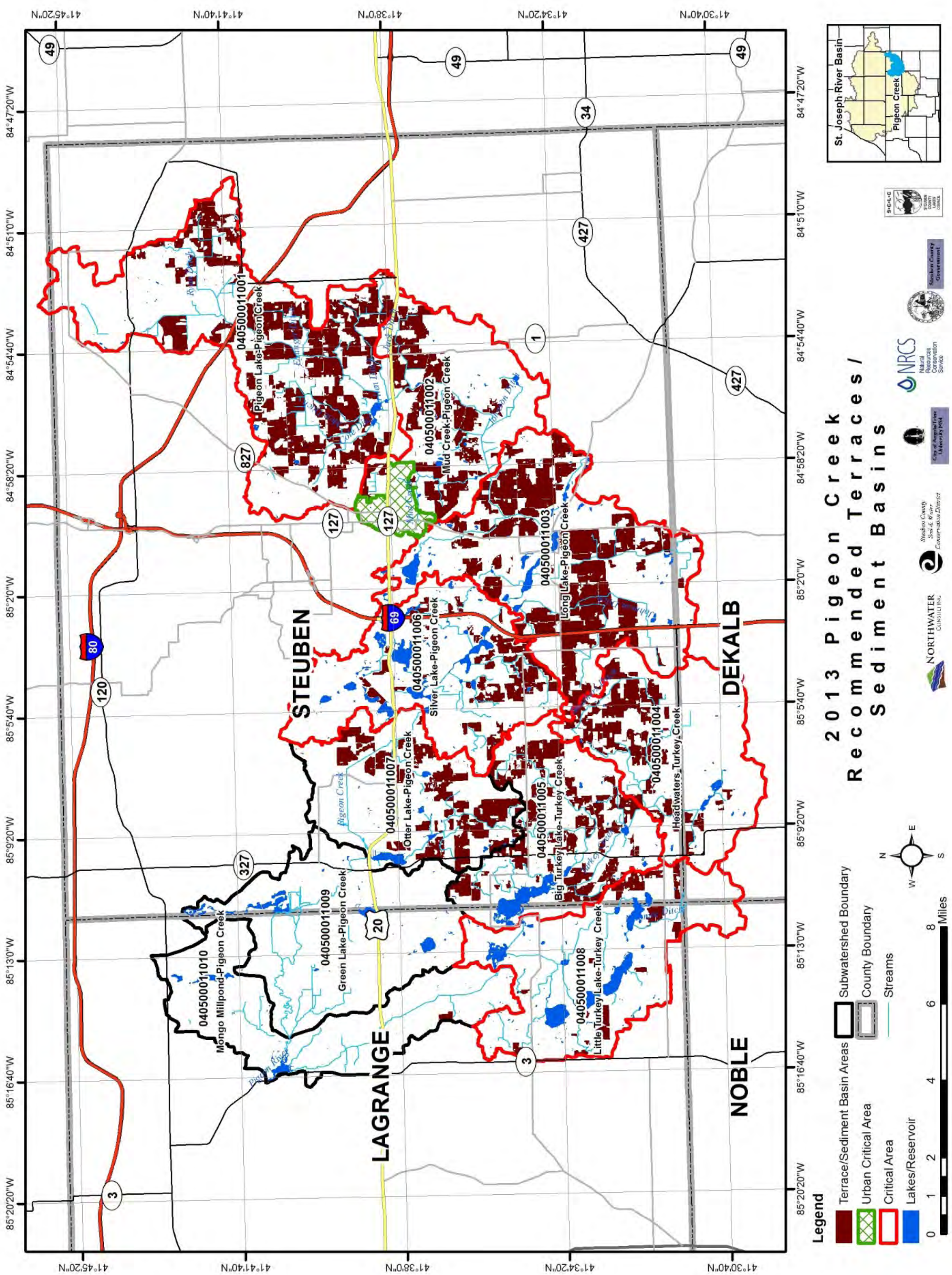


Terraces, or Water and Sediment Control Basins, are recommended to treat 25,916 acres (19%) throughout the watershed. Areas targeted for these practices include cropped HEL soils. Table 70 lists acreage and load reductions by subwatershed and Figure 54 shows the distribution throughout the watershed. The implementation of terraces on sloping crop ground in the watershed will achieve significant reductions in sediment (1 ton/ac/yr) and phosphorus (0.53 lbs/ac/yr) and to a lesser extent, nitrogen (2.8 lbs/ac/yr) and bacteria (0.41 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

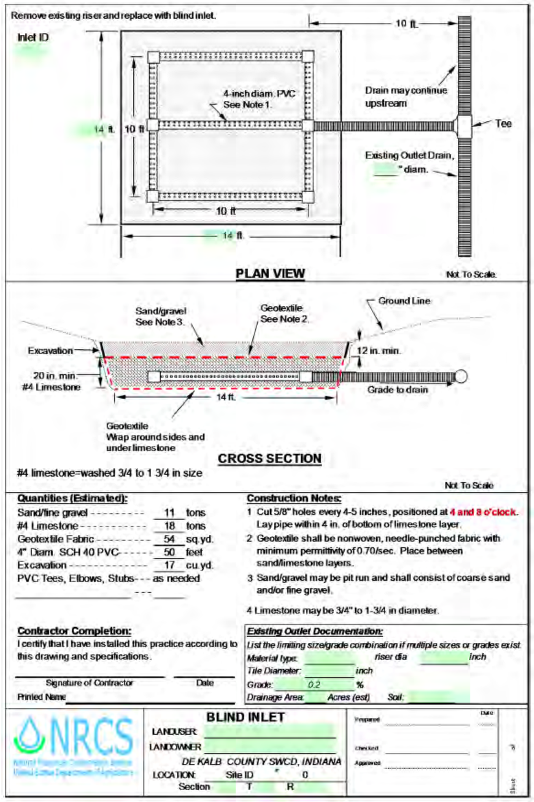
Table 70 - Terrace & Water & Sediment Control Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Terraces	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	**040500011001**	6,793	3,844	20,674	3,009	6,045
Mud Creek-Pigeon Creek	**040500011002**	2,777	1,669	8,979	1,307	3,788
Long Lake-Pigeon Creek	**040500011003**	6,251	3,286	17,673	2,573	5,521
Headwaters Turkey Creek	040500011004	2,221	1,120	6,024	877	1,849
Big Turkey Lake-Turkey Creek	040500011005	2,952	1,338	7,198	1,048	2,582
Silver Lake-Pigeon Creek	040500011006	1,558	935	5,028	732	1,995
Otter Lake-Pigeon Creek	040500011007	2,403	1,033	5,556	809	2,290
Little Turkey Lake-Turkey Creek	040500011008	915	450	2,421	352	893
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	47	14	77	11	36
Grand Total		**25,916**	**13,689**	**73,631**	**10,718**	**24,999**

Figure 54 - Pigeon Creek Recommended Terrace/Water & Sediment Control Basin Areas



9.1.3 – Blind Inlets

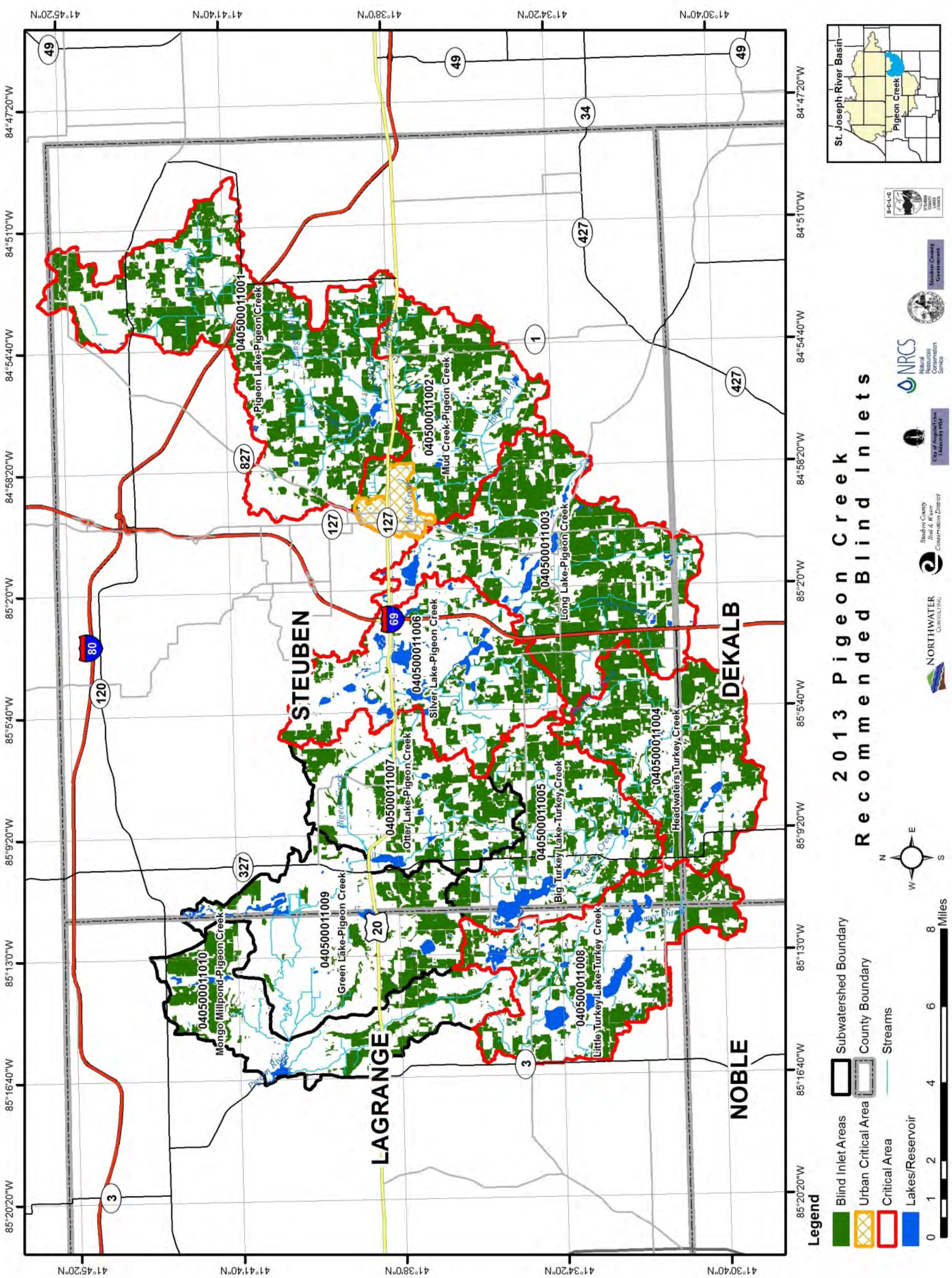


Blind Inlets are recommended for the treatment of 51,870 acres (38%) throughout the watershed. Table 71 lists acreage and load reductions by subwatershed and Figure 55 shows the distribution throughout the watershed. Areas targeted for blind inlets include both flat and sloping crop ground and those tillable fields that drain to a central “pot hole” or depressional area. The widespread implementation of blind inlets in the watershed will achieve significant reductions in sediment (1.32 tons/ac/yr) and phosphorus (0.9 lbs/ac/yr) and, to a lesser extent, nitrogen (3.4 lbs/ac/yr) and bacteria (0.58 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

Table 71 - Blind Inlet Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Blind Inlet	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	10,371	9,994	38,706	6,573	13,726
Mud Creek-Pigeon Creek	040500011002	5,062	4,861	18,827	3,197	8,918
Long Lake-Pigeon Creek	040500011003	9,363	8,467	32,792	5,569	11,951
Headwaters Turkey Creek	040500011004	6,219	5,481	21,226	3,605	7,975
Big Turkey Lake-Turkey Creek	040500011005	4,029	3,178	12,306	2,090	4,994
Silver Lake-Pigeon Creek	040500011006	2,677	2,511	9,724	1,651	4,284
Otter Lake-Pigeon Creek	040500011007	3,582	2,677	10,367	1,760	4,449
Little Turkey Lake-Turkey Creek	040500011008	4,796	4,198	16,258	2,761	6,603
Green Lake-Pigeon Creek	040500011009	2,606	1,963	7,603	1,291	3,262
Mongo Millpond-Pigeon Creek	040500011010	3,164	2,124	8,225	1,397	2,340
Grand Total		**51,870**	**45,454**	**176,031**	**29,895**	**68,503**

Figure 55 - Pigeon Creek Recommended Blind Inlet Areas



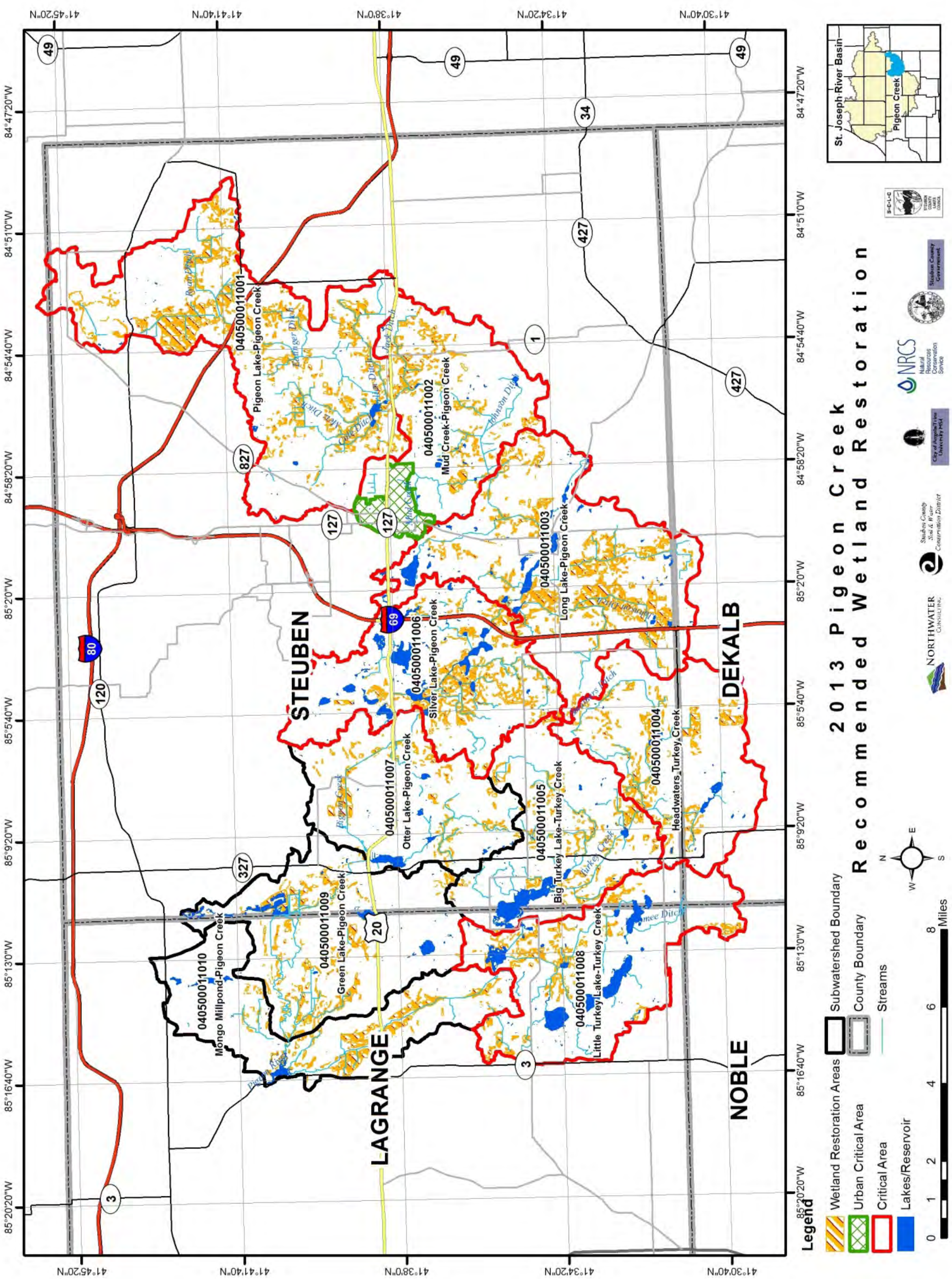
9.1.4 – Wetland Restoration

Wetland restoration is recommended on 12,054 acres (9%) throughout the watershed. Wetland restoration sites include existing and degraded wetlands; restoring these sites will improve filtering, storage capacity, and habitat diversity. Restoration actions can include sediment removal and minor excavation, installing buffer strips around wetlands, the removal of drain tiles and native vegetation planting. Table 72 lists acreage and load reductions by subwatershed and Figure 56 shows the distribution throughout the watershed. Conducting wetland restoration will achieve nominal reductions in sediment (0.14 tons/ac/yr) phosphorus (0.37 lbs/ac/yr), and nitrogen (3 lbs/ac/yr). Wetland restoration will result in higher per-acre bacteria reductions (0.56 billion CFU/ac/yr). Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below). It is also important to note that protection of the existing high-quality wetlands described in Section 3.2.4 will also result in addressing flood storage and nutrient reductions as a healthy and protected wetland will maximize both water storage and filtration.

Table 72 - Wetland Restoration Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Wetland Restoration	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	2,839	1,398	11,554	1,875	559
Mud Creek-Pigeon Creek	40500011002	841	363	3,086	542	137
Long Lake-Pigeon Creek	**40500011003**	2,338	938	7,728	1,327	293
Headwaters Turkey Creek	40500011004	973	438	3,587	593	181
Big Turkey Lake-Turkey Creek	40500011005	758	256	2,107	403	79
Silver Lake-Pigeon Creek	**40500011006**	1,207	317	2,664	763	150
Otter Lake-Pigeon Creek	40500011007	561	140	1,132	256	71
Little Turkey Lake-Turkey Creek	**40500011008**	692	231	1,866	376	68
Green Lake-Pigeon Creek	40500011009	972	124	1,123	286	47
Mongo Millpond-Pigeon Creek	40500011010	874	247	1,929	360	104
Grand Total		**12,055**	**4,451**	**36,778**	**6,781**	**1,690**

Figure 56 - Pigeon Creek Recommended Wetland Restoration Areas



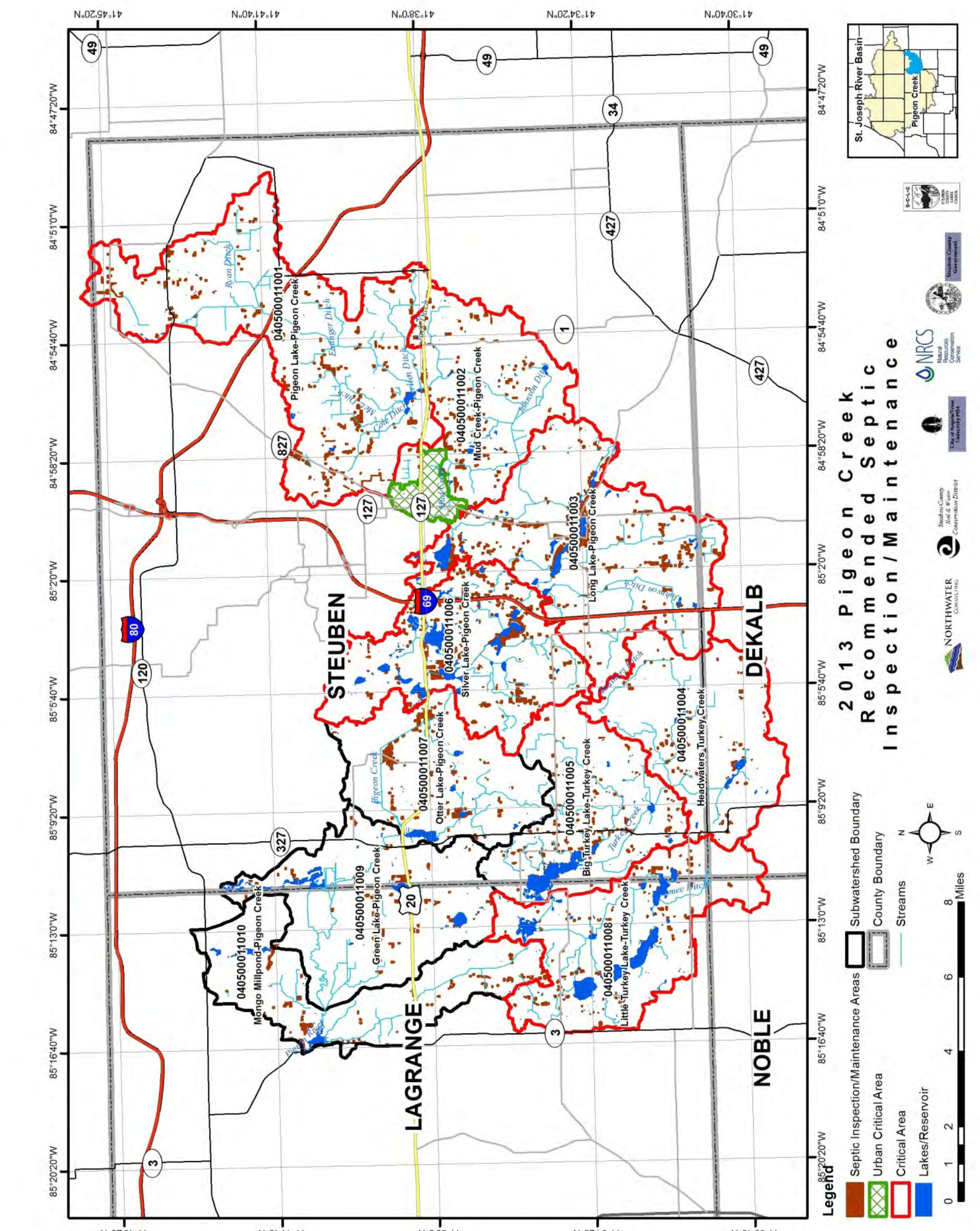
9.1.5 – Septic Systems

Recommendations to address septic systems through an inspection and maintenance program can be directed to 2,667 acres (2%) throughout the watershed. Assuming a conservative average lot size of 0.5 acres, this could translate into 5,334 individual homes. As noted in Section 7.1.2, there are an estimated 9,108 septic systems within the watershed and 1,365 of these are likely to be failing. It can be assumed that an inspection and maintenance program targeted to the 2,667 acres recommended in this section will capture all or most of the failing septic systems within the watershed. Table 73 lists acreage by subwatershed and Figure 57 shows the distribution throughout the watershed. Due to the lack of specific knowledge on the location of failing septic systems, load reductions are estimated basin-wide as a total. It is assumed that addressing failing septic systems will result in 100% reduction in phosphorus, nitrogen and bacteria and no reductions in sediment. Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below).

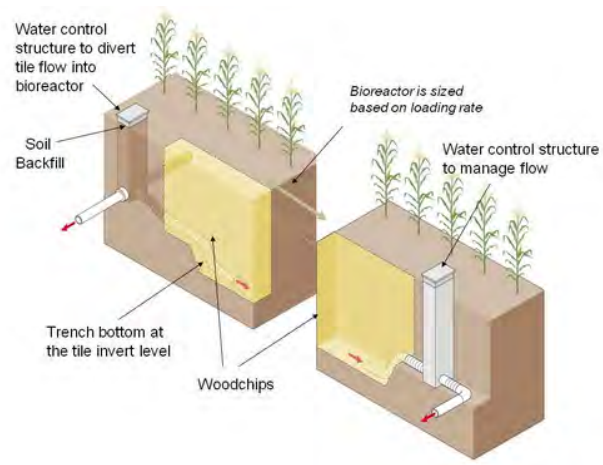
Table 73 - Septic System Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Inspection/ Maintenance Area (acres) Septic	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	435	13,679	34,926	149,468
Mud Creek-Pigeon Creek	40500011002	222			
Long Lake-Pigeon Creek	**40500011003**	623			
Headwaters Turkey Creek	40500011004	85			
Big Turkey Lake-Turkey Creek	40500011005	135			
Silver Lake-Pigeon Creek	**40500011006**	468			
Otter Lake-Pigeon Creek	40500011007	212			
Little Turkey Lake-Turkey Creek	**40500011008**	161			
Green Lake-Pigeon Creek	40500011009	173			
Mongo Millpond-Pigeon Creek	40500011010	153			

Figure 57 - Pigeon Creek Recommended Septic Inspection/Maintenance Areas



9.1.6 – Denitrifying Bioreactors

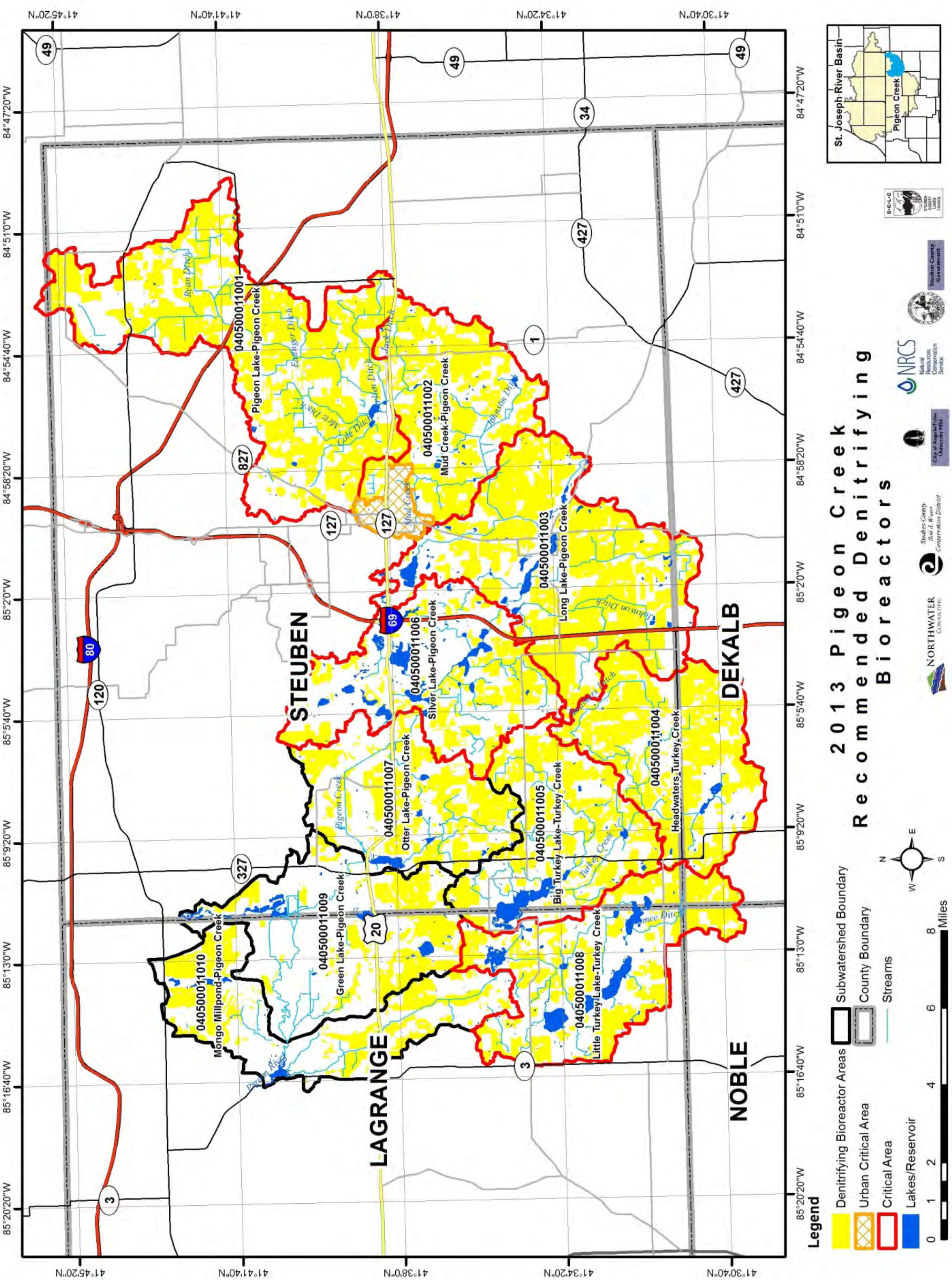


Similar to blind inlets or controls on tile systems, denitrifying bioreactors are an NRCS eligible practice designed to treat or manage tile or subsurface flow. These practices are specific to controlling nitrogen and are recommended for the same areas targeted for blind inlets. Denitrifying bioreactors are recommended for the treatment of 51,870 acres (38%) throughout the watershed. Table 74 lists acreage and load reductions by subwatershed and Figure 57 shows the distribution throughout the watershed. The implementation of denitrifying bioreactors in the watershed will achieve significant reductions in nitrogen (5.7 lbs/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

Table 74 - Denitrifying Bioreactor Load Reductions

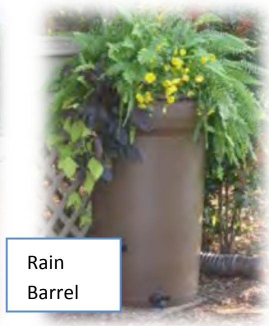
Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Nitrogen Bioreactor	Load Reduction Nitrogen (lbs/yr)
Pigeon Lake-Pigeon Creek	**40500011001**	10,371	64,509
Mud Creek-Pigeon Creek	**40500011002**	5,062	31,378
Long Lake-Pigeon Creek	**40500011003**	9,363	54,653
Headwaters Turkey Creek	40500011004	6,219	35,376
Big Turkey Lake-Turkey Creek	40500011005	4,029	20,510
Silver Lake-Pigeon Creek	40500011006	2,677	16,206
Otter Lake-Pigeon Creek	40500011007	3,582	17,278
Little Turkey Lake-Turkey Creek	40500011008	4,796	27,096
Green Lake-Pigeon Creek	40500011009	2,606	12,671
Mongo Millpond-Pigeon Creek	40500011010	3,164	13,709
Grand Total		**51,870**	**293,386**

Figure 58 - Pigeon Creek Recommended Denitrifying Bioreactor Areas



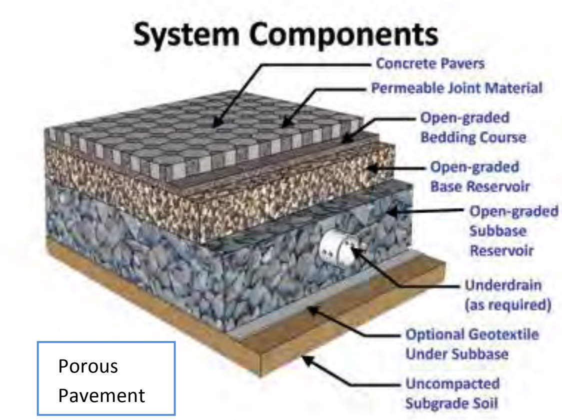
9.1.7 – Rain Barrels, Rain Gardens & Porous/Permeable Pavement

Rain Garden



Rain Barrel

A combination of rain barrels, rain gardens, and porous pavement are recommended, primarily in the urban or residential areas of the watershed. Installation of rain barrels, rain gardens, and porous pavement can be applied to 6,724 acres (5%) throughout the watershed. Assuming a conservative average lot size of 0.5 acres, this could translate into 3,362 individual homes/properties. Table 75 lists acreage and load reductions by subwatershed and Figure 59 shows the distribution throughout the watershed. Installing rain barrels, rain gardens, and porous pavement to treat each acre will achieve nominal reductions in sediment (0.14 tons/ac/yr) and moderate reductions in phosphorus (0.37 lbs/ac/yr) and nitrogen (3 lbs/ac/yr). Due to relatively high concentrations of bacteria loading from residential areas, these practices will result in significant reductions (0.56 billion CFU/ac/yr) despite being low in terms of removal efficiencies for bacteria. Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below), as well as the critical urban area that covers the City of Angola (Mud Creek-Pigeon Creek in red).

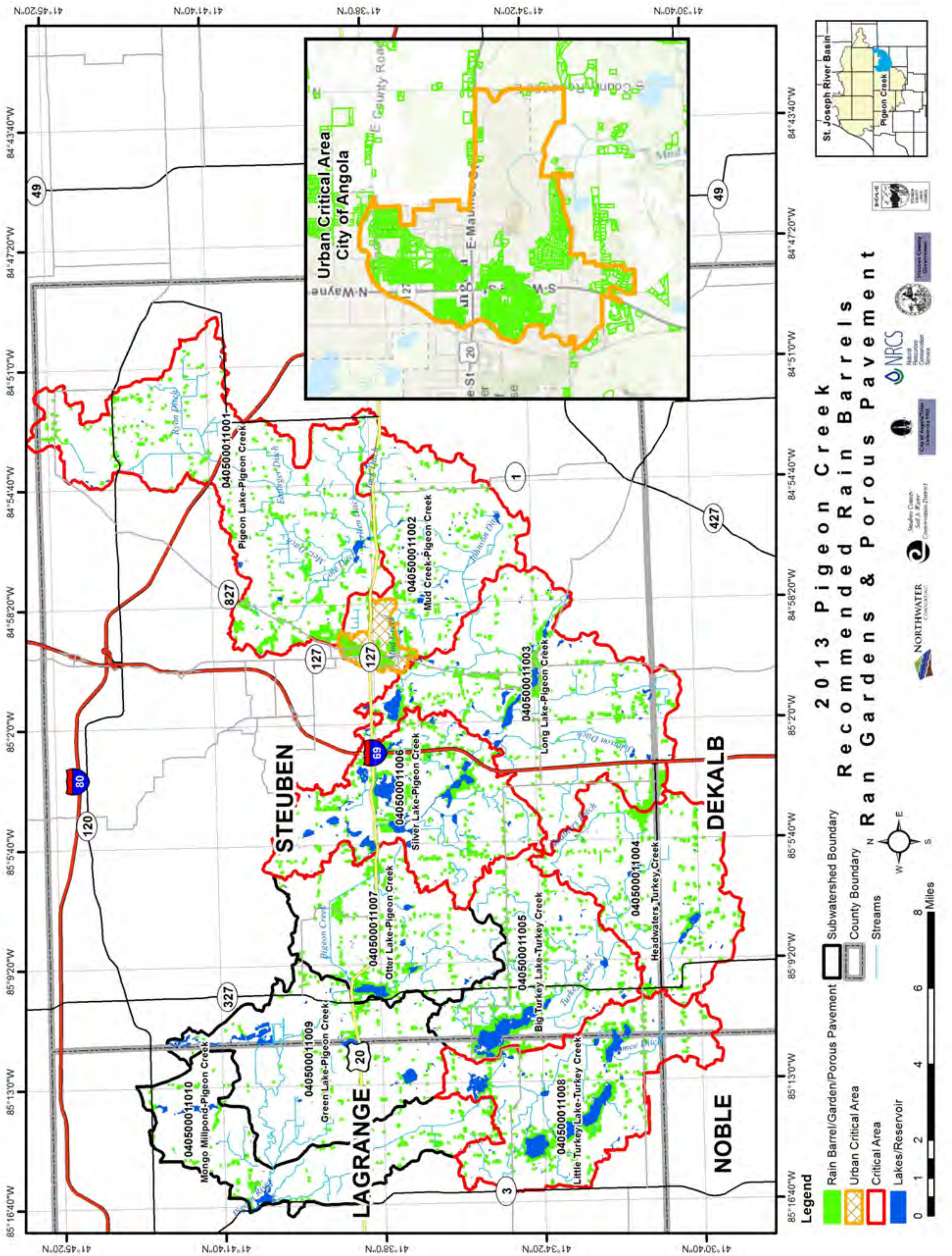


Porous Pavement

Table 75 - Rain Barrel, Rain Garden, & Porous Pavement Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Rain Garden, Rain Barrel, Porous Pavement	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	883	366	2,163	1,690	76
Mud Creek-Pigeon Creek	40500011002	686	233	1,647	1,272	52
Long Lake-Pigeon Creek	40500011003	1,073	400	2,667	2,079	87
Headwaters Turkey Creek	40500011004	546	207	1,229	973	42
Big Turkey Lake-Turkey Creek	40500011005	642	240	1,640	1,274	58
Silver Lake-Pigeon Creek	40500011006	854	330	2,147	1,680	79
Otter Lake-Pigeon Creek	40500011007	563	184	1,121	885	41
Little Turkey Lake-Turkey Creek	40500011008	803	284	2,072	1,597	72
Green Lake-Pigeon Creek	40500011009	339	100	559	446	20
Mongo Millpond-Pigeon Creek	40500011010	334	103	586	467	21
Grand Total		**6,724**	**2,445**	**15,830**	**12,364**	**546**

Figure 59 - Pigeon Creek Recommended Rain Barrel, Rain Garden, & Porous Pavement Areas



9.1.8 – Education & Outreach

The adoption of many of the conservation practices or BMPs listed in this plan will include some form of education and outreach. In addition, specific campaigns should be developed to educate landowners on practices or actions that can be implemented to improve water quality. Pollution load reductions are not provided for education and outreach. Specific education and outreach recommendations include:

1. Host one (1) annual agricultural field day or workshop to promote a particular practice or combination of practices such as cover crops or pasture management.
2. Host one (1) annual urban workshop. A workshop could include community rain garden planting or a rain barrel distribution and maintenance workshop.
3. Organize one (1) annual watershed bus tour.
4. Organize one (1) annual community ditch cleanup day.
5. Develop (or utilize existing) and distribute educational pamphlets or brochures on agricultural BMPs and available resources, septic system maintenance and available resources, and appropriate lawn fertilizer application and urban BMPs.
6. Host one (1) annual youth conservation field day
7. Participate in one (1) annual youth "Duck Days" in participation with the Delta Waterfowl Alliance.
8. Continue hosting "Lake Life" workshop series. Lake Life is a six-week class focusing on different aspects of lake living in Steuben County, including conservation. The class includes meeting once a week for two and a half hours.
9. Focus on developing a conservation series on a local cable channel, radio, or newspaper. This could include a regular "conservation column" in the local newspaper.

9.2 – Site-Specific Best Management Practices

Site-specific BMPs are those practices where a field visit has resulted in the identification of a specific project and project location. Site-specific practices are located throughout the watershed and include:

1. Grassed Waterway: a grassed strip in fields that acts as an outlet for water to control silt, filter nutrients and limit gully formation.
2. Terraces/Water and Sediment Control Basin (WASCOB): earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
3. Detention Basin/Pond: a sediment or water impoundment made by constructing an earthen dam. Detention basins are recommended for both urban and agricultural areas.
4. Feed Lot BMP; Waste Lagoon: an impoundment made by constructing an earthen dam used to trap and filter livestock waste from concentrated feeding areas. Solids are trapped in a sediment basin installed upstream of the lagoon.
5. Rock Riffle: a rock structure constructed in a stream channel or gully to stabilize grade.
6. Wetland Creation: a shallow water area constructed by creating an earth embankment or excavation. Wetland creation practices can include a water control structure and are designed to mimic natural wetland hydrology.

7. Two-Stage Ditch: two-stage ditches are drainage ditches that have been modified by adding benches that serve as floodplains within the overall channel. This form is more consistent with fluvial form and process and, therefore, leads to greater channel stability. The benches can also function as wetlands during certain times of the year, reducing ditch nutrient loads.
8. Filter Strip: a filter strip is a narrow band of grass or other permanent vegetation used to reduce sediment, nutrients, pesticides, and other contaminants.
9. Pasture BMPs: a variety of individual livestock management practices designed to manage runoff and improve profitability. Specific practices included under pasture management are fencing (stream, and interior), stream crossings, alternative watering systems, filter/buffer strips and diversions.
10. Other: additional BMPs include detention basin for a future truck stop and streambank stabilization.

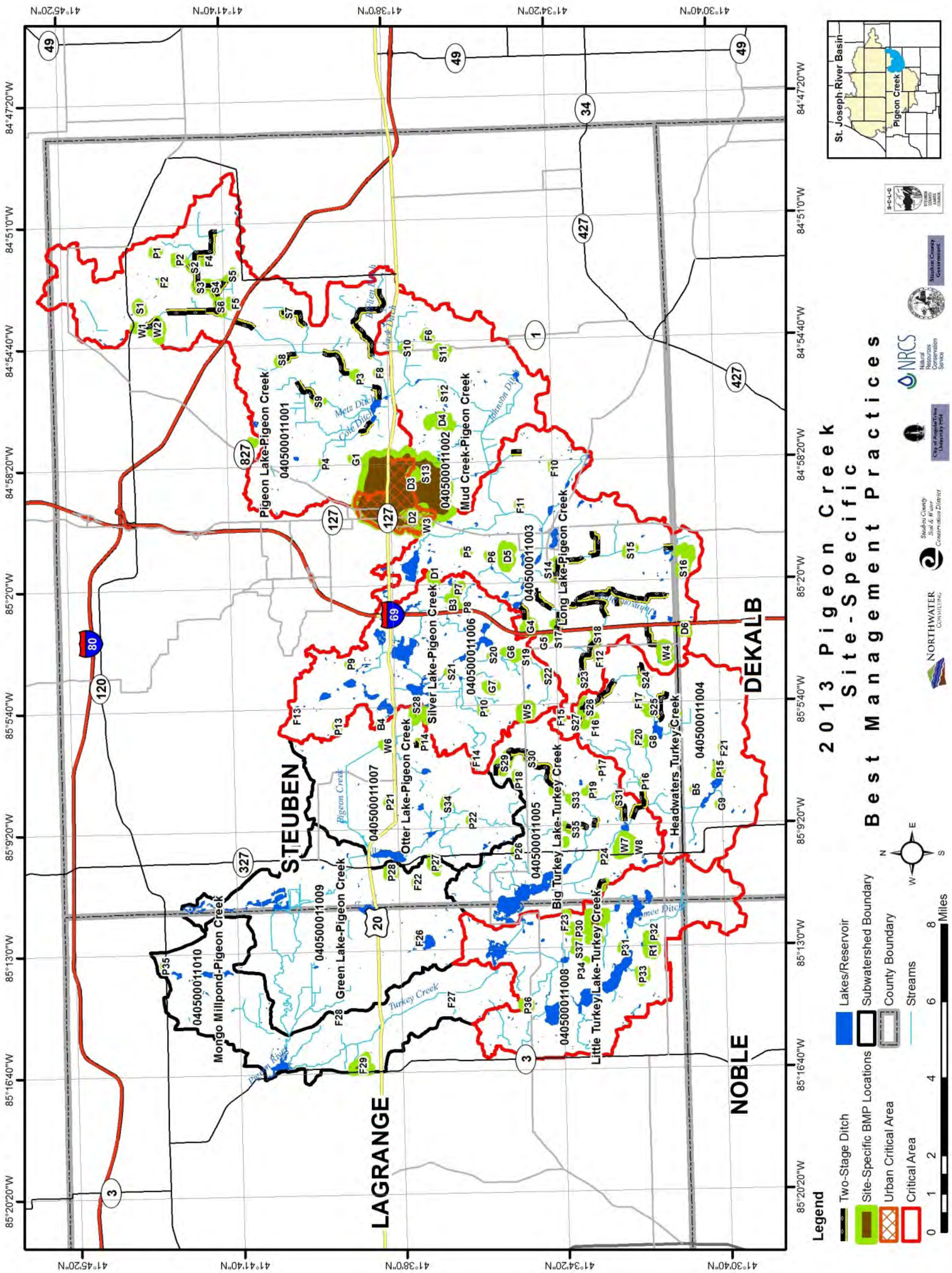
Priority should be given to those BMPs with the greatest load reductions and/or that fall within a designated critical area (highlighted red in the table below). Site-specific BMP recommendations for Pigeon Creek will treat 5,300 acres in the watershed (4%). Table 76 provides a summary of all site-specific BMPs by subwatershed, their treated area, and expected load reductions; per-acre figures are based on total watershed area. Figure 60 shows the location of all site-specific practices based on their drainage/benefited area. Also highlighted red in Table 76 are the top three highest per-acre load reductions. Results at the subwatershed level show that the implementation of site-specific practices in Mud Creek, Long Lake, Big Turkey and Little Turkey Lake will provide the highest per-acre reductions.

Table 76 - Site-Specific BMP Load Reduction Summary

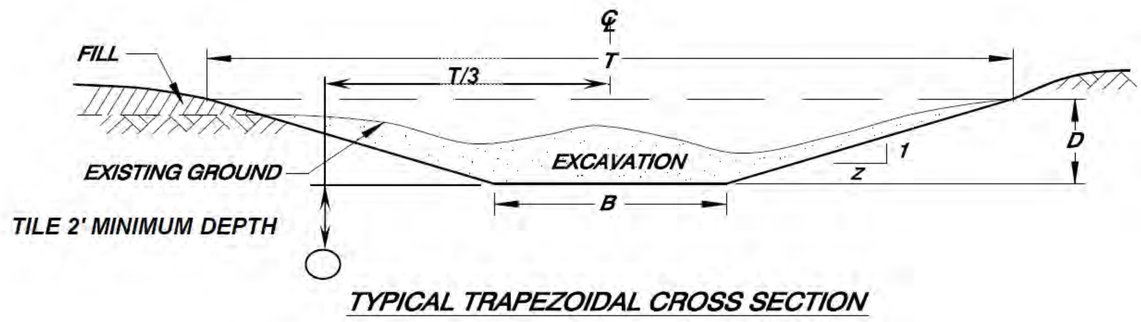
Subwatershed Name	HUC 12 Subwatershed Codes	Acres Benefited by BMP	Load Reduction Phosphorus (lbs/yr)	Per acre	Load Reduction Nitrogen (lbs/yr)	Per acre	Load Reduction Bacteria (billion CFU/yr)	Per acre	Load Reduction Sediment (tons/yr)	Per acre
Pigeon Lake-Pigeon Creek	**040500011001**	441	1,345	0.06	10,339	0.47	1,265	0.06	309	0.01
Mud Creek-Pigeon Creek*	**040500011002**	2,827	1,044	**0.09**	5,445	**0.48**	2,409	**0.21**	1,275	**0.11**
Long Lake-Pigeon Creek	**040500011003**	565	1,252	**0.07**	8,688	**0.47**	944	**0.05**	763	**0.04**
Headwaters Turkey Creek	**040500011004**	234	542	**0.05**	3,729	0.32	567	0.05	255	0.02
Big Turkey Lake-Turkey Creek	040500011005	297	559	0.05	4,048	**0.37**	402	0.04	163	0.01
Silver Lake-Pigeon Creek	**040500011006**	274	355	0.03	1,786	0.14	515	0.04	352	**0.03**
Otter Lake-Pigeon Creek	**040500011007**	84	69	0.01	473	0.05	125	0.01	57	0.01
Little Turkey Lake-Turkey Creek	**040500011008**	414	298	0.02	2,806	0.21	1,923	**0.15**	115	0.01
Green Lake-Pigeon Creek	040500011009	73	43	0.003	426	0.03	384	0.03	10	0.001
Mongo Millpond-Pigeon Creek	040500011010	91	93	0.01	763	0.07	540	0.05	62	0.01
	Grand Total	**5,300**	**5,599**	**0.04**	**38,503**	**0.28**	**9,074**	**0.07**	**3,361**	**0.02**

*The Mud Creek – Pigeon Creek subwatershed includes a large regional detention area at Bill Deller Rd and load reductions reflect the implementation of this BMP. Removing this practice would reduce load reductions in phosphorus to 475 lbs/yr, 2,188 lbs/yr for nitrogen, 677 billion CFU/yr for bacteria, and 449 tons/yr for sediment. The area benefited from this BMP would reduce the total to 350 acres, a reduction of 2,477 acres.

Figure 60 - Pigeon Creek Site-Specific BMPs



9.2.1 – Grassed Waterways

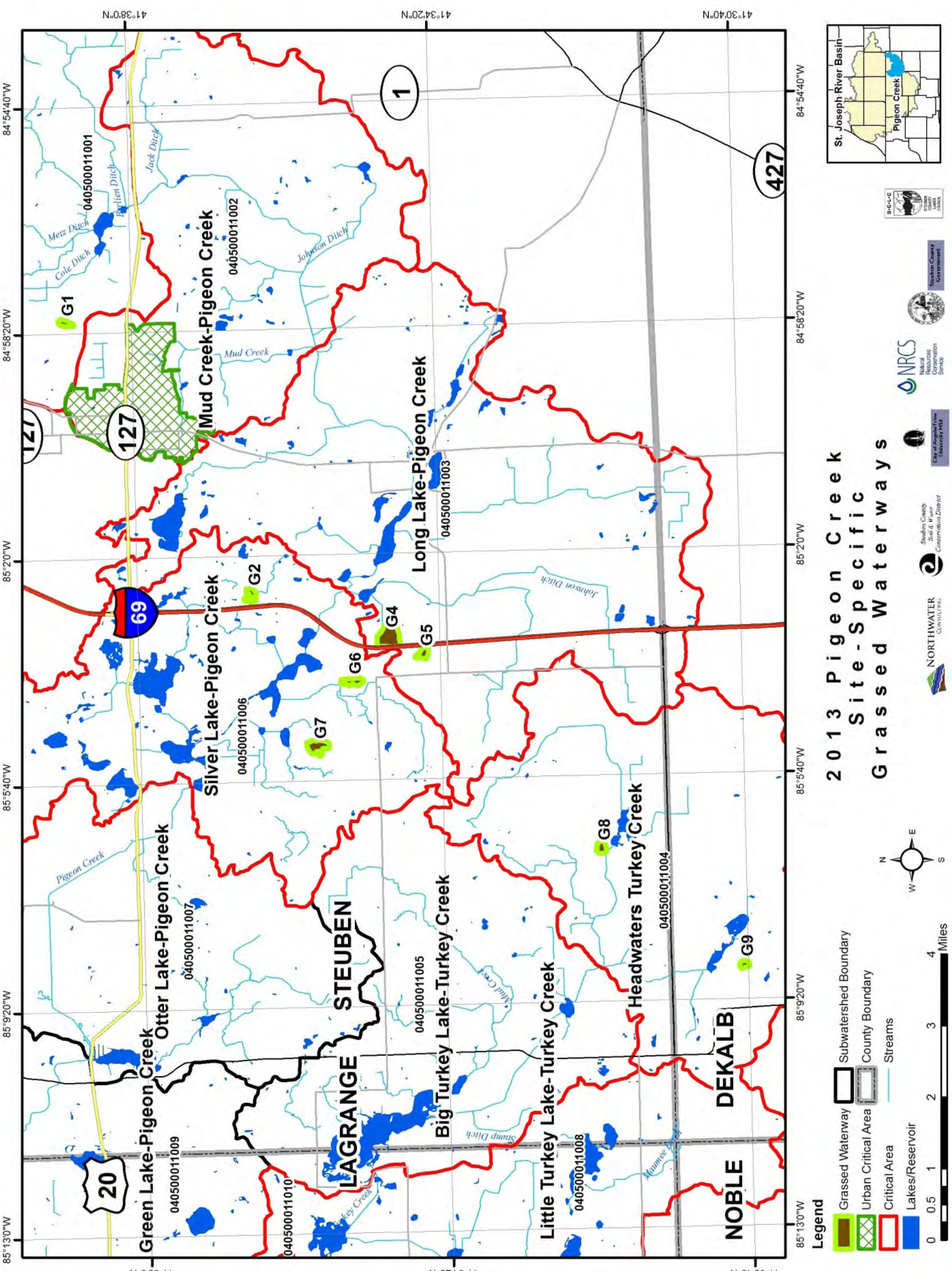


Site-specific grassed waterways are recommended at nine (9) sites throughout the watershed. If implemented, these practices will benefit 157 acres and will reduce phosphorus loads by 350 lbs/yr, nitrogen loads by 1,532 lbs/yr, bacteria loads by 168 billion CFU/yr, and sediment by 659 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 77). Figure 61 shows the location of these practices in the watershed.

Table 77 - Site-Specific Grassed Waterways Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	G1	Grassed Waterway	9.3	8.3	48.1	5.8	7.6
Silver Lake-Pigeon Creek	40500011006	G2	Grassed Waterway	8.3	12.2	74.0	9.0	22.8
Silver Lake-Pigeon Creek	40500011006	G3	Grassed Waterway	7.3	22.8	76.7	11.0	22.8
Long Lake-Pigeon Creek	40500011003	G4	Grassed Waterway	53.8	173.4	720.4	73.6	412.7
Long Lake-Pigeon Creek	40500011003	G5	Grassed Waterway	12.6	13.6	65.1	7.4	17.3
Silver Lake-Pigeon Creek	40500011006	G6	Grassed Waterway	16.2	27.6	155.2	18.7	59.5
Silver Lake-Pigeon Creek	40500011006	G7	Grassed Waterway	29.2	30.2	210.9	27.0	52.4
Headwaters Turkey Creek	40500011004	G8	Grassed Waterway	12.3	29.9	94.3	7.7	31.2
Headwaters Turkey Creek	40500011004	G9	Grassed Waterway	7.6	32.1	87.3	8.3	33
	Grand Total			157	350	1,532	168	659

Figure 61 - Pigeon Creek Site-Specific Grassed Waterway Locations



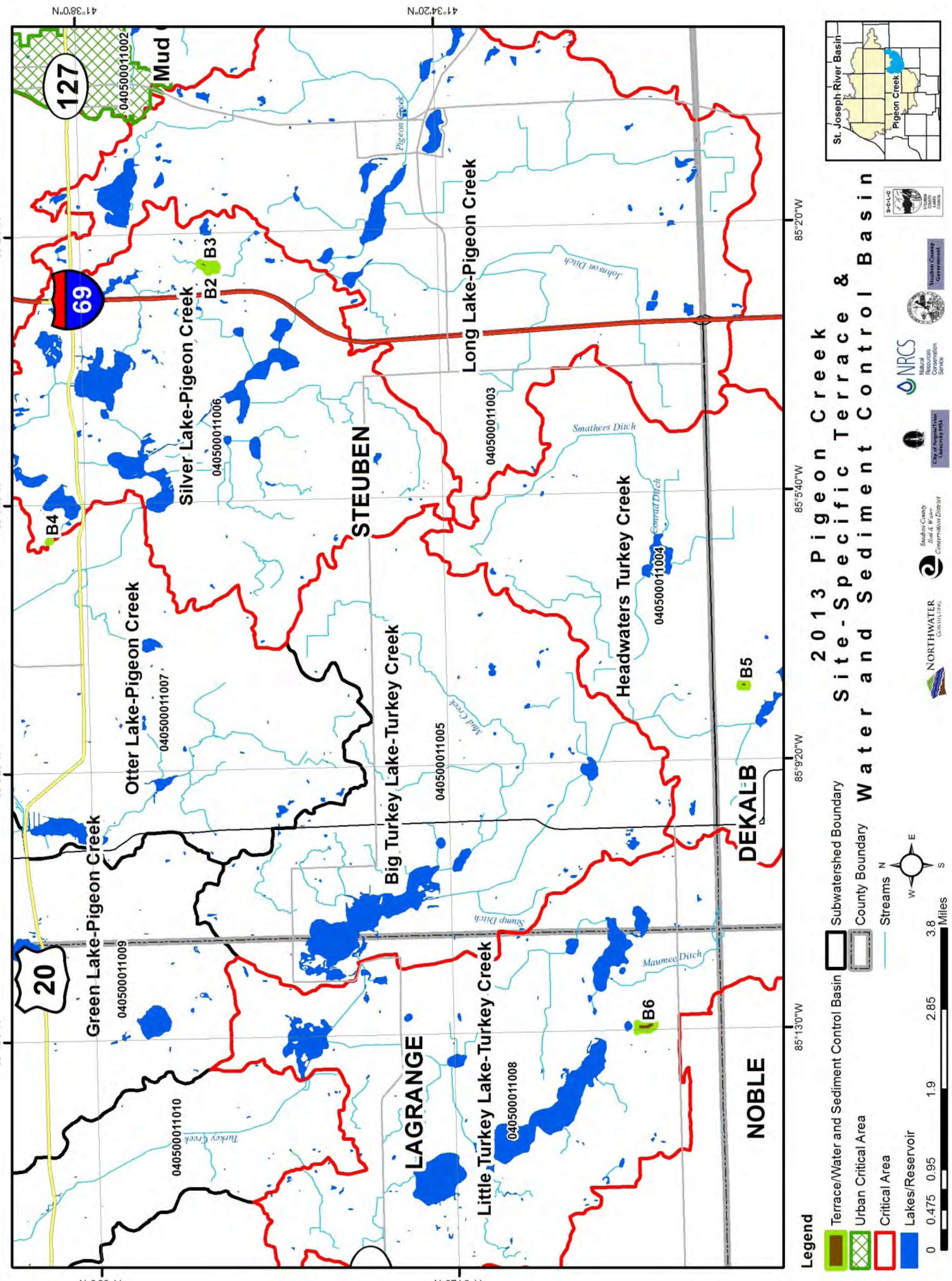
9.2.2 – Terraces & Water & Water & Sediment Control Basins

Site-specific terraces and/or water and sediment control basins are recommended at five (5) sites throughout the watershed. If implemented, these practices will benefit 33 acres and will reduce phosphorus loads by 158 lbs/yr, nitrogen loads by 324 lbs/yr, bacteria loads by 17 billion CFU/yr, and sediment by 148 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 78). Figure 62 shows the location of these practices in the watershed.

Table 78 - Site-Specific Terrace/Water & Sediment Control Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	40500011006	B2	Water and Sediment Control Basin	4.6	36.7	75.0	3.6	34.8
Silver Lake-Pigeon Creek	40500011006	B3	Water and Sediment Control Basin	8.3	31.4	61.2	2.9	27.7
Silver Lake-Pigeon Creek	40500011006	B4	Water and Sediment Control Basin	0.8	65.7	109.6	0.1	54.7
Headwaters Turkey Creek	40500011004	B5	Water and Sediment Control Basin	5.2	12.6	33.4	3.7	11.6
Little Turkey Lake-Turkey Creek	40500011008	B6	Water and Sediment Control Basin	14.4	11.5	44.9	7.2	19.2
	Grand Total			33	158	324	17	148

Figure 62 - Pigeon Creek Site-Specific Terraces/Water & Sediment Control Basin Locations



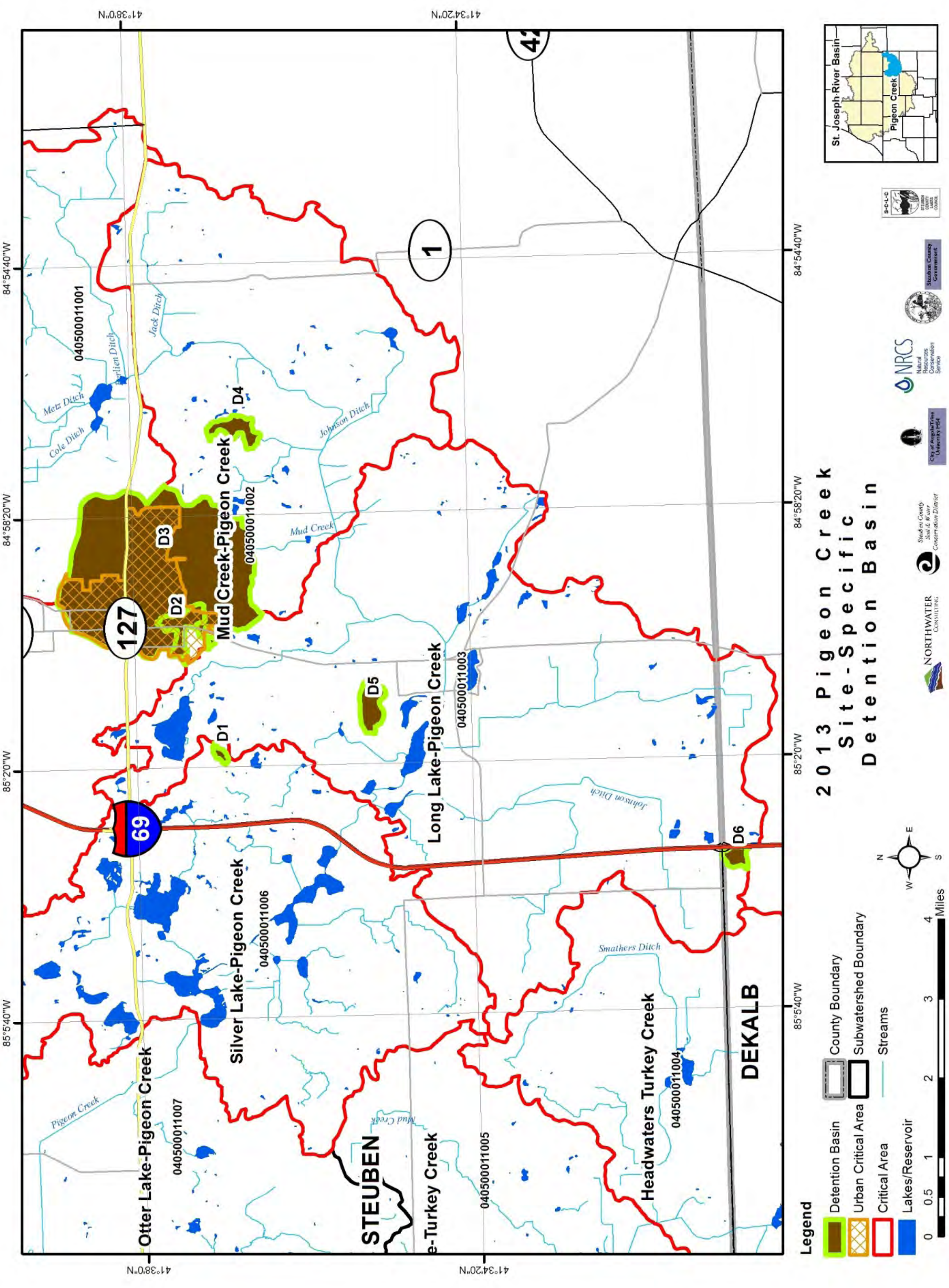
9.2.3 – Detention Basins/Ponds

Site-specific detention basins or ponds are recommended at six (6) sites throughout the watershed. If implemented, these practices will benefit 2,832 acres and will reduce phosphorus loads by 990 lbs/yr, nitrogen loads by 4,943 lbs/yr, bacteria loads by 2,208 billion CFU/yr, and sediment by 1,247 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in Table 79). Figure 63 shows the location of these practices in the watershed.

Table 79 - Site-Specific Detention Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	40500011006	D1	Detention Basin	16.9	6.9	40.5	20.9	8.51
Mud Creek-Pigeon Creek	40500011002	D2	Detention Basin	106.4	212.3	590.8	207.9	157.2
Mud Creek-Pigeon Creek	40500011002	D3	Detention Basin	2,477	568.9	3,257	1732	826.3
Mud Creek-Pigeon Creek	40500011002	D4	Detention Basin	91.4	121.3	620.1	136.2	184.9
Long Lake-Pigeon Creek	40500011003	D5	Detention Basin	97.5	73.2	388.3	82.1	68.1
Long Lake-Pigeon Creek	40500011003	D6	Detention Basin	43.7	7.1	46.1	29.0	1.52
	Grand Total			**2,832**	**990**	**4,943**	**2,208**	**1,247**

Figure 63 - Pigeon Creek Site-Specific Detention Basin Locations



9.2.4 – Feed Area Waste Lagoon System

Site-specific feed area waste lagoon systems are recommended at twenty-nine (29) sites throughout the watershed. A concept design is provided in Figures 64 through 67. The recommended system includes three individual practices working in series; a settling basin to capture solids, a rock spreader and vegetated swale for initial waste treatment and, finally, a treatment wetland to capture and treat the remaining waste. This conceptual system is recommended for small feed areas with less than 50 animal units and under one acre of drainage. For sites where drainage areas exceeding one acre or where building runoff is a concern, water diversions and gutter systems are also recommended.

If implemented, these systems will benefit 232 acres and will reduce phosphorus loads by 267 lbs/yr, nitrogen loads by 2,005 lbs/yr, bacteria loads by 1,836 billion CFU/yr, and sediment by 114 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 80). Figure 68 shows the location of these practices in the watershed. Small feed area waste lagoon systems should receive priority over other practices due to their high per-acre reductions in bacteria loads.

Figure 64 - Feed Area Waste System Concept Plan

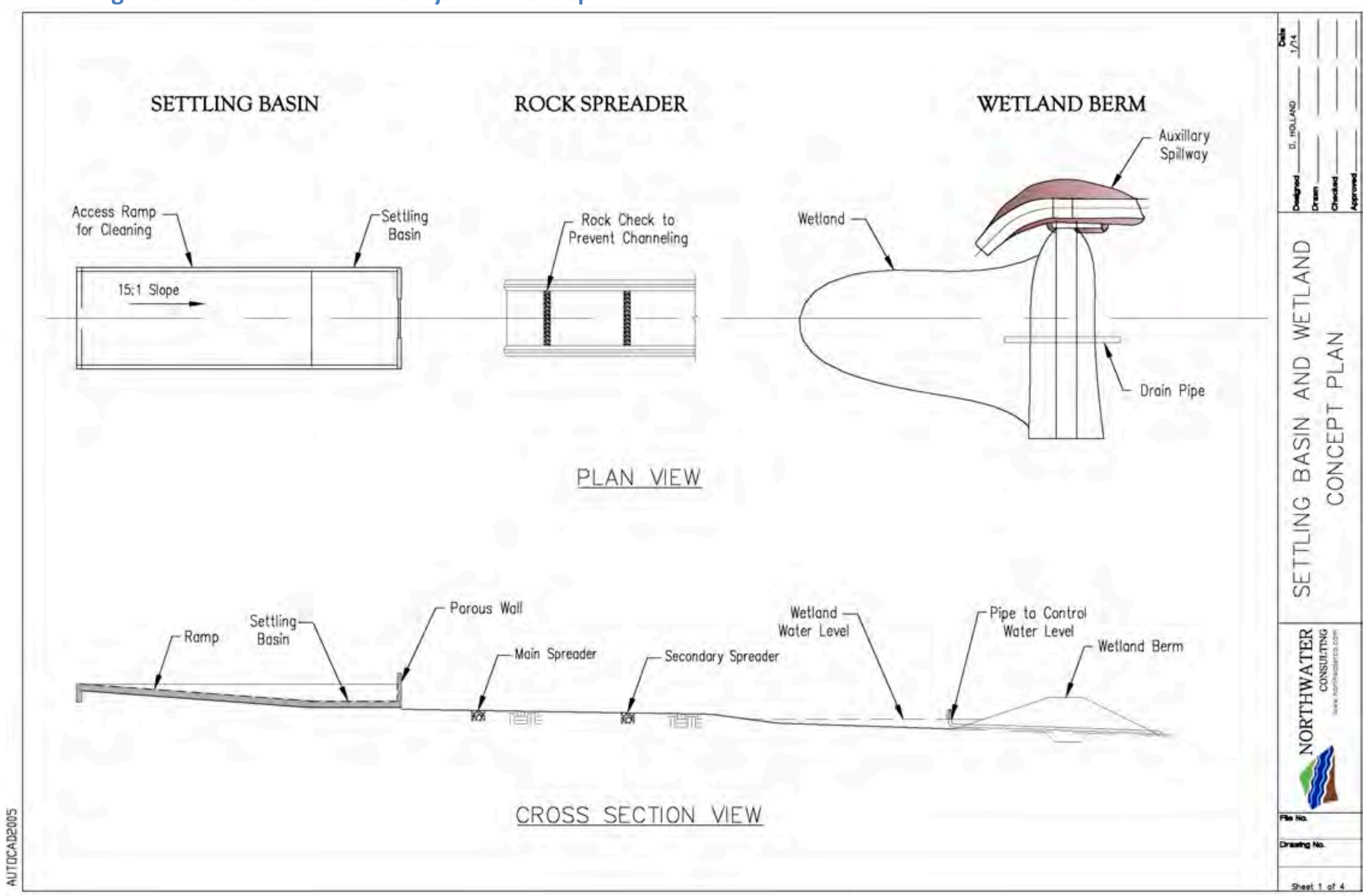


Figure 65 - Feed Area Waste System Concept Plan; Settling Basin

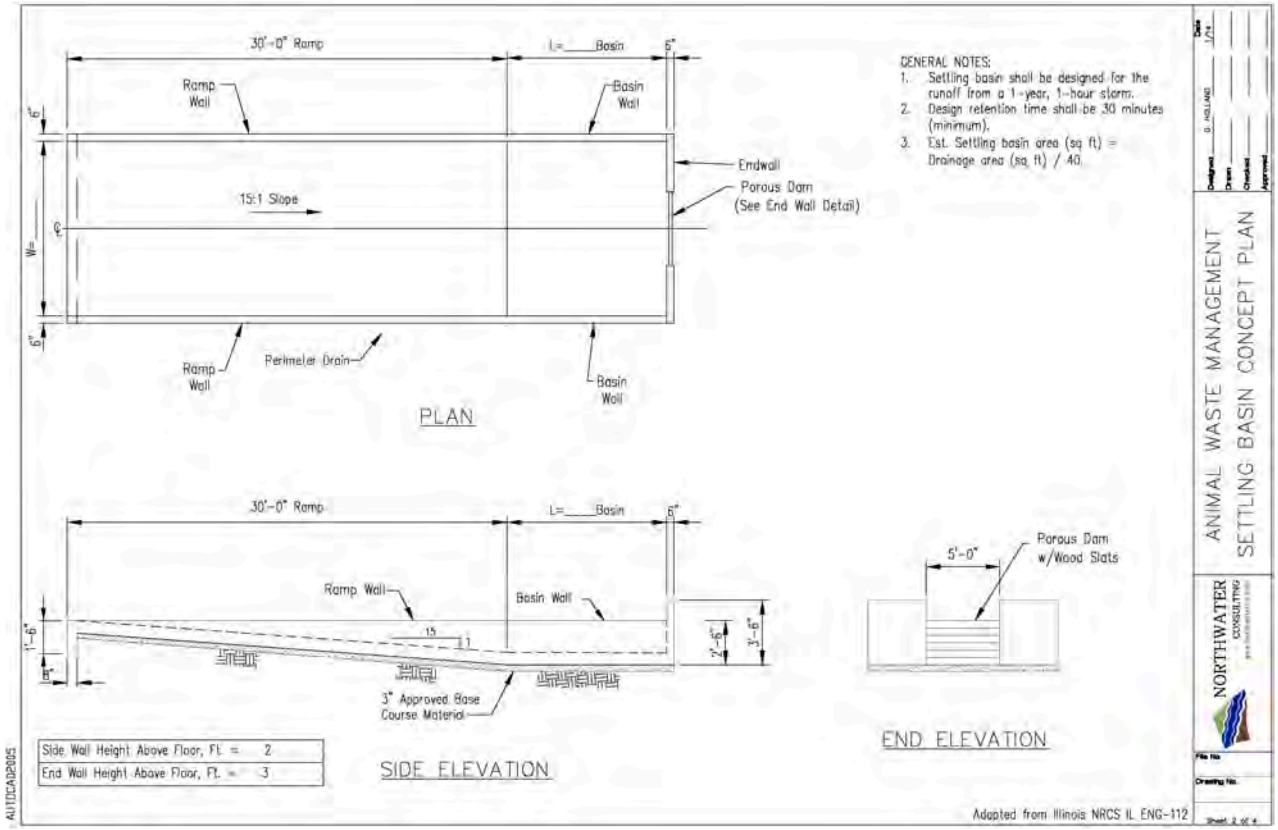


Figure 66 - Feed Area Waste System Concept Plan; Rock Spreader/Vegetated Swale

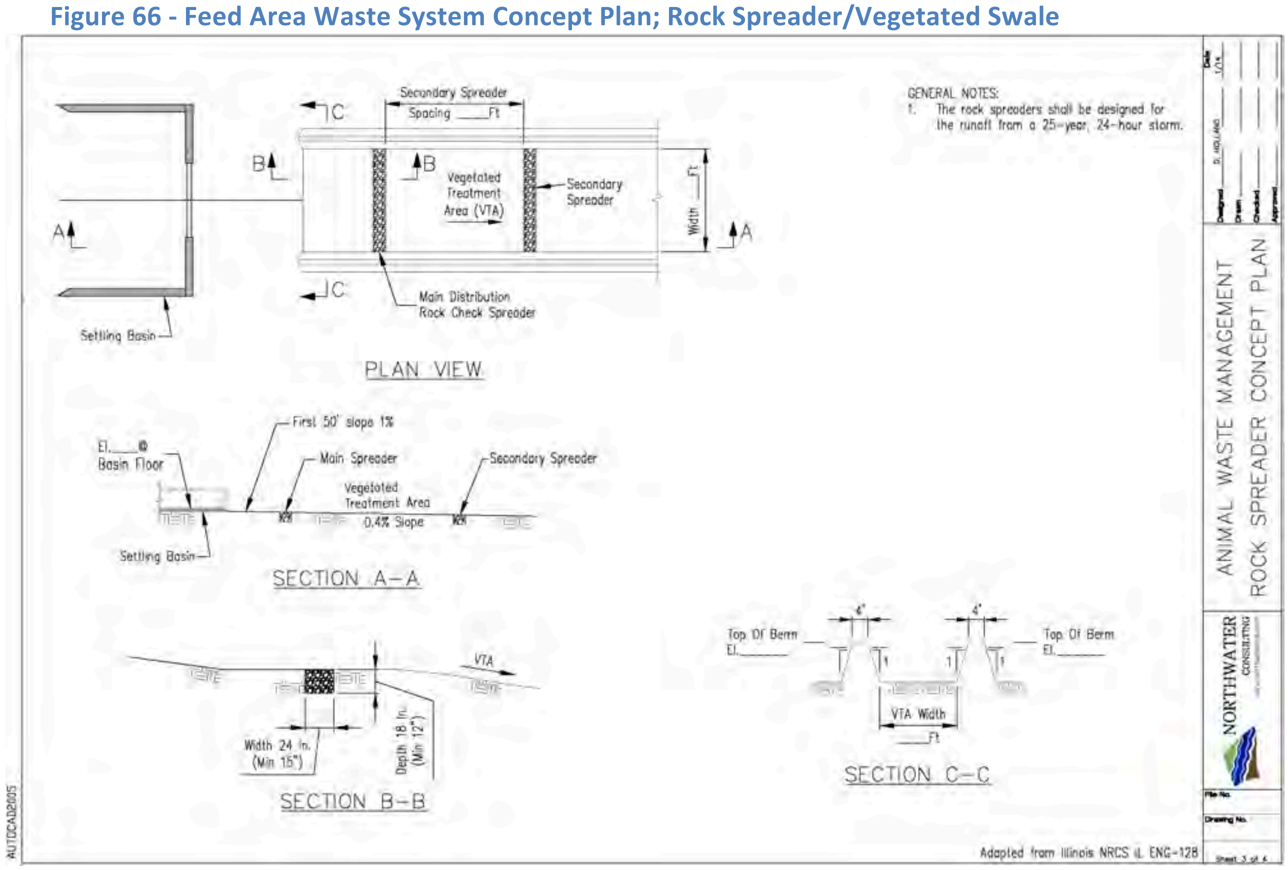


Figure 67 - Feed Area Waste System Concept Plan; Treatment Wetland

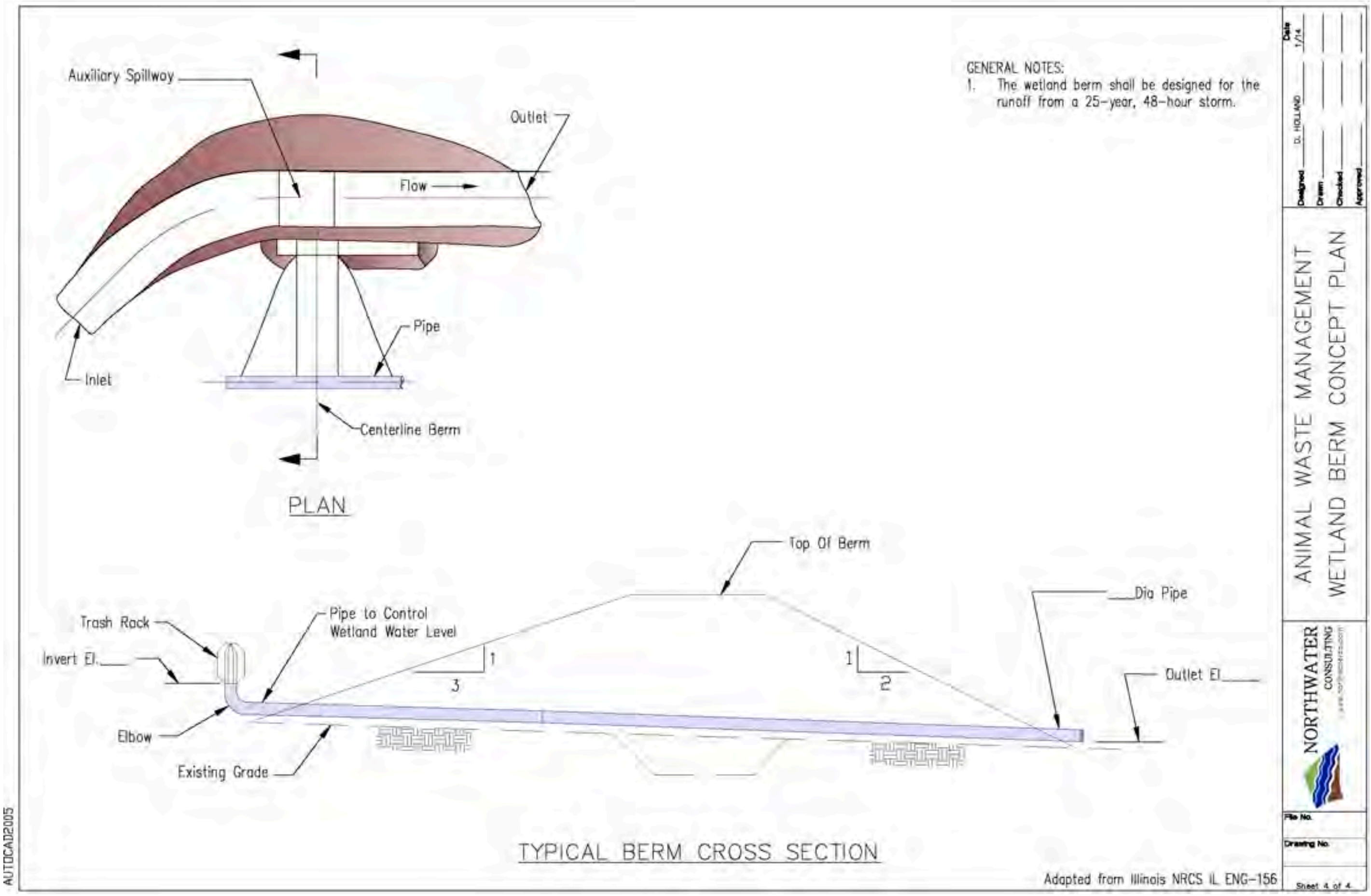
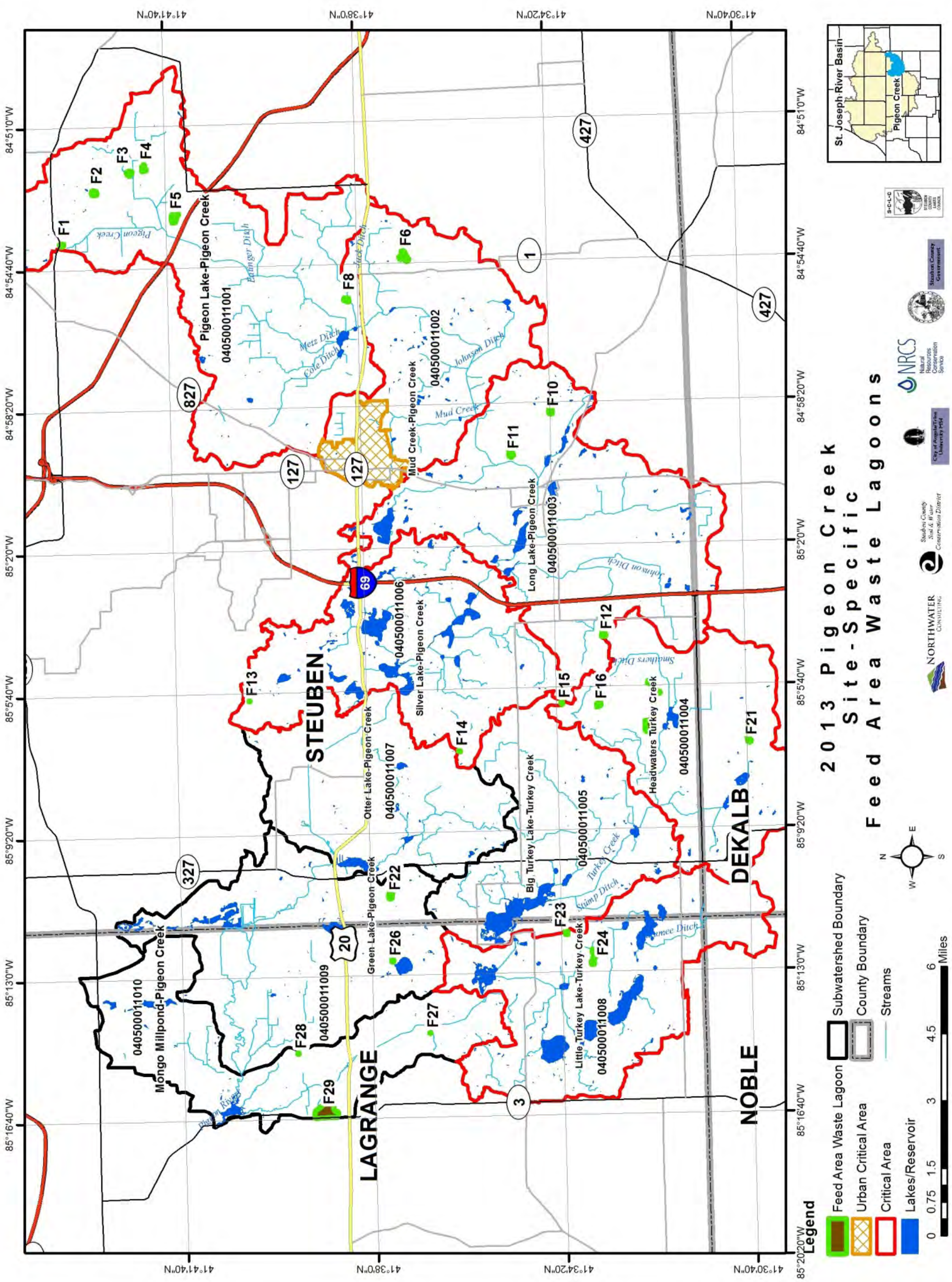


Table 80 - Site-Specific Feed Area Waste Lagoon Load Reductions

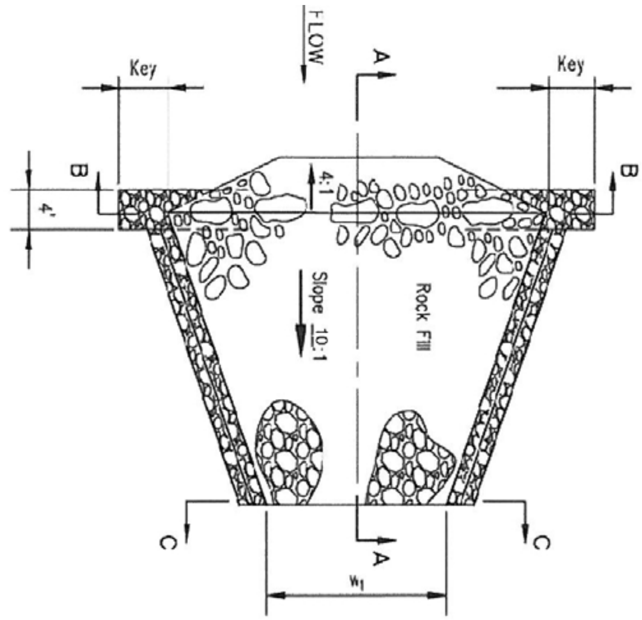
Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	F1	Feed Area Waste Lagoon	3.5	6.8	35.2	44.3	0.48
Pigeon Lake-Pigeon Creek	40500011001	F2	Feed Area Waste Lagoon	6.7	6.7	69.4	51.4	3.75
Pigeon Lake-Pigeon Creek	40500011001	F3	Feed Area Waste Lagoon	6.2	13.2	68.6	109.1	2.39
Pigeon Lake-Pigeon Creek	40500011001	F4	Feed Area Waste Lagoon	6.2	7.6	45.2	58.3	1.30
Pigeon Lake-Pigeon Creek	40500011001	F5	Feed Area Waste Lagoon	13.6	10.1	70.0	75.7	0.41
Mud Creek-Pigeon Creek	40500011002	F6	Feed Area Waste Lagoon	11.2	19.2	114.4	128.5	8.72
Mud Creek-Pigeon Creek	40500011002	F7	Feed Area Waste Lagoon	4.0	6.2	49.1	58.9	0.39
Pigeon Lake-Pigeon Creek	40500011001	F8	Feed Area Waste Lagoon	5.2	8.8	83.7	70.7	1.48
Long Lake-Pigeon Creek	40500011003	F9	Feed Area Waste Lagoon	2.3	4.9	25.3	44.3	0.47

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Long Lake-Pigeon Creek	40500011003	F10	Feed Area Waste Lagoon	5.3	6.2	44.1	70.2	0.30
Long Lake-Pigeon Creek	40500011003	F11	Feed Area Waste Lagoon	6.7	7.0	60.7	41.5	2.81
Headwaters Turkey Creek	40500011004	F12	Feed Area Waste Lagoon	4.1	4.8	34.8	29.1	1.60
Silver Lake-Pigeon Creek	40500011006	F13	Feed Area Waste Lagoon	0.3	0.3	3.0	2.8	0.04
Silver Lake-Pigeon Creek	40500011006	F14	Feed Area Waste Lagoon	0.6	0.7	6.0	5.2	0.21
Headwaters Turkey Creek	40500011004	F15	Feed Area Waste Lagoon	1.1	1.2	10.7	9.6	0.15
Headwaters Turkey Creek	40500011004	F16	Feed Area Waste Lagoon	6.2	4.9	47.0	36.0	1.10
Headwaters Turkey Creek	40500011004	F17	Feed Area Waste Lagoon	2.7	2.8	25.9	21.6	0.49
Headwaters Turkey Creek	40500011004	F18	Feed Area Waste Lagoon	1.2	0.8	9.0	5.6	0.28
Headwaters Turkey Creek	40500011004	F19	Feed Area Waste Lagoon	2.7	4.3	23.4	21.0	2.0
Headwaters Turkey Creek	40500011004	F20	Feed Area Waste Lagoon	29.8	21.2	162.5	76.6	16.4
Headwaters Turkey Creek	40500011004	F21	Feed Area Waste Lagoon	3.8	4.0	33.5	25.5	1.79
Green Lake-Pigeon Creek	40500011009	F22	Feed Area Waste Lagoon	6.4	8.7	73.8	53.3	4.58
Little Turkey Lake-Turkey Creek	40500011008	F23	Feed Area Waste Lagoon	3.0	7.2	34.9	79.7	0.21
Little Turkey Lake-Turkey Creek	40500011008	F24	Feed Area Waste Lagoon	5.7	6.7	60.2	62.7	0.58
Little Turkey Lake-Turkey Creek	40500011008	F25	Feed Area Waste Lagoon	3.2	9.6	58.3	101.7	0.39
Green Lake-Pigeon Creek	40500011009	F26	Feed Area Waste Lagoon	1.7	3.5	21.1	34.3	0.45
Mongo Millpond-Pigeon Creek	40500011010	F27	Feed Area Waste Lagoon	0.3	0.6	6.0	5.2	0.11
Mongo Millpond-Pigeon Creek	40500011010	F28	Feed Area Waste Lagoon	0.5	0.3	2.9	2.1	0.06
Mongo Millpond-Pigeon Creek	40500011010	F29	Feed Area Waste Lagoon	87.7	88.9	725.7	510.9	61.4
	Grand Total			**232**	**267**	**2,005**	**1,836**	**114**

Figure 68 - Pigeon Creek Site-Specific Feed Area Waste Lagoon Locations



9.2.5 – Rock Riffle

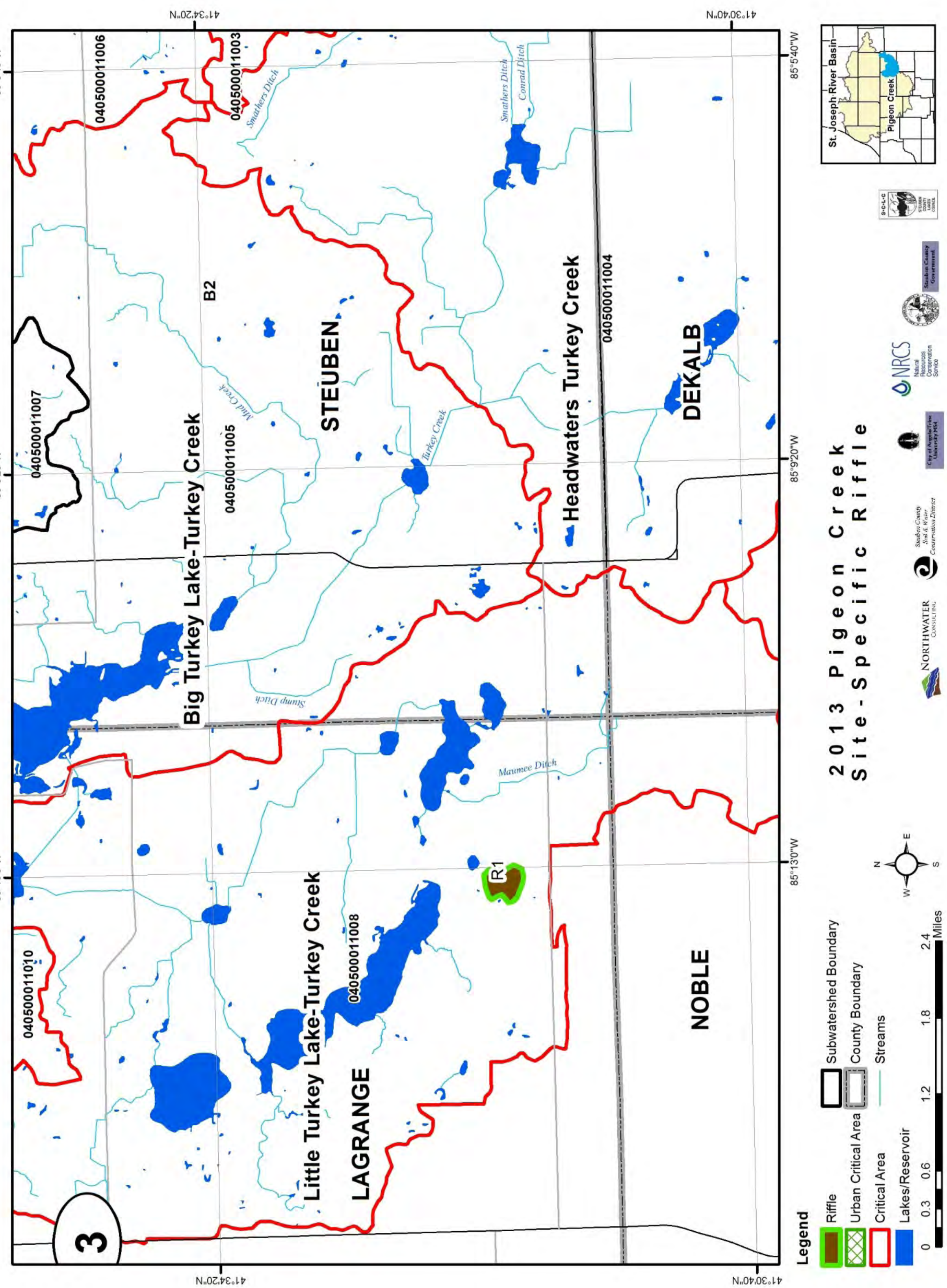


One (1) site-specific riffle (R1) is recommended in the watershed. If implemented, this practice will benefit 42 acres and will reduce phosphorus loads by 29 lbs/yr, nitrogen loads by 127 lbs/yr, bacteria loads by 13 billion CFU/yr, and sediment by 38 tons/yr. Priority should be given to this site as it is within a critical subwatershed (highlighted red in Table 81). Figure 69 shows the location of this practice in the watershed.

Table 81 - Site-Specific Riffle Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Little Turkey Lake-Turkey Creek	40500011008	R1	Rock Riffle	42	28.6	126.9	12.6	37.82

Figure 69 - Pigeon Creek Site-Specific Riffle Locations



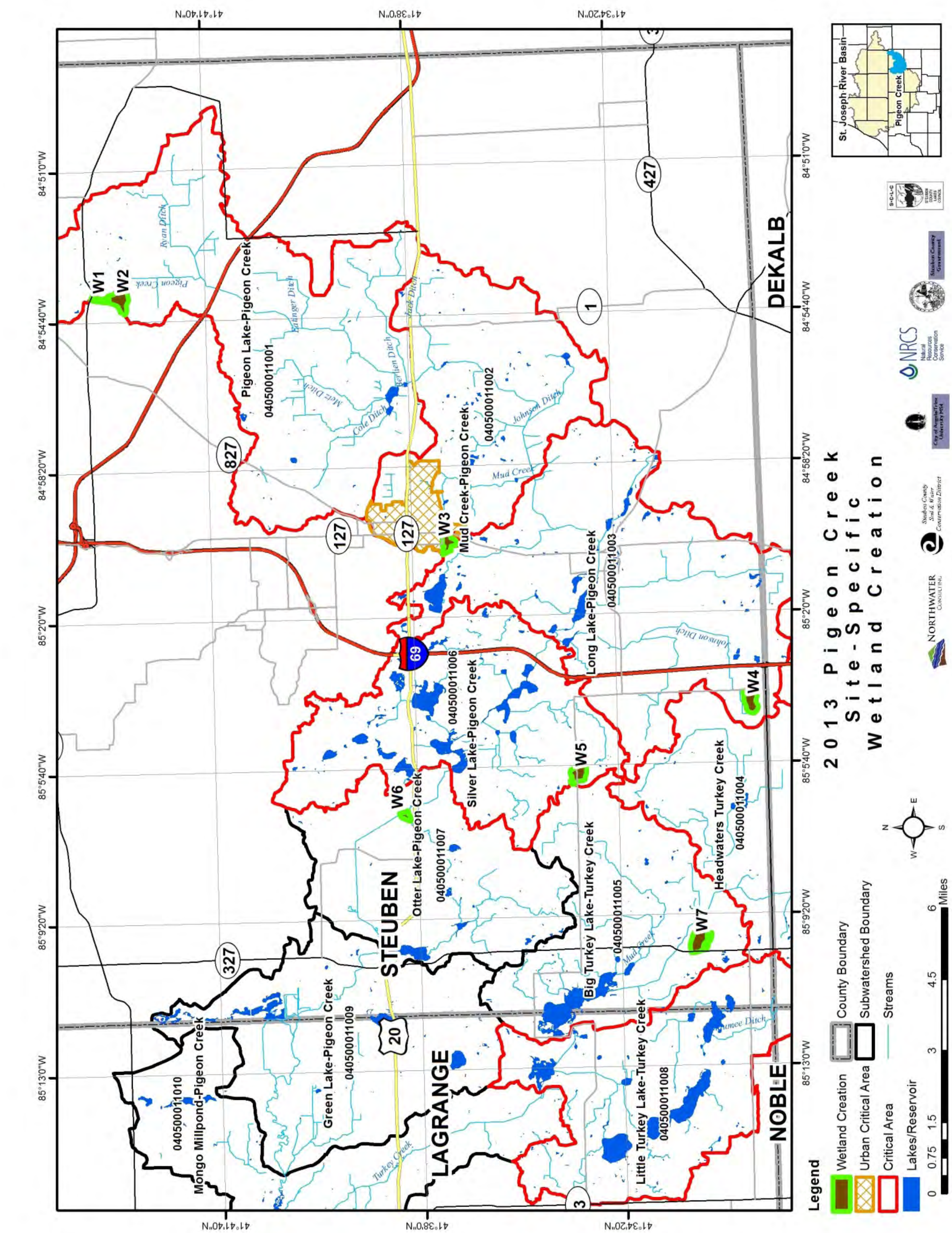
9.2.6 – Wetland Creation

Site-specific wetland creation is recommended at eight (8) sites throughout the watershed to treat urban and agricultural runoff. All of these sites are intended to be natural functioning wetlands. If implemented, these practices will benefit 441 acres and will reduce phosphorus loads by 251 lbs/yr, nitrogen loads by 1,773 lbs/yr, bacteria loads by 504 billion CFU/yr, and sediment by 172 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in Table 82). Figure 70 shows the location of these practices in the watershed.

Table 82 - Site-Specific Wetland Creation Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	**40500011001**	W1	Wetland Creation	19.9	10.2	72.1	16.4	5.76
Pigeon Lake-Pigeon Creek	**40500011001**	W2	Wetland Creation	**89.0**	**86.1**	**612.2**	**111.5**	**48.6**
Mud Creek-Pigeon Creek	**40500011002**	W3	Wetland Creation	55.2	10.4	108.6	61.4	2.79
Long Lake-Pigeon Creek	**40500011003**	W4	Wetland Creation	**77.9**	**39.4**	**291.6**	**88.2**	**34.3**
Silver Lake-Pigeon Creek	**40500011006**	W5	Wetland Creation	67.5	26.4	267.8	134.7	19.5
Otter Lake-Pigeon Creek	40500011007	W6	Wetland Creation	19.6	10.7	78.3	21.1	9.34
Big Turkey Lake-Turkey Creek	40500011005	W7	Wetland Creation	**92.9**	**56.8**	**263.5**	**56.7**	**44.8**
Big Turkey Lake-Turkey Creek	40500011005	W8	Wetland Creation	18.6	11.0	78.8	14.3	6.51
	Grand Total			**441**	**251**	**1,773**	**504**	**172**

Figure 70 - Pigeon Creek Site-Specific Wetland Creation Locations



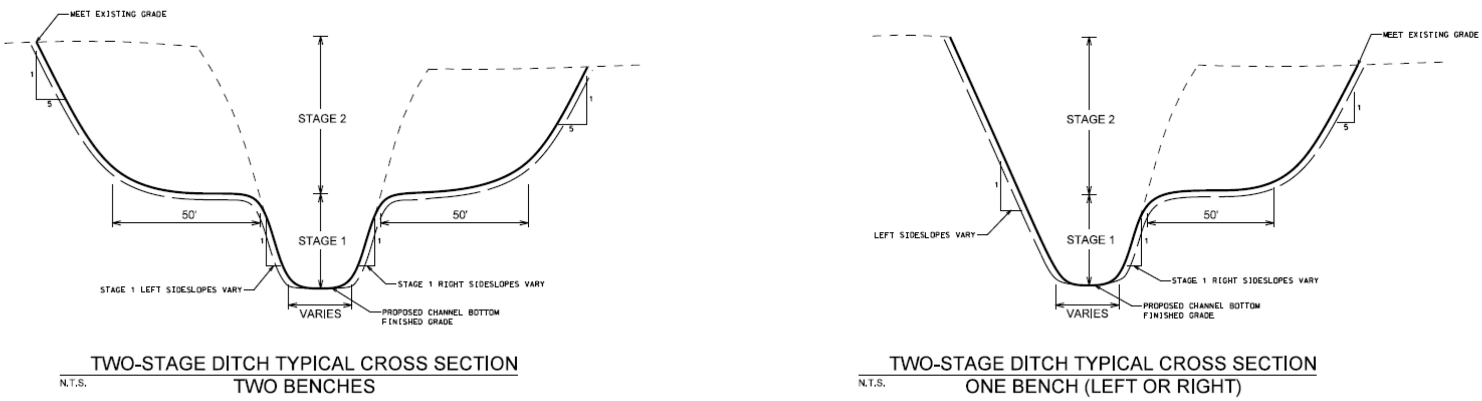
9.2.7 – Two-Stage Ditch

A windshield survey completed in April of 2013, landowner property visits and an analysis of existing GIS data resulted in the identification of over sixty (60) potential two-stage ditch sites. From these sites, a feasibility study was completed to determine the amount of potential new flood volume created by excavating and transforming existing one-stage ditches into two-stage ditches. Using available aerial 2-foot contour topography, the existing slope and bottom width at each site was calculated and then maintained in the proposed two-stage design. For each ditch location, the existing ditch cross-sectional area was calculated and compared to the proposed cross-sectional area that resulted from the addition of either one 50-foot-wide second stage shelf on one side of the ditch, or two 50-foot-wide second stage shelves, one on each side of the ditch. The increase in cross-sectional flow area was calculated by the length of the proposed two-stage improvements to calculate a net increase in flood storage volume. Despite location variability, the total bankfull flood storage volume associated with the proposed two-stage improvements is two to five times greater than the existing bankfull storage.

The bankfull capacity of the existing ditches was also calculated and compared to the bankfull capacity of the proposed two-stage ditch improvements. Similar to the total bankfull flood storage volume calculations, the total bankfull capacity associated with the proposed two-stage improvements is two to five times greater than the existing bankfull storage capacity. Additional calculations were also performed to calculate the theoretical reductions in ditch water surface elevations as the result of the two-stage ditch improvements (the calculations were based on existing bankfull flow with the new two-stage ditch capacity). Although the calculations indicate that the two-stage ditches result in water surface elevations that are approximately 1 to 3.5 feet lower (for existing bankfull flow conditions), it should be noted that this approach only provides a theoretical or conceptual evaluation that is intended to provide more qualitative information for consideration in the planning process. The calculated flood reduction benefits are not the result of a comprehensive flood study and the calculations performed do not take into account differences in storm events and downstream constraints that could reduce or eliminate the calculated flood reduction benefits. A more detailed design would require additional information regarding culverts and road crossings, nearby developments, more accurate topography and a detailed hydrologic analysis of the watershed.

A total of 176,485 feet of two-stage ditches are recommended for the Pigeon Creek watershed. If implemented, these practices will result in 881 acre-feet of water storage and will reduce phosphorus loads by 2,155 lbs/yr, nitrogen loads by 16,999 lbs/yr, bacteria loads by 475 billion CFU/yr, and sediment by 233 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 83). Figure 72 shows the location of these practices in the watershed.

Figure 71 - Two-Stage Ditch Cross-Section

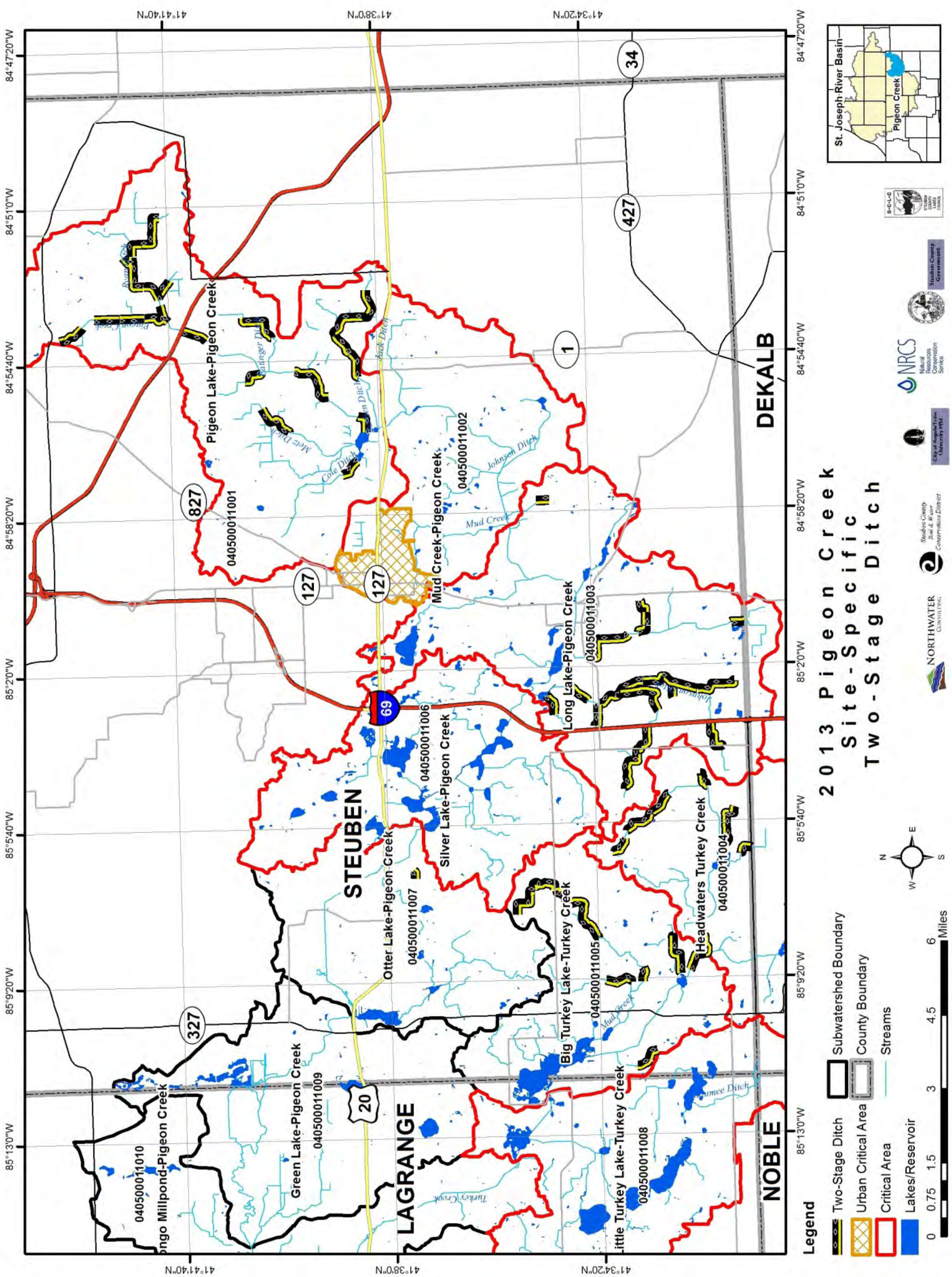


Note that the dimensions of the design shown in Figure 71 have been used to calculate load reductions and cost estimates for this plan. These dimensions provide the maximum benefits for improving water quality and flooding reductions and show an example cross-section with a generous bench width. More site-specific planning and design will be required based on landowner needs, hydrology and site constraints.

Table 83 - Site-Specific Two-Stage Ditch Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Length Two-Stage Ditch (ft)	Acre-ft of Water Storage	Phosphorus Load Reduction (lbs/yr)	Nitrogen Load Reduction (lbs/yr)	Bacteria Load Reduction (billion CFU/yr)	Sediment Load Reduction (tons/yr)
Pigeon Lake-Pigeon Creek	**040500011001**	64,590	368	900	7,096	199	4.97.4
Mud Creek-Pigeon Creek	**040500011002**	0	0	0	0	0	0
Long Lake-Pigeon Creek	**040500011003**	59,473	271	663	5,230	146	71.8
Headwaters Turkey Creek	**040500011004**	21,968	106	260	2,054	58	28.2
Big Turkey Lake-Turkey Creek	040500011005	29,513	131	321	2,532	71	34.8
Silver Lake-Pigeon Creek	**040500011006**	0	0	0	0	0	0
Otter Lake-Pigeon Creek	040500011007	941	4.51	11	87	2.4	1.2
Little Turkey Lake-Turkey Creek	**040500011008**	0	0	0	0	0	0
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	0	0	0	0	0	0
Grand Total		**176,485**	**881**	**2,155**	**16,999**	**475**	**233**

Figure 72 - Pigeon Creek Site-Specific Two-Stage Ditch Locations



9.2.8 – Filter Strips

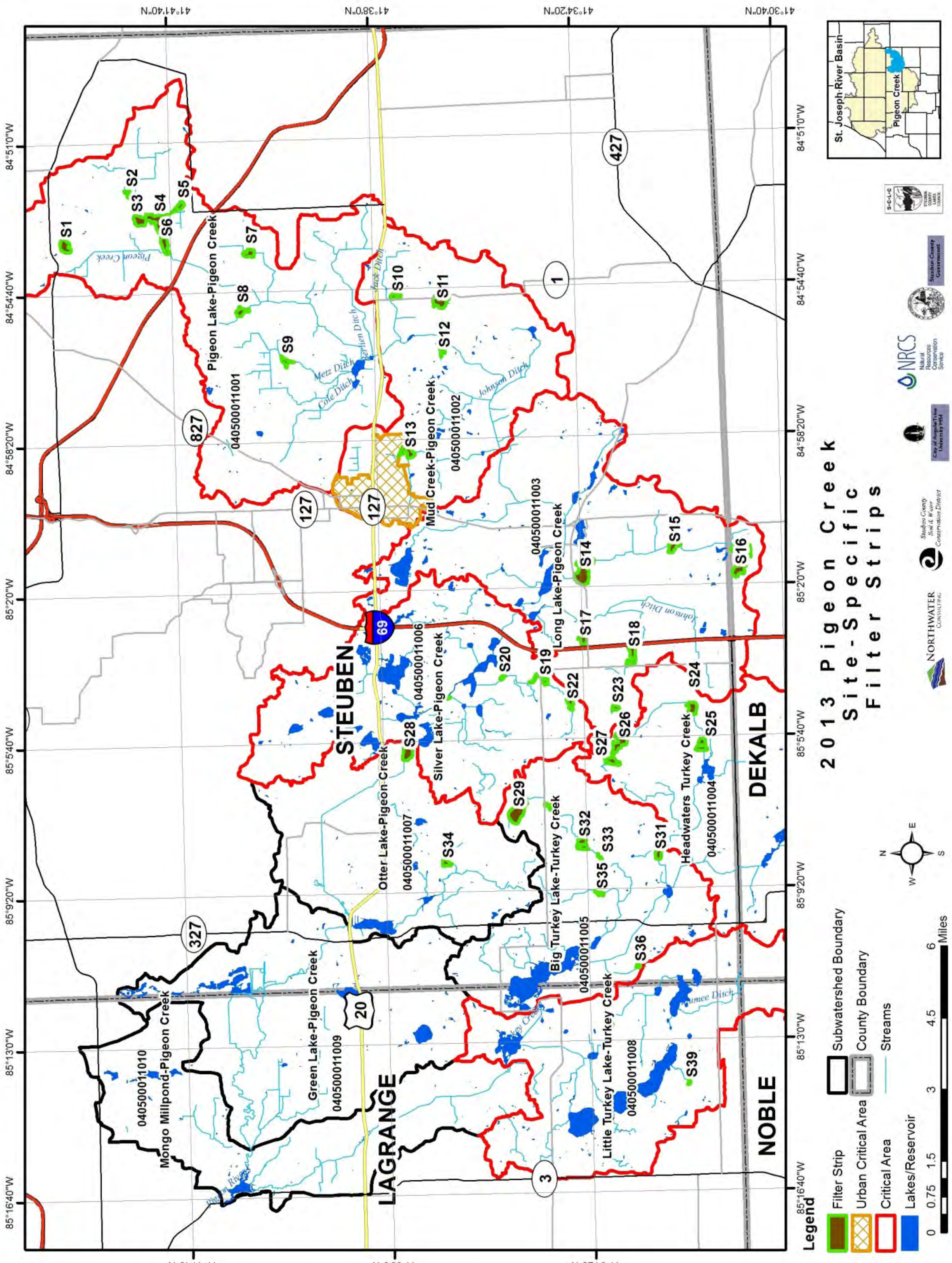
Site-specific filter strips are recommended at thirty-nine (39) sites throughout the watershed. If implemented, these practices will benefit 918 acres and will reduce phosphorus loads by 1,010 lbs/yr, nitrogen loads by 6,754 lbs/yr, bacteria loads by 817 billion CFU/yr, and sediment by 671 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 84). Figure 73 shows the location of these practices in the watershed.

Table 84 - Site-Specific Filter Strip Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	S1	Filter Strip	29.4	21.7	154.6	16.6	10.9
Pigeon Lake-Pigeon Creek	40500011001	S2	Filter Strip	15.5	13.0	91.1	9.7	2.23
Pigeon Lake-Pigeon Creek	40500011001	S3	Filter Strip	28.5	26.1	183.5	18.8	8.92
Pigeon Lake-Pigeon Creek	40500011001	S4	Filter Strip	58.4	75.0	506.2	57.1	79.6
Pigeon Lake-Pigeon Creek	40500011001	S5	Filter Strip	14.5	14.8	104.0	10.7	0.58
Pigeon Lake-Pigeon Creek	40500011001	S6	Filter Strip	26.1	39.5	270.9	29.3	7.34
Pigeon Lake-Pigeon Creek	40500011001	S7	Filter Strip	18.1	17.7	125.6	13.1	2.86
Pigeon Lake-Pigeon Creek	40500011001	S8	Filter Strip	18.0	26.9	186.5	20.5	11.9
Pigeon Lake-Pigeon Creek	40500011001	S9	Filter Strip	13.4	19.0	130.2	14.0	11.5
Mud Creek-Pigeon Creek	40500011002	S10	Filter Strip	12.5	19.4	126.7	15.2	48.4
Mud Creek-Pigeon Creek	40500011002	S11	Filter Strip	36.9	35.2	222.1	32.2	30.7
Mud Creek-Pigeon Creek	40500011002	S12	Filter Strip	4.9	6.3	48.7	4.1	4.20
Mud Creek-Pigeon Creek	40500011002	S13	Filter Strip	27.8	44.5	307.9	32.8	11.7
Long Lake-Pigeon Creek	40500011003	S14	Filter Strip	87.5	43.1	321.3	55.0	12.1
Long Lake-Pigeon Creek	40500011003	S15	Filter Strip	20.1	22.4	149.6	17.2	12
Long Lake-Pigeon Creek	40500011003	S16	Filter	77.7	99.7	697.4	79.0	45.5

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
			Strip					
Long Lake-Pigeon Creek	40500011003	S17	Filter Strip	20.0	23.9	140.1	20.5	21.8
Long Lake-Pigeon Creek	40500011003	S18	Filter Strip	33.0	46.7	305.6	37.5	44.1
Silver Lake-Pigeon Creek	40500011006	S19	Filter Strip	18.8	29.2	189.7	23.4	16.9
Silver Lake-Pigeon Creek	40500011006	S20	Filter Strip	4.2	4.4	25.9	3.7	4.89
Silver Lake-Pigeon Creek	40500011006	S21	Filter Strip	1.4	4.1	15.0	1.7	1.94
Silver Lake-Pigeon Creek	40500011006	S22	Filter Strip	14.3	21.6	147.2	16.6	13.6
Long Lake-Pigeon Creek	40500011003	S23	Filter Strip	8.7	8.6	52.6	6.9	14.1
Headwaters Turkey Creek	40500011004	S24	Filter Strip	24.9	29.0	196.5	21.9	27.89
Headwaters Turkey Creek	40500011004	S25	Filter Strip	24.7	31.4	201.5	25.0	9.07
Headwaters Turkey Creek	40500011004	S26	Filter Strip	44.5	56.1	349.1	45.6	52.8
Headwaters Turkey Creek	40500011004	S27	Filter Strip	24.1	31.5	201.2	25.2	35.3
Otter Lake-Pigeon Creek	40500011007	S28	Filter Strip	39.0	23.8	141.4	23.9	27.2
Big Turkey Lake-Turkey Creek	40500011005	S29	Filter Strip	70.3	62.8	407.0	50.6	21.2
Big Turkey Lake-Turkey Creek	40500011005	S30	Filter Strip	7.3	9.1	62.1	7.2	14.7
Big Turkey Lake-Turkey Creek	40500011005	S31	Filter Strip	15.6	23.6	149.6	19.0	2.57
Big Turkey Lake-Turkey Creek	40500011005	S32	Filter Strip	26.4	28.7	186.1	22.6	13.7
Big Turkey Lake-Turkey Creek	40500011005	S33	Filter Strip	2.4	2.9	18.8	2.3	1.62
Otter Lake-Pigeon Creek	40500011007	S34	Filter Strip	12.6	12.2	71.6	10.4	15.3
Big Turkey Lake-Turkey Creek	40500011005	S35	Filter Strip	6.0	6.0	37.2	5.0	7.11
Big Turkey Lake-Turkey Creek	40500011005	S36	Filter Strip	7.4	8.6	63.8	6.0	2.89
Little Turkey Lake-Turkey Creek	40500011008	S37	Filter Strip	14.9	19.0	148.4	12.2	8.36
Little Turkey Lake-Turkey Creek	40500011008	S38	Filter Strip	5.4	0.4	4.0	2.9	0.02
Little Turkey Lake-Turkey Creek	40500011008	S39	Filter Strip	2.4	2.2	13.6	1.8	3.59
	Grand Total			**918**	**1,010**	**6,754**	**817**	**661**

Figure 73 - Pigeon Creek Site-Specific Filter Strip Locations



9.2.9 – Pasture BMPs

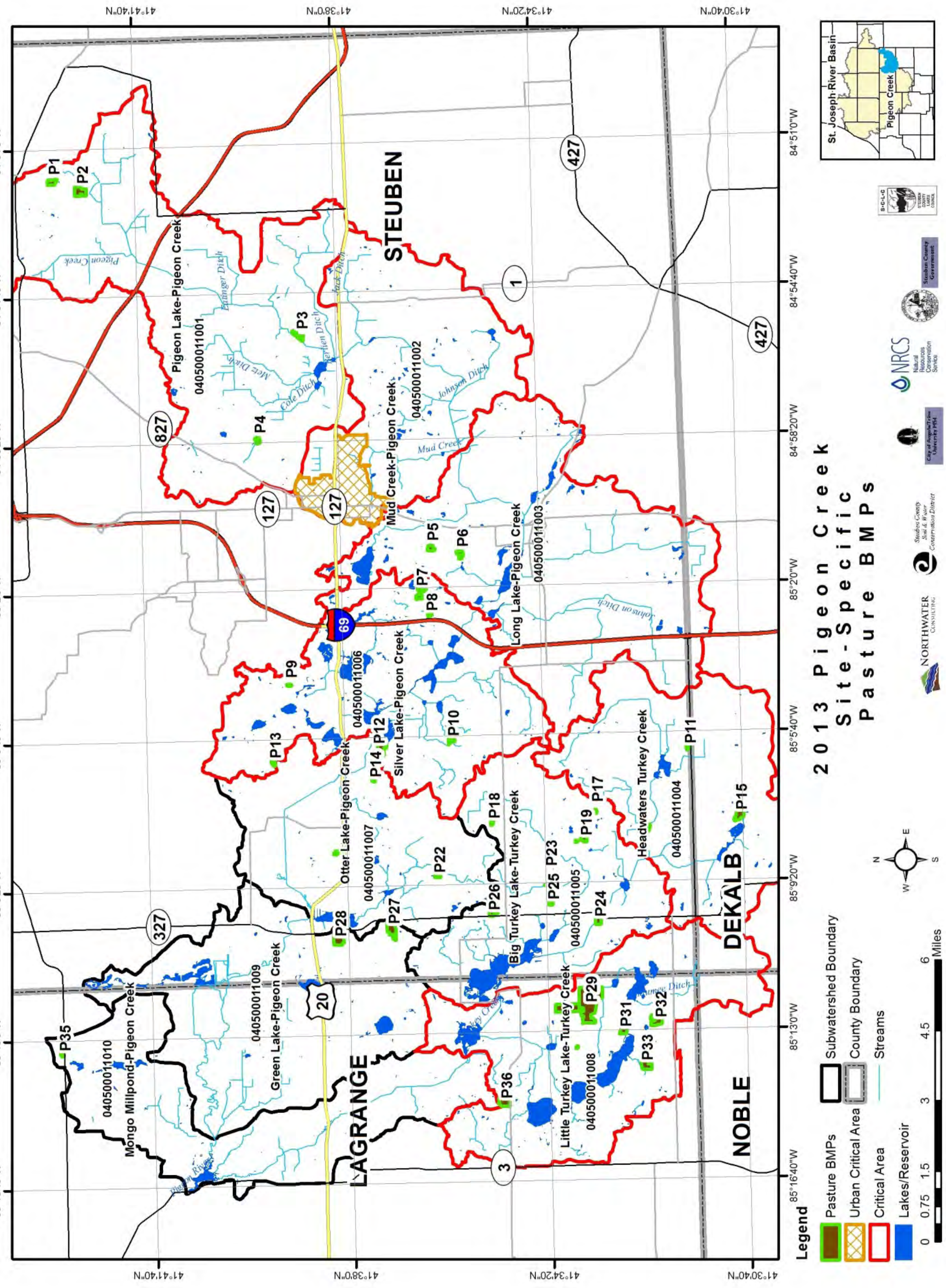
Site-specific pasture BMPs are recommended at thirty-six (36) sites throughout the watershed. As previously listed, pasture BMPs can include fencing (stream and interior), stream crossings, alternative watering systems, filter/buffer strips and diversions. If implemented, these practices will benefit 628 acres and will reduce phosphorus loads by 376 lbs/yr, nitrogen loads by 4,017 lbs/yr, bacteria loads by 3,016 billion CFU/yr, and sediment by 77 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 85). Figure 74 shows the location of these practices in the watershed.

Table 85 - Site-Specific Pasture BMP Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	P1	Pasture BMPs	13.1	12.6	146.8	128.5	1.02
Pigeon Lake-Pigeon Creek	40500011001	P2	Pasture BMPs	26.5	6.8	71.4	56.6	0.70
Pigeon Lake-Pigeon Creek	40500011001	P3	Pasture BMPs	12.8	10.9	119.7	108.4	1.69
Pigeon Lake-Pigeon Creek	40500011001	P4	Pasture BMPs	6.7	4.2	48.0	40.4	0.67
Long Lake-Pigeon Creek	40500011003	P5	Pasture BMPs	9.0	4.1	45.8	29.8	0.28
Long Lake-Pigeon Creek	40500011003	P6	Pasture BMPs	9.5	12.5	141.5	114.9	1.43
Silver Lake-Pigeon Creek	40500011006	P7	Pasture BMPs	17.3	11.4	125.8	101.7	0.97
Silver Lake-Pigeon Creek	40500011006	P8	Pasture BMPs	2.1	1.7	19.5	16.6	0.15
Silver Lake-Pigeon Creek	40500011006	P9	Pasture BMPs	2.4	1.2	12.6	10.0	0.34
Silver Lake-Pigeon Creek	40500011006	P10	Pasture BMPs	7.7	7.1	80.4	66.5	0.72
Headwaters Turkey Creek	40500011004	P11	Pasture BMPs	4.0	1.4	15.6	12.8	0.13
Silver Lake-Pigeon Creek	40500011006	P12	Pasture BMPs	25.8	0.6	5.6	4.9	0.06
Silver Lake-Pigeon Creek	40500011006	P13	Pasture BMPs	5.4	1.7	19.3	16.6	0.27
Otter Lake-Pigeon Creek	40500011007	P14	Pasture BMPs	1.6	1.8	12.2	6.2	2.35
Headwaters Turkey Creek	40500011004	P15	Pasture BMPs	28.3	7.9	81.1	77.8	0.85
Headwaters Turkey	40500011004	P16	Pasture	6.4	6.0	67.9	56.5	1.05

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Creek			BMPs					
Big Turkey Lake-Turkey Creek	40500011005	P17	Pasture BMPs	2.7	1.6	17.2	13.3	0.45
Big Turkey Lake-Turkey Creek	40500011005	P18	Pasture BMPs	4.4	2.3	15.9	5.1	2.27
Big Turkey Lake-Turkey Creek	40500011005	P19	Pasture BMPs	9.0	3.0	34.2	22.3	0.20
Big Turkey Lake-Turkey Creek	40500011005	P20	Pasture BMPs	1.3	1.5	14.4	11.9	0.14
Otter Lake-Pigeon Creek	40500011007	P21	Pasture BMPs	3.5	2.1	19.4	16.3	0.24
Otter Lake-Pigeon Creek	40500011007	P22	Pasture BMPs	4.8	6.9	62.4	44.5	1.76
Big Turkey Lake-Turkey Creek	40500011005	P23	Pasture BMPs	3.4	3.8	30.6	10.2	0.90
Big Turkey Lake-Turkey Creek	40500011005	P24	Pasture BMPs	14.9	9.8	64.3	24.5	7.81
Big Turkey Lake-Turkey Creek	40500011005	P25	Pasture BMPs	5.1	2.2	20.6	16.5	0.59
Big Turkey Lake-Turkey Creek	40500011005	P26	Pasture BMPs	9.0	4.5	51.1	43.4	0.40
Green Lake-Pigeon Creek	40500011009	P27	Pasture BMPs	**34.7**	**16.9**	**180.3**	**169.8**	**3.20**
Green Lake-Pigeon Creek	40500011009	P28	Pasture BMPs	30.3	13.5	150.8	126.6	1.56
Little Turkey Lake-Turkey Creek	**40500011008**	P29	Pasture BMPs	**173.1**	**144**	**1,653**	**1,269**	**13.4**
Little Turkey Lake-Turkey Creek	**40500011008**	P30	Pasture BMPs	**53.5**	**40.8**	**446.4**	**262.0**	**3.69**
Little Turkey Lake-Turkey Creek	**40500011008**	P31	Pasture BMPs	11.3	4.5	48.3	34.1	0.35
Little Turkey Lake-Turkey Creek	**40500011008**	P32	Pasture BMPs	25.9	4.7	40.9	32.9	1.05
Little Turkey Lake-Turkey Creek	**40500011008**	P33	Pasture BMPs	30.4	15.4	96.2	17.4	25.3
Little Turkey Lake-Turkey Creek	**40500011008**	P34	Pasture BMPs	1.1	0.6	5.5	2.7	0.72
Mongo Millpond-Pigeon Creek	40500011010	P35	Pasture BMPs	2.9	3.1	28.2	21.5	0.40
Little Turkey Lake-Turkey Creek	**40500011008**	P36	Pasture BMPs	27.8	2.7	24.9	23.8	0.26
	Grand Total			628	376	4,017	3,016	77

Figure 74 - Pigeon Creek Pasture BMP Locations



9.2.1 – Other BMPs

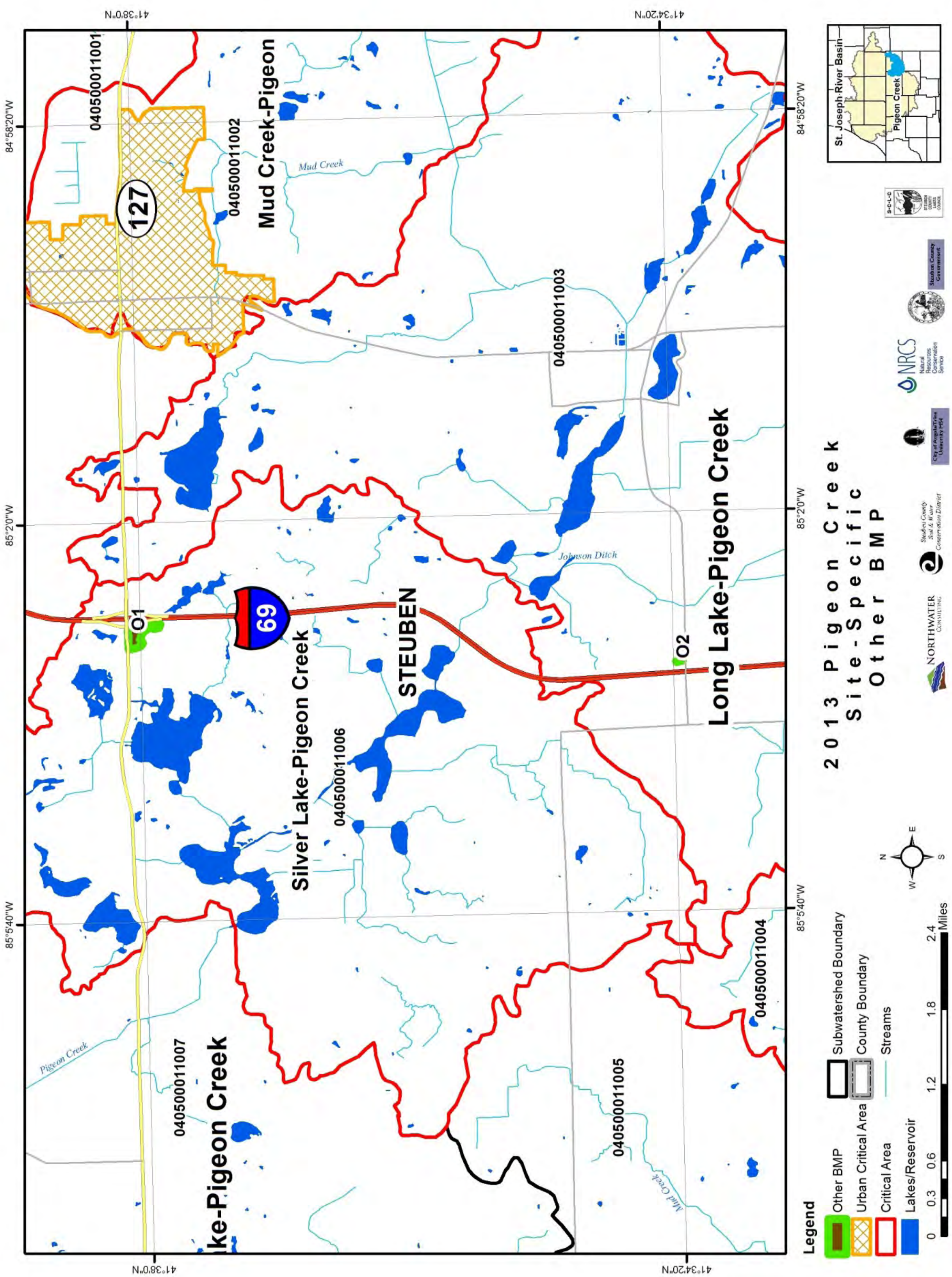
Site-specific other BMPs are recommended at two (2) sites in the watershed and include streambank stabilization and detention for a new truck stop development. If implemented, these practices will benefit 18 acres and will reduce phosphorus loads by 40 lbs/yr, nitrogen loads by 118 lbs/yr, bacteria loads by 19 billion CFU/yr, and sediment by 33 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 86). Figure 75 shows the location of these practices in the watershed.

Table 86 - Site-Specific Other BMP Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	40500011006	O1	Detention for Truck Stop	17.6	10.5	65.8	18.0	8.7
Long Lake-Pigeon Creek	40500011003	O2	Streambank Stabilization	0.3	29.5	52.3	0.6	24.2
	Grand Total			18	40	118	19	33

Pigeon Creek; Streambank Stabilization

Figure 75 - Pigeon Creek Other BMP Locations



9.3 – Existing Best Management Practices

Past efforts to improve water quality in the Pigeon Creek watershed have resulted in the implementation of over 140 individual BMPs. These efforts have already resulted in pollution load reductions and should receive credit for doing so. Only those known practices are included in this section; due to privacy issues, data on existing USDA practices implemented through the Conservation Reserve Program (CRP) and the Environmental Quality Incentive Program (EQIP) are unavailable. However, it is important to note that both CRP and EQIP practices exist in the watershed and are having a positive effect on water quality. Practices implemented by the Steuben County SWCD and the City of Angola are detailed in Section 3.6 and are currently treating 3,686 acres (2.7%); these practices include:

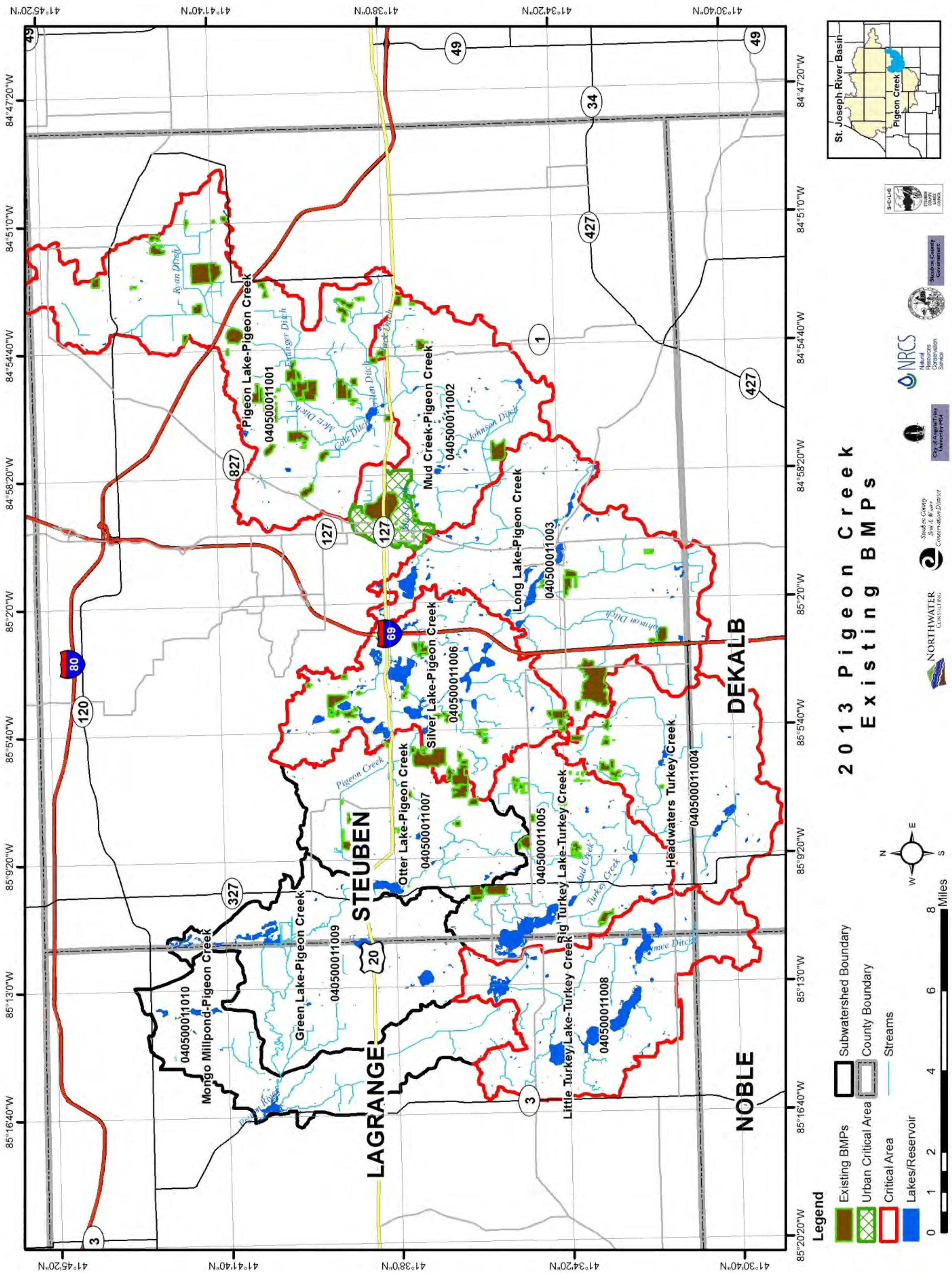
- Filter strips and grassed waterways.
- Water and Sediment Control Basins.
- Streambank stabilization.
- Livestock fencing and hay and tree planting.
- Wetland creation.
- Rain barrels and pervious concrete.
- Bioswales and rain gardens.

Load reductions were calculated for all existing BMPs using SWAMM and are summarized by subwatershed in Table 87. The locations of existing BMPs are also shown in Figure 76.

Table 87 - Existing BMP Load Reductions

Subwatershed Names	HUC 12 Subwatershed Codes	Treated Area (acres)	Phosphorus Load Reduction (lbs/yr)	Nitrogen Load Reduction (lbs/yr)	Bacteria Load Reduction (billion CFU/yr)	Sediment Load Reduction (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	1,283	1,109	6,331	1,001	953
Mud Creek-Pigeon Creek	040500011002	481	179	1,352	797	171
Long Lake-Pigeon Creek	040500011003	554	494	3,496	522	572
Headwaters Turkey Creek	040500011004	103	93	567	85	117
Big Turkey Lake-Turkey Creek	040500011005	272	173	1,086	178	247
Silver Lake-Pigeon Creek	040500011006	561	376	2,306	483	502
Otter Lake-Pigeon Creek	040500011007	432	222	1,306	242	208
Little Turkey Lake-Turkey Creek	040500011008	0	0	0	0	0
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	0	0	0	0	0
Grand Total		**3,686**	**2,647**	**16,445**	**3,307**	**2,770**

Figure 76 - Pigeon Creek Existing BMP Locations



9.3.1 – Existing BMP Highlights

A selection of previously installed, on-the-ground BMPs is presented below. Included is the J Leach Wetland, rain gardens in the City of Angola, livestock fencing, streambank stabilization, tree planting, and pervious pavement at the Angola WWTP. These projects only represent a fraction of the work completed or underway in the watershed to improve water quality and habitat. Not present in this section are all the other efforts to conserve soil and reduce erosion such as grass waterways, filter strips, cover crops, water and sediment control basins, as well as the numerous education programs organized and implemented by the Steuben County SWCD.

1) J. Leach Wetland: work began on this 2.66-acre wetland project September 7th, 2012, and was completed October 15th, 2012. This large restoration project included a wetland detention area with an outlet structure. The goal of this project was to restore a wetland habitat in the Pigeon Creek watershed. Located on the property of the Angola Parks Department, the J. Leach Wetland is storing and filtering urban stormwater runoff, as well as improving local wildlife habitat.

2) Rain Garden, City of Angola: numerous green infrastructure BMPs have been installed within the City of Angola, including rain barrels, pervious/porous pavement, and riparian buffers. This rain garden, located in downtown Angola, is trapping and filtering roof and pavement runoff. Future plans include additional rain gardens and urban green infrastructure BMPs.

3) Rotational Grazing and Fencing: completed in 2011, this project included the installation of 4,295 feet of rotational grazing and exclusion fencing located on pasture ground southeast of the Jack Ditch. The landowner also replaced a tile riser in his grazing field with a blind inlet-style drain to further reduce sediment and runoff. Voluntary projects such as this help to improve both water quality and grazing productivity.

4) Streambank Stabilization: this project on the south bank of Pigeon Creek, just upstream of Long Lake, involved the Installation of a 307-foot log revetment. Bank erosion along this stretch has been significantly reduced and is estimated at roughly 40 tons per year. Natural bank stabilization projects such as this are more cost effective than rock systems and provide the same level of bank protection under the right conditions.

5) Tree Planting: through a combination of cost-share funds from the IDEM 319 grant program and LARE Watershed Land Treatment grant program, 30 acres of trees were planted along US 20, just east of the Jack Ditch and south of the Berlien Ditch, both of which flow into Pigeon Creek. Numerous other tree planting projects have been completed in the watershed.

6) Pervious (porous) Pavement & Bioswale: located at the Angola Wastewater Treatment Plant, a 5,000-square-foot parking lot was retrofitted with 324 sq. ft. (6'x54') of pervious concrete and is designed to handle a stormwater volume of 625 cubic feet. To complement the pervious pavement, a 4,100-square-foot Bio-Swale (bio-retention area) was also installed, increasing stormwater storage volume by an additional 8,310 cubic feet.

10.0 Action Register & Schedule

The Action Register describes each goal's scheduled objectives and milestones, estimated financial costs, and possible partners.

10.1 Objectives

Objectives incorporate the watershed goals but focus on specific processes that can be managed, such as pollutant loading and riparian conditions. Target audiences are those groups or individuals that will likely be involved in implementation. Objectives are directly tied to site-specific and basin-wide recommendations described in previous sections. Objectives are achievable; they represent realistic implementation targets.

Table 88 - Goals, Indicators, Objectives & Target Audience

Goal	Primary Indicator	Secondary Indicator	Objectives (S refers to site-specific / B refers to basin-wide)	Target Audience
Reduce Bacteria Loading	Number of water quality samples exceeding 235 CFU/100 mL	Number of category 4 & 5 impaired streams and lakes for *E. coli* (bacteria)	1. Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems (B) 2. Install diversions and waste lagoons on 25 small animal feed operations (S) 3. Implement pasture management practices on 30 pasture operations (S) 4. Install 5 detention basins (B) 5. Continue local education and water quality monitoring (B)	1. Private residential -landowners and County Health Department 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners 4. Agricultural (AG) landowners, City of Angola 5. All stakeholders
Reduce Phosphorus and Nitrogen Loading	Nitrogen: Number of water quality samples exceeding 10 Mg/L Phosphorus: Number of water quality samples exceeding 0.3 mg/L	Number of category 4 & 5 impaired streams and lakes for phosphorus and Impaired Biotic Communities (IBC)	1. Install cover crops on 5,000 acres (B) 2. Install 100 acres of filter strips (S) 3. Install 5 detention basins (S) 4. Create 2 wetlands in urban areas and 3 wetlands on agricultural ground (S) 5. Restore 100 acres of existing wetlands (B) 6. Treat 5,000 acres with denitrifying bioreactors (B) 7. Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement (B) 8. Continue local education and water quality monitoring (B)	1. Agricultural (AG) landowners 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners, residential landowners and municipalities 4. Agricultural (AG) landowners, residential landowners and municipalities 5. Agricultural (AG) landowners, residential landowners and municipalities 6. Property owners and municipalities 7. All stakeholders
Reduce Sediment	Number of water quality samples exceeding 30 mg/L	Number of category 4 & 5 impaired streams and lakes for TSS (sediment)	1. Install blind inlets on 100 fields (B) 2. Install 5 detention basins (S) 3. Install 1 rock riffle (S) 4. Install terraces or WASCOB systems on 100 fields (B) & (S) 5. Install 9 grass waterways (S) 6. Continue local education and water quality monitoring (B)	1. Agricultural (AG) landowners 2. Agricultural (AG) landowners, residential landowners and municipalities 3. Residential landowner 4. Agricultural (AG) landowners 5. Agricultural (AG) landowners 6. All stakeholders

Goal	Primary Indicator	Secondary Indicator	Objectives (S refers to site-specific / B refers to basin-wide)	Target Audience
Reduce Flooding by increasing storage	1) Acres of restored wetland in headwaters 2) Feet of two-stage drainage ditches	Flooding is no longer a concern for watershed stakeholders	1. Install 25,000 feet of two-stage drainage ditch (S) 2. Implement 1 regional detention area; Bill Deller Rd. (S) 3. Restore 100 acres of existing wetlands (B) 4. Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement (B) 5. Continue local education programs (B)	1. Agricultural (AG) landowners and county surveyor 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners, residential landowners and municipalities 4. Property owners, municipalities 5. All stakeholders

10.2 Measurable Milestones

Milestones represent a time period or a deadline for realizing watershed implementation objectives, as well as any specific tasks required. A simple scorecard was developed for the watershed. Scorecard milestones are based on short-term (1-5 years), medium-term (6-10 years) and long-term (10+ years) objectives. The milestones and "scorecard" can be used to identify and track plan implementation to ensure that progress is being made towards achieving the plan targets and to make corrections, as necessary. Scorecards for each goal and objective are provided in Appendix B and an example is included below (Figure 77).

Pigeon Creek Watershed; Completed Rain Garden

Figure 77 - Pigeon Creek Example Score Card

Goal #1 Milestone Scorecard: Reduce Bacteria Loading

Milestones; S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	*Indicator*		*Milestone*	*Grade*
Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	250 systems	
		M	500 systems (cumulative)	
		L	1,000 systems (cumulative)	
Install diversions and waste lagoons on 25 small animal feed operations	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	5 operations	
		M	10 operations (cumulative)	
		L	25 operations (cumulative)	
Implement pasture management practices on 30 pasture operations	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	10 operations	
		M	20 operations (cumulative)	
		L	30 operations (cumulative)	
Install 5 detention basins	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	2 basins	
		M	2 basins (additional)	
		L	1 basin (additional)	
Continue local education and water quality monitoring programs.	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System
A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

10.3 Cost Estimates, Responsible Partners & Technical Assistance

This section summarizes costs associated with BMPs and those entities or individuals who will likely be responsible for implementation.

10.3.1 Cost Estimates

The costs presented in this section and associated with BMP recommendations in Pigeon Creek are only estimates and should be revised through project-specific planning. Built into all estimates are costs for technical assistance, engineering, salaries, travel, and expenses.

The following assumptions were used to determine the appropriate water quality implementation costs:

1. Basin-wide residential practices include a combination of rain barrels and rain gardens. Assumes an average treatment area of 0.25 acres. Each treatment area assumes 2, 60-gallon

rain barrels and one rain garden or infiltration trench. Assumed costs are $160 for rain barrels and $3,500 for each rain garden or infiltration trench.

2. Cost estimates for a denitrifying bioreactor were developed from an Iowa State study. The study provided per-acre cost estimates from six sites. The average per-acre cost is calculated at $152/ac.
3. Cost estimates for blind inlets are based on Steuben County cost-share rates and assume construction and material costs of $3000/inlet. Each inlet assumes treatment of 50 acres.
4. Porous/Permeable pavement retrofits assume an average material cost of $9/square foot and an average construction cost of $3.75/square foot.
5. The per-foot cost for two-stage ditches was calculated using a cost estimator Excel tool produced by TNC. All cost estimates are based on the assumptions that all recommended ditches are of equal dimensions with a 50-ft bench on both banks and a 4:1 side slope. Cost estimates also assume one outlet protection structure, one drop structure, one rock structure, a berm on both banks, all applicable seeding, and average land rental rates for a 250-ft stretch. Using these assumptions, per-foot cost estimates total $139.16 ($61.63 for construction and materials and $77.53 for land rental/payment).
6. Costs for filter and riparian buffer strips are calculated at $700/ac, assuming a minimum width of 50 feet. Costs are generated using NRCS cost-share rates and include land preparation, materials and seeding.
7. Costs for cover crops are based on NRCS cost-share rates and are assumed to cost $70/ac on average.
8. Costs for riffles and grade control structures are based on professional judgment and field experience, and total $8000 per individual structure.
9. Wetland creation and/or restoration assumes a cost of $2000 per water control structure and engineering and dirt work or excavation costs ranging from $10,0000-$14,000 per site.
10. Costs for detention basins and waste lagoons are based on site conditions and professional judgment/experience, and range from $14,000-$65,000.
11. Grassed waterways assume a cost of $3000/acre based on typical NRCS cost-share rates.
12. Water and sediment control basin costs are based on NRCS cost-share rates and professional experience, and assume $1000/basin.
13. Costs for terraces are based on professional experience and NRCS cost-share rates and assume a cost of $500 for every five acres of treatment.
14. Pasture management include a combination of costs for multiple practices and are based on a combination of NRCS cost-share rates and professional experience and judgment. Costs assume $2.50/ft for fencing, $10,000-$20,000 per detention basin, $8,000 for each stream crossing, $5000 for each diversion, and $10,000 for a water system.
15. The cost to establish a training and inspection program for septic pumpers is estimated to cost $50,000.

The total estimated cost to implement all basin-wide BMPs is *$1,362,177,180*. Cost to implement all site-specific recommendations is *$31,867,495* for a grand total of ***$1,394,044,674***. Table 89 lists estimated costs for all basin-wide and site-specific BMP recommendations.

Table 89 - Pigeon Creek BMP Cost Estimates

Best Management Practice	Area/Amount	Unit Cost	Total Cost
	Basin Wide BMPs		
Cover Crops	39,186 acres	$70/acre	$2,743,020
Terraces and WASCOB	25,416 acres	$500 per 5 acres	$2,591,600
Blind Inlet	51,870 acres	$3,000 per 50 acres	$3,112,200
Wetland Restoration	12,054 acres	$12,000/acre	$144,648,000
Septic Inspection & Maintenance Program	2,667 ac	n/a	$50,000
Denitrifying Bioreactor	51,870 acres	$152/acre	$7,884,240
Rain Barrel/Garden	6,724 acres	$15,280/acre	$102,742,720
Porous Pavement	6,724 acres	$163,350/acre	$1,098,365,400
Education & Outreach (all recommendations in Section 9.1.8)	2 workshops, 1 bus tour, 1 ditch cleanup day, educational pamphlets, Lake Life Workshop, local conservation series	n/a	$40,000/year
Total			**$1,362,177,180**
	Site-Specific BMPs (costs represent a sum of individual Installed BMPs)		
Detention Basin*	6	n/a	$5,236,000
Feed Area Waste Lagoon	29	n/a	$744,000
Filter Strip	38 (144 acres)	n/a	$100,842
Pasture BMPs	36	n/a	$888,500
Riffle	1	$8,000	$8,000
WASCOB/Terrace	6	n/a	$17,000
Grassed Waterway	9	n/a	$37,500
Wetland Creation	8	n/a	$239,000
Other BMP	2	n/a	$37,000
Two-Stage Ditch	176,485 feet	$139.16	$24,559,653
Total			**$31,867,495**
Grand Total			**$1,394,044,674**

*Includes an estimated $5,000,000 cost for Bill Deller Rd regional flood storage area

10.3.2 Responsible Parties & Technical Assistance

Responsible parties in the Pigeon Creek watershed include city and county government, private landowners (agricultural and urban), county SWCDs, and NRCS staff. City government includes Angola, Hudson, and Ashley. County government includes Steuben and LaGrange County, County Assessors, and the Department of Health. Private landowners are made up of residents within city limits, residents outside of city limits, agricultural producers and lake residents. The primary government agency responsible for plan implementation is the Steuben County SWCD and the Steuben County NRCS. In some cases, a project may include multiple responsible parties; for example, a project on private land within city limits may require participation from both the city and the landowner.

Various funding and financing mechanisms exist that can assist with the implementation of plan recommendations and provide technical assistance. Common programs already being utilized by the Steuben County SWCD include the EPA 319 Grant through the IDEM and the LARE program through IDNR. These competitive grant programs provide financial cost-share and technical assistance for various

BMPs and are usually administered through a local agency or SWCD, as is the case with the Steuben County SWCD.

Other Federal programs such as the USACE Continuing Authorities Program (CAP) or the Great Lakes Restoration Initiative (GLRI) may also be applicable in the watershed and should be researched to determine if opportunities for funding exist. The CAP program from Section 206 of the 1996 Water Resources Development Act targets wetland restoration with the objective to restore degraded ecosystem structure, function, and dynamic processes to a less degraded and more natural condition. The GLRI program is focused on improving the health of the Great Lakes and provides financial assistance for the implementation of BMPs to address water quality issues and other contaminants.

Most relevant to the Pigeon Creek watershed are those agricultural conservation and cost-share programs administered through the USDA – NRCS. All USDA – NRCS programs also provide technical assistance in the form of conservation planning and engineering and design. There are three incentive programs that have applicability in the watershed: the Environmental Quality Incentives Program (EQIP), the Wetland Reserve Easements program (WRE), and the Conservation Reserve Program (CRP). The goal of WRE is to restore and protect degraded wetlands such as farmed wetlands. WRE has three options available: permanent easements, 30-year easements and restoration agreements. The NRCS will reimburse the landowners for easements on the property plus a portion of the restoration costs based on the type of easement agreed to by the landowner.

EQIP is applicable to numerous practices identified in the PCWMP, including livestock and pasture recommendations, two-stage ditches, blind inlets, denitrifying bioreactors, wetlands, filter and buffer strips, grassed waterways, terraces, WASCOBs, riffles, streambank stabilization, cover crops, and many other practices. Typically, EQIP monies will fund 75% of land improvements and installation of conservation practices.

The goal of the CRP program is to give incentives to landowners who take frequently flooded and environmentally sensitive land out of crop production and plant specific types of vegetation. Participants earn annual rental payments and sign-up incentives. This program offers up to 90% cost share. Rental payments are boosted by 20% for projects such as installation of riparian buffers and filter strips.

Finally, funding and technical assistance can come from municipal, county, or private sources. In Pigeon Creek, the City of Angola, for example, has contributed financially to projects such as wetland restoration, rain gardens, rain barrels, and porous pavement. Private landowners who wish to participate can also contribute financially. Private funds or landowner contributions are required for all USDA-NRCS programs and being able to demonstrate a financial commitment from private landowners when applying for a competitive grant can often help to improve the likelihood of receiving funding. Local funding sources, such as the City of Angola and individual landowners, should be approached to participate in a grant application; often times, this can be critical in leveraging state or federal funds that require local matching dollars. Table 90 lists responsible parties and funding options for site-specific and basin-wide BMPs.

Table 90 - Responsible Entities, Financial & Technical Assistance

Best Management Practice/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
Basin Wide BMPs		
BMP: Cover Crops **Objective:** Install cover crops on 5,000 acres	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***: 319 Grant/Private Funds/EQIP/LARE
BMP: Terraces and WASCOB **Objective:** Install terraces or WASCOB systems on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance:*** SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Blind Inlet **Objective:** Install blind inlets on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Wetland Restoration **Objective:** Restore 100 acres of existing wetlands	Private Landowner/SWCD/County Assessor/City Government, if applicable	***Technical Assistance***: SWCD/NRCS/City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE/WRP/USACE
BMP: Septic Inspection & Maintenance Program **Objective:** Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems	Landowner/Health Department/SWCD	***Technical Assistance***: SWCD/NRCS/Health Department ***Funding Mechanism***: Private Funds/County/City/Health Department/ 319 Grant
BMP: Denitrifying Bioreactor **Objective:** Treat 5,000 acres with denitrifying bioreactors	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Rain Barrel/Garden **Objective:** Treat 500 acres with rain barrels and rain gardens	Private Landowner/SWCD/County/City Government	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE
BMP: Porous Pavement **Objective:** Treat 500 acres with porous pavement	Private Landowner/SWCD/County/City Government	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE
BMP: Education & Outreach (all recommendations in Section 9.1.8) **Objective:** Continue local education and monitoring programs	SWCD	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/LARE
Site-Specific BMPs		
BMP: Detention Basin **Objective:** Install 5 detention basins	City of Angola/Steuben County Assessor/SWCD/Landowner	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private Funds/County Funds
BMP: Feed Area Waste Lagoon **Objective:** Install diversions and waste lagoons on 25 small animal feed operations	Private Landowner/SWCD	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/LARE
BMP: Filter Strip **Objective:** Install 100 acres of filter strips	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Pasture BMPs **Objective:** Implement pasture	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private

Best Management Practice/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
management practices on 30 pasture operations		Funds/EQIP/LARE
BMP: Riffle **Objective:** Install 1 rock riffle	County Road Commissioner/Landowner	***Technical Assistance***: SWCD/NRCS/County Road Commissioner ***Funding Mechanism***:319 Grant/Private Funds
BMP: WASCOB/Terrace **Objective:** Install terraces or WASCOB systems on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism:*** 319 Grant/Private Funds/EQIP/LARE
BMP: Grassed Waterway **Objective:** Install 9 grassed waterways	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/CRP/LARE
BMP: Wetland Creation **Objective:** Create 2 wetlands in urban areas and 3 wetlands on agricultural ground	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/WRP/CRP/LARE
BMP: Other BMP **Objective:** N/A	Property Owner/County Assessor	***Technical Assistance***: SWCD/NRCS/County Assessor ***Funding Mechanism***: Private, County Funding/EQIP
BMP: Two-Stage Ditch **Objective**: Install 25,000 feet of two-stage drainage ditch	Private Landowner/SWCD/NRCS/County Assessor	***Technical Assistance***: SWCD/NRCS/County Assessor ***Funding Mechanism***:319 Grant/Private Funds/EQIP/County Funds/LARE

11.0 Tracking Effectiveness & Future Planning

This plan is meant to be a flexible tool to achieve water quality improvements within the Pigeon Creek watershed. The PCWMP can be evaluated by assessing the progress made toward implementing plan recommendations. The Steuben County SWCD and the Pigeon Creek Steering Committee are the primary responsible entities for both implementation and monitoring/tracking. The Steuben County NRCS and the City of Angola are two key partners that can assist in both plan implementation and monitoring. It is not anticipated that any financial resources will be required to track plan effectiveness above and beyond the cost of a continued water quality monitoring program.

The plan should be evaluated every five (5) years to assess the progress made, as well as to revise the plan based on the progress achieved. The plan should also have a comprehensive review every 15-20 years. Amendments and changes may be made more frequently as laws change or new information becomes available that will assist in providing a better outlook for the watershed. As goals are accomplished and additional information is gathered, efforts may need to be shifted to watershed issues of higher priority.

In addition to a five (5) year evaluation and update, local stakeholders and city/county/agency staff will have a key role in evaluating implementation progress on an annual basis. They can review the status of milestones annually and then identify the top priority actions for the following year's focus. The local Steering Committee, stakeholders and professional staff should identify how they will implement the plan (subcommittees, reporting structure, meeting schedule, etc.). Other opportunities for evaluating the status of plan implementation can include the completion of quarterly project reports or group meeting minutes. Since this plan is a flexible tool, tracking changes/modifications are anticipated based on usability and changes in priorities throughout implementation.

11.1 Monitoring Strategy

Monitoring can be divided up into programmatic monitoring and water quality monitoring. Programmatic monitoring tracks progress made toward plan objectives and recommendations whereas water quality monitoring involves the orderly collection of chemical and biological data in order to determine if numerical water quality targets are being met.

11.1.1 Programmatic Monitoring

The purpose of the programmatic monitoring plan for the Pigeon Creek watershed is to define action items and assess the overall implementation success of BMPs and other plan recommendations. This can be accomplished by conducting the following actions:

1. Track implementation of management measures in the watershed.
2. Estimate effectiveness of management measures.
3. Implement water quality monitoring as outlined in Appendix D.

Tracking the implementation of plan recommendations can be used to address the following monitoring goals:

- Determine the extent to which plan recommendations and practices have been implemented over time compared to action needed to meet water quality targets.
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts.
- Measure the extent of voluntary implementation efforts.

Local resource agencies track program successes and implementation to satisfy internal requirements. For example, the USDA and SWCDs monitor program successes and report at the county level. Tracking implementation at the watershed level is rarely conducted unless local agencies are 1) willing to provide the information and 2) a formal request is made from local stakeholders. This only occurs if a watershed group or interested entity is active in the area.

In the Pigeon Creek watershed, the current Steering Committee could work with the appropriate parties to voluntarily establish a monitoring program to track plan implementation. This could involve an annual report that summarizes BMPs currently in place and the work stakeholders have already completed. This would form the baseline from which to measure success and monitor plan implementation.

The milestones “scorecard” presented in Section 10 are based on BMP recommendations and load reduction targets. This scorecard system can serve as the organizational monitoring plan and a tool for tracking progress toward meeting specific recommendations/action items. Realistic short-term (1-5 yr), medium- (6-10 yr) and long-term (10+ yr) milestones and indicators are included in the scorecard. Each milestone is a specific action recommendation and is intended to fulfill plan objectives, if executed. Indicators are to be used as measurement tools when determining if each milestone has or has not been met. If the measurement of each indicator becomes problematic, the watershed Steering Committee should revisit and make adjustments, where needed. It is up to local stakeholders to determine the priority of each milestone based on their ability to follow through with them; Sections 8 and 9 provide direction for prioritization including critical subwatersheds and load reduction quantities. There are no anticipated costs or technical assistance needed to track progress; the Steuben County SWCD will be responsible providing information on implementation projects to the Steering Committee.

11.1.1 Water Quality Monitoring

Water quality monitoring for Pigeon Creek and watershed tributaries should follow the existing monitoring plan in place. A 2012 Quality Assurance Project Plan (QAPP) is included in Appendix D. Additional monitoring recommendations include:

1. Increase sampling frequency of high flow events
2. Flow data and discharge measurements are limited for high flow events. When conditions permit, make every effort to collect additional flow data.
3. Coordinate with IDEM and incorporate state water quality collection data into existing databases.

12.0 References

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18. *Unless otherwise referenced, all GIS data was obtained from:*
    - *The Indiana Geographic Information Council via the Indiana Map website*
    - *Steuben, LaGrange, Dekalb and Noble County, IN, GIS Centers*
    - *Steuben County Soil and Water Conservation District*

Appendices

2014 Pigeon Creek Watershed Management Plan

Appendix A

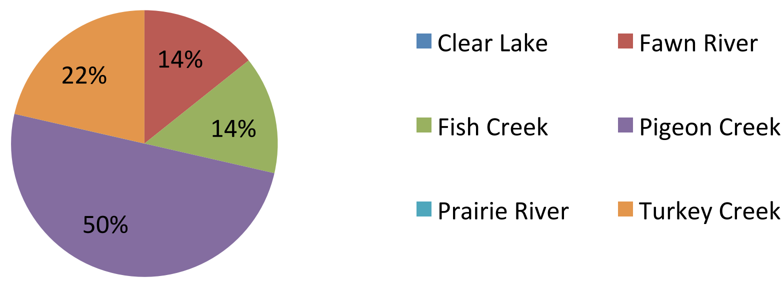
Public Participation

&

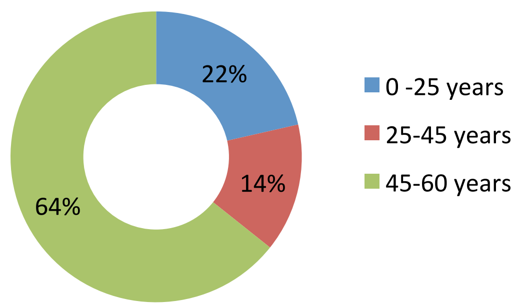
Supplemental Project Information

Annual Meeting 2013 Survey Results, Participants in survey: 14

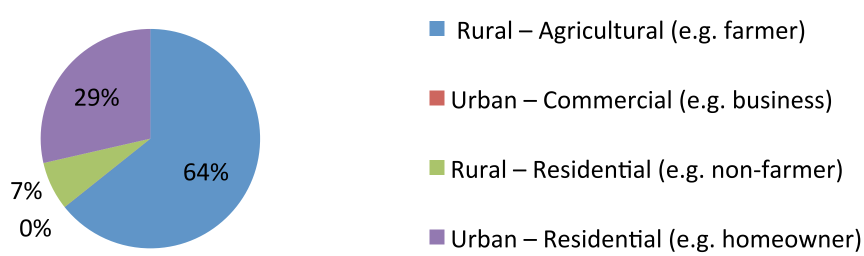
1) Which watershed that best represents where you live or work?



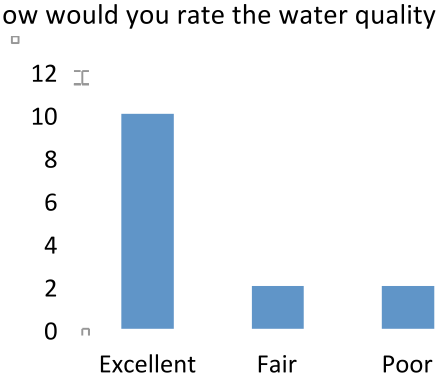
2) How long have you lived (or worked) in that watershed?



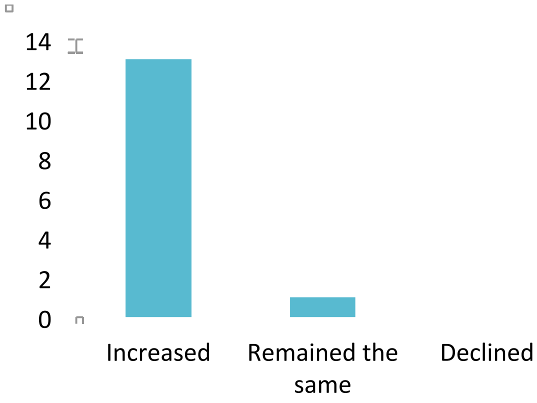
3) Which one of the following best represents your relationship to your watershed?



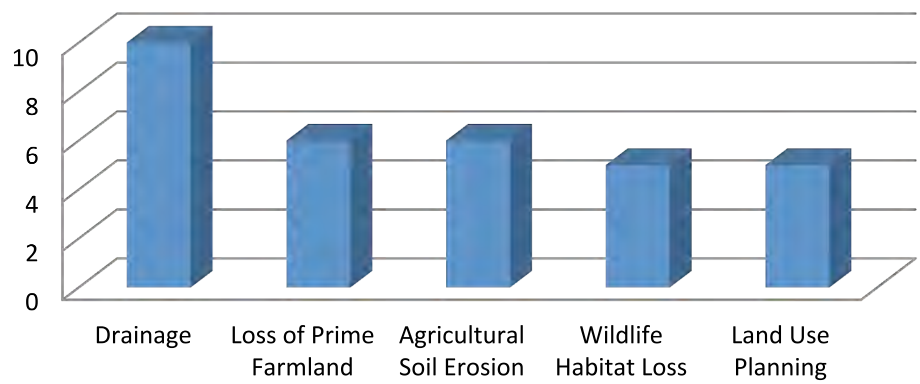
4) How would you rate the water quality of your watershed?



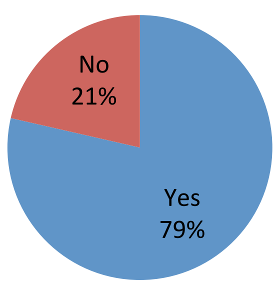
5) Do you believe conservation knowledge & practices within your watershed have:



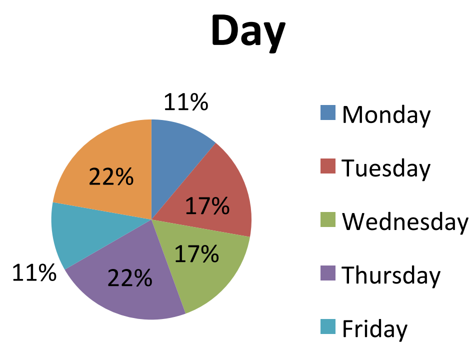
6) Mark your top 5 natural resource concerns for your watershed from the topics listed below

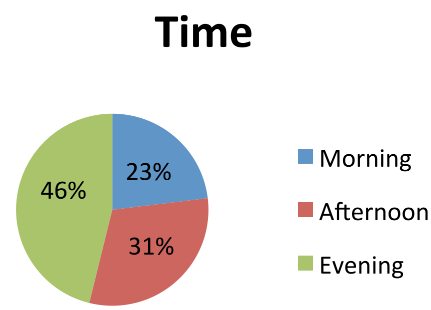


7) Have you ever attended SWCD informational meetings or field days?

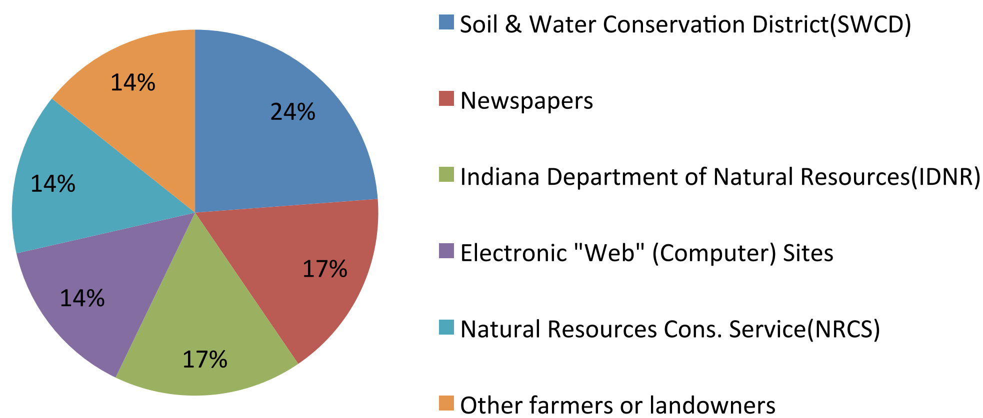


8) If you were interested in attending future SWCD informational meetings or field days, when would you most likely attend such an event?(Please choose one)





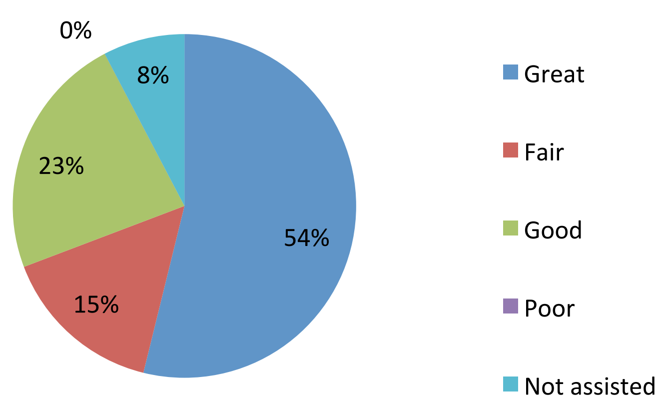
9) Where do you get information on natural resources topics? (Mark your top 5 sources)



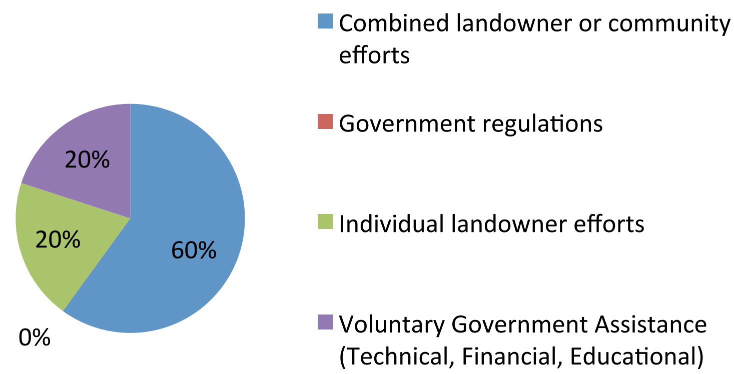
10) What topics should be included in such future events?

- Best use of land without doing CRP
- Soil analysis organic improvement: testing current soil

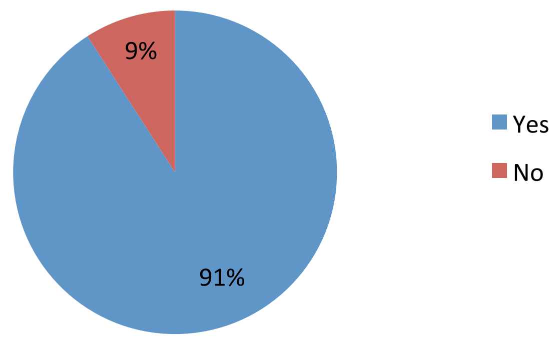
11) How would you rate the assistance provided to you by the SWCD in the past?



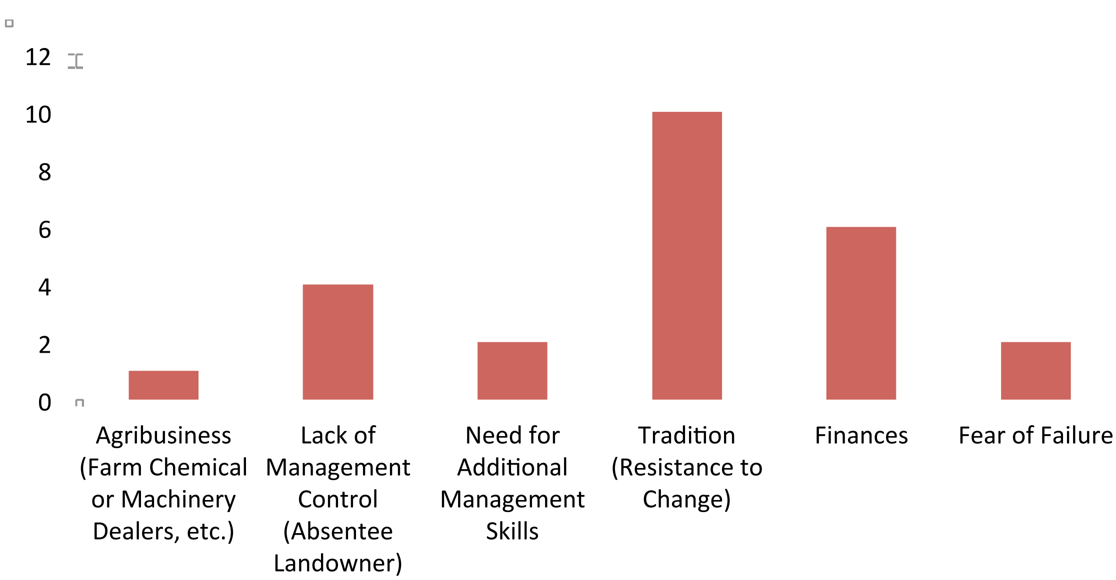
12) How should the water quality issues within your watershed be addressed?



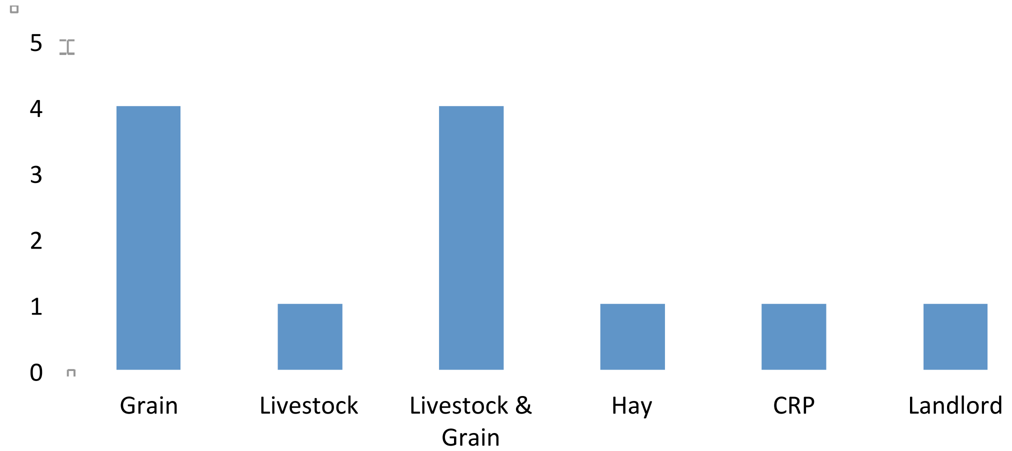
13) Would you recommend conservation practices to other farmers or landowners?



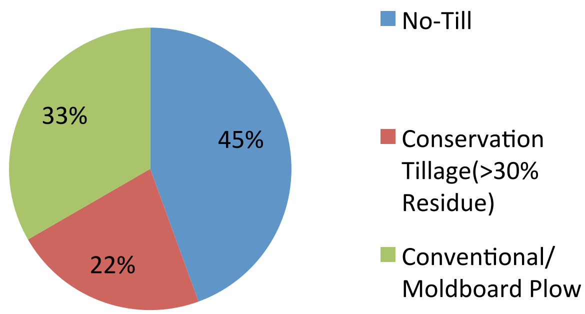
14) Which of the following factors do you feel limit the adoption of conservation practices in your watershed? (Mark all that apply)



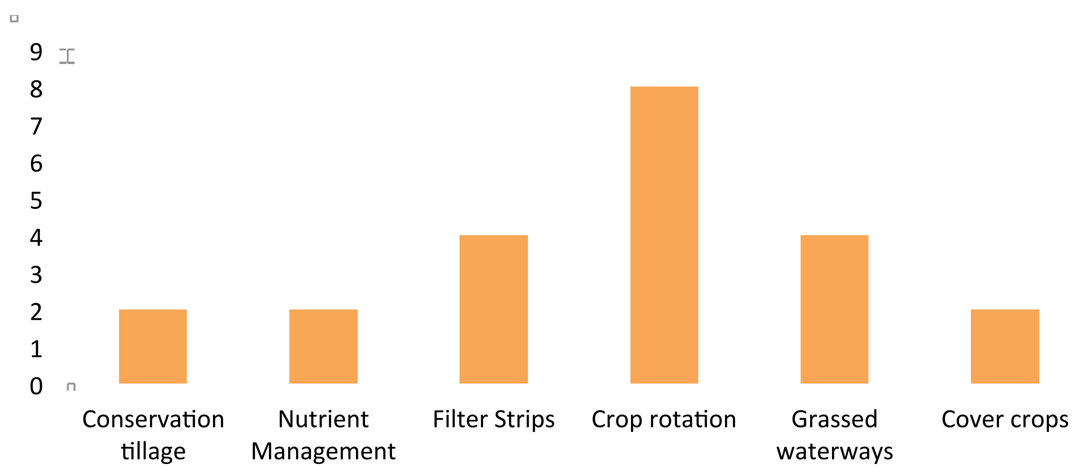
15) If you farm: What type of farming operation do you have?



What is your predominant tillage system?



What conservation practices do you use to control soil erosion?



16) Additional Comments: Our watershed in Steuben is a great asset to a huge area of this country. Keep up the progress towards excellent information sharing.

List of Attendees at April 9, 2013 Steering Committee Meeting

Attendee	Affiliation
Kayleen Hart	Administrative Coordinator SWCD
Mandy Courtright	Resource Conservationist SWCD
Lee Courtright	Landowner in Pigeon
John Williamson	West Otter Lake
Eric Henion	MS4
Brian Musser	NRCS
Tharon Shultz	Pigeon Creek Watershed (Hudson)/Trine University
Rachel Wisman	Trine University
Bob Glick	Long Lake
Beth Warner	The Nature Conservancy
Tom Green	SWCD Chairman of the Board
Larry Gilbert	Surveyor
Bill Schmidt	Steuben County Lakes Council
Joe Schmees	IDEM Project Manager

Detailed Past Project Summary Table (Agricultural)

Project Table - Agricultural

	HUAs (#)	Filter Strips (acres)	Grassed Waterways (feet)	Water and Sediment Control Basin/ Drop Inlet Structure	Hay/ Pasture (acres)	Fence - Exclusion and Rotational Grazing (feet)	Livestock Watering Facility (number)	Trees (acres)	Cover Crops (acres)	Critical Area Seeding (acres)	Wetlands (acres)	Two-Stage Ditch (acres)	Compre-hensive Nutrient Manage-ment Plan (acres)
Phase 1 (319)		0.65	3,550	20									
Phase 2 (319)					15	4295		30					
LARE (2007-2012)		20.6	3,200		683	36,832	4	86	878	8.35			
CWI (2012)	2								355				
LARE Pigeon (2013)					92.5			2	124	4			83
LARE Turkey (2013)					34			10	14		6		
NRCS (2006-2013)								15	2,963		406	1.3	
TOTAL	2	21.25	6,750	20	824.5	41,127	4	143	4,334	12.35	412	1.3	83

Detailed Past Project Summary Table (Urban)

Project Table - Urban

	Wetlands (acres)	Streambank Stabilization	Rain Garden (number)	Rain Barrels (number)	Pervious Concrete (Square Feet)	Bio-Swale (Square-feet)
Phase 2 (319)	2.66	307	3	43	324	4,100
National Cons. Found. Award (NCF)				51 (Pigeon/Turkey)		

Appendix B

Monitoring Score Cards

Goal #1 Milestone Scorecard: Reduce Bacteria Loading

Milestones; S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	***Indicator***		***Milestone***	***Grade***
Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	250 systems	
		M	500 systems (cumulative)	
		L	1,000 systems (cumulative)	
Install diversions and waste lagoons on 25 small animal feed operations	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	5 operations	
		M	10 operations (cumulative)	
		L	25 operations (cumulative)	
Implement pasture management practices on 30 pasture operations	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	10 operations	
		M	20 operations (cumulative)	
		L	30 operations (cumulative)	
Install 5 detention basins	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	2 basins	
		M	2 basins (additional)	
		L	1 basin (additional)	
Continue local education and water quality monitoring programs.	*Number of water quality samples exceeding 235 CFU/100 mL*	*S*	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System

A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

Goal #2 Milestone Scorecard: Reduce Phosphorus & Nitrogen Loading

Milestones; S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	***Indicator***		***Milestone***	***Grade***
Install cover crops on 5,000 acres	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	2,000 acres	
		M	3,000 acres (cumulative)	
		L	5,000 acres (cumulative)	
Install 100 acres of filter strips	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	50 acres	
		M	75 acres (cumulative)	
		L	100 acres (cumulative)	
Install 5 detention basins	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	2 basins	
		M	2 basins (additional)	
		L	1 basin (additional)	
Create 2 wetlands in urban areas and 3 wetlands on agricultural ground	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	2 wetlands	
		M	2 wetlands (additional)	
		L	1 wetland (additional)	
Restore 100 acres of existing wetlands	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	25 acres	
		M	50 acres (additional)	
		L	25 acres (additional)	
Treat 5,000 acres with denitrifying bioreactors	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L*	*S*	2,000 acres	
		M	3,000 acres (cumulative)	
		L	5,000 acres (cumulative)	
Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	100 acres	
		M	200 acres (cumulative)	
		L	500 acres (cumulative)	
Continue local education and water quality monitoring programs to evaluate reductions in phosphorus and nitrogen	*a) Nitrogen: Number of water quality samples exceeding 10 Mg/L* *b) Phosphorus: Number of water quality samples exceeding 0.3 mg/L*	*S*	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System

A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

Goal #3 Milestone Scorecard: Reduce Sediment Loading

Milestones; S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	***Indicator***		***Milestone***	***Grade***
Install blind inlets on 100 fields	*Number of water quality samples exceeding 30 Mg/L*	*S*	25 fields	
		M	50 fields (additional)	
		L	25 fields (additional)	
Install 5 detention basins	*Number of water quality samples exceeding 30 Mg/L*	*S*	2 basins	
		M	2 basins (additional)	
		L	1 basin (additional)	
Install 1 rock riffle	*Number of water quality samples exceeding 30 Mg/L*	*S*	1 riffle	
		M	No action	
		L	No action	
Install terraces or WASCB systems on 100 fields	*Number of water quality samples exceeding 30 Mg/L*	*S*	25 fields	
		M	50 fields (additional)	
		L	25 fields (additional)	
Install 9 grass waterways	*Number of water quality samples exceeding 30 Mg/L*	*S*	5 waterways	
		M	3 waterways (additional)	
		L	1 waterway (additional)	
Continue local education and water quality monitoring programs	*Number of water quality samples exceeding 30 Mg/L*	*S*	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System

A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

Goal #4 Milestone Scorecard: Reduce Flooding by Increasing Storage

Milestones; S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	***Indicator***		***Milestone***	***Grade***
Install 25,000 feet of two-stage drainage ditch	*1) Acres of restored wetland in headwaters* *2) Feet of two-stage drainage ditches*	*S*	10,000 feet	
		M	10,000 feet (additional)	
		L	5,000 feet (additional)	
Implement 1 regional detention area; Bill Deller Rd	*1) Acres of restored wetland in headwaters* *2) Feet of two-stage drainage ditches L*	*S*	No action	
		M	1 detention area	
		L	No action	
Restore 100 acres of existing wetlands	*1) Acres of restored wetland in headwaters* *2) Feet of two-stage drainage ditches*	*S*	25 acres	
		M	50 acres (additional)	
		L	25 acres (additional)	
Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement	*1) Acres of restored wetland in headwaters* *2) Feet of two-stage drainage ditches*	*S*	100 acres	
		M	200 acres (cumulative)	
		L	500 acres (cumulative)	
Continue local education programs	*1) Acres of restored wetland in headwaters* *2) Feet of two-stage drainage ditches*	*S*	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System

A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

Appendix C

Biological Data

T&E Species List

Scientific Name	Common Name	Type	Frequency Occurrence
Accipiter striatus	Sharp-shinned Hawk	Bird	1
Actaea rubra	Red Baneberry	Vascular Plant	2
Aeshna mutata	Spatterdock Darner	Insect Odonata	3
Aeshna tuberculifera	Black-tipped Darner	Insect Odonata	3
Ambystoma laterale	Blue-spotted Salamander	Amphibian	1
Amelanchier humilis	Running Serviceberry	Vascular Plant	1
Anepia capsularis	The Starry Campion Capsule Moth	Insect Lepidoptera	1
Apamea verbascoides	The Boreal Apamea	Insect Lepidoptera	1
Arabis missouriensis var. deamii	Missouri Rockcress	Vascular Plant	1
Ardea herodias	Great Blue Heron	Bird	2
Armoracia aquatica	Lake Cress	Vascular Plant	1
Aster borealis	Rushlike Aster	Vascular Plant	2
Bidens beckii	Beck Water-marigold	Vascular Plant	1
Boloria selene myrina	Silver-bordered Fritillary	Insect Lepidoptera	2
Botaurus lentiginosus	American Bittern	Bird	1
Botrychium matricariifolium	Chamomile Grape-fern	Vascular Plant	2
Calephelis muticum	Swamp Metalmark	Insect Lepidoptera	1
Calla palustris	Wild Calla	Vascular Plant	1
Capis curvata	A Noctuid Moth	Insect Lepidoptera	1
Carex alopecoidea	Foxtail Sedge	Vascular Plant	1
Carex debilis var. rudgei	White-edge Sedge	Vascular Plant	3
Carex flava	Yellow Sedge	Vascular Plant	1
Carex limosa	Mud Sedge	Vascular Plant	1
Carex retrorsa	Retrorse Sedge	Vascular Plant	1
Catocala praeclara	Praeclara Underwing	Insect Lepidoptera	1
Certhia americana	Brown Creeper	Bird	2
Chimaphila umbellata ssp. cisatlantica	Pipsissewa	Vascular Plant	2
Chlidonias niger	Black Tern	Bird	1
Chortodes inquinata	Tufted Sedge Moth	Insect Lepidoptera	1
Circaea alpina	Small Enchanter's Nightshade	Vascular Plant	2
Cistothorus palustris	Marsh Wren	Bird	1
Cistothorus platensis	Sedge Wren	Bird	2
Clemmys guttata	Spotted Turtle	Reptile	5
Condylura cristata	Star-nosed Mole	Mammal	4
Cordulegaster bilineata	Brown Spiketail	Insect Odonata	1
Coregonus artedi	Cisco	Fish	5
Crambus girardellus	Orange-striped Sedge Moth	Insect Lepidoptera	1
Cryptocala acadiensis	Catocaline Dart	Insect Lepidoptera	1
Cypripedium calceolus var. parviflorum	Small Yellow Lady's-slipper	Vascular Plant	3
Cypripedium candidum	Small White Lady's-slipper	Vascular Plant	2
Dasychira cinnamomea	A Moth	Insect Lepidoptera	1
Dendroica cerulea	Cerulean Warbler	Bird	1
Dendroica virens	Black-throated Green Warbler	Bird	1
Deschampsia cespitosa	Tufted Hairgrass	Vascular Plant	1

Dorocordulia libera	Racket-tailed Emerald	Insect Odonata	1
Drosera intermedia	Spoon-leaved Sundew	Vascular Plant	
Eleocharis robbinsii	Robbins Spikerush	Vascular Plant	1
Empidonax alnorum	Alder Flycatcher	Bird	2
Emydoidea blandingii	Blanding's Turtle	Reptile	7
Epioblasma triquetra	Snuffbox	Mollusk	1
Equisetum variegatum	Variegated Horsetail	Vascular Plant	1
Eriocaulon aquaticum	Pipewort	Vascular Plant	1
Eriophorum viridicarinatum	Green-keeled Cotton-grass	Vascular Plant	2
Euphydryas phaeton	Baltimore	Insect Lepidoptera	5
Exyra rolandiana	Pitcher Window Moth	Insect Lepidoptera	1
Forest - flatwoods sand	Sand Flatwoods	High Quality Natural Community	1
	Wet Floodplain Forest	High Quality Natural Community	2
Forest - upland dry	Dry Upland Forest	High Quality Natural Community	2
Forest - upland dry-mesic	Dry-mesic Upland Forest	High Quality Natural Community	1
Forest - upland mesic	Mesic Upland Forest	High Quality Natural Community	1
Fuirena pumila	Dwarf Umbrella-sedge	Vascular Plant	1
Gallinula chloropus	Common Moorhen	Bird	1
Geum rivale	Purple Avens	Vascular Plant	1
Glaucopsyche lygdamus couperi	Silvery Blue	Insect Lepidoptera	1
Glyceria borealis	Small Floating Manna-grass	Vascular Plant	2
Glyceria grandis	American Manna-grass	Vascular Plant	1
Gnaphalium macounii	Winged Cudweed	Vascular Plant	1
Grammia phyllira	The Sand Barrens Grammia	Insect Lepidoptera	1
Grus canadensis	Sandhill Crane	Bird	1
Hemidactylium scutatum	Four-toed Salamander	Amphibian	2
Iodopepla u-album	A Noctuid Moth	Insect Lepidoptera	1
Ixobrychus exilis	Least Bittern	Bird	3
Juncus balticus var. littoralis	Baltic Rush	Vascular Plant	1
Juniperus communis	Ground Juniper	Vascular Plant	1
Lake - lake	Lake	High Quality Natural Community	2
Lemna valdiviana	Pale Duckweed	Vascular Plant	1
Leucania inermis	A Moth	Insect Lepidoptera	1
Leucania multilinea		Insect Lepidoptera	1
Loxagrotis grotei	Grote's Black-tipped Quaker	Insect Lepidoptera	1
Lutra canadensis	Northern River Otter	Mammal	1
Lycaeides melissa samuelis	Karner Blue	Insect Lepidoptera	1
Lycaena dorcas dorcas	Dorcas Copper	Insect Lepidoptera	2
Lycopodiella inundata	Northern Bog Clubmoss	Vascular Plant	2
Lycopodium hickeyi	Hickey's Clubmoss	Vascular Plant	1
Lycopodium obscurum	Tree Clubmoss	Vascular Plant	1
Lynx rufus	Bobcat	Mammal	5
Macrochilo absorptalis	A Moth	Insect Lepidoptera	1
Macrochilo bivittata	Two-striped Cord Grass Moth	Insect Lepidoptera	1

Macrochilo hypocritalis	A Noctuid Moth	Insect Lepidoptera	1
Matteuccia struthiopteris	Ostrich Fern	Vascular Plant	1
Melampyrum lineare	American Cow-wheat	Vascular Plant	1
Melanchra assimilis	The Shadowy Arches	Insect Lepidoptera	1
Milium effusum	Tall Millet-grass	Vascular Plant	1
Moxostoma valenciennesi	Greater Redhorse	Fish	1
Mustela nivalis	Least Weasel	Mammal	3
Nannothemis bella	Elfin Skimmer	Insect Odonata	2
Nehalennia gracilis	Sphagnum Sprite	Insect Odonata	3
Neonympha mitchellii mitchellii	Mitchell's Satyr	Insect Lepidoptera	1
Nerodia erythrogaster neglecta	Copperbelly Water Snake	Reptile	1
Oligia bridghami	A Noctuid Moth	Insect Lepidoptera	1
Oryzopsis racemosa	Black-fruit Mountain-ricegrass	Vascular Plant	1
Pandion haliaetus	Osprey	Bird	1
Panicum boreale	Northern Witchgrass	Vascular Plant	4
Panicum leibergii	Leiberg's Witchgrass	Vascular Plant	1
Panicum subvillosum	A Panic-grass	Vascular Plant	2
Papaipema silphii	Silphium Borer Moth	Insect Lepidoptera	1
Pieris oleracea	Eastern Veined White	Insect Lepidoptera	3
Platanthera ciliaris	Yellow-fringe Orchis	Vascular Plant	2
Platanthera hyperborea	Leafy Northern Green Orchis	Vascular Plant	3
Platanthera leucophaea	Prairie White-fringed Orchid	Vascular Plant	1
Platanthera psycodes	Small Purple-fringe Orchis	Vascular Plant	3
Poa alsodes	Grove Meadow Grass	Vascular Plant	1
Poa paludigena	Bog Bluegrass	Vascular Plant	1
Poanes viator viator	Big Broad-winged Skipper	Insect Lepidoptera	1
Potamogeton friesii	Fries' Pondweed	Vascular Plant	1
Potamogeton pusillus	Slender Pondweed	Vascular Plant	1
Potamogeton richardsonii	Redheadgrass	Vascular Plant	1
Potamogeton robbinsii	Flatleaf Pondweed	Vascular Plant	3
Psilocarya scirpoides	Long-beaked Baldrush	Vascular Plant	2
Pyrola rotundifolia var. americana	American Wintergreen	Vascular Plant	3
Rallus limicola	Virginia Rail	Bird	1
Rana pipiens	Northern Leopard Frog	Amphibian	2
Rhynchospora macrostachya	Tall Beaked-rush	Vascular Plant	3
Salix serissima	Autumn Willow	Vascular Plant	2
Scirpus purshianus	Weakstalk Bulrush	Vascular Plant	1
Scirpus subterminalis	Water Bulrush	Vascular Plant	2
Sistrurus catenatus catenatus	Eastern Massasauga	Reptile	7
Spartiniphaga includens	The Included Cordgrass Borer	Insect Lepidoptera	1
Speyeria idalia	Regal Fritillary	Insect Lepidoptera	1
Spiranthes lucida	Shining Ladies'-tresses	Vascular Plant	1
Spiranthes romanzoffiana	Hooded Ladies'-tresses	Vascular Plant	3
Stipa avenacea	Blackseed Needlegrass	Vascular Plant	
Stylurus amnicola	Riverine Clubtail	Insect Odonata	1
Sympetrum semicinctum	Band-winged Meadowhawk	Insect Odonata	1
Taxidea taxus	American Badger	Mammal	12

Tofieldia glutinosa	False Asphodel	Vascular Plant	4
Triglochin palustris	Marsh Arrow-grass	Vascular Plant	5
Utricularia cornuta	Horned Bladderwort	Vascular Plant	2
Utricularia minor	Lesser Bladderwort	Vascular Plant	2
Utricularia purpurea	Purple Bladderwort	Vascular Plant	2
Utricularia resupinata	Northeastern Bladderwort	Vascular Plant	1
Vaccinium oxycoccos	Small Cranberry	Vascular Plant	1
Valeriana uliginosa	Marsh Valerian	Vascular Plant	2
Venustaconcha ellipsiformis	Ellipse	Mollusk	3
Vermivora chrysoptera	Golden-winged Warbler	Bird	1
Viburnum cassinoides	Northern Wild-raisin	Vascular Plant	4
Viburnum opulus var. americanum	Highbush-cranberry	Vascular Plant	1
Wetland - fen	Fen	High Quality Natural Community	8
Wetland - flat muck	Muck Flat	High Quality Natural Community	3
Wetland - marsh	Marsh	High Quality Natural Community	3
Wetland - meadow sedge	Sedge Meadow	High Quality Natural Community	1
Wetland - swamp forest	Forested Swamp	High Quality Natural Community	
Wetland - swamp shrub	Shrub Swamp	High Quality Natural Community	1
Wilsonia canadensis	Canada Warbler	Bird	1
Wilsonia citrina	Hooded Warbler	Bird	2
Zigadenus elegans var. glaucus	White Camas	Vascular Plant	5

Appendix D

Water Quality Monitoring

Quality Assurance Report
&
Quality Assurance Project Plan (QAPP)

Quality Assurance Report

for

2012 Pigeon Creek Water Quality Sampling

Steuben County, Indiana

ARN # 9-275

Prepared by:
Scott Banfield

Aquatic Biologist, Aquatic Enhancement & Survey, Inc.

for

Steuben County Soil and Water Conservation District, Steuben County Lakes Council

Indiana Department of Environmental Management

Office of Water Management

NPS/TMDL Section

Introduction

To serve the goal and objectives listed in section 8.1 of the ARN 9-275 monitoring QAPP (Aquatic Enhancement & Survey, Inc. 2010) water samples were collected from sixteen Pigeon Creek sites. Samples for total phosphorus, total suspended solids, and E coli were collected three times in 2012 (sites 1-16, page 8). Measurements for pH, temperature, D.O., specific conductance, and discharge were made at each of these sites where conditions permitted. Samples were delivered to Sherry Laboratories in Fort Wayne, Indiana for professional analysis. Data was used to provide simple estimations for each respective parameter to provide general insight into water quality in the Pigeon Creek watershed. Monitoring was not designed to trigger specific project decisions, actions, or quantify load reductions resulting from specific project BMP installations. Collections occurred in May, July, and August of 2012. Five sites were located at or near the exit points of each 12 digit HUC within ARN#9-275 to generally guage the water quality influence of each respective unit. Sites were also selected to include the confluence point and exit point of Pigeon Creek with each lake in the Pigeon Creek Chain, sites with a prior history of notable poor water quality, and sites immediately downstream of the confluence of major tributaries to the Pigeon. Fourteen of the sites were funded with the Phase 2 319 grant for ARN#9-275. Two additional sites have been funded by the City of Angola/Trine University MS4 Program. Although sampling occured at sites one through nine following a rain event in July, droughty conditions generally persisted throughout the 2012 sampling season and all sampling represents relatively "low flow" conditions. Sampling, blank, and duplicate analysis results are presented in the accompanying AIMS data upload results spreadsheet. This Report is presented to provide a short summary of 2012 season findings with regard to water quality target goals established in the QAPP and present a summary of Q.C. data and year 2012 deviations from quality goals.

Summary of Water Quality Target Results

Table 1 contains water quality targets from the Pigeon Creek Management Plan (PCMP V3, 2006) as well as revised targets from the current QAPP and results from 2010, 2011, and 2012 sampling.

E-coli: Pigeon Creek and tributary baseline flow data from the 2006 PCMP indicated variable concentrations of 250-4500 Colonies per 100 ml. This was refined by utilizing more recent data collected from Pigeon Creek by the Steuben County Lakes Council (SCLC) in 2008 and 2009. This data was used to produce a characterization for Pigeon Creek of variable concentrations of 3-1240 with an average concentration of 240. These figures are based on sites 2,3; 6-9; and 11-16. To maintain comparability in this analysis with the 2008 and 2009 data, the reported data/ranges are limited to baseline flow from the same sites. The target goals from both the PCMP (goal for 2010) and QAPP (goal for 2013) are based on the IDEM maximum of 235. Concentrations in baseline flow (no rain events) in 2012 sampling were variable, with results occurring between 1 and 1990. E-coli measurements were generally considerably lower in 2012 than in previous seasons. Of 48 samplings only five exceeded the target maximum of 235. The average concentration was 184, in compliance with the target goal of maximum 235. Droughty conditions may have contributed to reduced E-coli measurements as runoff produced during the sampling period was quite limited.

Total Phosphorus Concentration: Pigeon Creek and tributary baseline flow data from the 2006 PCMP indicated total phosphorus concentrations between .2 and 3 mg/l. This figure was refined by utilizing more recent baseline flow data collected from Pigeon Creek proper by the SCLC in 2008 and 2009 to produce and average of .03 mg/l. The target goals from both the PCMP (goal for 2011) and QAPP (goal for 2013) are based on the IDEM state standard maximum of .025 mg/l. While additional sampling sites were added after 2009, sampling sites included in average calculations for this report were limited to those sampled during 2008-2009 to facilitate direct comparison. Concentrations in baseline flow 2012 sampling were variable, with results occurring between .02 and .12 mg/l. The average concentration was .05 mg/l, slightly above the 2011 season average of .04 mg/l and equal to the .05 mg/l average of 2010. This exceeds the 2010 PCMP and 2013 QAAP target goal of max. .025 mg/l and exceeds the 2008/2009 SCLC average of .03 mg/l.

Total Phosphorus Target Load Reduction: In the QAPP an annual phosphorus load reduction goal was established. An estimate was calculated using the projected 2010 stream flow from the 2006 PCMP (100 CFS) and the average total phosphorus concentration from Pigeon Creek 2008 and 2009 baseline sampling (.03 mg/l). This established an annual total phosphorus loading figure of 2679.30 kg/year. Based on the target baseline flow goal of .025 mg/l. average total phosphorus concentration, the estimated flow rate (104 CFS based on PCMP) would produce a load of 2232.75 kg/year. This was used to establish a target load reduction of 446.55 kg/year for 2013. The average concentration in 2012 baseline samples (collected from the same sampling sites as in 2008-2009) was .05 mg/l. This was used to produce an estimated annual loading figure of 4465.50 kg/year for 2012 using the estimated flow rate from the PCMP. No loading reduction was apparent. The estimated loading figure for 2012 increased by 1786.20 kg/year. Using flow data collected in 2012 near the former USGS monitoring site used to produce the PCMP flow estimate produced an average baseline flow rate for 2012 of 1585.11 CFM (26.42 CFS). In the drought conditions of 2012 the flow rate was only 25% of that estimated in the PCMP. It should be noted that this yields an annual loading figure of only 1179.78 kg/year, well below the 2232.75 kg/year target.

Total Suspended Solids: Pigeon Creek baseline flow sampling data from the 2008-2009 SCLC dataset indicated total suspended solids (TSS) concentrations between <1 and 104 mg/l. with an average of 13 mg/l Results in 2012 ranged between <2 and 87 mg/l with an average of 11 mg/l. All but a single sample were below the 30 mg/l QAPP target goal for 2013.

Dissolved Oxygen: Pigeon Creek baseline flow sampling data from the 2008-2009 SCLC dataset indicated (D.O.) concentrations between 6.56 and 15.04 with an average of 9 mg/l. Baseline flow data from the same sites in 2012 ranged between 4.50 and 14.19 mg/l. with an average of 8.50 mg/l. Three sites exceeded the upper limit of the QAPP 2013 target goal range of 4-12 mg/l. Photosynthetic activity in the lake basins may have produced unusually high dissolved oxygen levels. All readings above 12 mg/l were recorded at lake outlets.

pH: Pigeon Creek and tributary baseline flow data from the 2008/2009 SCLC data set indicated variable pH's between 7.37 and 8.61 with an average of 8. The 2012 season baseline flow data collected from the same sites was similar, with pH's ranging between 7.31 and 8.35 with an average of 7.94. All fell within the 2013 QAPP target goal of 6 to 9.

PCMP Goal	Parameter	Current Status (2006 PCMP)	Current Status (2008, 2009 SCLC data)	Target Goal (2006 PCMP, target date 2010)	2010 Results	2011 Results	2012 Results	Target Goal (Phase 2, target date 2013)
Improved Water Quality	E. coli	Variable Concentrations 250-4500 Colonies/100 ml	Variable Concentrations <3-1240 Colonies or CFU per 100/ml average 240	235 Colonies/100 ml (Dry weather- excludes 48-72 hours after rain)	Variable Concentrations 10-880 Colonies or CFU per 100/ml average 231	Variable Concentrations 10-13,680 Colonies or CFU per 100/ml average 720	Variable Concentrations 1-1990 Colonies or CFU per 100/ml average 184	235 Colonies/100 ml (Dry weather- excludes 48-72 hours after rain, IAC
	Phosphates	Avg. 0.2-3 mg/l	<.01-.09 average .03	0.025 mg/l	.02-.11 average .05	.01-.12 average .04	.02-.12 average .05	0.025 mg/l (source PCMP, "state standard" cited)
	Nitrates	0-39 mg/l	-	10 mg/l	-			-
	Total Suspended Solids	-	<1-104 mg/l average13	-	1-26 mg/l average 11	7-34 mg/l average 15	<2-87 mg/l average 11	Max 30 mg/L, IDEM draft TMDL
	Dissolved Oxygen	-	6.56-15.04 mg/l average 9	-	5.44-10.16 mg/l average 7.35	4.94-10.22 mg/l average 7.29	4.50-14.19 mg/l average 8.50	Min 4 mg/L, Max 12 mg/L, IDEM cited IAC
	pH	-	7.37-8.61 average 8	-	7.63-8.28 average 7.96	7.37-8.61 average 8	7.31-8.35 average 7.94	6-9 may exceed 9 daily if coincides with photosynthetic activity, IAC
		-	**Annual Load**	**Target Load Reduction 2006 PCMP**	**Load Reduction 2010**	**Load Reduction 2011**	**Load Reduction 2012**	**Target Load** **Reduction Phase 2**
	Phosphates	-	2679.30 kg/yr	1.28 tons/yr	-1786.20 kg/yr (load 4465.50)	-1035.99 kg/yr (load 3715.29)	-1786.20 kg/yr (load 4465.50)	446.55 kg (.49 tons/yr)
	Nitrates	-	-	19.3 tons/yr	-	-	-	-

Table 1 Summary of revised water quality target goals, target load reductions, and 2010-2012 monitoring results. Current status data is average baseline flow measurements from May-August Baseline 2012 SCLC data, sites 2, 3, 6-9, 11-16. Sites 1, 4, 5, and 9 were omitted from the current analysis as they were not included in the 2008 and 2009 reference data. Data from PCMP 2006 is average baseline flow measurements from Hoosier Riverwatch volunteer data.

Site	At or near HUC 12 Outlet	Lat	Lon	Location Description	Mean baseline flow total phosphorus. (mg/l)			Mean baseline flow total suspended solids. (mg/l)			Mean baseline flow E-coli. (Colonies/100 ml)		
					2010	2011	2012	2010	2011	2012	2010	2011	2012
4.	04050001 1001	N41° 37' 54.9 27"	W84 ° 56' 15.9 39"	Pigeon, U.S. 20 Bridge, Below juncture with Berlien Ditch	.06	.04	.05	8	18	11	112	149	100
6.	04050001 1002	N41° 35' 46.8 13"	W84 ° 58' 31.8 15"	Pigeon Creek, Bill Deller Road	.08	.05	.06	15	16	13	513	580	780
10.	04050001 1003	N41° 35' 28.9 93"	W85 ° 02' 35.5 01"	Pigeon Creek, Mud Lake Outlet just west of Long Lake, Johnson Ditch from Ashley	.05	.04	.05	10	8	11	168	48	30
15.	04050001 1006	N41° 37' 25.7 24"	W85 ° 05' 43.6 54"	Pigeon Creek, Hogback Lake Outlet	.04	.04	.03	9	12	5	32	70	38
16.	04050001 1007	N41° 39' 4.78 0"	W85 ° 10' 27.3 12"	Pigeon Creek at 327	.04	.03	.03	6	10	4	220	258	102

Table 2 Baseline flow results for T.P., T.S.S. and E-coli from sampling points near HUC 12 Outlets.

12 Digit Hydrologic Units: Table 2 summarizes 2010 through 2012 data collected from the 5 sampling sites located within ARN 9-275 which are at or near the outlet of HUC 12 units. In baseline flow 2012 sampling all of these sites averaged above the .025 mg/l target concentration for total phosphorus. Phosphorus measurements were highest at the outlet of HUC 040500011002 (Bill Deller Road) averaging .06 mg/l. The highest total suspended solids average (13 mg/l) also occurred at Bill Deller Rd. This T.S.S. figure was still well below the QAPP 2013 target goal of a maximum of 30 mg/l. The E-coli average was also highest at Bill Deller Road (780 col/100 ml). Bill Deller was the only HUC outlet site average to exceed the 235 col/100 ml target goal listed in the PCMP and QAPP. As it did in 2010, the data suggests that the Bill Deller unit (HUC 040500011002) may be reasonably prioritized as a candidate area for management practice improvement. It should however be noted that comparisons with sites 4,10 and 15 should be made cautiously as these sites are influenced by the filtering effects of large water bodies just upstream of the collection sites. The Bill Deller site passes drainage waters from a relatively large watershed area without those waters being subjected to attenuation by any large upstream water bodies.

Sampling Site	Parameter or Measurement	Proposed Annual Samples	Samples Needed to Accomplish Project Objectives	Possible Constraints	Completeness Goal (% of proposed samples)	2012 Completeness (% of proposed samples)	2012 Constraint
All	Total Phosphorus	3	3	Container loss or damage, unusual flow conditions	100	100	n/a
All	Total suspended solids	3	3	Container loss or damage, unusual flow conditions	100	100	n/a
All	E-coli	3	3	Container loss or damage, expiration, unusual flow conditions	100	100	n/a
All	Dissolved oxygen	3	2	equipment/probe failure, data record loss in field, exclusion for accuracy/ bias	67	100	n/a
All	Specific conductance	3	2	equipment/probe failure, data record loss in field, exclusion for accuracy/ bias	67	100	n/a
All	Temperature	3	2	equipment/probe failure, data record loss in field, exclusion for accuracy/ bias	67	100	n/a
All	pH	3	2	equipment/probe failure, data record loss in field, exclusion for accuracy/ bias	67	100	n/a
All	Discharge	3	2	Deep/flooded conditions, equipment/probe failure	67	88	Deep conditions & timber in stream

Table 3. Sampling site goals and performance for completeness.

Quality Results

Completeness: Completeness information is listed in table 3. All samples planned in the QAAP were collected and analyzed in 2012. Discharge was not measured at sites 11 and 13 due to the depth of water, fallen timber, and soft bottom conditions in those areas. The completeness in 2012 met all QAPP goals.

Precision and Accuracy: Precision and accuracy information is listed in table 4. All precision figures for data collected met QAPP control goals with the exception of E-coli. An average relative percent difference of 44% for duplicate E-coli samples exceeded the QAPP goal of 25% RPD. It's expected that this resulted from the E-coli counts in the duplicate sampling being relatively low (7.3 to 52 Col.) rather than from an inherent imprecision in the sampling or analysis. Per the QAPP, because the average RPD was between the control limit and two times the control limit, the data is estimated. The two samples exceeding the QAPP RPD goal will be flagged "D" and will be included as useful project data. Accuracy goals were met for nearly all parameters. A single pH measurement of a blank returned an 89% recovery, slightly below the 90% recovery goal. It's not expected that this deviation will affect project goals or warrant data rejection.

Parameter	duplicates (5% goal)	Field Precision Goal	Precision 2012 Result (mean)	Accuracy Goal	Accuracy 2012 Result (field blanks)	Data Qualifiers and Flags
Total Phosphorus	8%	25% RPD	11% RPD	90% – 110% recovery	100% no bias noted	
Total suspended solids	8%	25% RPD	11% RPD	90% – 110% recovery	100% no bias noted	
E-coli	8%	25% RPD	44% RPD	90% – 110% recovery	100% No bias noted	D
Dissolved oxygen	8%	10% RPD	1% RPD	±.39 mg/L	n/a	
Specific conductance	8%	10% RPD	0% RPD	90% – 110% recovery	102% recovery	
Temperature	8%	10% RPD	1% RPD	±.2 º C	n/a	
pH	8%	10% RPD	1% RPD	90% – 110% recovery	89% - 108% recovery	
Velocity (flow speed)	8%	20%	9% RPD	n/a	n/a	

Table 4. Quality goals and performance for accuracy and precision.

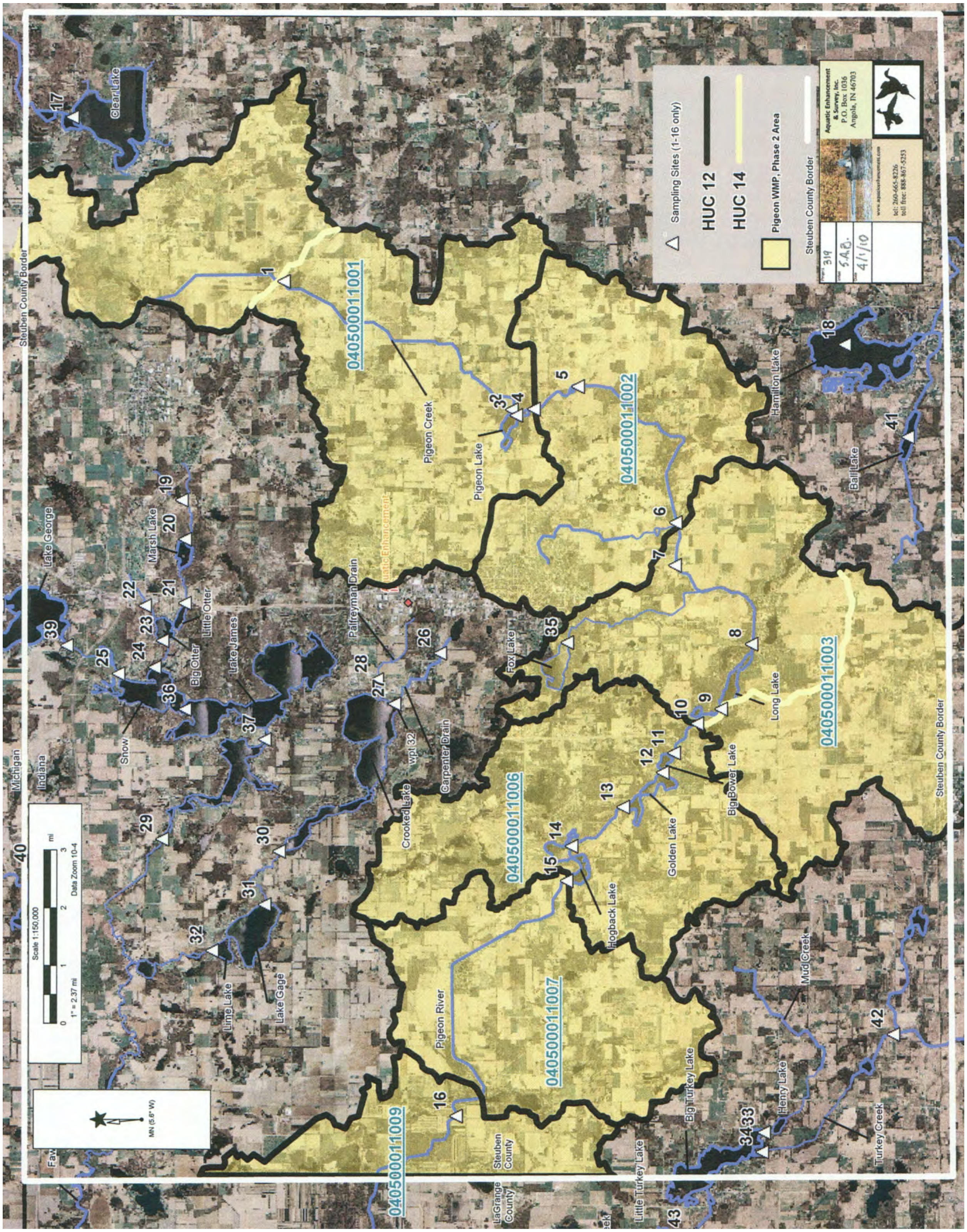


Figure 1. Pigeon Creek Sampling Map

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Quality Assurance Report

for

2010 Pigeon Creek Water Quality Sampling

Steuben County, Indiana

ARN # 9-275

Prepared by:

Scott Banfield

Aquatic Biologist, Aquatic Enhancement & Survey, Inc.

for

Steuben County Soil and Water Conservation District, Steuben County Lakes Council

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Due to the size of this document, it can be accessed at the following link:

http://www.aquaticenhancement.com/AES%20documents/ARN%209-275%20phase%202%20QAPP%20draft.pdf

Appendix E

Two-Stage Ditch

Supplemental Information

Tri-State Hydraulic Geometry Relationships for Sizing Two-Stage Agricultural Ditches

Applying knowledge to improve water quality
Great Lakes Regional Water Program
A Partnership of USDA NIFA & Land Grant Colleges and Universities
GREAT LAKES REGION
2013

The objective of this fact sheet is to provide guidelines for the tri-state region (Indiana, Michigan, Ohio) on determining the geometry of a two-stage ditch system based on the size of the upstream drainage area. In the region, agricultural drainage ditches serve as outlets for subsurface drainage systems. They traditionally are designed with a trapezoidal cross-section to move water downstream efficiently. In comparison to streams that have connected and active floodplains, trapezoidal ditches lack floodplains and as a result often experience bank erosion or excessive accumulation of sediments (Figure 1A). An improvement on the traditional trapezoidal ditch design is a two-stage channel system that is designed to take advantage of the benefits of active floodplains[1]. These systems are more self-sustaining as they work in harmony with fluvial processes so that sediment transport is in balance (Figure 1B).

Figure 1. A: A trapezoidal ditch in Indiana with bank erosion and mass bank failures.

Figure 1. B: A two-stage ditch in Michigan.

The main objectives in modifying a ditch to a two-stage geometry are to provide a connected active floodplain, to reduce maintenance, reduce bank erosion, reduce the frequency of flooding into adjacent fields, improve water quality, and enhance the ecological function of the system[1,2]. Two-stage channel systems consist of an inset channel (1st Stage) to convey the bankfull discharge and attached benches or shelves (2nd Stage) that serves as a floodplain to aid in sustaining dynamic equilibrium in the system (Figure 1B). Agricultural fields, woods, pastures, roads, and areas associated with human activities adjacent to the ditch for the top of the two-stage system and are important because: (1) runoff from these areas might cause erosion problems; (2) they are the upper boundary of the system that influence bank stability; (3) excavated material is often placed in these areas; and (4) in agricultural settings, this is where Best Management Practices (BMP) are located.

The two-stage system is best suited for drainage areas smaller than 10 square miles where natural drainage patterns have been altered, in ditches with bed slopes that are less than 0.5%, and in settings where existing land use must be preserved. To a large extent, the approach is a floodplain enhancement practice that does not modify an existing inset channel or the ditch channel below the benches (see Figure 3B). Sizing a two-stage channel involves A) determining the inset channel geometry, which defines the bench height, B) sizing the flooded width at the bankfull elevation of the inset channel, and C) determining the channel side slope for the second stage. The floodplain width includes the two constructed benches and the channel width (Figure 2). The elevation and size of the benches should be based on data collection and analyses associated with a weight-of-evidence approach[3,4,5]. Ideally, the analysis should use published regional hydraulic geometry relationships for agricultural ditches, or the development and use of these relationships, to provide estimates of the expected inset channel geometry[3,5,6]. These relationships relate drainage area to the dimensions of the fluvial channel, the inset channel, that might naturally occur in a particular setting.

Estimates from the regional relationships should be compared with actual measured fluvial features at the project site, the reference reach, hydrologic estimates, shear stress depth, and estimated bankfull/effective discharge depth. If there is good agreement between all of these factors then the likelihood of success is high and the project should proceed.

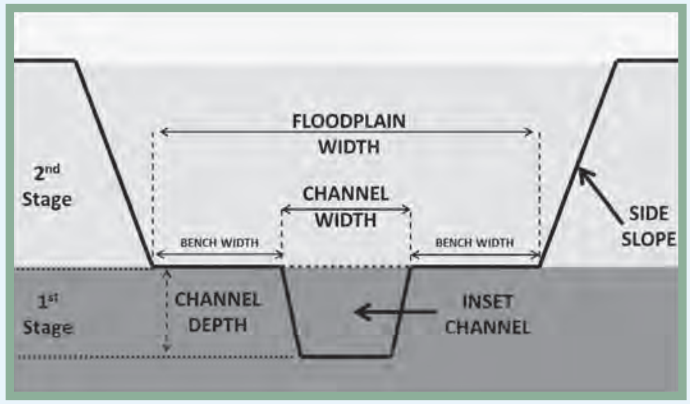

Figure 2: Dimensions of a two-stage ditch that need to be sized.

The design of the new floodplain width in the ditch is a function of the top width of the inset channel. In systems with cohesive bank materials that can readily be vegetated with grasses, the ratio of the flooded width to the inset channel width should be 3 to 5. The bench elevation corresponds to the height above the channel bed as estimated by the inset channel depth; the existing bank will be excavated at the bench elevation (Figure 2). In cohesive soils, the inset channel side slopes typically form at slopes steeper than 1.5 to 1. In the 2nd Stage of the channel, side slopes should be constructed at two-to-one or flatter slopes. The side slopes need to be stable so slump failures do not occur during high flow events. By constructing benches, and perhaps flatter slopes, the conveyance capacity of the modified ditch will be greater than the existing trapezoidal channel. If there is a need to further increase conveyance to satisfy an extreme discharge design requirement, or to provide flood storage, this can be accomplished by increasing the bench widths or further flattening the side slopes of the 2nd stage. Wider benches should provide more fluvial and ecosystem benefits but also increase the potential for the inset channel to meander and encroach on the banks of the 2nd Stage.

Table 1: Approximate hydraulic geometry relationships for two-stage agricultural ditches in Indiana, Michigan and Ohio

Drainage Area	Inset Channel Width	Max. Inset Channel Depth	3:1 Ratio		5:1 Ratio	
			Each Bench	Flooded Width	Each Bench	Flooded Width
mi^2	ft	ft	ft	ft	ft	ft
1	7	1.2	7	21	14	35
2	9	1.4	9	27	18	45
3	11	1.6	11	33	22	55
4	13	1.8	13	39	26	65
5	14	1.9	14	42	28	70
6	15	2.0	15	45	30	75
8	17	2.2	17	51	34	85
10	19	2.4	19	57	38	95

A. Channel widths and depths are the tabulated inset channel dimensions.
B. Floodplain widths are the tabulated flooded widths.

In many cases, published regional hydraulic geometry relationships for agricultural ditches are not available, developing relationships for sizing purposes is beyond the expertise of the project team, or there is a need to develop a preliminary design for feasibility purposes. The relationships presented in Table 1 should provide reasonable hydraulic geometry estimates for low gradient agricultural ditches in the tri-state region.

The benches do not need to be the same size but we recommend caution in using a one-sided construction as we have seen some failures with that approach – either because the one-sided bench was too small or the hydraulics of the system resulted in scour of the bench. The existing inset channel size likely will be different from the predicted inset channel size. The flooded width and depth sizes in Table 1 are guidelines primarily for use in evaluating the cost and feasibility of a proposed project. It is recommended that final designs be based on measured data at the ditch and for the region that are specific to agricultural ditches. In most cases, final dimensions based on measured data will probably not deviate by more than 25% from the values in Table 1. Making the depths a few tenths of a foot shallower will promote flooding on to the benches and should provide more water quality and ecological benefits. In the absence of measured data the flooded width should not be made less than that for a 3:1 ratio in Table 1.

Example: A ditch with a 3.5 mi^2 drainage area has a measured inset channel width of 12 ft and existing 3-4 ft wide benches about 1.7 ft above the bottom of the ditch. If a two-stage ditch will solve an existing problem then we would recommend widening the existing benches to give a total flooded width of 36 ft (from Table 1) about 1.7 ft above the bottom of the ditch. Figure 3.A shows the original geometry (dashed line), the excavated material (shaded areas), the design geometry (solid line), a 8 ft bench to the left of the inset channel, and a 16 ft bench to the right of the inset channel 9 (corresponds to 24 ft of benches in Table 1 for a 3:1 ratio). Figure 3.B show the two-stage construction concept that does not modify the inset channel, leaves the grass fringe along the inset channel, and pulls back the banks to establish benches.

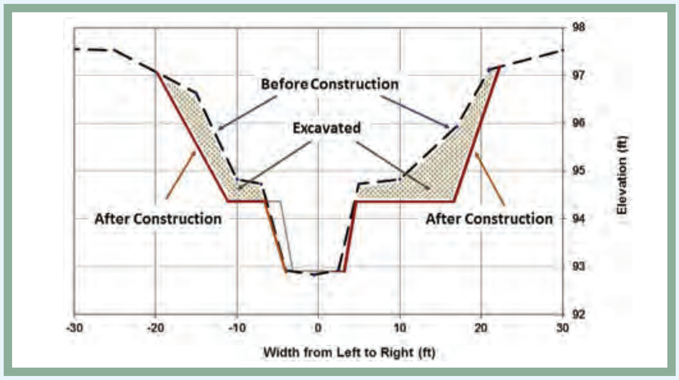

Figure 3. A: Pre and post-construction geometry for the example.

Figure 3. B: Modification of a ditch to a two-stage geometry by pulling the banks back to form benches.

[1] D'Ambrosio, J.D. Witter, and A.D. Ward. 2011 Building Better Ditches. Madison: Great Lakes Regional Water Program.

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[3] Powell, G.E., A.D. Ward, D.E. Mecklenburg, and A.D. Jayakaran. 2007a. Two-stage channel systems: Part 1, a practical approach for sizing agricultural ditches. JSWC, 62(4):277-286.

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[5] USDA-NRCS. 2007. National Engineering Handbook Part 654 Stream Restoration Design. Chapter 10 Two-Stage Channel Design. (available of the internet so conduct a search)

[6] Ward, A.D., Witter, J.D., J.L. D'Ambrosio, J. Magner. 2013. Developing regional hydraulic geometry relationships for streams and ditches. Madison: Great Lakes Regional Water Program.

CONTACTS

Andy Ward ward.2@osu.edu, **Jonathan D. Witter** witter.7@osu.edu, **Jessica L. D'Ambrosio** dambrosio.9@osu.edu
Department of Food, Agricultural and Biological Engineering and the Ohio NEMO Program, The Ohio State University

Dan Mecklenburg dan.mecklenburg@dnr.state.oh.us, The Ohio Department of Natural Resources

Joe Magner magne027@umn.edu, Department of Biosystems & Bioproducts Engr., University of Minnesota

Kent Wamsley kwamsley@tnc.org, The Nature Conservancy

Applying knowledge to improve water quality
Great Lakes Regional Water Program
A Partnership of USDA NIFA & Land Grant Colleges and Universities
http://greatlakeswater.uwex.edu/

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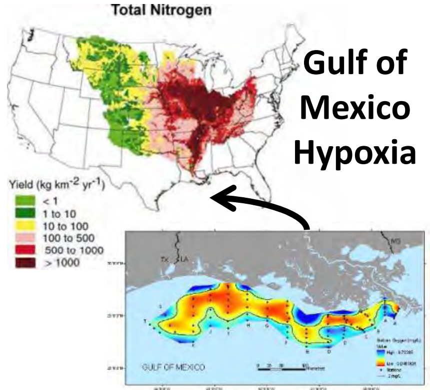
Two-Stage Management: Nitrogen & Sediment Dynamics in Agricultural Streams

Laboratory of Dr. Jennifer Tank, Department of Biological Sciences

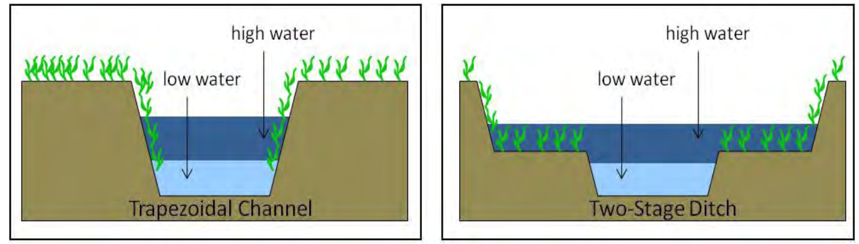
Problem of Excess

Streams in the agricultural Midwest can be a source of excess nutrients and sediments that pollute downstream ecosystems. Example: fertilizer runoff is responsible for the periodic "dead zone" in the Gulf of Mexico. Our goal is to maximize in-stream N and sediment removal before downstream export.

Can 2-stage ditch management reduce nitrogen and sediment export?



Two-Stage Restoration Strategy

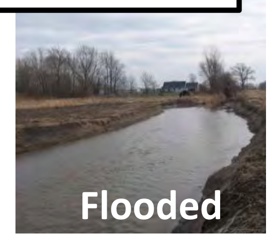


During high flows, water spreads onto the floodplains, increasing the area over which N removal can occur.

N Removal via Denitrification

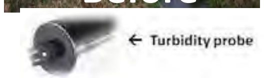
- Denitrification is the microbial conversion of nitrate (NO_3^-) to dinitrogen gas (N_2), and is a **permanent removal of nitrogen**
- Denitrification occurs naturally in stream sediments
- The two-stage ditch increases stream surface area, resulting in increased permanent N removal

Shatto Ditch Demonstration Project



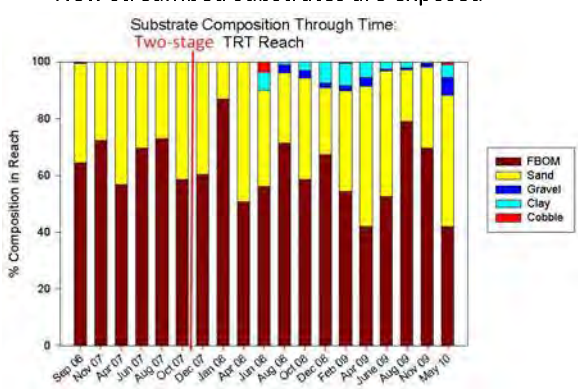
Bench Flooding

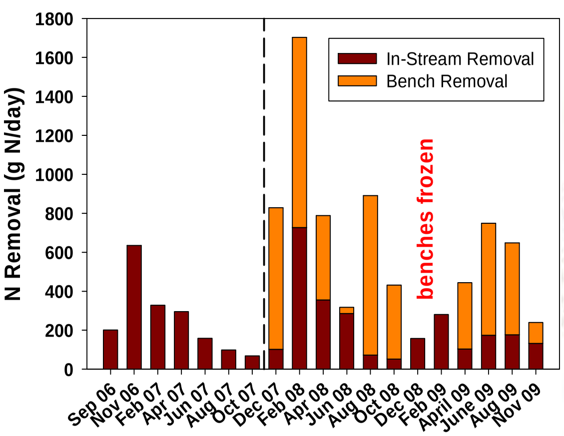
- Most N & sediment export occurs during high flows
- Flooded benches increase water residence time, which results in increased N processing and sediment removal
- Conditions are ideal for denitrification in flooded benches (high NO_3^- and C, anoxia)



Sediment Effects

- Water column turbidity decreased by 43%
- New streambed substrates are exposed





Data from Roley et al. in press, 29 July 2011

Implications for Downstream Water Quality

- Because of very high N loads, the increase in N removal translates only to 2-16% of the NO_3^- load
- In-stream management practices are most effective if coupled with watershed and landscape-level management programs
- **Both enhancing in-stream removal and reducing inputs are necessary to reduce downstream export**

Future Directions

- Study the effect of the two-stage across a range of streams and determine the change in two-stage function over time and with varying nitrate loads.
- Develop a management tool to evaluate the influence of the two-stage in different conservation scenarios.

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Two-Stage Ditches

Much of the landscape in the Wabash River basin, a large-river watershed that drains to the Gulf of Mexico, has been converted to agricultural use. With this massive landscape conversion has come altered hydrologic function and significant changes in the flow of nutrients and sediments out of these agricultural watersheds. Infrastructure of old simply can't handle the needs and demands that they are receiving today. One tool in the toolbox to combat this is the Two-Stage Ditch. Utilizing current infrastructure of drainage ditches, the Two-Stage Ditch enhances these systems to provide additional function of sediment removal, nutrient uptake, and still allows for sufficient water flows and drainage.

Issues: impaired water quality, stream bank erosion, sedimentation, turbidity, flooding

Function: "mini floodplains" or "benches" that slows down the water velocity and allows for sediment sorting and nutrient uptake to occur, reconnecting agricultural streams to floodplains.

Two-Stage Ditch performance:

1. Yearly in a ½ mile segment the sediment inputs reduce by 53 tons versus a conventional ditch
2. As benches age the nutrient uptake and removal increases (a gift that keeps on giving)
3. Benches filter tile water, provide bank stability, and decreases water velocities by 50%
4. Performs the best in elevated water flows resulting in lower peak discharges in storm events
5. Reduces regular ditch maintenance frequency as a result of self cleaning/stability
6. Shows increased nutrient uptake and removal immediately after construction

Details: Flooding is the key to naturally mitigating the impacts of high flows. Properly designed Two-Stage Ditches accommodate large flows and should rarely, if ever, flood surrounding land except for extreme conditions. Two-Stage Ditches do form naturally, but generally this is when the perception is to dip them out, not always is there a drainage impact. Two-Stage Ditches do require more room than conventional ditches and they do cost more to construct. Typical bottom cleanout of conventional ditches as the result of sediment build up will cost between $1 and $1.50 per linear foot. The average Two-Stage Ditch will cost around $10-$12/linear foot. One option is immediate the other is permanent.

Challenges and Future Direction: Farmers (usually the same ones already with land in some program) are being asked to take land out of production to create them. A Two-Stage Ditch will take some ground out of production (.5 to 1.5 acres per ½ mile). The practice does reduce ponding in fields and limits soil loss from bank failure/erosion. It is essential to maintain highly productive agriculture land and at the same time improve water quality. Two-Stage Ditches are detailed in the NRCS Technical Manual, but not yet recognized by the Farm Service Agency (FSA) as a contracting practice. It is cost-sharable through the EQIP program (75% cost share), but will not rank out as high as other practices and therefore is not being adopted as readily. Conservation begins at the farm scale and ramps up to larger watershed areas to make improvements locally that will have impacts that reach far downstream to places like the Mississippi River and ultimately the Gulf of Mexico. When managed for water quality, ditches have the potential to make positive impacts toward improving water quality. The Nature Conservancy believes that the Two-Stage Ditch is a viable and practical conservation tool.

Appendix F

SWAMM Methodology

SWAMM Pollutant Load Model Methodology

NORTHWATER CONSULTING

1/31/2014

Table of Contents

Tables

Pollutant Loading Model Methodology

1.0 Introduction

A GIS spatially based pollution load model or SWAMM (Spatial Watershed Assessment and Management Model) was developed to estimate field level pollutant loading from, phosphorus, nitrogen, sediment and bacteria (Fecal Coliform). Constructed using soils, landuse and precipitation data the model provides both annual and storm event loading for individual land parcels within the Pigeon Creek Watershed. Results are organized through a unique combination of parcel ownership, landuse and soils, delineated into individual units of pollution loading. Accepted equations for calculating runoff and soil erosion are integrated into the model to provide realistic estimations of the quantity and distribution of pollution loading throughout the study area. The model was directly calibrated to local water quality data. A time period of 12/31/1982 to 12/31/2012 was used for generating rainfall values.

The GIS data set is organized in such a way that results can easily be queried by subwatersheds, by parcel boundaries and by landuse. Results can also be analyzed based on user defined boundaries and presented in map format, easily overlaid on existing base maps. The model includes 100,651 unique records from which to assess pollution loading. The following methodology document provides key model equations and values, references and summary statistics.

2.0 Methodology

The custom SWAMM model consists of two primary components:

- Universal Soil Loss Equation (USLE) Component
- Event Mean Concentration (EMC) Component

2.1 USLE Component

The overall analysis methodology modified by Northwater from*:*

Mitasova and Lubos Mitas: Modeling soil detachment with RUSLE3d using GIS, 1999; University of Illinois. http:/skagit.meas.ncsu.edu/~helena/gmslab/erosion/usle.html

The Universal Soil Loss Equation (USLE) component of the model is applied to agricultural land uses within the watershed (Row Crops). The USLE methodology incorporated into the model is summarized below:

- 1:24,000 NRCS Soil Survey Geographic Database (SSURGO) Digital Soils.
- Selected appropriate soil types and relevant USLE factors identified and calculated from SSURGO soils dataset and information from local Soil and Water Conservation District staff and staff from the Natural Resource Conservation Service.
- USLE erosion calculated with the following equation: LS * K * C * R. The P-factor was not incorporated as it is set to 1 for all soil units.

Table 1 - USLE factors

Landcover	C factor	K factor	LS factor	R factor	P factor
Agriculture Crops (Row Crops)	Initial Values Provided by County NRCS Final Calibrated Values: 0.18, 0.09, and 0.001	Values included in SSURGO tabular data	Values included in SSURGO tabular data; calculated from slope and slope length values or from local NRCS Staff	140	1 used for all soil polygons

2.2 EMC Component

A) All formulas and selected variables are derived from: *STEPL (Spreadsheet Tool for Estimation of Pollutant Load) Version 3, Tetra Tech, 2004.* For Bacteria, Schueler's Simple Method (1987) is modified for calculating bacterial loads.

B) A storm runoff module was created to estimate runoff and pollutant loading from a 1.5 inch "first-flush" storm, 10 year (3.73 inches) and 25 year (4.46 inches) rainfall event. Runoff was computed as described in the table below. P or rainfall/precipitation values were provided by the Steuben County NRCS.

C) Event Mean Concentration Values and Curve Numbers were derived from the following sources:

1. *Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) Technical Guide, Version 1.0 Release 1, November 2004.*
2. *Lower DuPage River Watershed Plan Pollution Load Model Methodology, 2010.*
3. *V3 Companies, 2008. Elkhart River Watershed Management Plan, Appendix J; Pollutant Load Model Documentation for Critical Areas.*
4. *Price, Thomas H., 1993. Unit Area Pollutant Load Estimates for Lake County Illinois Lake Michigan Watersheds.*
5. *Todd D. Stuntebeck, Matthew J. Komiskey, Marie C. Peppler, David W. Owens, and Dennis R. Frame 2011. Precipitation-Runoff Relations and Water-Quality Characteristics at Edge-of-Field. Stations, Discovery Farms and Pioneer Farm, Wisconsin, 2003–08.*
6. *Northwater Consulting. 2013. Spatial Watershed Assessment and Management Model. Prepared for Chicago Metropolitan Agency for Planning, Chicago, IL.*

D) Precipitation: annual precipitation, number of rain days and correction factors using the following weather station: Angola, IN COOP Station ID 120200. A period of 30 years was used (1982-2012).

Table 2 – Rainfall Factors

Average Number of Rain Days	Rain Days Correction Factor	P Value (inches)
124.4	0.446	0.6

E) Delivery Ratio; distance based delivery ratio: *Minnesota Board of Water & Soil Resources, "Pollution Reduction Estimator Water Erosion - Microsoft Excel® Version September 2010."*

Polygon distance from major stream (ft) ^-0.2069

Table 3 - Pollutant Load Model Values

Model	Rain days	Correction Factor (precipitation and rain days)	Curve Number (by soil hydrologic group)	Runoff (by soil hydrologic group in inches)	EMC for N, P, TSS, Bacteria
All landuse	see table above	see table above	See below	Calculated using the following equation: $Q = \frac{(P - (Ia \times S))^2}{P + 0.8 \times S}$ $S = \frac{1000}{CN} - 10$ Q = Runoff (inches) P = Precipitation (inches) S = Potential max retention (inches) CN = Curve Number Ia = Initial abstraction factor; set to 0 for annual runoff and 0.2 for first flush, 10 and 25yr events	See Table Below

Table 4 - Event Mean Concentrations and Curve Numbers

Landuse Category	EMC P (mg/l)	EMC N (mg/l)	EMC TSS (mg/l)	Bacteria (counts/100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
2 - Golf Course	0.7	3.6	84	7,200	39	61	74	80
3 - Vacant (Undeveloped)	0.13	1.4	30	2,600	39	61	74	80
4 - Row Crops	1.1	7.1	N/A*	7,200	74	83	88	90
4 - Row Crops (Irrigated)	1.1	7.1	N/A*	7,200	76	85	90	92
5 - Open Space (Non-Tillable)	0.3	0.7	15	9,000	30	58	71	78
6 - Woodland	0.2	1.4	45	7,800	39	61	74	80
7 - Pasture (Low)	0.8	3.46	50	10,500	30	58	71	78
7 - Pasture (Medium)	1	6.75	100	13,000	67	78	85	89
7 - Pasture (High)	0.8	10.1	200	22,000	75	84	89	91
8 - Residential	0.4	3.2	150	9,000	76	85	90	92
9 - Residential Farm	0.6	3.3	175	10,500	74	83	88	90
10 - Quarry	0.31	1.79	93.9	2,500	81	88	91	93
11 - Primary Commercial/Industrial/Institutional	0.3	2.4	72	2,500	81	88	91	93
12 - Secondary Commercial/Industrial/Institutional	0.31	2.4	190	2,500	89	92	94	95
13 - Undeveloped Usable Commercial and Industrial	0.2	1.4	60	2,600	39	61	74	80
14 - Undeveloped Unusable Commercial and Industrial	0.2	1.4	60	2,600	39	61	74	80
15 - Nursery	0.6	3.6	240	5,200	32	58	72	79
16 - Open Water Lake/Pond	0.1	0.375	1.5	7,200	98	98	98	98
17 - Open Water Stream	0.3	1.25	3.1	5,200	98	98	98	98
21 - Classified Forest Land	0.2	1.4	45	7,200	39	61	74	80
22 - Classified Wildlife Habitat	0.2	1.4	20	7,200	30	58	71	78
26 - Cemeteries	0.46	3.1	80	5,200	49	69	79	84
70 - Feed Area (Low)	1	6.75	120	13,000	67	78	85	89

Landuse Category	EMC P (mg/l)	EMC N (mg/l)	EMC TSS (mg/l)	Bacteria (counts/100ml)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
70 - Feed Area (Medium)	1.3	10.1	240	18,000	77	85	90	92
70 - Feed Area (High)	2.2	13.5	390	36,000	89	92	94	95
71 - Other Farmland/Farm Buildings and Barn Lots	0.6	7.1	195	9,500	89	92	94	95
73 - Wetlands	0.3	0.7	1	8,000	85	85	85	85
81 - Legal Ditch	0.9	7.1	3.1	5,200	98	98	98	98
82 - Road	0.34	2.3	240	1,700	98	98	98	98
83 - Public Utility Transmission Towers	0.34	2.1	153	1,400	81	88	91	93
85 - Railroad Right-of-Way	0.3	2	65	5,200	49	69	79	84
86 - Cellular Towers	0.3	2.1	65	2,600	49	69	79	84
91 - Public Open Space	0.3	1.4	30	7,200	49	69	79	84
92 - Agricultural Excess Area	0.2	1.4	30	5,200	30	58	71	78
98 - Confinement (Low)	0.6	6.75	60	10,500	89	92	94	95
98 - Confinement (Medium)	1.3	7.1	120	21,000	89	92	94	95
98 - Confinement (High)	2.6	13.5	240	57000	89	92	94	95
99 - Feed Area Hogs	2.6	13.5	350	57,000	89	92	94	95

USLE equation used

3.0 Model Calibration

Model calibration was performed to verify the model results against local water quality data and average per acre loading results for the Midwest. The calibration and verification served three purposes:

1. Quality Assurance / Quality Control – to find and correct user errors in the model scripts and algorithms.
2. To evaluate whether stream-flow (runoff) and pollutant loading were in the correct ranges based on existing data and literature.
3. To calibrate model by adjusting parameters so that cumulative model results represent regional averages.

The model is estimating accumulated/delivered pollutant loading, represented mostly in the literature. Important notes on the model include:

- The model does not directly account for point source pollution.
- The model estimates annual pollutant mobilization from individual parcels of land and does not take into account storage, fate and transport watershed processes.
- The model accounts for precipitation runoff; but not base flow, point source discharges or drainage-tile contributions.

Model calibration was performed by deriving streamflow statistics and analyzing readily available water quality data for each of the ten HUC 12 subwatersheds. Bacteria statistics were derived from the 2012 TMDL Report for the Pigeon River; this included samples from fifty stations during a sampling period in 2010. Total suspended sediment (TSS) and total phosphorus statistics were derived from water quality data provided by Steuben County, representing a period between 2007 and 2013 from thirty different stations.

Subwatershed average annual flow estimates were derived from the USGS Station 04099510, Pigeon Creek near Angola, Indiana. The period of 1990 – 2013 was used to determine average annual flow from the basin. An estimate of average annual flow for each subwatershed was calculated by downscaling from the USGS station based on drainage area.

Analysis of water quality data commonly results in underestimating nonpoint source pollutant loading. This is primarily due to the lack of data during storm events when nonpoint source loading is typically highest. Further, many collection events do not measure stream-flow discharges which makes it difficult to estimate loading. The water quality data was used only as a validation tool to calibrate the model so that the results were not lower, or significantly higher than the values estimated with streamflow and water quality data.

To calibrate the Pigeon Creek SWAMM to existing water quality data, the following was performed:

- Water quality data was analyzed by subwatershed and annual in-stream loading was calculated.
- Adjustments were made to SWAMM to get modeled results within acceptable ranges for phosphorus, bacteria and sediment (TSS) including:
  - Crop C factors were reduced to account for differences in TSS.
  - Upward adjustments were made to EMCs for phosphorus and bacteria by individual landuse category.
  - EMCs for TSS were reduced for individual landuse categories
- No adjustments were made to nitrogen.
- Model calibration was performed over three iterations.

The model was also calibrated based using the delivery ratio; to account for differences between the delivery of sediment versus the delivery of dissolved pollutants. Since the delivery ratio is based on studies of sediment transport and not dissolved pollutants, an adjustment or multiplier of **1.25** was applied to the delivery ratio for nitrogen, phosphorous and bacteria to get the results within acceptable regional ranges. The assumption was made that dissolved pollutants are delivered at a slightly higher rate than that of sediment.

4.0 Model Notes

1. A 2012 local landuse layer was used and provided by the Steuben County Assessors office. The Landuse layer was modified to represent a hybrid landuse/landcover layer by interpreting recent aerial imagery and digitizing/labeling polygons. For example, the agriculture landuse category was further dissected into row crops and grazing. Residential areas were modified and classified into high, medium and low density and major road boundaries were digitized out of the base landuse layer.
2. Data on the location of irrigated fields was incorporated and associated curve numbers were adjusted upwards.
3. High, medium and low areas were determined based on a visual interpretation of density. High areas generally represented greater than 50% impervious, medium 25-50% impervious and low, less than 25%.
4. In general, residential farm areas also include some type of livestock or animal feeding area/barn and therefore received higher EMC values for nutrients, sediment and bacteria.
5. Pasture was classified into high, medium and low based on pasture quality and the observed impact to water quality during the 2012 windshield survey.
6. The stream/waterbody file used to run proximity calculations for the purposes of determining a delivery ratio was modified using NHD data and a Hydrology layer provided by the Steuben County Assessor's office. Duplicate lines were deleted to create a "clean" line file representing all streams and open water outlines.
7. An EMC of 750 mg/l for TSS was used for calculating row crop sediment loading from storm events, replacing the USLE.