Glenn Shoals Lake & Lake Hillsboro Watershed-Based Plan

Montgomery County, Illinois

Funded by:
The City of Hillsboro, Illinois

Prepared by:
Northwater Consulting

With assistance from:
The City of Hillsboro and
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Acronyms

1. AFT – American Farmland Trust
2. BMP – Best Management Practice
3. CDP – Census Designated Place
4. CREP – Conservation Reserve and Enhancement Program
5. CIG – Conservation Innovation Grant
6. CRP – Conservation Reserve Program
7. CSP – Conservation Stewardship Program
8. CWS – Community Water Supply
9. DO – Dissolved Oxygen
10. DWM - Drainage Water Management
11. DFIRM - Digital Flood Insurance Rate Maps
12. EMC – Event Mean Concentration
13. FEMA - Federal Emergency Management Agency
14. FSA – Farm Service Agency
15. EQIP – Environmental Quality Incentive Program
16. fasl – feet above sea level
17. GIS – Geographic Information System
18. GIGO - Green Infrastructure Grant Opportunities
19. HEL – Highly Erodible Soil
20. HUC – Hydrologic Unit Code
21. ICG – Illinois Corn Growers
22. IDNR – Illinois Department of Natural Resources
23. IDOA – Illinois Department of Agriculture
24. Illinois EPA – Illinois Environmental Protection Agency
25. IFCA – Illinois Fertilizer and Chemical Association
26. ILICA – Illinois Land Improvement Contractors Association
27. INLRS – Illinois Nutrient Loss Reduction Strategy
28. INSAC – Illinois Nutrient Science Advisory Committee
29. ISGS – Illinois State Geologic Survey
30. ISWS – Illinois State Water Survey
31. ISA – Illinois Stewardship Alliance
32. LRR – Lateral Recession Rate
33. MCSWCD – Montgomery County Soil and Water Conservation District
34. NGRREC - National Great Rivers Research & Education Center
35. NHEL – Non-Highly Erodible Soil
36. NHD - National Hydrography Dataset
37. NCWS – Non-Community Water Supply
38. NWQI – National Water Quality Initiative
39. NO3 – Nitrate
40. NPDES – National Pollutant Discharge Elimination System
41. NPS– Nonpoint Source Pollution
42. NRCS – Natural Resource Conservation Service
43. NVSS – Nonvolatile Suspended Solids
44. NTCHS – National Technical Committee for Hydric Soils
45. NWI – National Wetlands Inventory
46. PHEL – Potentially Highly Erodible Soil
47. PFC – Partners for Conservation
48. PCM – Precision Conservation Management
49. RCPP – Regional Conservation Partnership Program
50. S.T.A.R. – Saving Tomorrow's Agriculture Resources Program
51. STEPL – Spreadsheet Tool for Estimating Pollutant Loads
52. STP – Stone Toe Protection
53. SSRP – Streambank Stabilization and Restoration Program
54. SFHA - Special Flood Hazard Areas (SFHA)
55. SWCD – Soil and Water Conservation District
56. TMDL – Total Maximum Daily Load
57. TN – Total Nitrogen
58. TNC – The Nature Conservancy
59. TP – Total Phosphorus
60. TSI – Timber Stand Improvement
61. TSP – Technical Service Providers
62. TSS – Total Suspended Solids
63. TWI – The Wetlands Initiative
64. USDA – U.S. Department of Agriculture
65. USEPA – U.S. Environmental Protection Agency
66. USFWS – U.S. Fish and Wildlife Service
67. USGS – United States Geological Survey
68. USLE – Universal Soil Loss Equation
69. VLMP – Volunteer Lake Monitoring Program
70. VRT - Variable Rate Technology
71. VSS – Volatile Suspended Solids
72. WBP – Watershed-Based Plan
73. WASCB – Water and Sediment Control Basin
74. WPCLP – Water Pollution Control Loan Program
75. WQX – Water Quality Exchange

Executive Summary

The Glenn Shoals Lake & Lake Hillsboro Watershed

The Glenn Shoals Lake and Lake Hillsboro Watershed-Based Plan (WBP) encompasses 53,542 acres from four Hydrologic Unit Code (HUC)-12 watersheds. Glenn Shoals Lake is 1,092 acres in size with a watershed area of 49,323 acres and Lake Hillsboro is 106 acres with a watershed area of 4,219 acres. The plan provides a road map to achieve water quality targets and City of Hillsboro and stakeholder goals. Nutrient and sediment water quality targets are in alignment with the Illinois Nutrient Loss Reduction Strategy (INLRS) and the 2006 Glenn Shoals – Hillsboro Watershed Total Maximum Daily Load (TMDL).

Glenn Shoals Lake and Lake Hillsboro are water supply reservoirs that serve the City of Hillsboro and surrounding areas. It is currently estimated that approximately 50,000 tons of sediment enter Glenn Shoals Lake and 2,500 tons enter Lake Hillsboro each year, diminishing holding capacity and future water availability. This, and sediment already in the reservoirs contain nutrients, primary phosphorus that can cause water quality issues and challenges to the water treatment process. To address this, the City of Hillsboro, in partnership with the Montgomery County Soil and Water Conservation District (MCSWCD) is undertaking a lake and watershed management program intended to accelerate past efforts and ensure a safe and resilient supply of water for residents in industry.

This plan is intended to be monitored, adopted and updated as cost-effective implementation activities achieve the highest load reductions. Priority or critical areas identified should serve as a starting point to guide implementation and outreach efforts by watershed managers and partners. The plan will also provide guidance for future grant applications and awards.

Leaders in the watershed have been working diligently to improve water quality and protect this important water supply. The City of Hillsboro and MCSWCD have led efforts over the years, supported by local stakeholders that include farmers, residents, government agencies, and non-profit groups. These efforts and partnerships will continue and are further strengthened as a result of the planning process. Complementary actions underway or initiated during plan development include: conservation cost-share from the Natural Resources Conservation Service (NRCS) and MCSWCD, establishment of a water quality monitoring program, grant applications, and landowner outreach. Lake and watershed activities to date have laid the critical groundwork needed to accelerate implementation activities detailed in this WBP.

The primary goals of the watershed plan are to reduce sedimentation to the lakes and improve water quality. This plan includes a detailed inventory and assessment of current conditions that inform strategic recommendations and projects. Table 1 summarizes and ranks stream and subwatershed characteristics that are contributing to water quality impairments followed by a summary of key recommendations.

Table 1 – Watershed & Lake Characteristics & Problem Ranking

Inventory/ Assessment Item	Summary	Ranking
Watershed Nutrient & Sediment Loading	Sediment loading from crop ground exceeds other sources and is responsible for 86% of the total to both lakes. Nutrient loading is also higher than urban and other land and is responsible for the greatest percentage of nitrogen (91%) and phosphorus (76%) loading. Up to 17% of the cropland nitrogen load is estimated to originate from subsurface flow or drain tiles. Agricultural Best Management Practices (BMPs) will be very effective in reducing nutrients and sediment, considering cost and feasibility. Further conversion to agriculture is not expected in the future. Prioritized in-field practices, especially those that treat surface runoff, such as cover crops and reduced tillage, will significantly reduce loading. Edge-of-field and structural practices (e.g., filter strips, terraces, and ponds) will address higher-risk areas and further reduce loading. Floodplain re-connection with wetland restoration and in-lake dams can be effective at treating large portions of the watershed. At a total estimated annual cost of $3,525,279, cover crops can be applied to 34,199 acres, reducing 30% of the total nitrogen, 21% of the total phosphorus and 31% of the total sediment load.	**High**
Tillage & Highly Erodible Soils	Mulch and no-till systems are common on 51% and 29% of all field acres respectively. These acres are responsible for approximately 80% of the crop sediment nutrient load. Conventional tillage is low overall but yields the greatest sediment per acre. The 3.6% conventionally tilled cropland delivers roughly 4% of the nutrient and almost 6% of the sediment load. Highly erodible and potentially highly erodible soils exist on 19% of the cropland and deliver 37% of the entire cropland sediment load. Most of these acres are in no-till, however, further increasing the percentage of no-till/strip-till and promoting cover crops will measurably reduce sediment and nutrient loading. Applying no-till/strip-till to 17,731 acres is estimated to cost $403,120 annually and reduce 25% of the total sediment load.	**High**
Internal Lake Loading	Each year a zone of oxygen depleted water forms in each lake. In these areas, nutrients, primarily phosphorus, is released for deposited lakebed sediment. This internal release causes frequent algal blooms that are a challenge for water treatment and can impact recreation. It is estimated that a total of 4,840 lbs/yr of phosphorus is released from sediments in both Lakes. This represents 5.2% of the total annual phosphorus load to Glenn Shoals Lake and 8.3% to Lake Hillsboro.	**High**
Lake Shoreline Erosion	Although only responsible for 3.1% of the total annual sediment to Glenn Shoals Lake and 2.6% of the sediment to Lake Hillsboro, a relatively small number of banks are eroding at extremely high rates. With the lakes under the jurisdiction of the City of Hillsboro, focused investments can achieve substantial reductions in sediment loading compared to other areas in the watershed. Shoreline stabilization can also enhance aquatic habitat if the correct techniques are used, and it is a visible practice to those that use the lakes for recreation. Stabilizing a total of 6,311 feet for a one-time cost of $788,875 can eliminate over 60% of all the sediment from banks in need of repair.	**High**
Streambank Erosion	Streambank erosion is a natural process that can be exacerbated by human changes. It is responsible for 2.7% of the annual phosphorus and 6.2% of the sediment delivered to Glenn Shoals Lake and 1.3% of the annual phosphorus and 5.1% of the sediment to Lake Hillsboro. Many stream segments inventories are eroding at very high rates, however, access limits available treatment options for many. Those stabilization practices recommended including stream riffles and stone toe protection, albeit costly upfront will yield substantial reductions over multiple years.	**Medium**

Inventory/ Assessment Item	Summary	Ranking
Gully Erosion	Gully erosion is responsible for a modest portion of the watershed sediment load, or 6.4%. Forested areas contribute most of this. These areas can be addressed through structural practices, primarily ponds and wetlands, to trap and filter sediment before entering the waterbodies. Structural practices defined as "critical" in Section 9 should be prioritized. Ponds could reduce 12% of the annual sediment, 9% of the phosphorus and 6% of the nitrogen load for a total cost of $15,712,640. This practice will generate reductions over multiple years.	**Medium**
Water Quality & Monitoring	Water quality data is limited, especially from streams. Both lakes and the Middle Fork Shoal Creek that drains to Glenn Shoals Lake are and have been impaired for manganese, phosphorus, sediment, low oxygen, and other chemicals, some of which were addressed in a 2006 TMDL. Water quality, especially sediment and phosphorus, is of high concern and a priority. More monitoring is needed from streams including frequent streamflow measurements. The current lake monitoring program should continue with an additional site. A lake bathymetry assessment is also recommended to track sediment accumulation.	**Medium**
NDPES Dischargers	Two National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge 0.2% of the total annual nitrogen and 1.3% of the total phosphorus load. Most of this is generated by the Village of Irving. All facilities are permitted through the Illinois EPA and United States Environmental Protection Agency (USEPA) and are considered low priority.	**Low**
Land Use Change & Urban Areas	The watershed contains a modest amount of developed land, more so on land draining to Lake Hillsboro. Some future development is expected around population centers. A small number of urban practices are recommended in this plan, however, the cost per unit of sediment and nutrients reduced is substantially higher compared with other practices. Little to no transition from natural areas is likely. These locations should be conserved/improved to promote habitat quality.	**Low**
Septic Systems	There are an estimated 514 homes with septic systems in the combined watershed. It is possible that up to 15% of all systems may be failing, or 77. Failing systems are estimated to account for a low portion of the overall nutrient load (0.4% nitrogen and 1% phosphorus). A septic system education program can prevent loading from failing systems in the future.	**Low**

Key Recommendations

1. Conduct targeted outreach and one-on-one communication with growers and landowners with critical practices and fields outlined in Section 9.0.
2. Apply for a United States Department of Agriculture Regional Conservation Partnership Program grant and Illinois EPA Section 319 grant for both in-field and structural practices.
3. Consider the Illinois State Revolving Funds for large and expensive in-lake and lake-adjacent projects.
4. Utilize this plan to direct City of Hillsboro lake maintenance dollars. Focus on shoreline stabilization.
5. Continue to expand water quality monitoring efforts and measure progress. Pursue additional resources for monitoring.
6. Address internal lakebed sediment nutrient release as outlined in this plan to mitigate algal blooms.

1.0 Introduction

The focus of this plan is the 53,542-acre Glenn Shoals Lake and Lake Hillsboro (also known as Old Lake Hillsboro) watershed, located almost entirely in Montgomery County, Illinois, with a very small portion in Christian County. The area of four United States Geological Survey (USGS) Hydrologic Unit Code (HUC)-12 subwatersheds makes up the project area:

1. Mount Zion Church – Middle Fork Creek HUC12 – 071402030201 (10,760 acres). This HUC covers Glenn Shoals Lake.
2. Little Creek HUC12 – 071402030202 (13,729 acres). This HUC covers Glenn Shoals Lake.
3. Lake Glenn Shoals – Middle Fork Shoal Creek HUC12 – 071402030203 (24,834 acres). This HUC covers Glenn Shoals Lake.
4. Cress Creek – Middle Fork Shoal Creek HUC12 – 071402030204 (4,219 acres). This HUC covers Lake Hillsboro.

The watersheds make up 9.1% of the entire 586,569-acre Shoal Creek HUC8 basin (07140203) which is part of the Kaskaskia River system. Figure 1 shows the location. This plan characterizes the two water supply reservoirs, Glenn Shoals and Lake Hillsboro and defines an achievable implementation strategy to address water quality concerns, specifically, sediment and nutrients. It provides a road map to achieve water quality targets, as well as City of Hillsboro, the MCSWCD and stakeholder goals for each reservoir. This plan is intended to be adapted and updated as implementation activities progress to achieve the highest load reductions and water quality improvement for the least possible investment. It will be used to secure future grants and assist Hillsboro in ensuring a reliable supply of water for residents and industry.

Both Lake Hillsboro and Glenn Shoals Lake have a history of water quality impairments. Sediment and nutrient reduction are critically important to the long-term resiliency of the reservoirs, as well as the recreational benefits they provide. Therefore, sediment, nitrogen, and phosphorus reduction are the primary drivers of this plan. Water quality targets of an 85% reduction in sediment, an 85% reduction in phosphorus and a 45% reduction in nitrogen are consistent with existing TMDL plans and the INLRS. The 85% sediment target is set to match the phosphorus TMDL and reflects Hillsboro's desire to achieve substantial reductions in it. If all recommended projects are implemented and constructed, sediment and nutrient reduction targets will be met or exceeded. This report includes the required WPB components and is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Watershed History
- Section 3 – Watershed Resource Inventory
- Section 4 – Pollutant Loading
- Section 5 – Sources of Watershed Impairments
- Section 6 – Nonpoint Source Management Measures & Load Reductions
- Section 7 – Cost Estimates
- Section 8 – Water Quality Targets
- Section 9 – Critical Areas
- Section 10 – Technical & Financial Assistance
- Section 11 – Implementation Milestones, Objectives & Schedule
- Section 12 – Information & Education
- Section 13 – Monitoring & Tracking Strategy

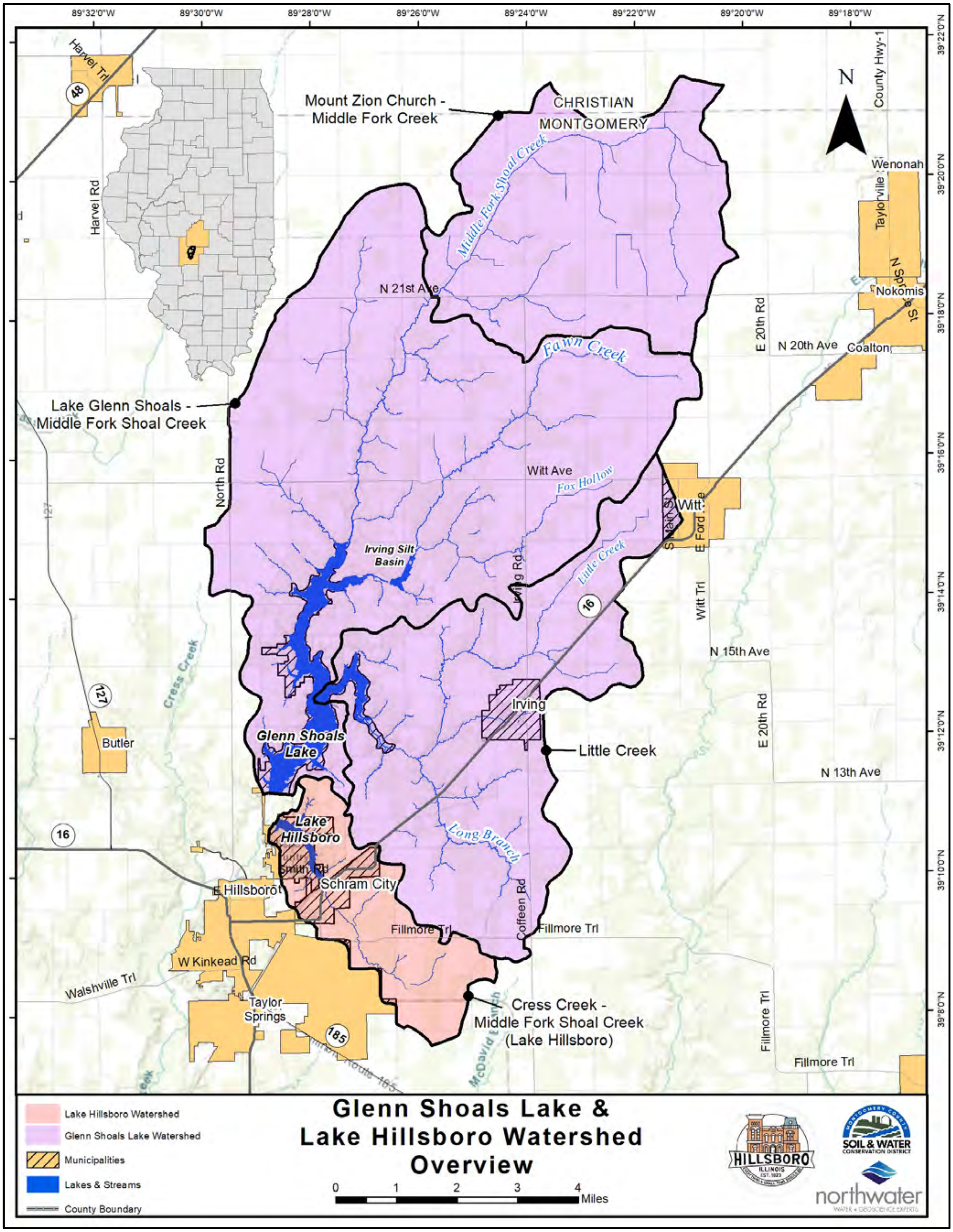


Figure 1 – Glenn Shoals Lake & Lake Hillsboro Watershed

2.0 Lake & Watershed History

Glenn Shoals Lake is owned by the City of Hillsboro and was completed in 1976 by impounding the Middle Fork of Shoal Creek. The smaller Lake Hillsboro, also owned by the city, was constructed in 1918 and serves as a supplemental water supply when needed. These reservoirs are a supply source for domestic, commercial, and industrial purposes in Hillsboro and surrounding communities. The lakes are a popular recreational resource for fishing, boating and other water-related activities. Small sections are surrounded by residential properties and other developed areas.

One water treatment plant and an industrial user withdraws an average of 3 to 4 Million Gallons per Day (MGD) from Glenn Shoals Lake. Drinking water is provided to approximately 4,402 people with 2,082 service connections. Water is also distributed to wholesale customers of Schram City, the Village of Taylor Springs, the City of Coffeen, Graham Correctional Center, and EJ Water – Montgomery County Rural Water, for a total of 9,400 people served.

2.1 Watershed Management

The City of Hillsboro and other key partners have been engaged in lake and watershed management dating back to 1990's when a planning and technical committee was formed to develop a resource plan for both lakes. This and subsequent reports focused on addressing concerns related to lake sedimentation and other contaminants.

Today, the city, in close partnership with the MCSWCD has taken the lead on lake and watershed improvements. The SWCD manages a state cost-share program, and together with the city conducts education and outreach and coordinates with numerous partners to leverage resources and technical assistance. The United States Department of Agriculture (USDA) NRCS Montgomery County office has also been active in the watersheds and county. More information on existing practices is provided in Section 3.12.

2.2 Concerns & Goals

Previous technical and stakeholder committees engaged the public to help identify concerns, develop reasonable solutions, and establish goals. Many of the same concerns are relevant today and include:

1. Sedimentation.
2. Capacity.
3. Education.
4. Contaminants and chemical/waste runoff.
5. Shoreline erosion.
6. Recreation.
7. Wildlife.
8. Property Developments.
9. Finances and cost of implementation.

Goals noted in the 2001 resource plan include:

1. Extend the life of the lakes.
2. Maintain or improve water quality.

Many, but not all, of these concerns persist today and align with the City of Hillsboro's strong focus on reducing sediment and nutrients. Furthermore, education, recreation, availability of financial resources, and the need to address runoff are still relevant, as are the 2001 goals. Based on current conditions, inventories and analysis completed to support this plan, the primary focus should address goals that achieve the greatest benefits versus costs or "most-bang-for-the-buck."

2.3 Relationship to Other Plans & Reports

The watershed and lakes have been the subject of research, planning, and implementation. This section summarizes those activities and reports to date and their relationship to the current plan. A concerted effort was made to secure all relevant documents/studies and recognize previous initiatives and projects that have helped to generate improvements to water quality and engaged stakeholders. Those relevant to and utilized by this plan are presented in Table 2.

Table 2 - Relevant Plans, Studies & Reports

Work Product	Year	Notes/Relevance
Lake Glenn Shoals and Lake Hillsboro Resource Plan	1994	Resource plan compiled to aid in improving water quality and quantity, specifically related to sedimentation. Included the formation of a planning committee, a watershed inventory and individual sediment surveys. Lake shoreline erosion and reservoir storage volume were assessed. The report indicated over 6,000 tons of sediment per year may be originating from shoreline erosion and approximately 40% of the Glenn Shoals water capacity had been lost. project alternatives such as upland treatments and in-lake basins were also presented.
Lake Hillsboro and Glenn Shoals Water Quality Protection Project Plan	1997	Proposal/report and scope of work to eliminate lake impairments (contaminated sediments). The report described sources of sediment, resource concerns from a 1994 planning committee, and potential solutions and costs. Projects included in-lake dams and shoreline stabilization.
Glenn Shoals Lake Resource Plan	2001	Resource plan compiled to aid in improving water quality and quantity, specifically related to sedimentation. Included the formation of a planning committee, identification of problems and opportunities, a watershed inventory and project alternatives such as upland treatments and in-lake basins.
Glenn Shoals Lake Phase 1 Diagnostic study	2001	The study included a detailed assessment of water quality and habitat, sources of pollutants, as well as potential solutions (projects), and cost estimates. Options for selective dredging and aeration were provided. Many of the same recommendations have been incorporated into this watershed plan with cost estimates adjusted for inflation. Loading estimates noted in the diagnostic study were also updated based on new data.
Glenn Shoals – Hillsboro Lake Watershed TMDL Report	2006	Phosphorus and manganese TMDL and implementation plan. See Section 3.2.3 for more information.

Work Product	Year	Notes/Relevance
A Raw Water Yield Analysis of Glenn Shoals Lake and Lake Hillsboro	2007	An analysis of available water supply conducted by HDR and Cochran & Wilken, Inc. The study indicated both reservoirs have an adequate supply.
Clean Lakes Study Review and Implementation Report for Lake Hillsboro	2007	A review of the 2001 diagnostic study by HDR and Cochran & Wilken, Inc. to provide recommendations on alternatives to extend the useful lifespan of the reservoir. Recommendations include shoreline stabilization, dredging, conservation in the watershed, education, aeration, and wetland detention.
Water Supply Yield Estimate for the City of Hillsboro	2016	An Illinois State Water Survey report on the safe yield of available water during critical drought periods. The yield estimates were based on a 2015 bathymetric survey. It was estimated that the lake storage capacity is reduced by 0.6% annually. Based on current demand, the water supply is believed to be adequate through 2050.
Dam Assessment Report Shoal Creek Watershed Structure No. 9 – Lake Glenn Shoals Dam	2024	Assessment report of the existing condition of Glenn Shoals Lake dam. The report was commissioned by the United States Department of Agriculture and provides many maintenance or rehabilitation recommendations including spillway modifications and reservoir dredging.

3.0 Watershed Resource Inventory

The resource inventory summarizes characteristics specific to Glenn Shoals Lake and Lake Hillsboro. It includes information on hydrology, land use, soils, habitat and water quality, demographics, and other relevant information.

3.1 Location & Watershed Boundaries

Figure 1 shows the location of Glenn Shoals Lake and Lake Hillsboro and their location in Illinois. The Middle Fork Shoal Creek is the primary tributary to Glenn Shoals Lake, which, downstream of the dam, eventually becomes Shoal Creek and then the Kaskaskia River. Lake Hillsboro drains to the Middle Fork immediately downstream of the Glenn Shoals Lake dam spillway. This plan encompasses the watershed area of the Middle Fork Shoal Creek from its headwaters along the Christian/Montgomery County line to just North and East of the City of Hillsboro, Illinois. The plan also includes all tributaries that drain to the lakes.

3.2 Water Impairments & Standards

This section provides an overview of applicable and relevant water quality standards, pollutants of concern and impairments for Glenn Shoals Lake, Lake Hillsboro and their watersheds. Water quality standards are laws or regulations established to enhance water quality and protect public health and welfare. Standards consist of criteria necessary to support and protect a specific "designated use" of a waterbody and an antidegradation policy. Examples of designated uses are primary contact, fish consumption, aesthetic quality, protection of aquatic life, and public and food processing water supply. Criteria are expressed numerically for standards with a numeric limit (e.g., 10% of samples over a period cannot exceed the standard expressed as a concentration), or as a narrative description for qualitative standards without a numeric limit (e.g., increased algae growth not meeting aesthetic standards). Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected. Waterbodies are considered impaired when they exceed these standards, meeting the criteria to be defined as impaired. Section 303(d) of the 1972 Clean Water Act requires the States to define impaired waters and identify them on the 303(d) list. When no regulatory standards are relevant for a parameter, water quality guidelines are often applied to assess the condition of a waterbody.

3.2.1 Water Quality Impairments

The watershed has three current 2024 303(d) impaired waterbodies. Glenn Shoals Lake is impaired for mercury, total suspended solids, and total phosphorus and Lake Hillsboro for total phosphorus and total suspended solids (TSS). Lake Glenn Shoals has been impaired for mercury since at least 2010 and Lake Hillsboro was also impaired for atrazine in 2014. The Middle Fork Shoal Creek has had various impairments since at least 2010. Current and historic impairments are shown in Table 3 and Table 4, respectively.

Table 3 – 2024 303(d) Impaired Waterbodies

Assessment ID	Waterbody	Size (ac or mi)	Designated Use	Cause
ROL	Lake Glenn Shoals	1,350 ac	Aesthetic Quality, Fish Consumption	Phosphorus (Total), Total Suspended Solids (TSS) Mercury
ROT	Lake Hillsboro	109 ac	Aesthetic Quality	Phosphorus (Total), Total Suspended Solids (TSS)
OIL-HB-C1	Middle Fork Shoal Creek	2.32 mi	Aquatic Life	Manganese, Dissolved Oxygen, Phosphorus (Total)

Table 4 – Historical 303(d) Impaired Waterbodies

Assessment ID	Waterbody	Designated Use	Cause
		2010	
ROL	Lake Glenn Shoals	Fish Consumption, Public Water Supplies	Mercury
OIL-HB-C1	Middle Fork Shoal Creek	Aquatic Life	Manganese, Phosphorus (Total)
		2012	
ROL	Lake Glenn Shoals	Fish Consumption, Public and Food Processing Water Supplies	Mercury
OIL-HB-C1	Middle Fork Shoal Creek	Aquatic Life	Manganese, Dissolved Oxygen, Phosphorus (Total)
		2014	
ROL	Lake Glenn Shoals	Fish Consumption, Public Water Supplies	Mercury
ROT	Lake Hillsboro	Public Water Supplies	Atrazine
OIL-HB-C1	Middle Fork Shoal Creek	Aquatic Life	Dissolved Oxygen, Manganese, Phosphorus (Total)
		2016	
ROL	Lake Glenn Shoals	Fish Consumption	Mercury

Assessment ID	Waterbody	Designated Use	Cause
OIL-HB-C1	Middle Fork Shoal Creek	Aquatic Life	Manganese, Dissolved Oxygen, Phosphorus (Total)
2018			
ROL	Lake Glenn Shoals	Fish Consumption	Mercury
OIL-HB-C1	Middle Fork Shoal Creek	Aquatic Life	Manganese, Dissolved Oxygen, Phosphorus (Total)
2022			
ROL	Lake Glenn Shoals	1,350 ac	Fish Consumption
ROT	Lake Hillsboro	109 ac	Aesthetic Quality
OIL-HB-C1	Middle Fork Shoal Creek	2.32 mi	Aquatic Life

3.2.2 Standards & Guidelines

Although there is little relevant water quality data available, the standards and guidelines for nitrogen, phosphorous and sediment are relevant. Enhanced data collection and monitoring of the lakes and tributaries as well as lake bathymetry would support an improved understanding of the sources of sediment and nutrient inputs and would allow for targeting of management practices to the areas that would have most impact.

Nitrogen: Nitrate-Nitrogen (NO_3-N) is the inorganic form of nitrogen and, when in high concentrations, can be toxic to humans, wildlife and aquatic ecosystems. Excess nitrogen in surface waters also aid algal growth and blooms.

- The public and food processing water supply standard, also known as the drinking water standard of 10 mg/L is applicable to Glenn Shoals Lake and Lake Hillsboro.

Nitrogen: Total Nitrogen (TN) includes the sum of nitrate, nitrite, and Total Kjeldahl Nitrogen (organic nitrogen and ammonia). Nitrate + Nitrite is another common measure that refers to the inorganic component of nitrogen.

- There are no TN standards for lakes or rivers/streams in Illinois, however, the Illinois Nutrient Science Advisory Committee (INSAC) recommends 3.8 mg/L as a guideline for wadable streams in the northern ecoregion (INSAC, 2018). It should be noted that the INSAC recommended standards have not been finalized.

Nitrogen: Ammonia-Nitrogen (NH_3-N) is a nitrogen compound that can cause direct toxic effects on aquatic life. When ammonia is present at high levels, aquatic organisms may not be able to sufficiently excrete ammonia, leading to hazardous levels. Sources include decomposition of organic matter, gas exchange from the atmosphere and nitrogenous animal wastes. Ammonia and its ionic form, ammonium can be taken up by plants and algae. This nutrient is typically quickly converted to nitrate by microbial organisms, and is thus usually present in small concentrations. It can also be a direct contributor to algal blooms and eutrophication. Ammonia-N can be released from sediments in anoxic water, providing an important "internal load" of nutrients to the lake environment.

- The Illinois Total Ammonia Nitrogen Water Quality standard is based on complex calculations incorporating temperature and pH, and the standard varies geographically, though in no case can it exceed 15 mg/L.

Total Phosphorus (TP) includes dissolved and particulate fractions and is often stored in aquatic biota such as algae. Dissolved fractions are more readily available and can stimulate processes that are harmful to water quality and aquatic life. Phosphorus sources include soil erosion, fertilizers and, to a lesser extent, human and animal waste. Phosphorus can also be released from sediments in anoxic water, known as "internal loading" or legacy phosphorus release.

- There is no phosphorus standard for rivers and streams in Illinois, however, the standard for lakes states that TP shall not exceed 0.05 mg/L in any stream at the point where it enters any reservoir or lake with a surface area greater than 20 acres. Further, the INSAC recommends a guideline of 0.113 mg/L for rivers in the northern ecoregion (INSAC 2018). It should be noted that the INSAC recommended standards have not been finalized.

Dissolved Oxygen (DO) measurements determine the amount of oxygen in the water available for fish and other aquatic life. Warm water fish typically require at least 5 mg/L to survive. Dissolved oxygen in waterbodies is affected by temperature, and various physical, chemical and biological processes. Seasonal stratification often results in a well-defined boundary between the upper layer of water that is well oxygenated called the epilimnion, and a bottom layer of poorly oxygenated water called the hypolimnion. This boundary is called the thermocline. There are several parts to the DO standard, including numeric criteria. The most relevant parts are summarized below.

- March – July: DO must not be below 5 mg/L at any time, or 6 mg/L daily mean averaged over 7 days in streams and in water above the thermocline of stratified lakes.
- August – February: DO must not be below 3.5 mg/L at any time, 4 mg/L daily minimum averaged over 7 days, or 5.5 mg/L daily mean averaged over 30 days in streams and in water above the thermocline of stratified lakes.
- The DO standard also states that waters below the thermocline in lakes must maintain sufficient concentration to support natural ecological functions and resident aquatic communities.

Total Suspended Solids (TSS) the fraction of total solids suspended in water as retained by a 1.5 µm filter. Concentrations vary temporally in rivers and lakes, typically increasing from erosion during runoff events, lake turnover, biological processes, and human disturbances. Total suspended solids can be differentiated between volatile suspended solids (VSS) and nonvolatile suspended solids (NVSS). Organic materials, such as algae, and decomposing organic matter make up VSS, and NVSS is made of non-organic "mineral" substances (Illinois EPA, 1998).

- There are no regulatory TSS standards for rivers and streams in Illinois, however, the Illinois EPA has a TSS statistical guideline of 116 mg/L for streams which is an indicator of conditions to support aquatic life.

3.2.3 TMDL

One TMDL has been completed relevant to the lakes and watershed (the 2006 Glenn Shoals – Hillsboro Watershed TMDL) which analyzed both lakes and addressed phosphorus and manganese impairments, primarily from internal lake release for manganese and from runoff and internal release for phosphorus. Most relevant to this plan are the impairments and needed reductions. It recommended the following phosphorus reductions to address impairments and meet water quality standards:

- Lake Hillsboro, Illinois EPA assessment unit ID IL_ROT – TP: 83% reduction.
    - The manganese reduction will be achieved if the phosphorus reduction is met.
- Glenn Shoals Lake, assessment unit ID IL_ROL – TP: 85% reduction.

The TMDLs did not directly address sediment which is linked to the loss of lake storage capacity and aquatic habitat impacts which are of concern to the City Hillsboro and stakeholders. State-wide, the INLRS has set a 15% reduction goal for nitrogen, and nationally, the Gulf Hypoxia Action Plan (2008) calls for a 45% reduction to address and reduce the hypoxic zone.

3.3 Water Quality Data – Lakes

There is limited water quality data available within both lakes, collected intermittently since 2000, the first year of data examined. The Illinois EPA has three monitoring stations in each lake as part of the Ambient Lakes Monitoring Program (Table 5 and Figure 2). In addition to Illinois EPA, the City of Hillsboro began collecting data in 2024, including DO depth profiles. There is historic Secchi depth data collected by participants in the Illinois EPA Volunteer Lake Monitoring Program (VLMP), though this program was discontinued, and the last data was collected in 2007 for Lake Hillsboro and in 2008 for Glenn Shoals. Phosphorus, nitrogen, and TSS are the focal parameters for this watershed plan, and lake DO data is also presented as it is an important factor for understanding internal loading of nutrients.

In summary, lake monitoring shows elevated levels of nitrogen, phosphorus and suspended sediment. Nutrients and sediment are transported from tributaries, which immediately impact water quality, and “legacy nutrients” that were deposited over many years can be released from anoxic (oxygen depleted) bottom sediments. This is known as internal loading and is an important contributor to overall water quality.

Table 5 - Lake Water Quality Monitoring Stations

Waterbody	Station Code	Latitude (dd)	Longitude (dd)	Period of Data	Notes	Relevant Parameters
Glenn Shoals Lake	ROL-1	39.18751	-89.47807	2001-2003, 2011-2012, 2022-2024	Near dam	Nitrogen, Phosphorus, TSS
Glenn Shoals Lake	ROL-2	39.210004	-89.464726	2001-2012, 2022-2024	Mid-lake	Nitrogen, Phosphorus, TSS
Glenn Shoals Lake	ROL-3	39.235282	-89.465838	2001-2012, 2022-2024	Upper lake	Nitrogen, Phosphorus, TSS
Lake Hillsboro	ROT-1	39.17917	-89.477782	2001-2012, 2023-2024	Near dam	Nitrogen, Phosphorus, TSS

Waterbody	Station Code	Latitude (dd)	Longitude (dd)	Period of Data	Notes	Relevant Parameters
Lake Hillsboro	ROT-2	39.175559	-89.466115	2001-2012, 2023-2024	Mid-lake	Nitrogen, Phosphorus, TSS
Lake Hillsboro	ROT-3	39.16697	-89.465945	2001-2002	Upper lake	Nitrogen, Phosphorus, TSS

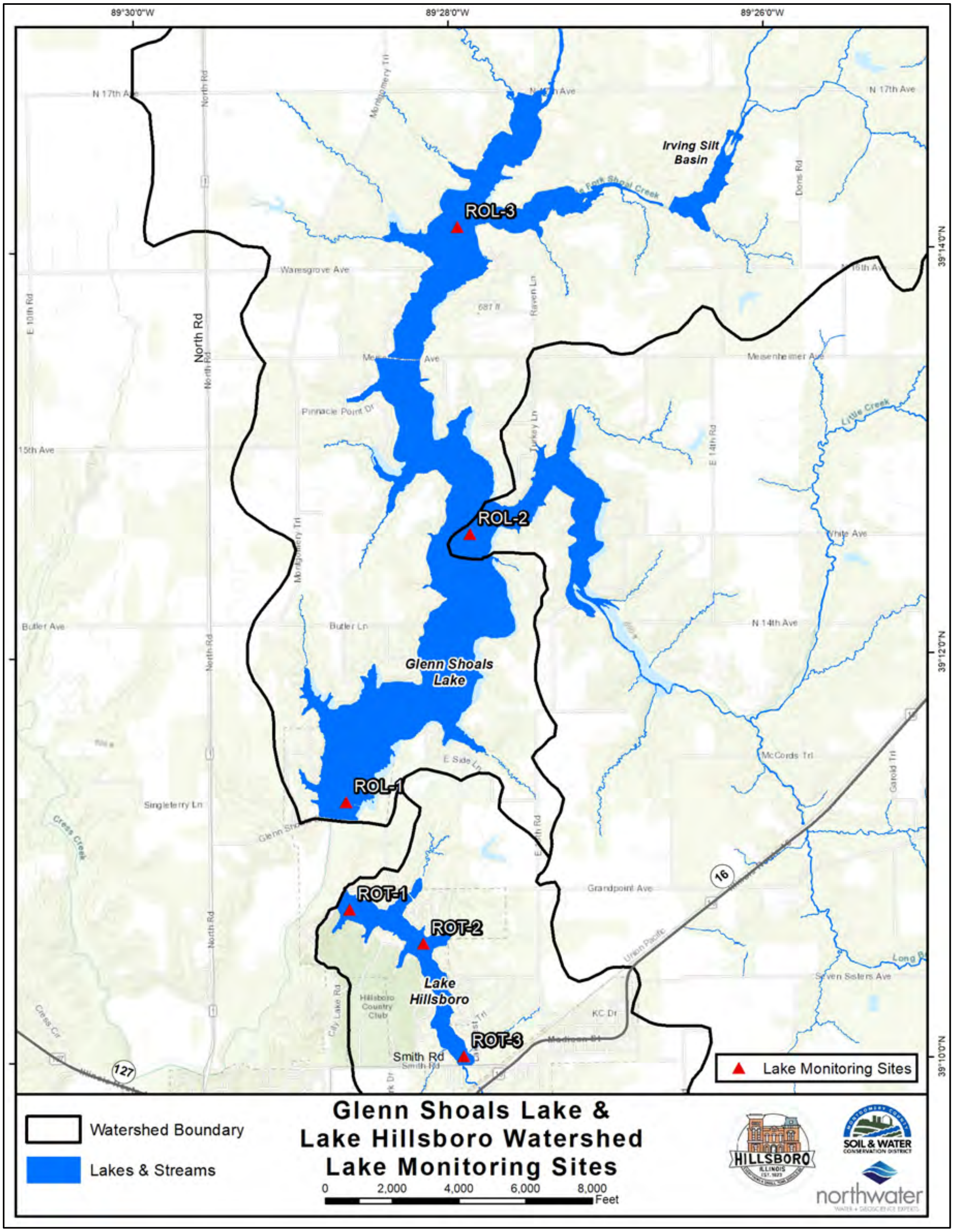


Figure 2 – Lake Monitoring Locations

3.3.1 Lake DO Characteristics

Both Lake Hillsboro and Glenn Shoals Lake seasonally stratify, which is a natural occurrence in deep reservoirs. In summer, cool water sinks to the bottom, called the hypolimnion while warmer water, called the epilimnion, stays above. A well-defined boundary called the thermocline separates the two layers, at approximately 11-13 ft of depth and prevents vertical mixing. Typically, the warmer epilimnion is oxygenated, while the hypolimnion becomes deoxygenated. This deoxygenated water creates conditions under which nutrients like phosphorus and nitrogen are released from sediments into the water column. This is known as internal loading and can be an important source of nutrients that promote water quality issues.

Lake Hillsboro strongly stratifies each summer with a thermocline at about 10 ft, typically from around May through September. Glenn Shoals also stratifies with a thermocline usually near 13-15 ft deep, though sometimes stratification appears to be weak or transient. This lasts from approximately June through September on Glenn Shoals and May through September on Lake Hillsboro. Example DO profiles typical for each lake during seasonal stratification are presented in Figure 3. The historic monitoring sites on Glenn Shoals are not well positioned to fully capture the duration and depth of seasonal stratification, so a precise timeframe and extent is unknown.

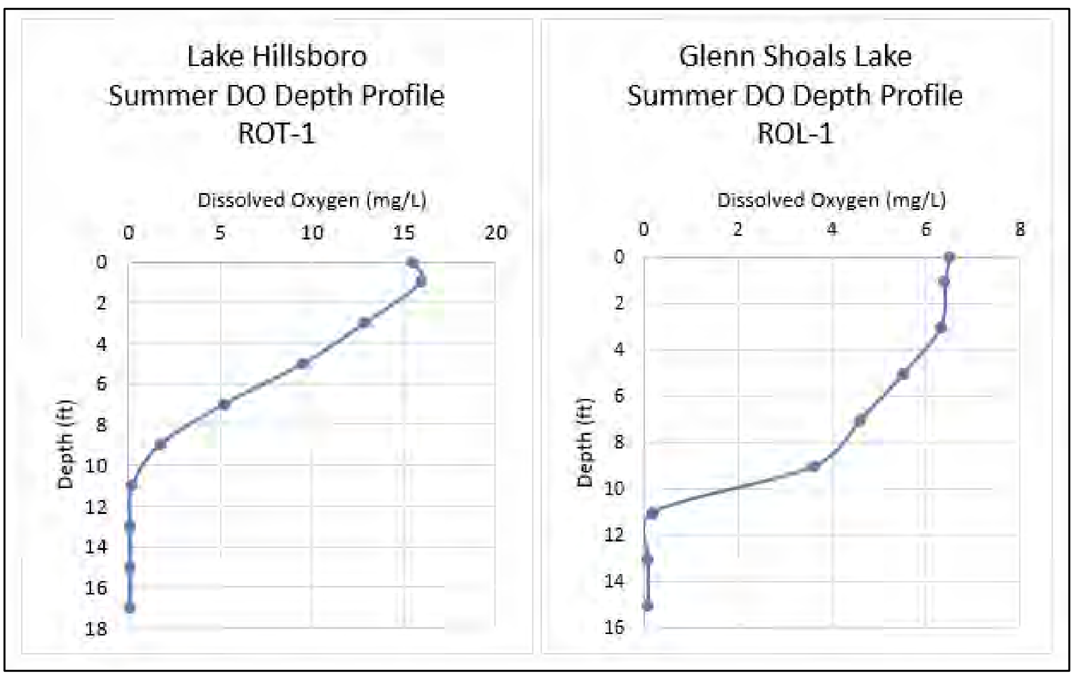


Figure 3 - Example Summer DO Depth Profiles

3.3.2 Lake Phosphorus

Total phosphorus for Glenn Shoals Lake is plotted in Figure 4. Nearly all samples were above the 0.05 mg/L water quality standard for lakes with an average of all shallow TP samples of 0.2 mg/L. There were few samples collected from the hypolimnion during stratified conditions, and the highest concentration in the record for Glenn Shoals Lake is a 2011 deep sample of 1.07 mg/L at ROL-1. This indicates that internal loading is an important factor in lake phosphorus chemistry though it is not well represented in the dataset.

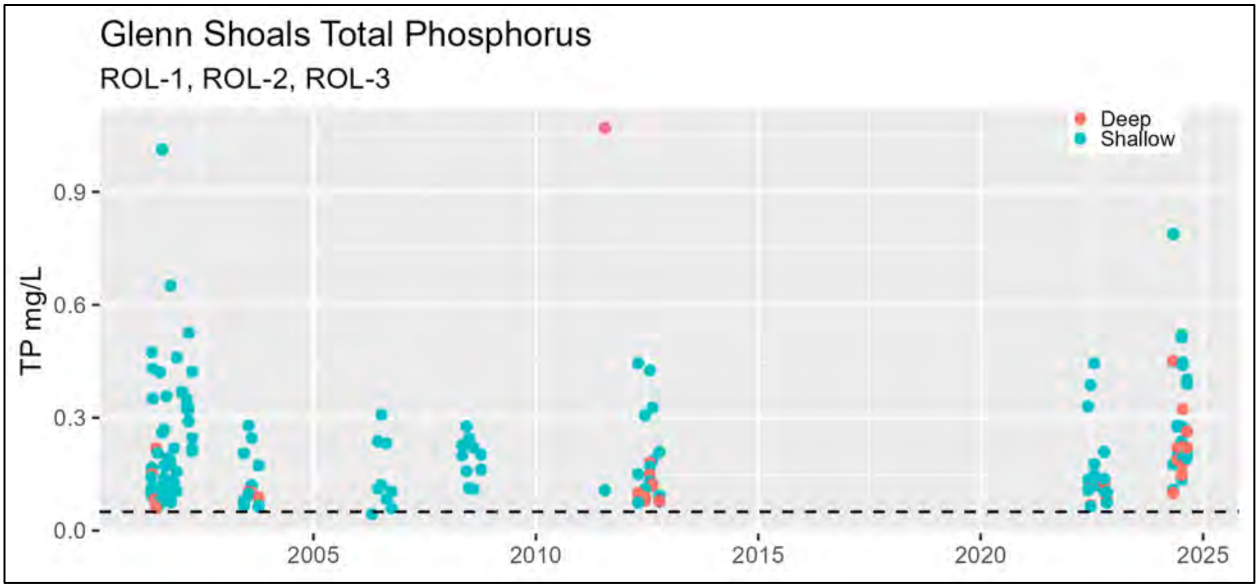


Figure 4 - Glenn Shoals Lake TP

Total phosphorus for Lake Hillsboro is plotted in Figure 5. All samples collected since 2000 were above the 0.05 mg/L water quality standard for lakes. Samples taken from the hypolimnion during stratification are elevated, with a maximum of 3.99 mg/L at ROT-1 in 2001.

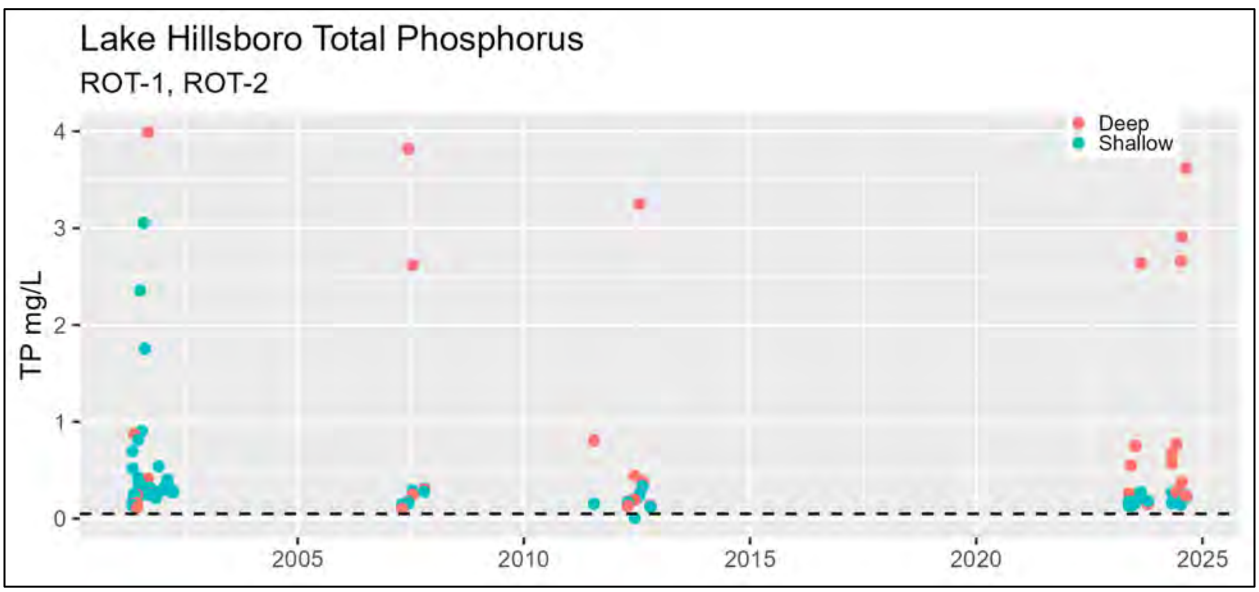


Figure 5 - Lake Hillsboro TP

3.3.3 Lake Nitrogen

Nitrogen sampling is uneven across the monitoring record for both lakes. Nitrate + nitrite, ammonia and TN all have been sampled. In the typical lake environment nitrogen is plentiful and is not viewed to be a major factor in eutrophication. However, in Glenn Shoals and Lake Hillsboro, it appears based on the number of non-detections and very low concentrations, that nitrogen can be limiting or also responsible for algal growth (95 of 155 measurements were non-detects or under 0.5 mg/L on Glenn Shoals, and 92 of 117 on Lake Hillsboro). The highest nitrate concentration observed was 8 mg/L in 2001 at Glenn Shoals Lake site ROL-2 and 2.4 mg/L in 2002 at Lake Hillsboro site ROT-3 (Figure 6 and Figure 7).

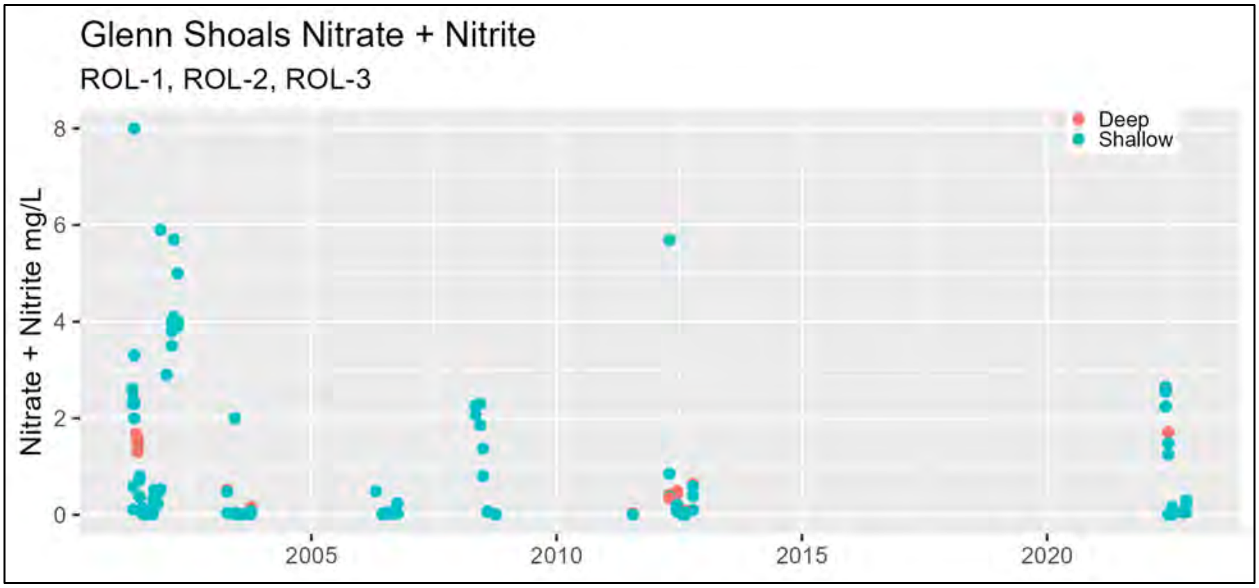


Figure 6 - Glenn Shoals Lake Nitrate + Nitrite

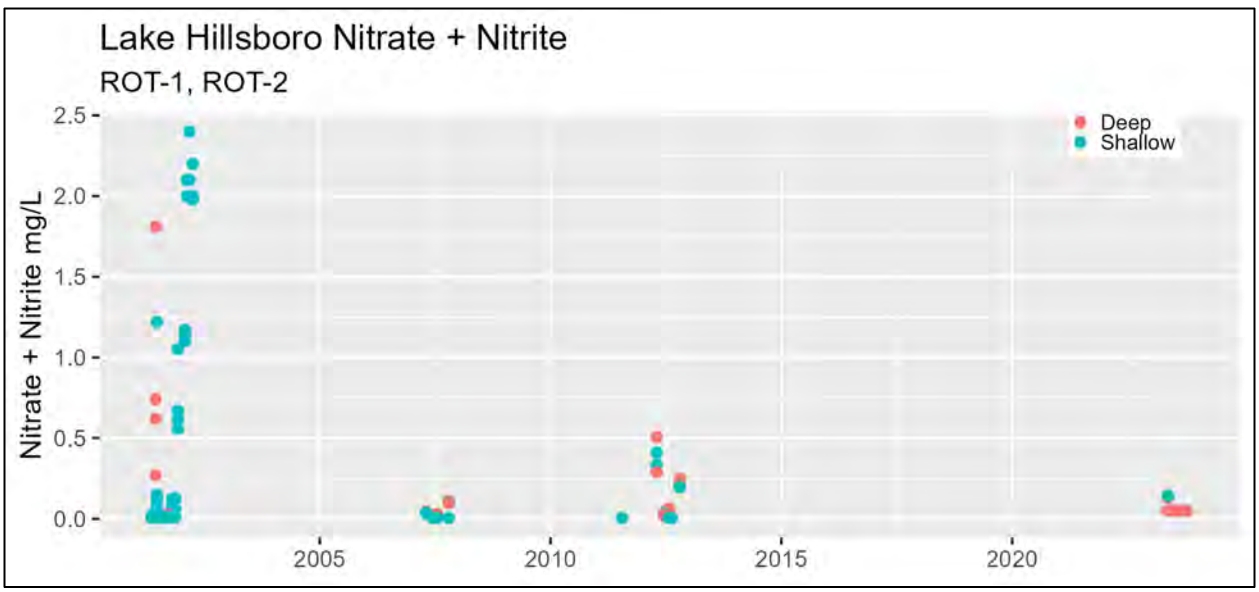


Figure 7 - Lake Hillsboro Nitrate + Nitrite

Ammonia is typically present in low levels in the lakes, with an average concentration in shallow samples of 0.16 mg/L in Glenn Shoals and 0.47 mg/L in Lake Hillsboro (Figure 8 and Figure 9). In samples taken in the hypolimnion during seasonal stratification, ammonia can be significantly elevated in Lake Hillsboro, including a maximum concentration of 14 mg/L observed in 2001 in a deep sample at ROT-1. Release of ammonia from lake sediments is an important source of nitrogen during seasonal stratification.

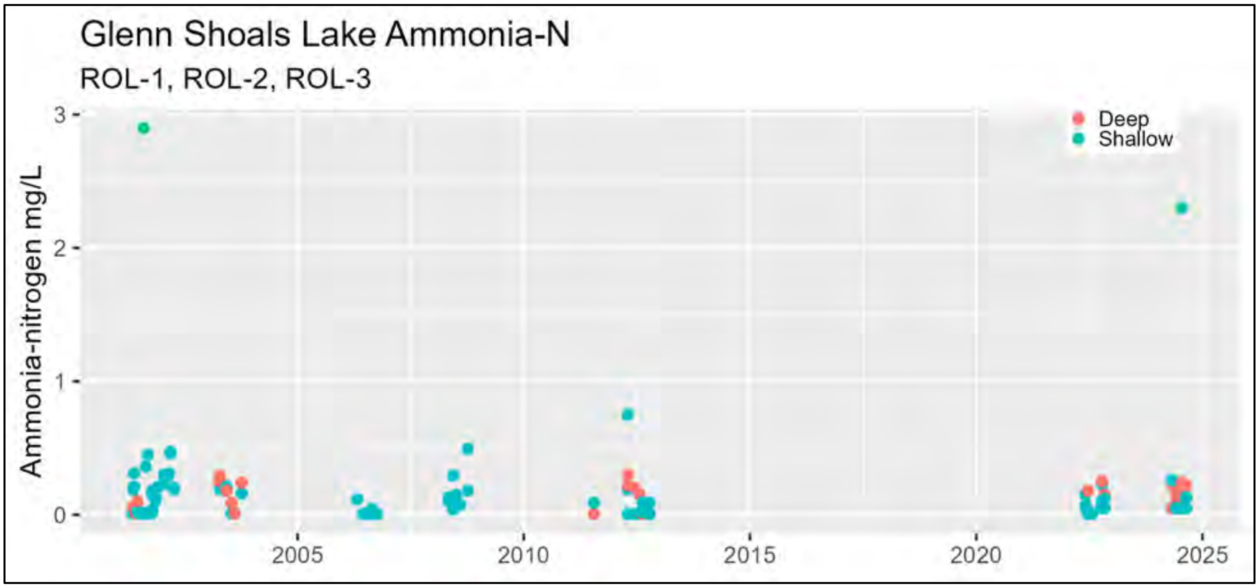


Figure 8 - Glenn Shoals Lake Ammonia-N

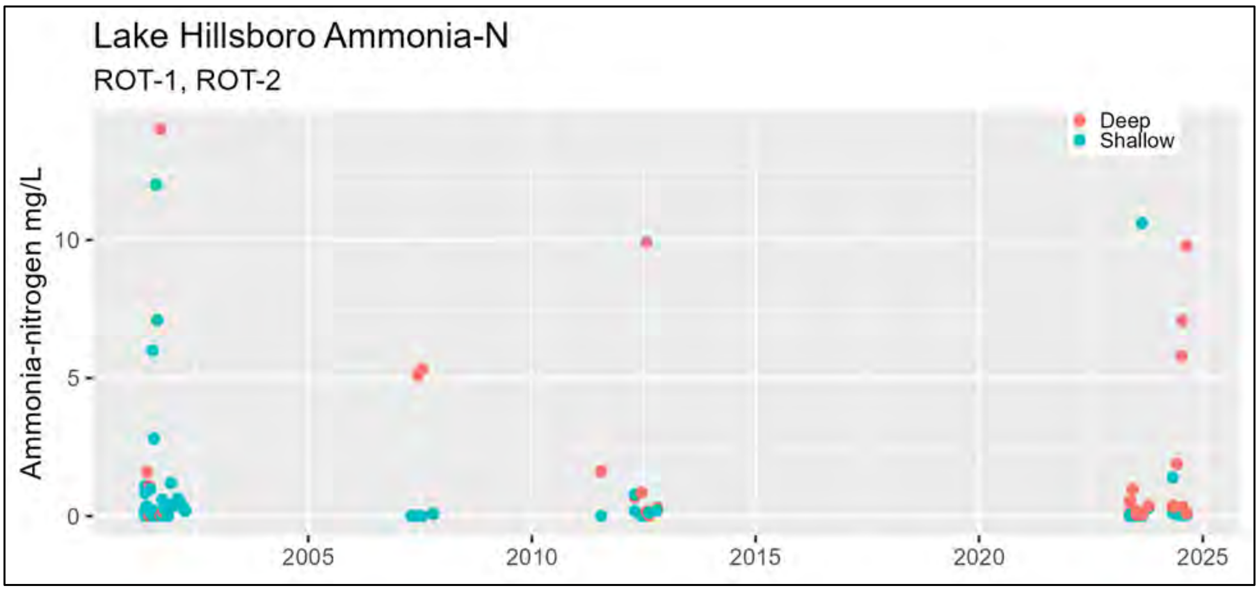


Figure 9 - Lake Hillsboro Ammonia-N

3.3.4 Lake Sediment

Total suspended solids concentrations for the lakes are plotted in Figure 10 and Figure 11. In Glenn Shoals, concentrations ranged from non-detection to 258 mg/L at ROL-1 in 2001 (Figure 10). In Lake Hillsboro concentrations ranged from non-detection to 183 mg/L, measured in a deep sample at ROT-1 in 2024 (Figure 11). Concentrations typically are higher near where tributaries enter and lowest near the dam. In recent Illinois EPA samples, VSS were differentiated and usually make up half or more of TSS, indicating high concentrations of algae and organic matter.

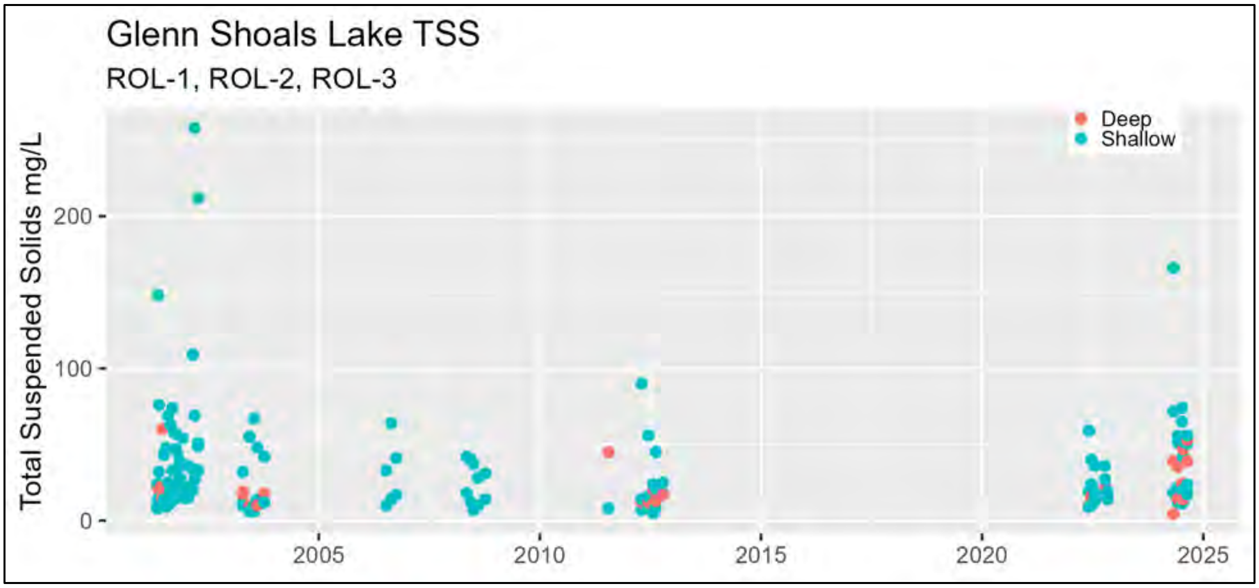


Figure 10 - Glenn Shoals Lake TSS

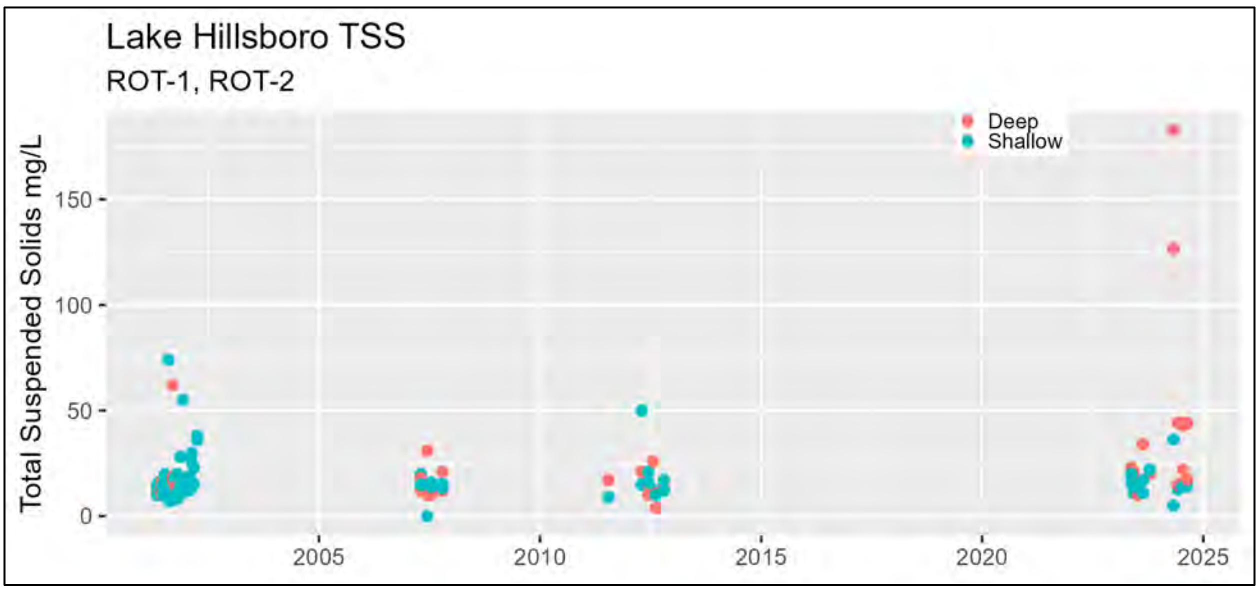


Figure 11 - Lake Hillsboro TSS

3.4 Water Quality Data – Tributaries

There are five monitoring stations on tributaries to Glenn Shoals Lake and one to Lake Hillsboro (Table 6 and Figure 12). In addition, there is a historic site at each lake's spillway, though the data is limited in scope and is thus excluded from the summaries below. The period of record and frequency of data collection varies. In addition to Illinois EPA, the City of Hillsboro collected data in 2023 and 2024 with an emphasis on capturing storm events, when most of the sediment and nutrient load is expected to be delivered to the lakes. There is no active flow monitoring station in the watershed, with the nearest United States Geological Survey (USGS) stream gage located on the East Fork of Shoal Creek. The lack of historic tributary flow data and the small amount of water quality data does not support reliable direct estimates of sediment and nutrient loading currently.

In summary, tributary phosphorus and sediment are above target levels, especially during storm runoff events when concentrations can be extremely high. Most of the nutrient and sediment load is delivered during these conditions. Nitrate data is limited to 2001 and 2002, but tributary concentrations are relatively low during that time (1.9 mg/L in Glenn Shoals tributaries, and 1.5 mg/L in the Lake Hillsboro tributary). The City of Hillsboro began collecting total nitrogen data in 2024, of which nitrate + nitrite makes up most of the total. The average TN concentration was 4.8 mg/L in Glenn Shoals tributaries and 2.1 mg/L in the Lake Hillsboro tributary, though these averages are likely skewed high due to the sampling program's emphasis on capturing storm samples, when concentrations are expected to be above baseline levels.

Table 6 – Tributary & Spillway Water Quality Monitoring Stations

Waterbody	Lake	Station Code	Latitude (dd)	Longitude (dd)	Period of Data	Notes	Relevant Parameters	Drainage Area (mi^2)
Below Spillway, Middle Fork Shoal Creek	Glenn Shoals	ROL-T1	39.1864	-89.4798	2001-2002	Lake Spillway	Nitrate, Phosphorus, TSS	76.2
Middle Fork Shoal Creek	Glenn Shoals	ROL-T2	39.2615	-89.4534	2001-2002	North arm	Nitrate, Phosphorus, TSS	21.5
Unnamed Tributary to Middle Fork Shoal Creek	Glenn Shoals	ROL-T2A	39.27576	-89.45310	2024	New site 2024, North arm	Nitrate, Phosphorus, TSS	6
Fawn Creek Sediment Trap	Glenn Shoals	ROL-T3	39.2369	-89.4442	2001-2002, 2024	Located at spillway of sediment trap that drains to lake, Northeast	Nitrate, Phosphorus, TSS	13
Little Creek	Glenn Shoals	ROL-T4	39.2027	-89.4283	2001-2002, 2024	East Arm	Nitrate, Phosphorus, TSS	8
Long Branch	Glenn Shoals	ROL-T5	39.1917	-89.4347	2001-2002, 2024	East Arm	Nitrate, Phosphorus, TSS	7.9
Below Spillway, Unnamed Tributary to Middle Fork Shoal Creek	Lake Hillsboro	ROT-T1	39.1809	-89.4784	2001-2002	Lake Spillway	Nitrate, Phosphorus, TSS	7.3
Unnamed Tributary to Middle Fork Shoal Creek	Lake Hillsboro	ROT-T2	39.1643	-89.4641	2001-2002, 2024	Tributary to Lake Hillsboro	Nitrate, Phosphorus, TSS	5.2

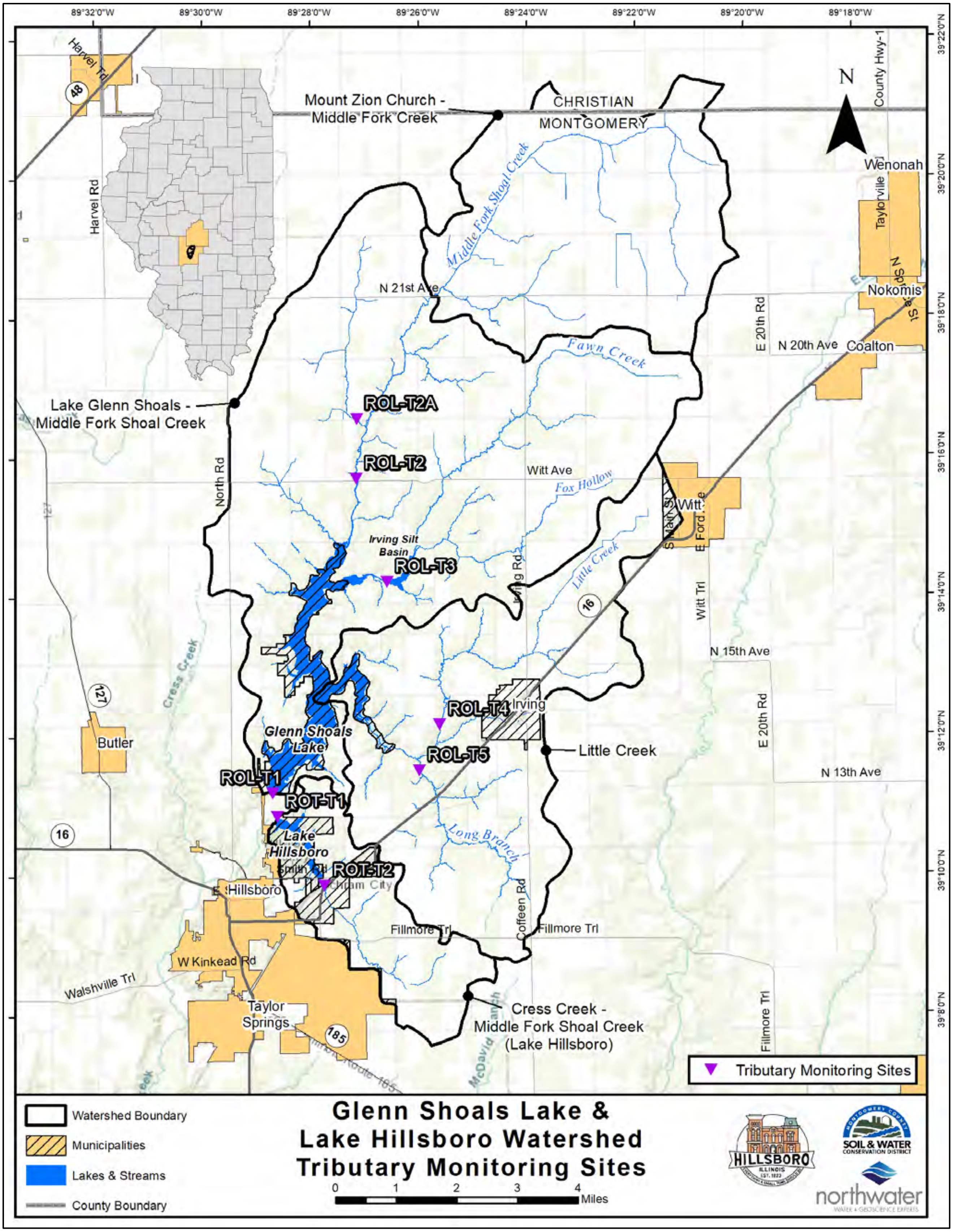


Figure 12 – Tributary Monitoring Locations

3.4.1 Tributary Phosphorus

Phosphorus samples are limited to 2001-2002 and 2024 in the tributaries, with an average concentration of 0.6 mg/L in Glenn Shoals tributaries (Figure 13), and 0.44 mg/L in Lake Hillsboro (Figure 14). While there is no water quality standard for TP in streams, the average is well above the INSAC recommendation of 0.110 mg/L for streams in the northern ecoregion of Illinois, and the 0.05 mg/L standard for lakes and streams at the point they enter a lake. No long-term trends are apparent from the limited data, and no patterns in concentration differences among sites are discernable.

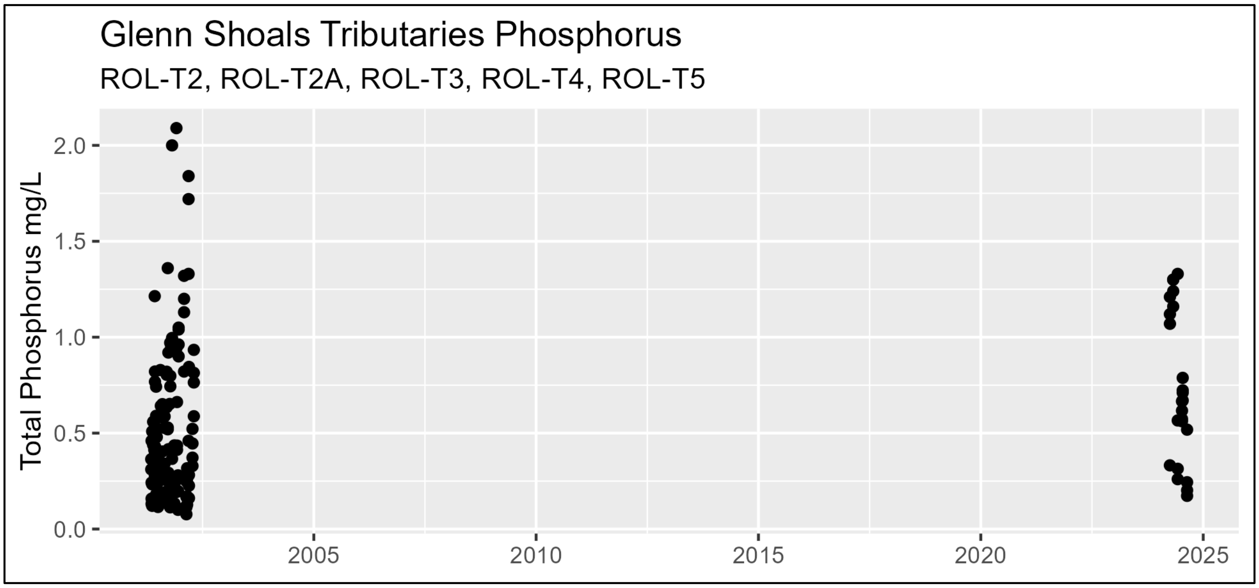


Figure 13 - Glenn Shoals Lake Tributary Phosphorus

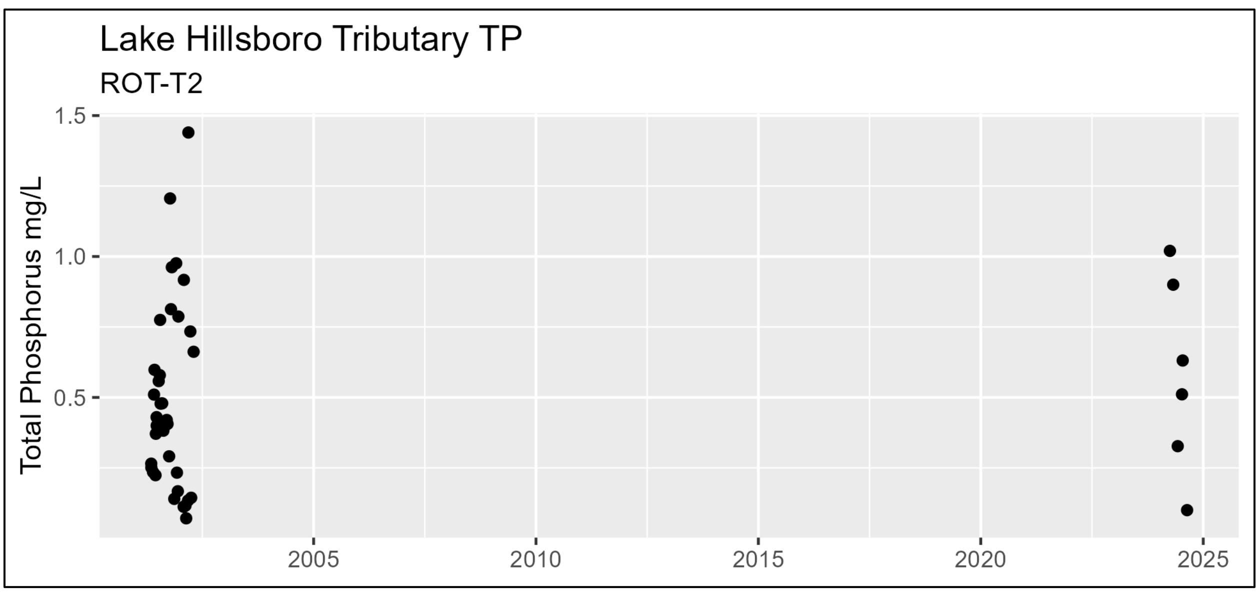


Figure 14 - Lake Hillsboro Tributary Phosphorus

3.4.2 Tributary Nitrogen

Historic nitrate data is limited to 2001 and 2002, but tributary concentrations follow a pattern typical of streams in an agricultural setting, with elevated concentrations in the spring, fall and winter, and relatively low concentrations during the growing season. Average concentrations are 1.8 mg/L in Glenn Shoals tributaries, and 1.3 mg/L in Lake Hillsboro (Figure 15, Figure 16). The City of Hillsboro began collecting TN data in 2024, with an average concentration of 4.8 mg/L in Glenn Shoals and 2.1 mg/L in Lake Hillsboro tributaries. These averages are likely skewed high due to the sampling program's emphasis on capturing storm events when concentrations are expected to be higher than baseline and the limited number of samples collected at the time of this report. Total nitrogen is above the INSAC guideline of 0.901 mg/L for the northern ecoregion of Illinois. It has not been above the 10 mg/L nitrate-nitrogen drinking water standard.

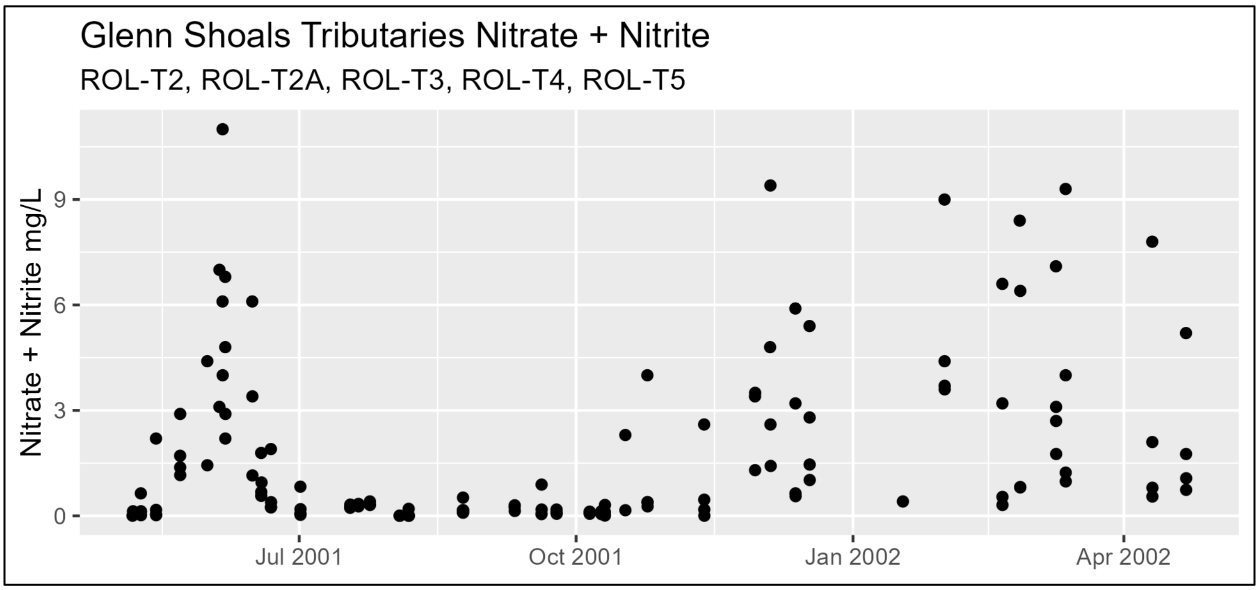


Figure 15 - Glenn Shoals Tributary Nitrate + Nitrite

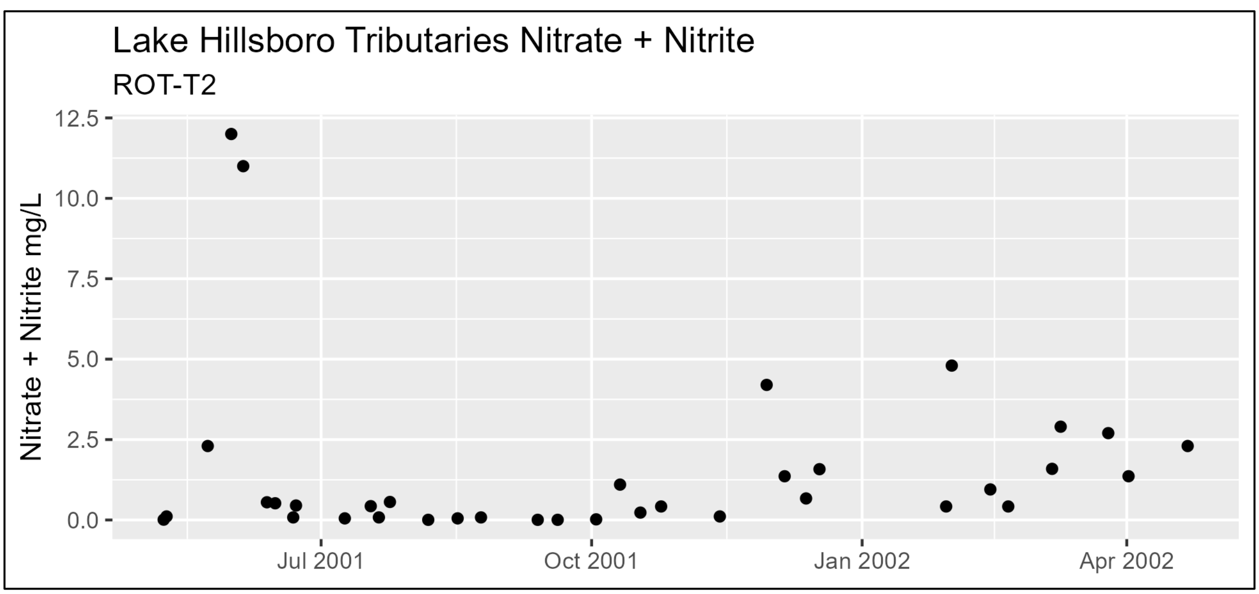


Figure 16 - Lake Hillsboro Tributary Nitrate + Nitrite

3.4.3 Tributary Sediment

Total suspended solids data for the tributary monitoring sites are also limited to data collected in 2001 and 2002 by Illinois EPA and in 2024 by Hillsboro. As the recent monitoring emphasizes storm sampling, average TSS concentrations are likely skewed higher than historic monitoring. With limited data collected thus far, no patterns or obvious differences among sites are yet apparent. In the Glenn Shoals tributary sites, the maximum TSS concentration from the historic data was 3,130 mg/L in 2002 at site ROL-T2 (Figure 17). In 2024, the maximum was 1,313 mg/L at ROL-T2A. At the only Lake Hillsboro Tributary site, the maximum was 1,595 mg/L in 2002 and was 402 mg/L in 2024 (Figure 18).

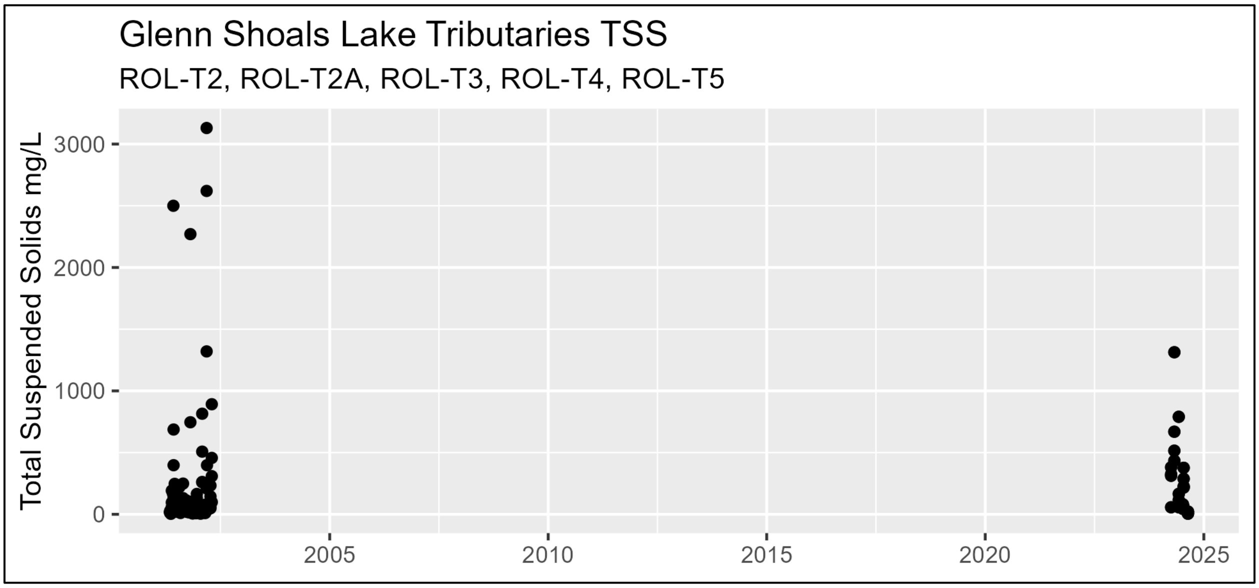


Figure 17 - Glenn Shoals TSS data

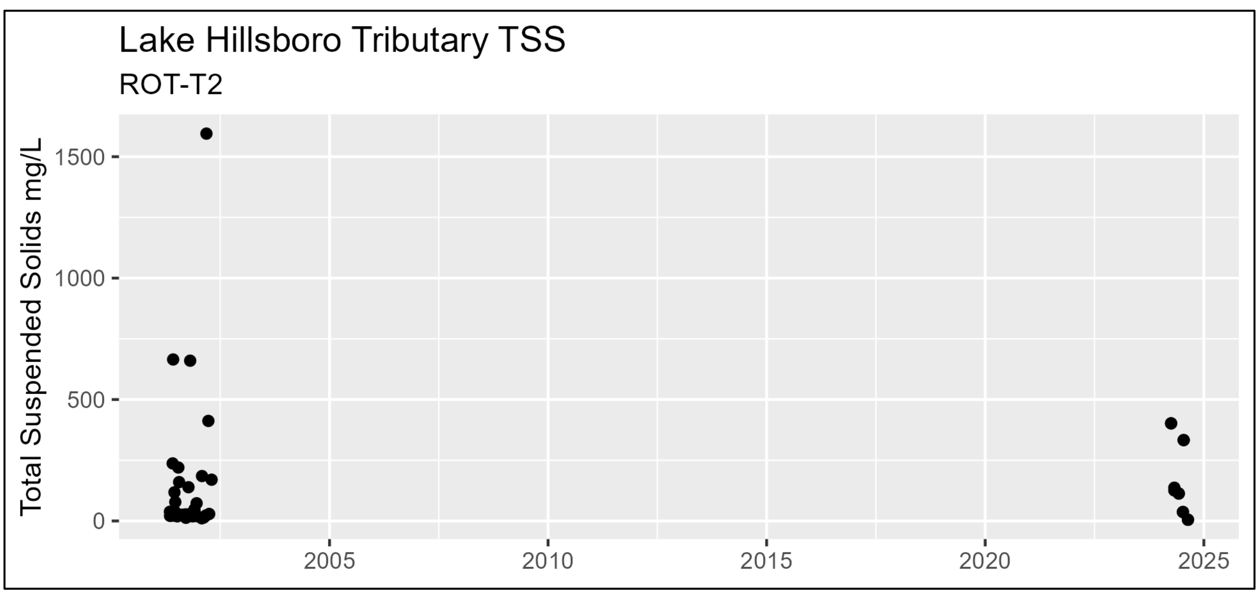


Figure 18 - Lake Hillsboro TSS data

3.5 Water Quality History and Trends

While water quality data on Glenn Shoals and Lake Hillsboro dates back to at least the early 2000s, it is insufficient to make reliable estimates of changes over time. Sampling is intermittent and infrequent. For example, tributary sampling occurred in 2001 and 2002, and not again until the city began sampling in early 2024. In addition, at the tributary sites, without streamflow it is impossible to know if data was influenced by high or low flow conditions, thus making comparisons between historic and recent data difficult. A brief review of available data showed generally similar nutrient and suspended sediment concentrations across time at each of the sites. Several historic reports such the 1990 Illinois State Water Survey (ISWS) report on reservoir characteristics, the 2006 TMDL, and a 2007 Clean Lakes program report were reviewed, and no trend conclusions were apparent. The INLRS 2023 Biennial Report indicated that the larger Kaskaskia watershed, of which Glenn Shoals and Lake Hillsboro are within, has experienced generally unchanged to slightly decreased nitrogen loads since the 1980-1996 baseline period. Total phosphorus has increased significantly, more than 100%, over the same time. While the load estimates cover a much larger watershed, they are illustrative of large-scale trends that may be impacting the lakes. Additional monitoring, as described in Section 13, will help to track long-term trends.

3.6 Watershed Jurisdictions, Demographics & Natural Areas

The Glenn Shoals and Lake Hillsboro watershed lies predominantly within Montgomery County – over 99% or 53,156 acres. Less than 1% or 386 acres is within Christian County (Figure 19). There are four municipalities and one Census Designated Place (CDP) that cover less than 8% of the watershed: Irving, Schram City, Wilt, and Hillsboro. Irving and Schram City are contained entirely within the watershed. Hillsboro has 2,819 of its 6,530 acres contained within, primarily adjacent to each lake. Witt has only 140 of its 791 total acres within the Little Creek subwatershed that drains to Glenn Shoals Lake (Table 7).

3.6.1 Watershed Jurisdictions & Jurisdictional Responsibilities

Figure 17 depicts most jurisdictional entities and areas. The watershed spans 10 different townships. Irving (19,690 acres) and Rountree (18,558 acres) occupy 72%. Table 8 lists Townships.

Table 7 – Municipalities

Municipality	Area (acres)	Percent of Watershed
Hillsboro	2,819	3.9%
Irving	574	1%
Schram City	417	0.8%
Witt	140	0.2%
Total	**3,951**	**6%**

Table 8 – Townships

Township Name	Area within Watershed (ac)	Percent of Watershed Total
Irving	19,690	37%
Rountree	18,558	35%
East Fork	6,305	12%
Nokomis	4,467	8.3%
Butler Grove	2,331	4.4%
Raymond	955	1.8%
Witt	541	1%
Greenwood	344	0.6%
Ricks	309	0.6%
Hillsboro	43	0.1%
Total	**53,542**	**100%**

The Illinois EPA Bureau of Water regulates wastewater and stormwater discharges to streams, rivers, and lakes through the National Pollutant Discharge Elimination System (NPDES). Two NPDES permits exist within the watershed (Section 3.16.1).

Residential Area on Lake Hillsboro

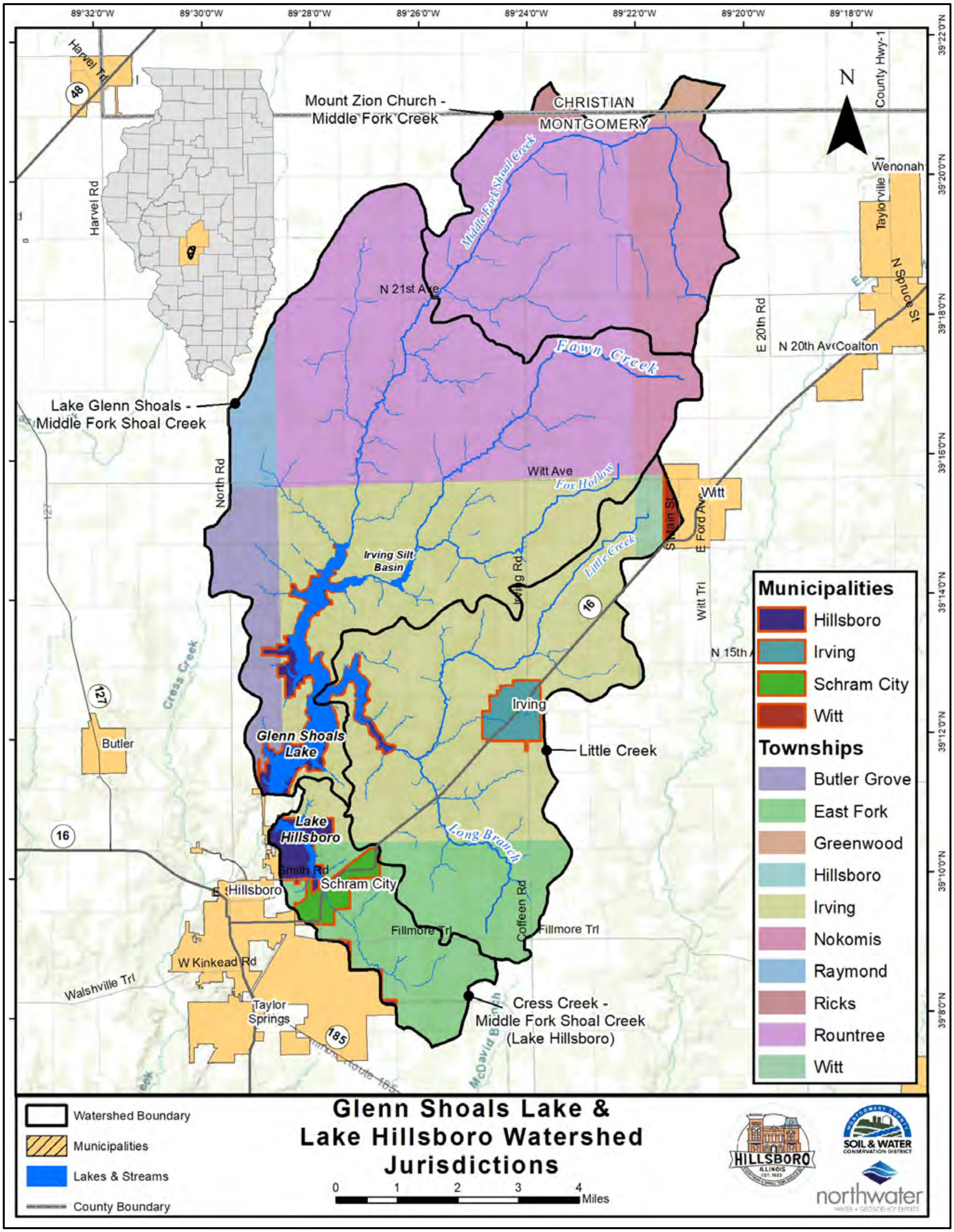


Figure 19 – Jurisdictional Boundaries

3.6.2 Protected Natural Areas & Significant Species

No federally owned properties exist in the combined watershed. There is one small State of Illinois protected Illinois Natural Areas Inventory site within the Glenn Shoals Lake watershed, the Irving Railroad Prairie consisting of 3.9 acres of mesic prairie. No properties exist on land draining to Lake Hillsboro. Despite a limited area of state owned/managed properties, large blocks of native prairie and forest exist.

Endangered & Threatened Species

There are no listed Endangered and Threatened species found within the combined watershed.

Native Prairie in the Watershed

3.6.3 Demographics

According to the 2023 United States Census, the total population of Montgomery County is 27,663. While 386 acres of the watershed are in Christian County, no residential areas are contained within. The median household income is $61,796. There are 12,520 housing units and a median age of 43. Roughly 22% of the of the population is above the age of 65. Using data by census block, population within the combined watershed is 2,661 with 1,259 housing units, 146 of which are vacant. Most of the area is rural and lies to the northeast of Hillsboro. (Figure 20).

Hillsboro is the largest city in the watershed with a population of 5,773 and median age of 40. This compares to a population of 6,207 in 2010, or a decrease of 2%.

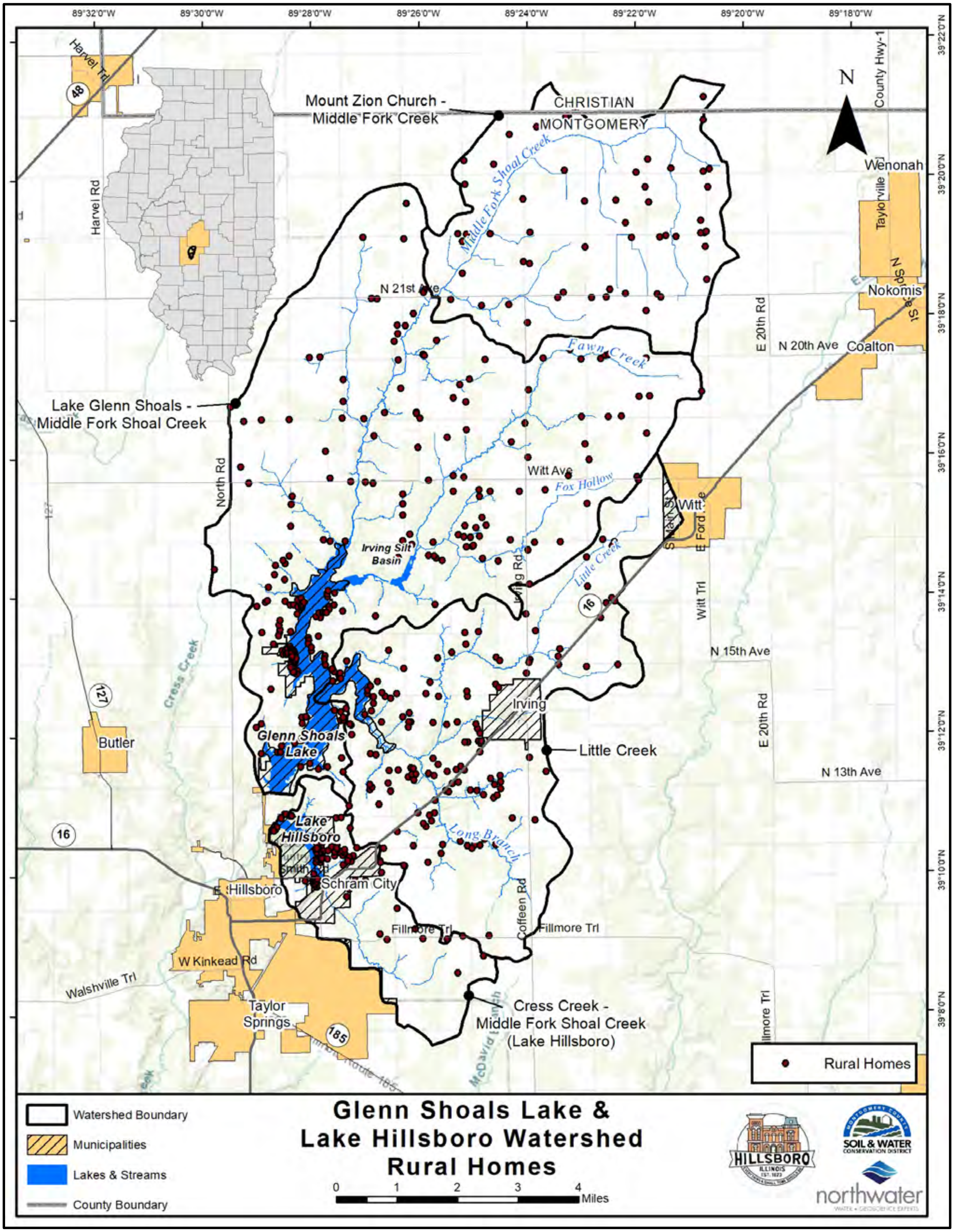


Figure 20 – Rural Homes

3.7 Geology, Hydrogeology, & Topography

This section includes information on surficial geology and hydrogeology, in addition to wells, surface elevation, and slope.

3.7.1 Geology

The watershed is in the Springfield Plain of the Till Plains physiographic division of Illinois. Surficial materials and hydrology have been fundamentally shaped by glacial processes of deposition and erosion. Surficial geology was adapted from Illinois State Geologic Survey (ISGS) 1995 Stack-Unit mapping of the top 15 meters of earth materials. The watershed is fully blanketed with Glasford formation glacial tills that are silt and clay matrix, or loam and sand matrix. There are some discontinuous layers of sand and gravels found within the till deposits. Recent alluvial deposits from the river systems overlie the Glasford tills across approximately 4% of the land area, and wind-blown loess deposits overlie the Glasford tills across approximately 16.7% (Figure 21 and Table 9). The fine-grained loess deposits are considered highly erodible, especially on steeper slopes.

Drift thickness, or depth to bedrock varies from less than 25 ft in the northeast quadrant (35%) of the watershed to 100 – 200 ft in two east-west trending bands in the southern portion of the watershed (17%). The remaining portions have drift thickness between 25 and 100 ft. The elevation of the bedrock surface ranges from approximately 650 to 450 feet above sea level (fasl). The primary bedrock formation that underlies the glacial deposits is the Upper Pennsylvanian-aged Bond formation. The Bond formation consists of shales, claystones and limestones. The deeper Carbondale formation houses the Herrin Coal, a coal seam typically 6 - 8 ft thick that has been historically and actively mined in the area with subsurface mining methods.

Table 9 – Surficial Geology of Glenn Shoals Lake & Lake Hillsboro Watershed

Surficial Geology	Description[1]	Area (acres)	Percent of Watershed
Alluvium	Thin Cahokia alluvium less than 6 meters thick *underlain by Glasford formation, loamy and sandy tills, small area with shale bedrock within 15m of surface*[2]	1,960	3.7%
Glacial Outwash	Thin Pearl Formation, thin layer of sand and gravel less than 6 meters thick *Underlain by Glasford formation, loamy and sandy tills, shale bedrock within 15m of surface*	127	0.2%
Loess	Thin Peoria and Roxana Loess (wind-blown silts and fine sand) *Underlain by Glasford formation, loamy and sandy tills, small area with shale bedrock within 15m of surface*[2]	8,925	17%
Glacial Tills	Glasford formation, silty and clayey glacial tills *Greater than 6m thick throughout the watershed, some discontinuous sand and gravel beds found within the tills*	25,120	47%
	Glasford formation, loamy and sandy tills *Underlain by Pennsylvanian age shales*[2]	17,410	33%

[1] Adapted from Illinois State Geological Survey Stack-Unit Mapping of Geologic Materials in Illinois to a Depth of 15 meters
[2] Refer to Figure 21 for areas with Pennsylvanian age shale bedrock interpreted to be within 15 meters of the surface

3.7.2 Hydrogeology

There are estimated to be at least 200 private water wells within the watershed based on the ISGS wells and borings database. There are no Community Water Supply (CWS) wells, and only 1 Non-Community Water Supply (NCWS) well recorded in the state database. The NCWS well is in the northwest corner of the watershed and belongs to Saint Paul Lutheran School.

Based on the available dataset of private wells, average depth is 45 ft with a minimum of 18 ft and a maximum of 262 ft. Most of the wells are drilled into unconsolidated materials and produce limited quantities of water from discontinuous sand and gravel layers that are within the Glasford formation tills. Several of the deeper wells appear to intersect shale and sandstone layers in the bedrock that produce low yields. The northern portion (~16%) of the watershed is the only area with continuous sand and gravel aquifers mapped. In general, geological formations do not promote significant aquifer systems. Deeper aquifer systems are present in sandstone and limestone formations at depths greater than 500 ft, however, the salinity of the water is well above drinking water standards.

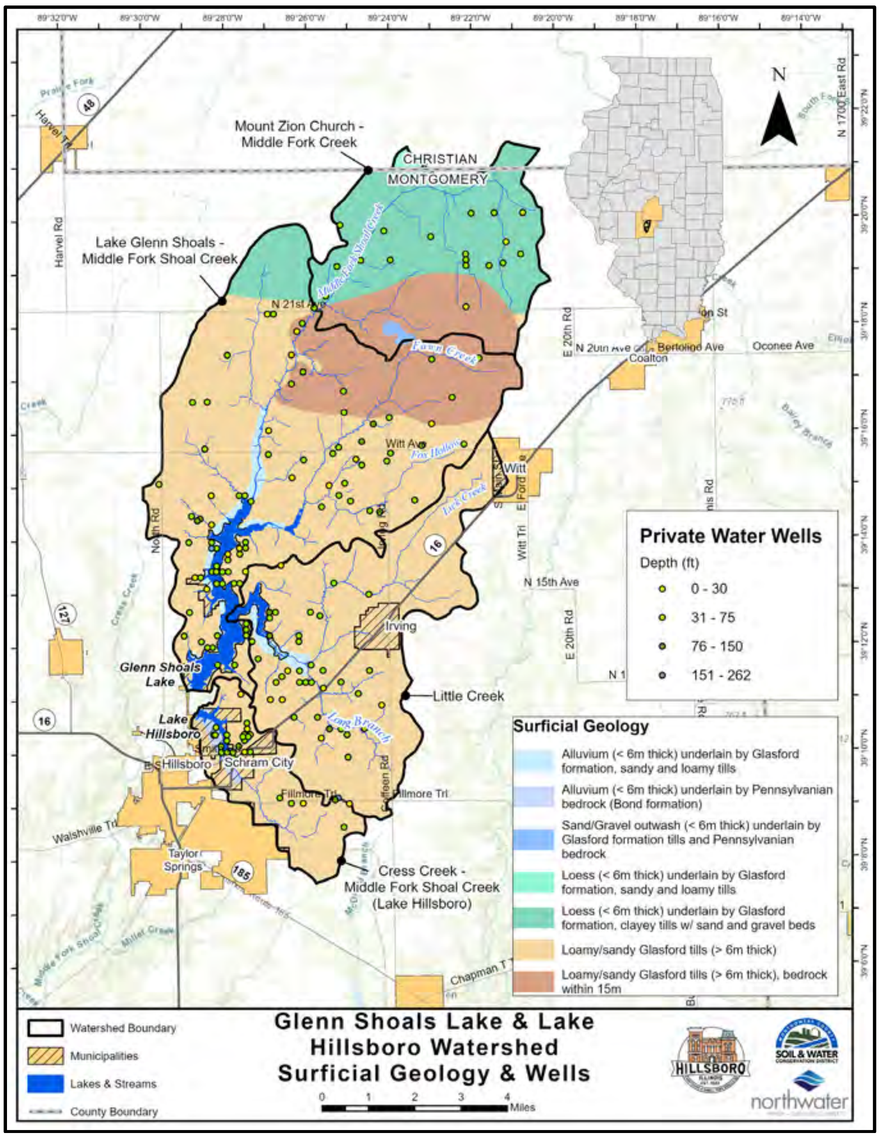


Figure 21 – Geology & Wells

3.7.3 Topography & Relief

Watershed elevation ranges from about 587 to 705 fasl. The lowest elevation where Glenn Shoals Lake outlets into Middle Fork Shoal Creek is at roughly 590 fasl. Most of the watershed is at 645 fasl or lower, with an average of about 643 fasl. The lowest elevations can be found near the lake outlets (Figure 22). Slopes are shown in Figure 23. The Glenn Shoals Lake and Lake Hillsboro watershed has a maximum slope of 433% (77°) with an average of 4% (2.3°). Headwaters and upland areas are generally flatter, transitioning quickly to steeper slopes adjacent to stream corridors and major waterbodies.

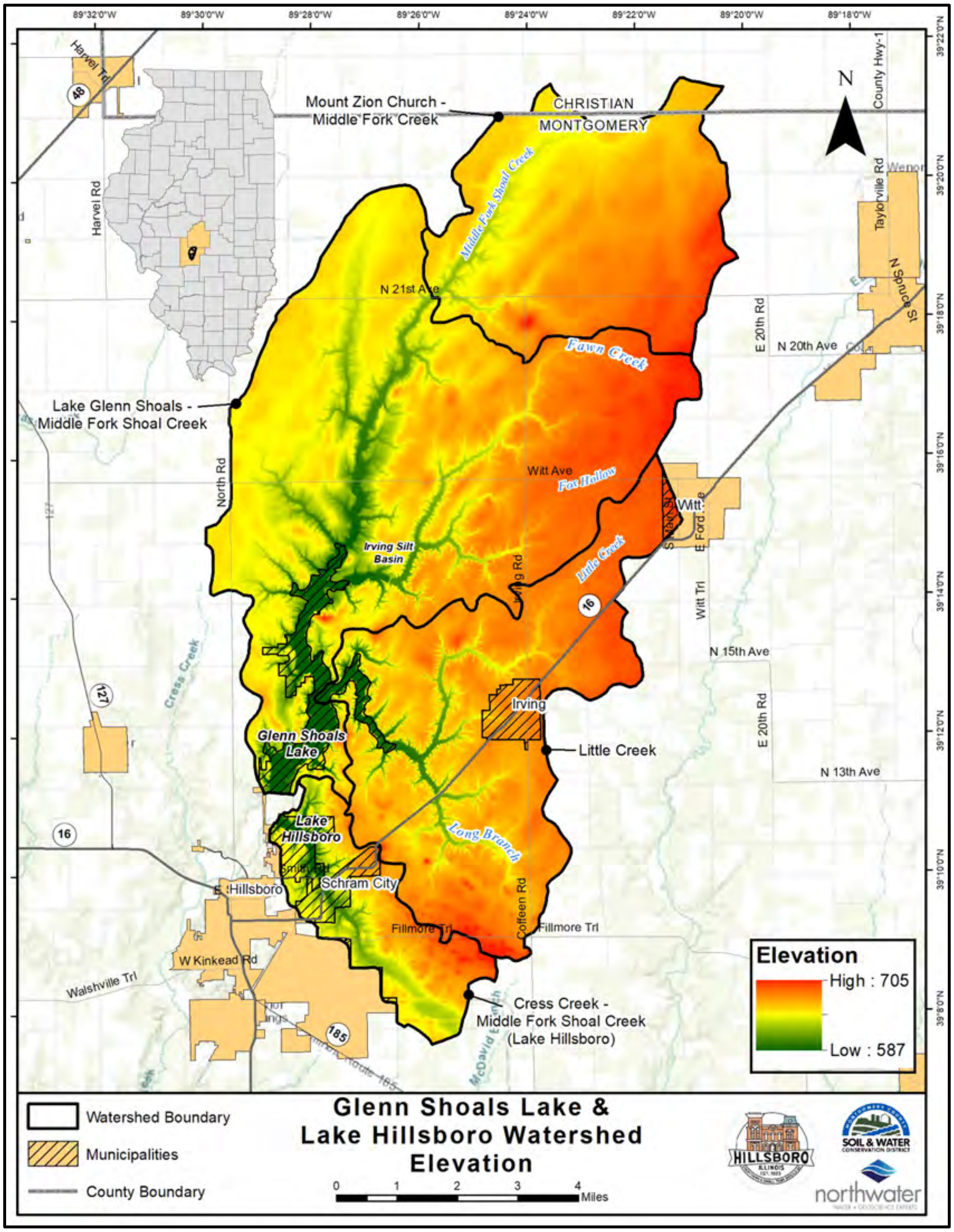


Figure 22 – Surface Elevation in Feet

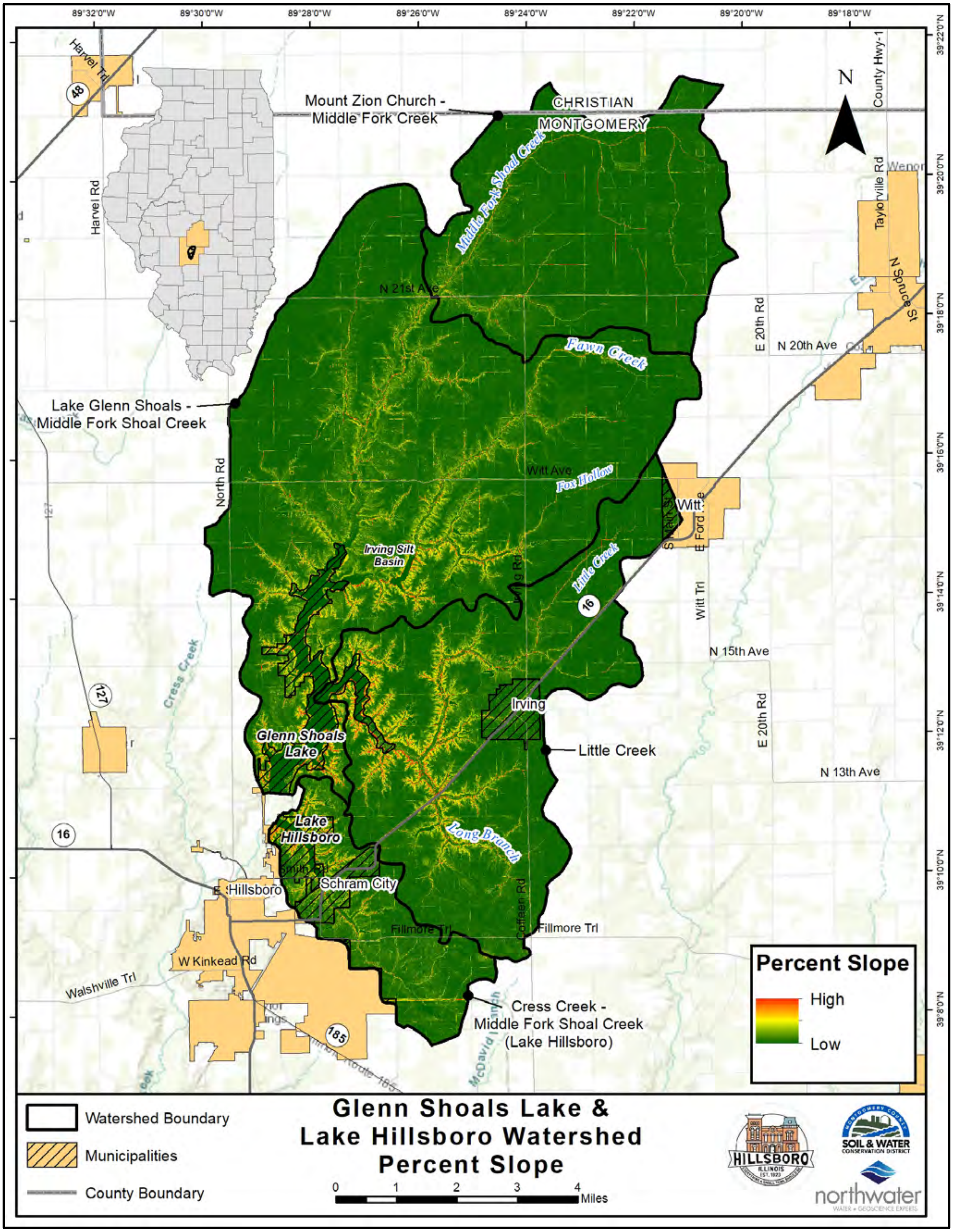


Figure 23 – Surface Slope in Percent

3.8 Climate

The National Centers for Environmental Information provides data from weather stations found across the state. Thirty-year normals for the watershed were acquired from a weather station in Hillsboro. The data consists of averages summarized from 1991-2020 and are shown in Table 10. Temperatures are measured in degrees Fahrenheit and the precipitation in inches.

Average annual temperature is 55.7° F. June through August experience monthly averages greater than 70° F; the lowest are in January (30.5° F). The highest average maximum is 88.2° F in July and the average minimum is in January (21.7° F). In general, minimum and maximums follow the same monthly trends as average temperatures.

Average annual precipitation for the 30-year time span is 45.7 in. The months with the highest levels of precipitation are May and June with a mean of 5 in. The lowest average monthly rainfall occurs in February (2.2 in). Average precipitation levels of this time frame follow an identical trend to the averages in recent years past.

Table 10 - Climate Normals (1991-2020)

Month	Maximum Temp (°F)	Minimum Temp (°F)	Mean Temp (°F)	Mean Precipitation (in.)
January	39.4	21.7	30.5	2.2
February	43.1	23.7	33.4	3
March	56	35.2	45.6	3.5
April	68.4	44.2	56.3	5.3
May	77.8	54.7	66.3	5
June	86.4	63.7	75	5
July	88.2	66.5	77.4	4.6
August	86.8	64.7	75.8	3.6
September	82	57.8	69.9	3.2
October	69.6	45.9	57.8	3.8
November	55.1	34.7	44.9	3.2
December	43.6	27	35.3	3.3
Average	**66.4**	**45**	**55.7**	**3.8 (45.7 yearly)**

Data were also acquired from the PRISM climate group from the last 15 years (October 2008 - September 2023). The PRISM climate group is a part of the Northwest Alliance for Computational Science and Engineering based at Oregon State University and supported by the USDA Risk Management Agency. Temperatures are presented in degrees Fahrenheit and the precipitation in inches (Table 11).

The average annual temperature is 54.4° F. June through August experience monthly averages greater than 70° F; the lowest average temperatures are in January (28.3° F). The highest average maximum is 86.9° F in July and the average minimum is in January (20.3° F).

Average levels of this time frame follow a very similar trend to those from the period of 1991-2020. In general, minimum, average, and mean temperatures follow the same monthly trends as average values from the same period.

The average annual precipitation for the most recent 15 years is 43.7 in. The month with the highest level is June with an average of 5.2. The lowest average monthly rainfall occurs in January (2.1 in). The wettest months of the year are April through July, where the average annual precipitation exceeds 4 in.

Table 11 - Monthly Climate, 2006 – 2021

Month	Maximum Temp (°F)	Minimum Temp (°F)	Mean Temp (°F)	Mean Precipitation (in.)
January	36.3	20.3	28.3	2.1
February	40.7	22.7	31.7	2.4
March	53.5	33.9	43.7	3.5
April	65.8	43.2	54.5	5.1
May	75.9	55.0	65.4	4.8
June	85.0	63.8	74.4	5.2
July	86.9	66.6	76.8	4.3
August	85.1	64.1	74.6	3.9
September	81.2	57.4	69.3	3.2
October	68.4	45.2	56.8	3.5
November	53.1	33.7	43.4	2.8
December	42.2	26.6	34.4	2.9
Average	**64.5**	**44.4**	**54.4**	**3.6 (43.7 yearly)**

3.9 Land Use

To characterize watershed land use and nonpoint source (NPS) pollution, a custom Geographic Information System (GIS) layer was developed from 2021 aerial imagery and verified to the extent possible through field surveys. Table 12 lists the results of classification.

As depicted in Figure 24, the predominant land use in the combined Glenn Shoals and Lake Hillsboro watershed is row crop agriculture which makes up 70% (37,527 acres), with 73% of the Glenn Shoals Lake watershed area but only 35% of Lake Hillsboro. Crops are primarily a corn-soy bean rotation.

Forest and grasslands are the second and third most prevalent overall, at 12% (6,316 acres) and 8.2% (4,374 acres), respectively. These categories are a higher overall percentage in Lake Hillsboro. Residential and developed urban areas (including all associated land use categories) cover approximately 2% of the combined watershed with a higher percentage in Lake Hillsboro. A total of 670 acres of pasture and small, open livestock feed areas are scattered throughout both lake watersheds.

Three livestock confinement operations are in the Glenn Shoals Lake watershed area. No confinements are located on land that drains to Lake Hillsboro. Animal units are unknown.

Table 12 – Land Use Categories & Area

Land Use Category	Area (ac)	% of Area	Land Use Category	Area (ac)	% of Area
Glenn Shoals Lake					
Row Crops	36,043	73%	Feed Area	14	0.03%
Forest[1]	5,506	11%	Cemetery	14	0.03%
Grasslands	3,404	6.9%	Junk Yard	11	0.02%
Open Space	1,404	2.8%	Confinement	9.4	0.02%
Open Water Pond/Reservoir	1,335	2.7%	Open Water Pond/Reservoir - Non-Discharging	8.4	0.02%
Pasture	606	1.2%	Utilities	1.7	0.003%
Roads	365	0.7%	Commercial	1.3	0.003%
Open Water Stream	204	0.4%	Warehousing	1	0.002%
Driveway	151	0.3%	Campground	0.8	0.002%
Farm Building	63	0.1%	Institutional	0.7	0.001%
Residential	63	0.1%	Dry Detention Basin	0.7	0.001%
Wetlands (open water)	44	0.1%	Beach	0.6	0.001%
Parking Lot	27	0.1%	Boat Ramp	0.2	0.001%
Railroad	26	0.1%	Solar Farm	0.1	0.0002%
Parks & Recreation	19	0.04%	***Subtotal***	***49,323***	***100%***
Lake Hillsboro					
Row Crops	1,484	35%	Parking Lot	21	0.5%
Grasslands	970	23%	Open Water Stream	12	0.3%
Forest[1]	810	19%	RV Park	11	0.3%
Open Space	290	6.9%	Manufacturing	6.7	0.2%
Open Water Pond/Reservoir	130	3.1%	Farm Building	4.7	0.1%
Solar Farm	85	2%	Commercial	3.1	0.1%
Wetlands (open water)	70	1.7%	Warehousing	1.9	0.05%
Roads	68	1.6%	Institutional	0.7	0.02%
Golf Course	56	1.3%	Dry Detention Basin	0.6	0.01%
Pasture	49	1.2%	Feed Area	0.5	0.01%
Parks & Recreation	44	1%	Open Water Pond/Reservoir - Non-Discharging	0.3	0.01%
Driveway	41	1%	Utilities	0.02	0.0005%
Residential	35	0.8%	***Subtotal***	***4,219***	***100%***
Railroad	22	0.5%	**Grand Total**	**53,542**	**100%**

[1] - Includes Forested Wetlands

3.9.1 Land Use Change

According to the 2012 Montgomery County Comprehensive Plan, no substantial change in land use is expected in the watershed. Hillsboro anticipates minor redevelopment of existing properties and outside of municipal limits, future growth is likely to be limited to small rural residences considering County recommendations and goals support preservation of existing farmland and conservation areas.

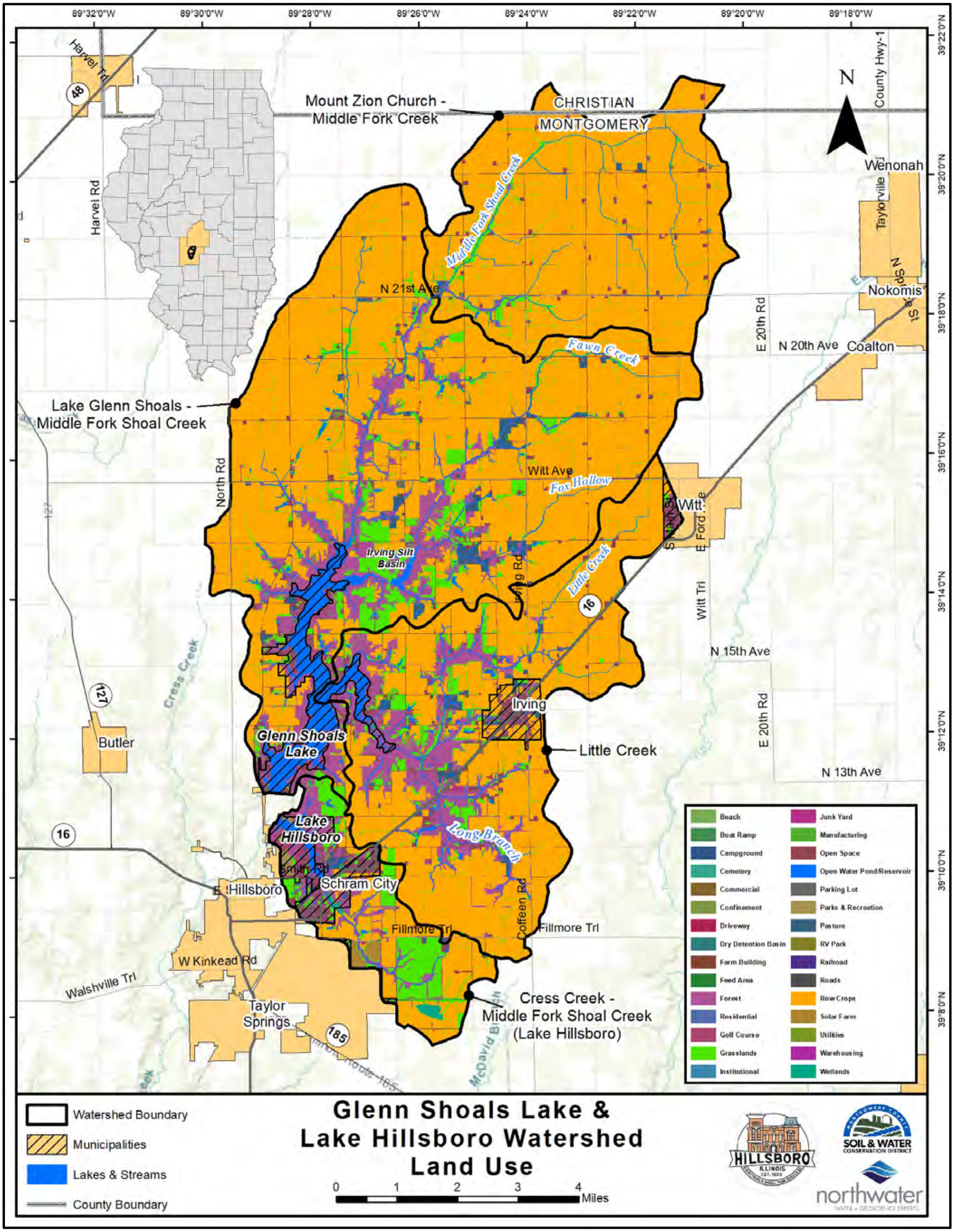


Figure 24 – Land Use

3.10 Soils

Based on soils data from the NRCS National Cooperative Soil Survey, 62 types exist in the watershed (Table 13, Figure 25). The dominant soil type in the watershed is Herrick-Biddle-Piasa silt loams, 0 to 2 percent slopes, accounting for about 22% of the entire watershed, or 11,816 acres. Herrick silt loam, 0 to 2 percent slopes is also prevalent and accounts for 12% (6,614 acres). Twenty-two other types combined account for 56%, while the remaining 38 together account for 9.3%.

The NRCS gives official soil series descriptions (NRCS, 2018b). The Herrick series consists of very deep, somewhat poorly drained soils formed in loess (wind-blown) on ground moraines, with slopes ranging from 0 to 5 percent. The Biddle series consists of very deep, somewhat poorly drained soils formed in loess, or in loess and the underlying silty pedisediment on nearly level parts of broad interfluves on till plains. Slopes range from 0 to 2 percent. The Virden series consists of very deep, poorly drained soils formed in loess on nearly level summits on till plains.

Table 13 - Soil Types & Extent

Soil Type	Area (ac)	Percent of Watershed
Herrick-Biddle-Piasa silt loams, 0 to 2 percent slopes	11,816	22%
Herrick silt loam, 0 to 2 percent slopes	6,614	12%
Virden silty clay loam, 0 to 2 percent slopes	3,613	6.7%
Cowden-Piasa silt loams, 0 to 2 percent slopes	3,393	6.3%
Oconee silt loam, 2 to 5 percent slopes	2,437	4.6%
Cowden silt loam, 0 to 2 percent slopes	1,712	3.2%
Keller silt loam, 2 to 5 percent slopes, eroded	1,689	3.2%
Oconee-Darmstadt-Coulterville silt loams, 2 to 5 percent slopes, eroded	1,615	3%
Hickory silt loam, 18 to 35 percent slopes	1,570	2.9%
Water	1,460	2.7%
Lawson silt loam, cool mesic, 0 to 2 percent slopes, frequently flooded	1,223	2.3%
Homen silt loam, 2 to 5 percent slopes	1,193	2.2%
Marine silt loam, 2 to 5 percent slopes	1,134	2.1%
Pierron silt loam, 0 to 2 percent slopes	1,030	1.9%
Harrison silt loam, 2 to 5 percent slopes	991	1.8%
Hickory silt loam, 10 to 18 percent slopes, eroded	954	1.8%
Herrick-Biddle silt loams, 0 to 2 percent slopes	933	1.7%
Oconee silt loam, 0 to 2 percent slopes	918	1.7%
Marine silt loam, 0 to 2 percent slopes	907	1.7%
Atlas silt loam, 5 to 10 percent slopes, eroded	903	1.7%
Hickory silt loam, 10 to 18 percent slopes	736	1.4%
Bunkum silt loam, 5 to 10 percent slopes, eroded	584	1.1%
Bunkum-Atlas silt loams, 5 to 10 percent slopes, eroded	576	1.1%
Atlas silt loam, 10 to 18 percent slopes, eroded	569	1.1%
38 other soil types, less than 5,000 acres and 10% of the watershed	4,971	9.3%
Total	**53,542**	

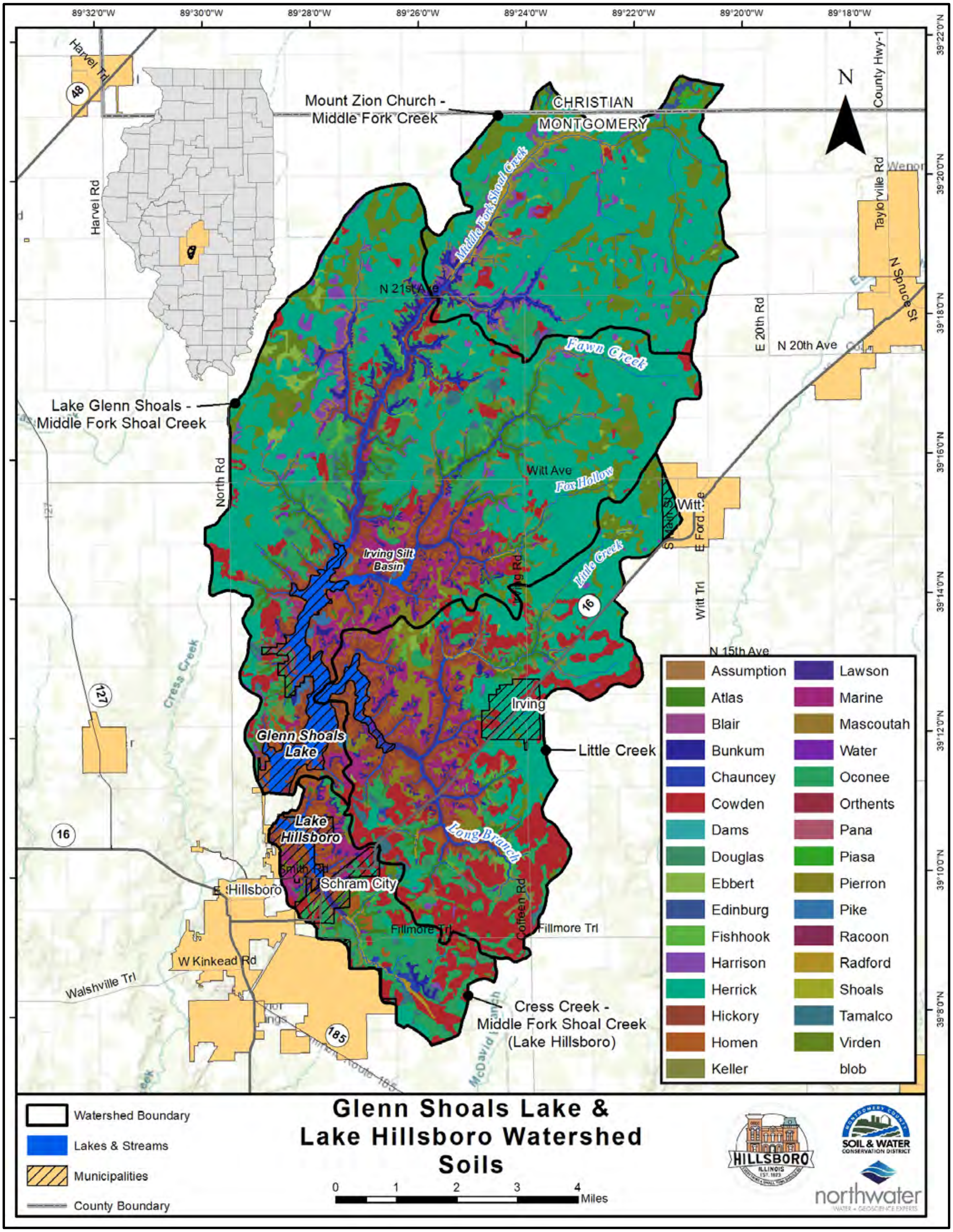


Figure 25 – Soils

3.10.1 Highly Erodible Soils

As defined by the NRCS, a highly erodible soil (HEL)/potentially highly erodible soil (PHEL), or soil map unit, has a maximum potential for erosion that is greater than eight times the tolerable erosion rate. The maximum erosion potential is calculated without consideration of crop management or conservation practices, which can markedly lower the actual erosion rate on a given field.

The location and extent of HEL and PHEL soils were identified using the USDA-NRCS SSURGO database and county frozen soils lists. About 11,815 acres of HEL and 4,967 acres of PHEL exist, representing 22% and 9.3% of the total combined watershed area, respectively (Figure 26). These soils are generally located immediately adjacent to streams and in steep forested or grassed areas. The majority are Non-HEL (NHEL) covering 36,670 acres.

3.10.2 Cropped Highly Erodible Soils

If a producer has a field identified as HEL and wishes to participate in a voluntary NRCS cost-share program, that producer is required to maintain a conservation system of practices that maintains erosion rates at a substantial reduction of soil loss. Fields that are determined not to be HEL are not required to maintain a conservation system to reduce erosion.

Of the 37,527 acres of cropland in the Glenn Shoals Lake and Lake Hillsboro watershed, 12%, or 4,594 acres are considered HEL and 2,590 acres, or 6.9%, are PHEL and could be prioritized for erosion control measures (Figure 26). Cropped HEL soils and tillage practices are further discussed in Section 5.0.

Steep Slope in the Watershed

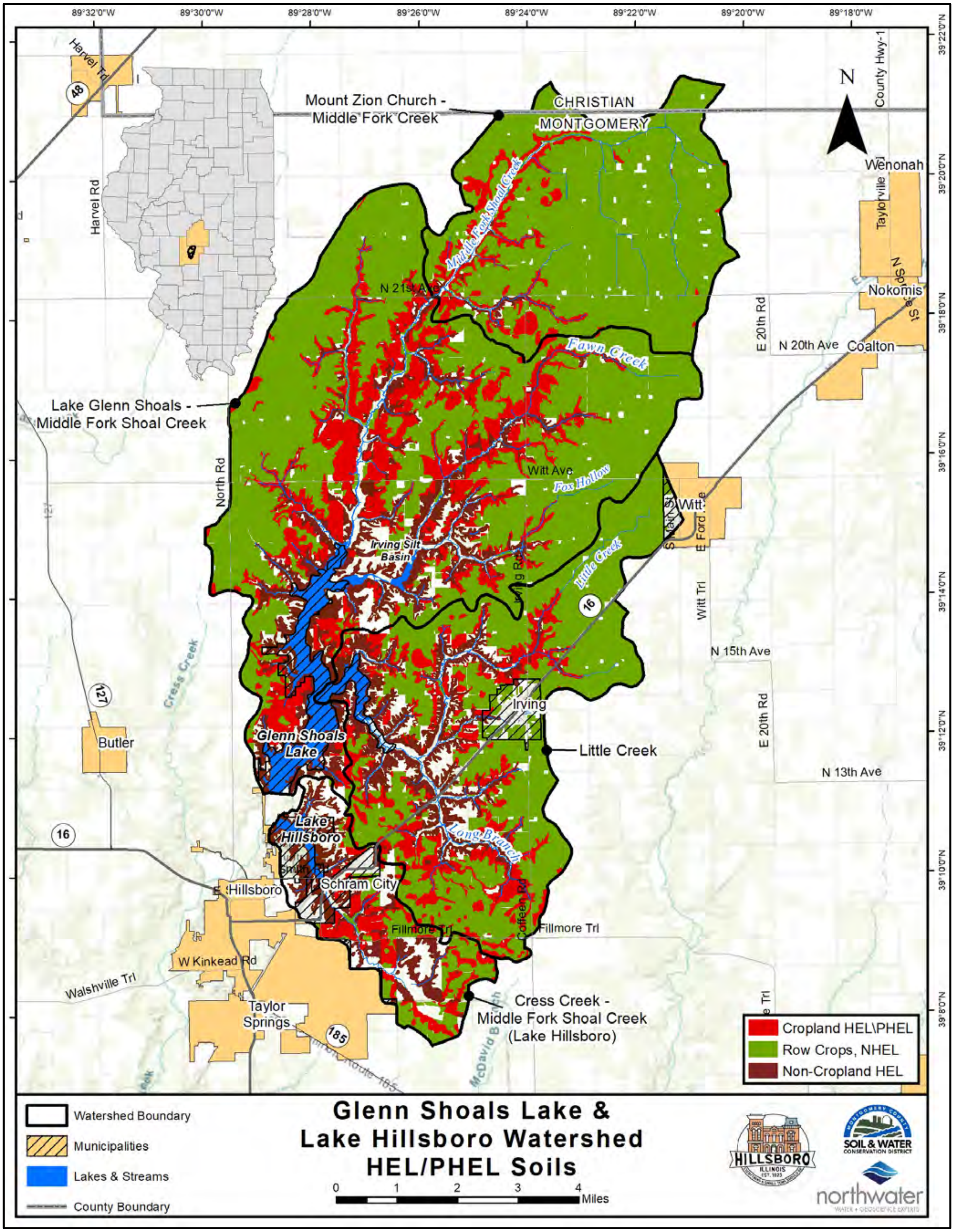


Figure 26 – HEL Soils

3.10.3 Hydric Soils

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation (NRCS, 2018a). As an indicator of the potential for wetland development, understanding where hydric soils are located can inform wetland restoration and creation activities.

A total of 10,810 acres of hydric soils are scattered throughout the watershed, with Glenn Shoals having 9,875 acres or 20% of the total area and Lake Hillsboro having 935 acres or 22% (Table 14 and Figure 27). Hydric soils are typically wet and will flood if overland or tile drainage is not present and represent 20% of the total combined watershed area over eight different soil types (Table 15). Virden silty clay loam is the dominant hydric soil at 6.7%

Table 14 – Hydric Soils by Lake Watershed

Lake Watershed	Hydric Rating	Area (ac)
Glenn Shoals Lake	Unranked	1,337
	No	38,111
	Yes	9,875
Lake Hillsboro	Unranked	134
	No	3,150
	Yes	935

Table 15 – Hydric Soil Types

Soil Type	Area (ac)	Percent of Watershed
Virden silty clay loam, 0 to 2 percent slopes	3,613	6.7%
Cowden-Piasa silt loams, 0 to 2 percent slopes	3,393	6.3%
Cowden silt loam, 0 to 2 percent slopes	1,712	3.2%
Pierron silt loam, 0 to 2 percent slopes	1,030	1.9%
Virden-Fosterburg silt loams, 0 to 2 percent slopes	463	0.9%
Ebbert silt loam, 0 to 2 percent slopes	383	0.7%
Edinburg silty clay loam, 0 to 2 percent slopes	72	0.1%
Chauncey silt loam, 0 to 2 percent slopes	58	0.1%
Mascoutah silty clay loam, 0 to 2 percent slopes	50	0.1%
Piasa silt loam, 0 to 2 percent slopes	36	0.1%
Racoon silt loam, 0 to 2 percent slopes, occasionally flooded	0.3	0.001%
Total	**10,811**	**20%**

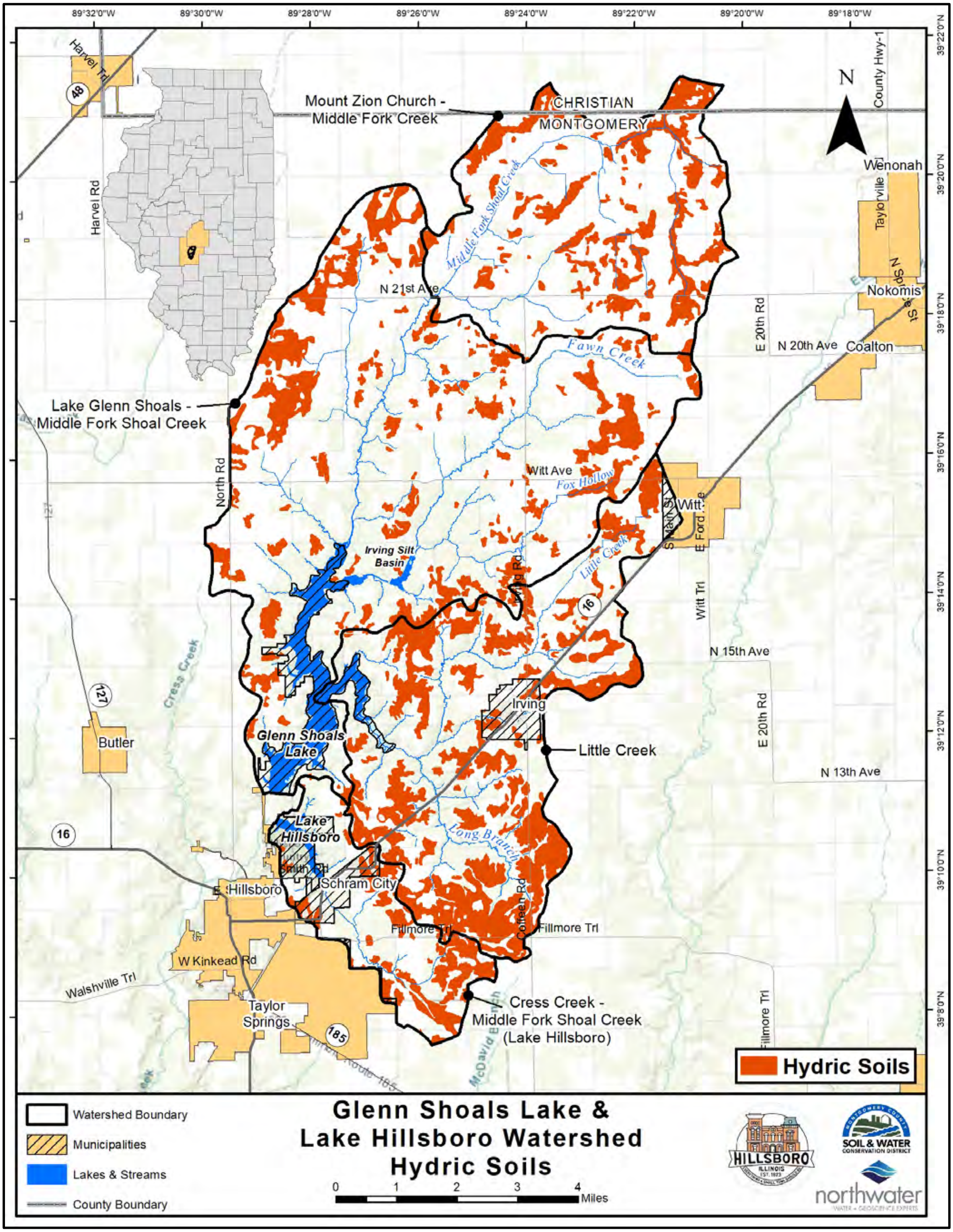


Figure 27 – Hydric Soils

3.10.4 Hydrologic Soil Groups

The NRCS has four hydrologic soil groups based on infiltration capacity and runoff potential. Group A has the greatest infiltration capacity and least runoff potential, while D has the least infiltration capacity and greatest runoff potential. A hydrologic soil group is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to an impermeable layer or to a water table (USDA, 2007). Certain wet soils are tabulated as D based solely on the presence of a water table within 24 inches of the surface, even though the saturated hydraulic conductivity may be favorable for water transmission. When adequately drained to a seasonal water table at least 24 inches below surface, dual hydrologic groups (A/D, B/D, C/D) are given, based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition (USDA, 2007). This section applies datasets disseminated by the USDA National Cooperative Soil Survey.

Figure 28 and Table 16 illustrate the hydrologic soil groups and statistics. The dominant group is C/D, which accounts for 36,742 acres (69%) of the combined watershed and have moderate to high rates of runoff. The percentage area of C/D group spoils is lower in Lake Hillsboro at only 51%, but still the dominant grouping. Group D soils encompass 12%, or 6,585 acres overall and have high runoff potential. Lake Hillsboro has a greater percentage of this group or 23% versus 11% for Glenn Shoals.

Table 16 – Hydrologic Soil Groups

Hydrologic Groupings and Total Area						
Glenn Shoals Lake						
Group	Unclassified	B	B/D	C	C/D	D
Area (ac)	1,340	3,479	1,542	2,761	34,588	5,614
Percentage of Watershed	**2.7%**	**7.1%**	**3.1%**	**5.6%**	**70%**	**11%**
Lake Hillsboro						
Group	Unclassified	B	B/D	C	C/D	D
Area (ac)	134	400	148	411	2,155	971
Percentage of Watershed	**3.2%**	**9.5%**	**3.5%**	**9.7%**	**51%**	**23%**
Total Watershed						
Group	Unclassified	B	B/D	C	C/D	D
Area (ac)	1,474	3,879	1,690	3,172	36,742	6,585
Percentage of Watershed	**2.8%**	**7.2%**	**3.2%**	**5.9%**	**69%**	**12%**

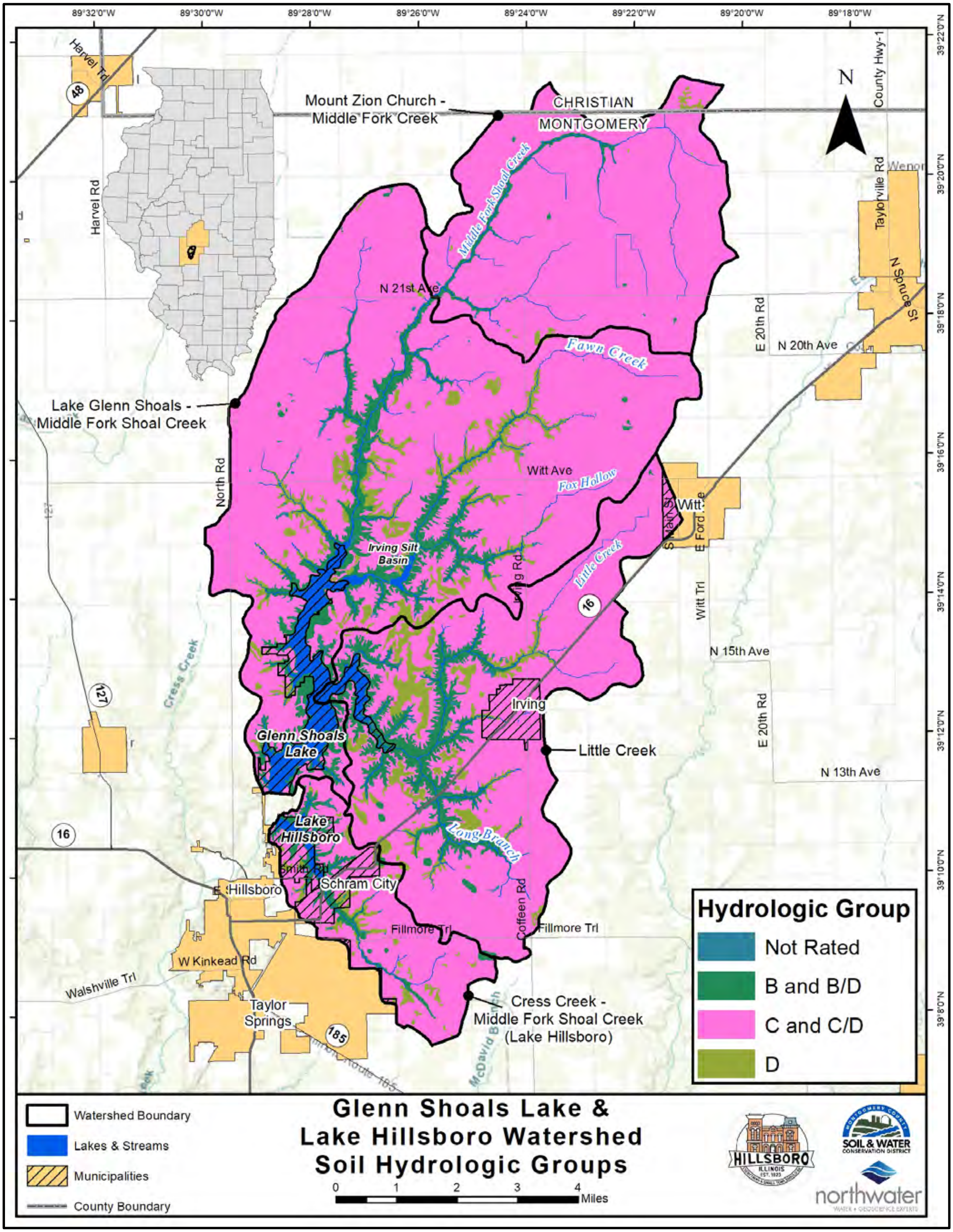


Figure 28 – Soil Hydrologic Groups

3.10.5 Septic System Suitability

Not all soil types support septic systems, and improper construction can lead to failure and leaching of wastewater into groundwater and surrounding waterways. Leached pollutants can include bacteria, nitrogen and phosphorus. Soil data was analyzed for the ability to support septic systems. Results show that 93%, or 49,939 acres (Table 17), of the combined watershed contain soils classified as "very limited" with respect to septic suitability. This does not indicate that soils are unsuitable for septic systems, but special consideration is required when establishing systems. A total of 465 homes/buildings believed to have septic systems are located on soils classified as very limited. Figure 29 illustrates the extent of limiting soils for septic fields.

Table 17 – Soil Septic System Suitability, Total Area & Home/Building Count

	Total Area (ac)	Total Homes on Septic	Very Limited		Somewhat Limited		Not Rated	
			Area	Septic Systems	Area	Septic Systems	Area	Septic Systems
Glenn Shoals Lake	49,324	424	46,090	391	1,893	33	1,341	0
Lake Hillsboro	4,218	90	3,849	74	235	16	134	0
Grand Total	**53,543**	**514**	**49,939**	**465**	**2,128**	**49**	**1,475**	**0**

Residence on Glenn Shoals Lake

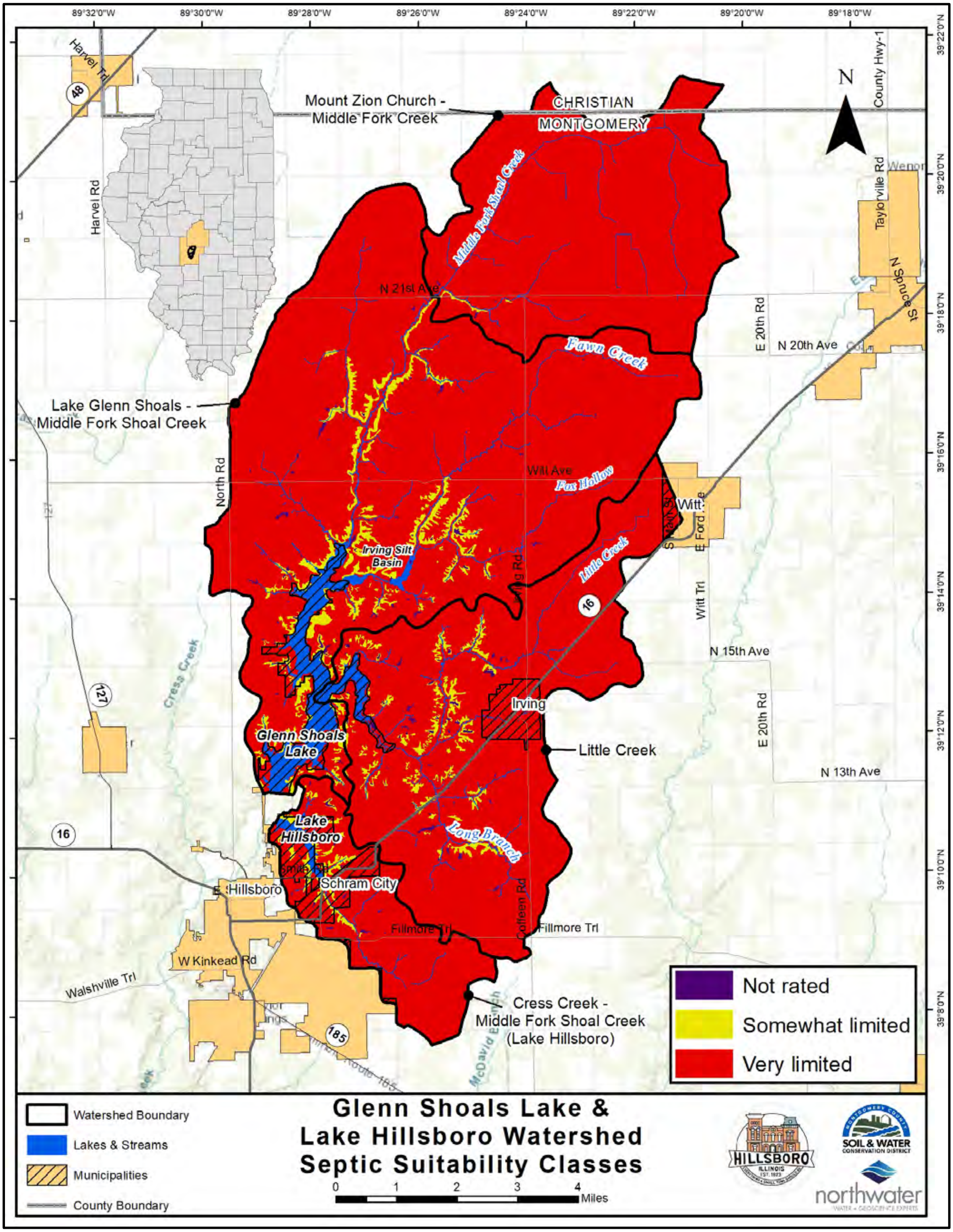


Figure 29 – Soil Septic Suitability

3.11 Tillage

Conventional Tillage

According to a 2018 Illinois Department of Agriculture (IDOA) tillage transect survey completed for Montgomery County, approximately 74% of corn acres use conventional tillage. Conventional tillage is used on 11% of the soybean acreage which leaves little or no residue on the surface. Reduced-till is used on 30% of soybean and 20% of corn acres, which can decrease soil loss by 30% compared to conventional tillage. The remaining 59% of soybean acres are mulch-till or no-till (21% no-till). Only 4.2% of corn acres are mulch-till or no-till (2.1% no-till). Mulch-till leaves 30% residue of the previous year's crop and can reduce soil loss by 75%.

A more detailed field-based assessment of tillage practices was performed in the spring of 2023 to better characterize current conditions specific to the watershed. Table 18 and Figure 30 show the acres of tillage types and distribution. Pollution loading by tillage is discussed in more detail in Section 5. Tillage is grouped into 8 categories: conventional, reduced-till, mulch-till, strip-till, no-till, wheat, and cover types consisting of cover crop, hay, and clover. Hay is also listed in the land use and addressed in the pollution loading and sources section. Cover crops are also addressed in the existing BMP section, as well as in sources.

Results show that mulch-till and no-till make up the largest portion of the Glenn Shoals Lake and Lake Hillsboro watershed (49% and 28%, respectively) followed by reduced-till (10%). Conventional accounts for 3.5%, and cover crops are used on 2,104 acres, or 5.6% of all cropland. As a percentage, no-till and conventional are higher in Lake Hillsboro. Glenn Shoals contains more mulch-till, reduced-till and hay/wheat.

Table 18 – Tillage Types, Acres & Percent of Cropland

Tillage Type	Total Area (ac)	% Cropland	Tillage Type	Total Area (ac)	% Cropland
Glenn Shoals Lake			**Lake Hillsboro**		
Mulch-Till	17,807	49%	No-Till	612	41%
No-Till	9,908	27%	Mulch-Till	547	37%
Reduced-Till	3,577	10%	Conventional	123	8%
Cover Crop[1]	2,018	6%	Reduced-Till	79	5%
Conventional	1,183	3%	Cover Crop[1]	86	6%
Hay/Wheat[1]	1,512	4%	Hay/Wheat[1]	46	3%
Clover[1]	37	0.001%	***Subtotal***	***1,493***	***100%***
Subtotal	***36,043***	***100%***			

[1] – not a tillage practice

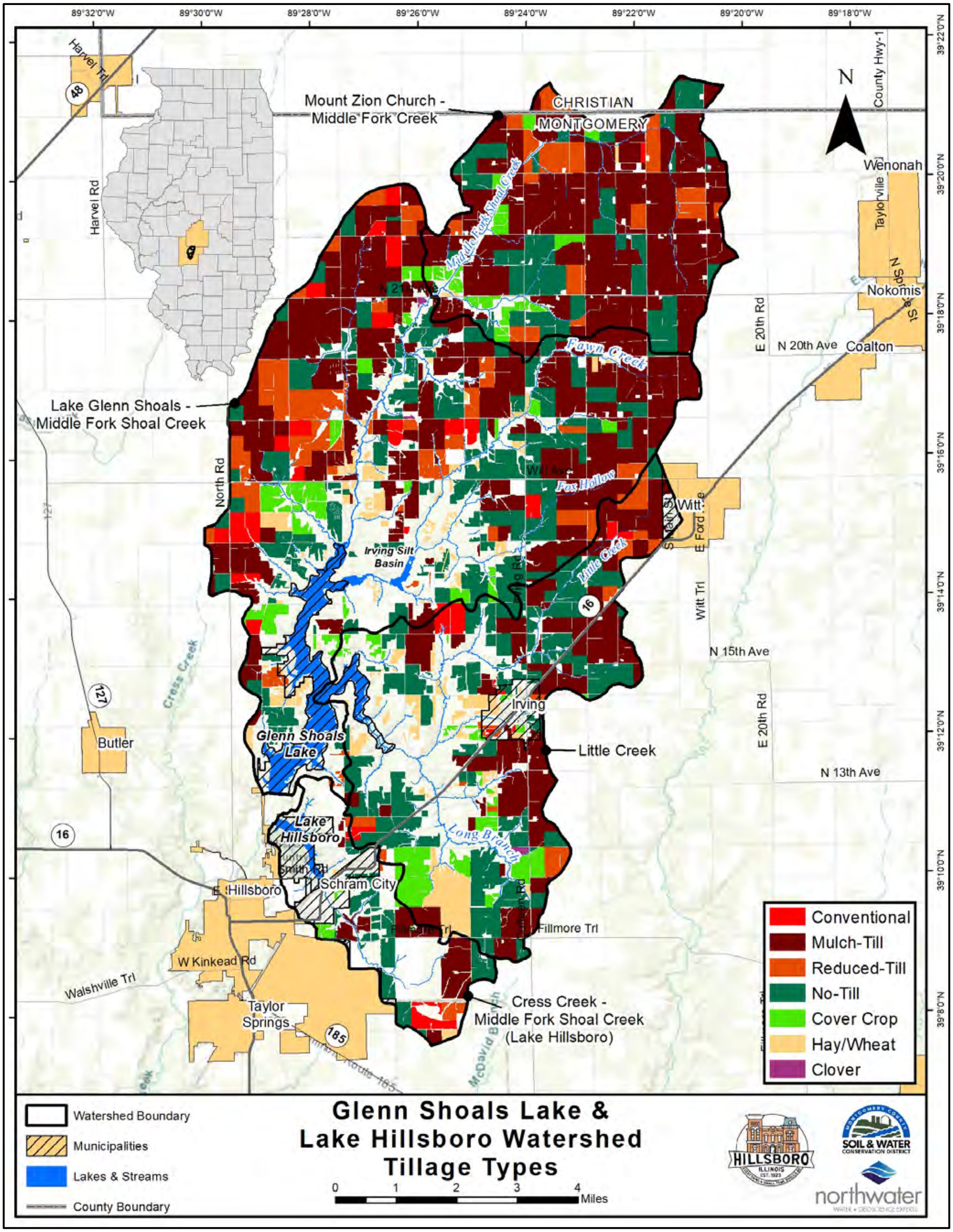


Figure 30 – Tillage Types

3.12 Existing Conservation Practices


WASCB

Existing management practices within the watershed are extensive and include grass riparian buffers and field borders, cover crops, grass waterways, ponds, terraces, water and sediment control basins (WASCB), sediment basins, grade control structures, wetlands, streambank, streambed and shoreline stabilization (including seawalls), fencing to exclude livestock from streams, and urban dry/wet detention basins. Nutrient management is likely practiced on many fields however, the extent is unknown. Table 19 below shows the total number or extent of each known management practice and Figure 31 shows their locations. In addition to those listed, the watershed contains large blocks of native and restored prairie, especially in Lake Hillsboro. Other relevant work has included numerous education and outreach events related to conservation and water quality.

With relatively large reductions still required to meet water quality goals stated in this plan, substantial opportunities exist to install new practices. This is especially true where nutrient loading is the greatest or where pollutants may bypass existing BMPs, such as tile water bypassing a filter strip. It is important to note that each practice varies in its ability to effectively remove pollutants, however, these practices are providing benefits to water quality and have been accounted for in the watershed pollutant loading estimates (Section 4.0). Historical efforts to address water quality cannot be understated. The practices listed below reflect years of hard work by the City of Hillsboro, the Montgomery County NRCS, the MCSWCD, and private landowners.

Table 19 – Existing Conservation Practices

TYPE	Quantity	Unit
Waterway	437	acres
Filter Strip[1]	381	acres
Field Border	227	acres
Sediment Basin	39	number
Terrace	37	number
WASCB	302	number
Grade Control Structure	12	number
Wetland (open water)	114	acres
Cover Crop	2,104	acres
Pond/Silt Basin	209	number
Lake Shoreline Stabilization (both lakes)	40,235	feet
Streambank Stabilization	1,031	feet
Livestock Fencing	4,700	feet
Urban Wet/Dry Detention Basin	3	number

[1] - Calculation of grass riparian buffers are an estimation and include grassed areas within 35 ft of a flowing stream.

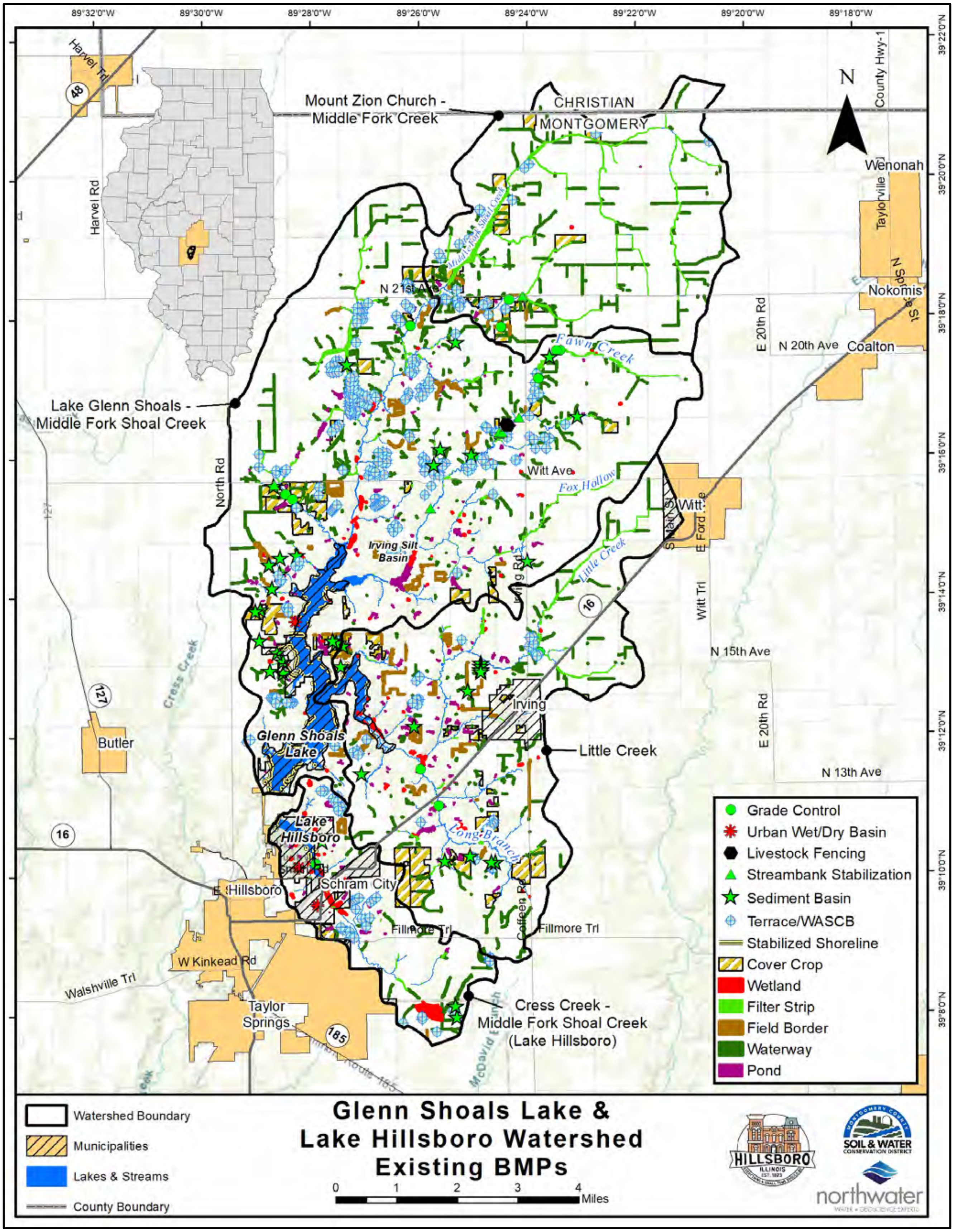


Figure 31 – Existing BMPs

3.13 Hydrology & Drainage System

There are five major named streams in the watershed: the Middle Fork Shoal Creek, Little Creek, Fawn Creek, Fox Hollow, and Long Branch. The Unnamed Tributary that flows to Lake Hillsboro is also included. Due to a lack of consistent flow records for these systems, USGS StreamStats was used to retrieve peak flow data (Table 20).

Table 20 – Primary Tributary Peak Flow Data

Stream	Peak Flow Data (ft^3/s) by Recurrence Level Interval (yrs)					Drainage Area (mi^2)	Stream Slope (ft/mi)
	2	5	10	100	500		
Fawn Creek	622	1,060	1,380	2,530	3,420	7.4	9.4
Fox Hollow	489	833	1,090	2,000	2,700	4.9	11.3
Little Creek	1,190	2,010	2,620	4,740	6,350	19.4	8.2
Long Branch	690	1,170	1,530	2,810	3,790	8	13.3
Middle Fork Shoal Creek	1,430	2,440	3,180	5,770	7,720	30.3	4.8
Unnamed Tributary – Lake Hillsboro	607	1,020	1,330	2,420	3,280	5.3	11.1

3.13.1 Streams & Lakes

Due to limitations with the accuracy of the National Hydrography Dataset (NHD), the custom land use layer was used to better represent the actual wetted extent of streams and lakes. Ponds and reservoirs total 1,467 acres, or 2.1% of the Glenn Shoals and Lake Hillsboro watershed. They range in size from 1,092 acres to less than an acre, with Glenn Shoals Lake at 1,092 acres, and Lake Hillsboro at 106. The Irving Silt Basin that was constructed to trap sediment from Fawn Creek prior to entering Glenn Shoals Lake is 38 acres. The drainage system is depicted in Figure 32.

Table 21 shows perennial open water tributary stream length. Results show a total of 115 miles. The largest stream is Middle Fork Shoal Creek at 15 miles, followed by Little Creek at 9.3 miles. All other named streams total 17.3 miles, with all unnamed tributaries totaling 74 miles. Although accuracy is limited, the NHD indicates all perennial, intermittent or ephemeral tributaries, forested gullies, and subsurface drainageways at 170 miles.

Table 21 – Open Water Perennial Streams & Tributaries

Tributary Name	Length (ft)	Length (mi)	NHD Waters* (mi)
Unnamed Tributary	389,332	74	86
Middle Fork Shoal Creek	79,254	15	37
Little Creek	48,873	9.3	16
Fawn Creek	38,893	7.4	10
Fox Hollow	27,340	5.2	9.1
Long Branch	25,127	4.8	11
Total	**608,819**	**115**	**170**

** = all NHD water sources including perennial streams, intermittent or ephemeral tributaries, forested gullies and subsurface drainageways*

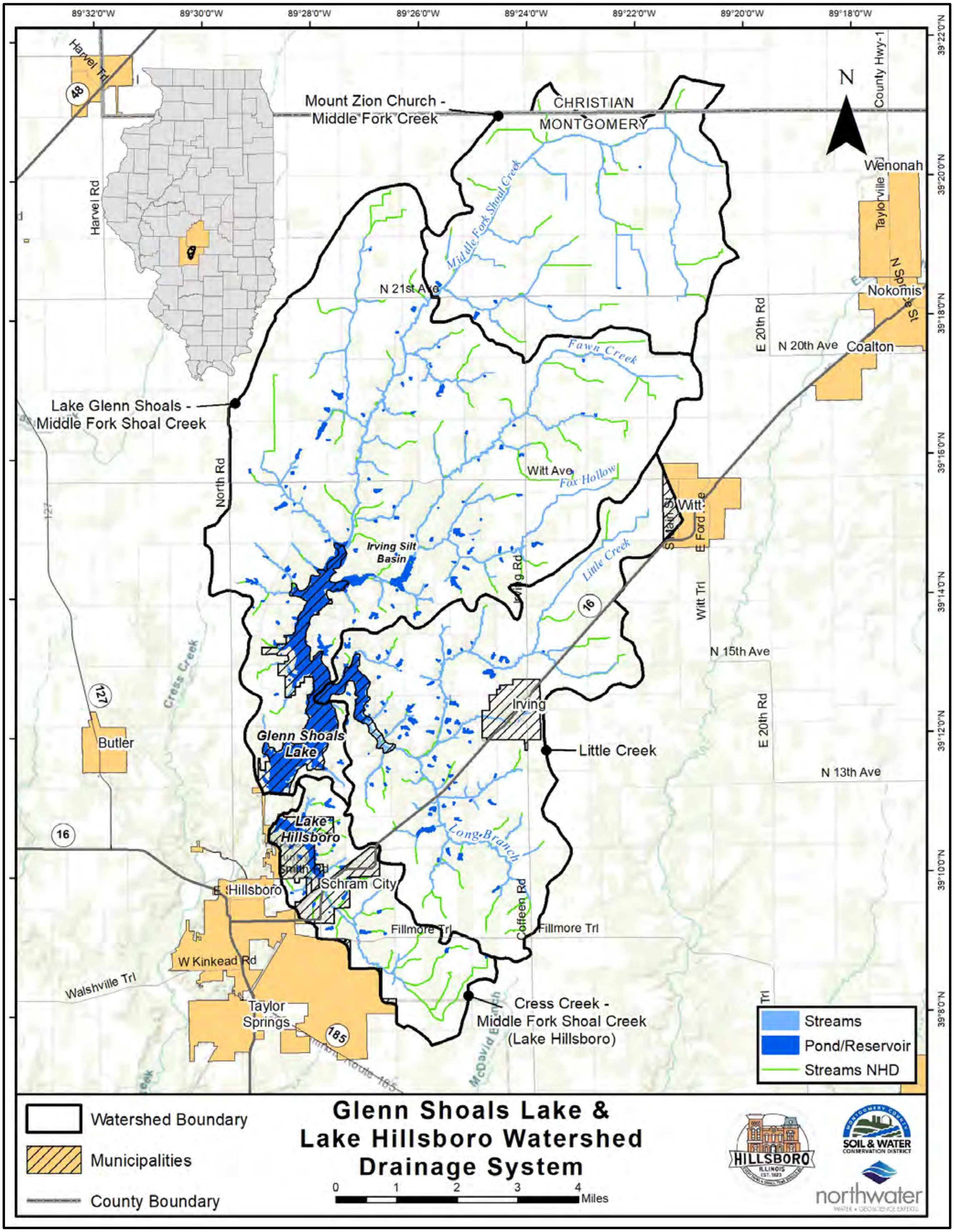


Figure 32 – Drainage System

3.13.2 Tile Drainage

Tile drainage in the watershed is believed to be low. Methods used to estimate tile drainage included direct observations performed during a watershed windshield survey, knowledge of landowners, and analysis of soils, elevation, imagery, and land use.

It is estimated that 196 fields, or 7,694 acres, are likely tile drained (full field and partial field), with 29,833 not. This corresponds to 21% of all cropland, or 14% of the entire watershed being tile drained. Only 13% of the cropland draining to Lake Hillsboro is tiled versus 21% that drains to Glenn Shoals Lake.

3.13.3 Stream Channelization

Stream channelization is the engineering of a river or stream by modifying channel cross section profiles into smooth and uniform trapezoidal or rectangular forms, and can include activities such as straightening, widening, or deepening the channel, clearing riparian and aquatic vegetation, and bank reinforcement. Typically, this causes increased volume and/or velocity of the water which disrupts stream equilibrium, causing conditions such as channel downcutting and bank erosion known as the Channel Evolution Model (Simon, 1989).

Channelized Stream

Aerial imagery from 2023 was evaluated to determine the extent of open water stream channelization. Results indicate that channelization is low to moderate. Out of a total of 115 stream miles, 31% (36 miles) are channelized. Long Branch is the least channelized at only 0.2% whereas 57% of Middle Fork Shoal Creek is (Table 22 and Figure 33).

Table 22 – Length of Channelized Streams

Stream Name	Total (ft)	Total (mi)	Channelized (ft)	Channelized (mi)	% Stream Length Channelized
Unnamed Tributary	389,332	74	115,404	22	30%
Middle Fork Shoal Creek	79,254	15	45,081	8.5	57%
Little Creek	48,873	9.3	13,573	2.6	28%
Fawn Creek	38,893	7.4	8,388	1.6	22%
Fox Hollow	27,340	5.2	6,940	1.3	25%
Long Branch	25,127	4.8	47	0.01	0.2%
Total	**608,819**	**115**	**189,434**	**36**	**31%**

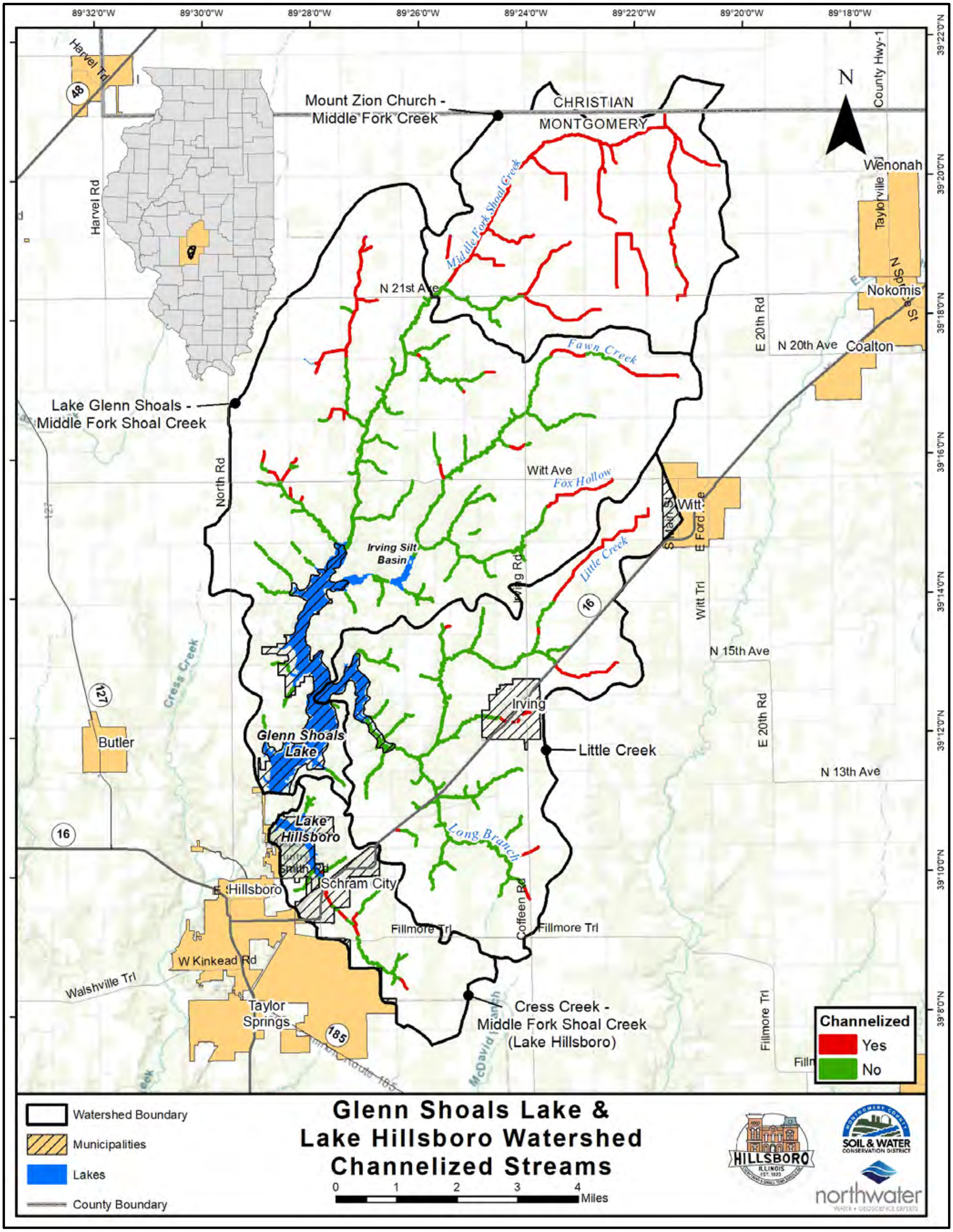


Figure 33 – Channelized Streams

3.13.4 Lake & Stream Buffers

Riparian and buffer areas exist adjacent to streams and major lakes in the watershed. A field assessment, combined with analysis of recent aerial imagery, was used to determine the adequacy and relative extent of natural stream buffers.

Methods – A buffer quality ranking was applied to stream segments. Two categories of buffer quality include:

1. Adequate – greater than or equal to 35 ft of un-impacted riparian or buffer area, either forest grass or wetland.
2. Inadequate – less than 35 ft riparian or buffer area impacted or degraded. Inadequate includes row crops, moderately to highly overgrazed pasture, roads, buildings, and urban open space.

Existing literature was reviewed to determine the minimum adequate buffer width; 35 ft was selected based on the following references:

1. The USDA-NRCS requires a minimum of a 20-foot buffer to be eligible for the Conservation Reserve Program (NRCS, 2010).
2. A study performed in Kansas determined that buffers between 27 and 53 ft significantly removed nitrogen, phosphorus, and suspended solids from entering the stream (Mankin, et al., 2007).

Stream Buffers

Streams are well buffered or approximately 71% of all banks (Table 23). Although most are well buffered, areas exist where improvements can be made. Buffers can be expanded on 63 miles (29%) of the Glenn Shoals Lake and Lake Hillsboro watershed (Figure 34). Buffer type varies with forest accounting for 51% of all stream bank miles. Row Crops make up 23%, grasslands 17%, pasture 5.4%, and open space 2.2%. It should be noted that buffer length does not match exactly with streambank lengths due to the method of analysis and a 35 ft setback, reducing overall buffer length compared to length of stream.

Table 23 – Buffer Adequacy

Stream Name	Total Bank Length (ft)	Total Bank Length (mi)	Inadequate (mi)	Adequate (mi)	Inadequate %	Adequate %
Fawn Creek	68,947	13.1	3.3	9.8	25%	75%
Fox Hollow	47,351	9	4.4	4.6	49%	51%
Little Creek	90,937	17.2	4.5	12.7	26%	74%
Long Branch	30,098	5.7	0.6	5.1	10%	90%
Middle Fork Shoal Creek	132,783	25.1	8.8	16.4	35%	65%
Unnamed Tributary	767,319	145	41.5	104	29%	71%
Total	**1,137,435**	**215**	**63**	**152**	**29%**	**71%**

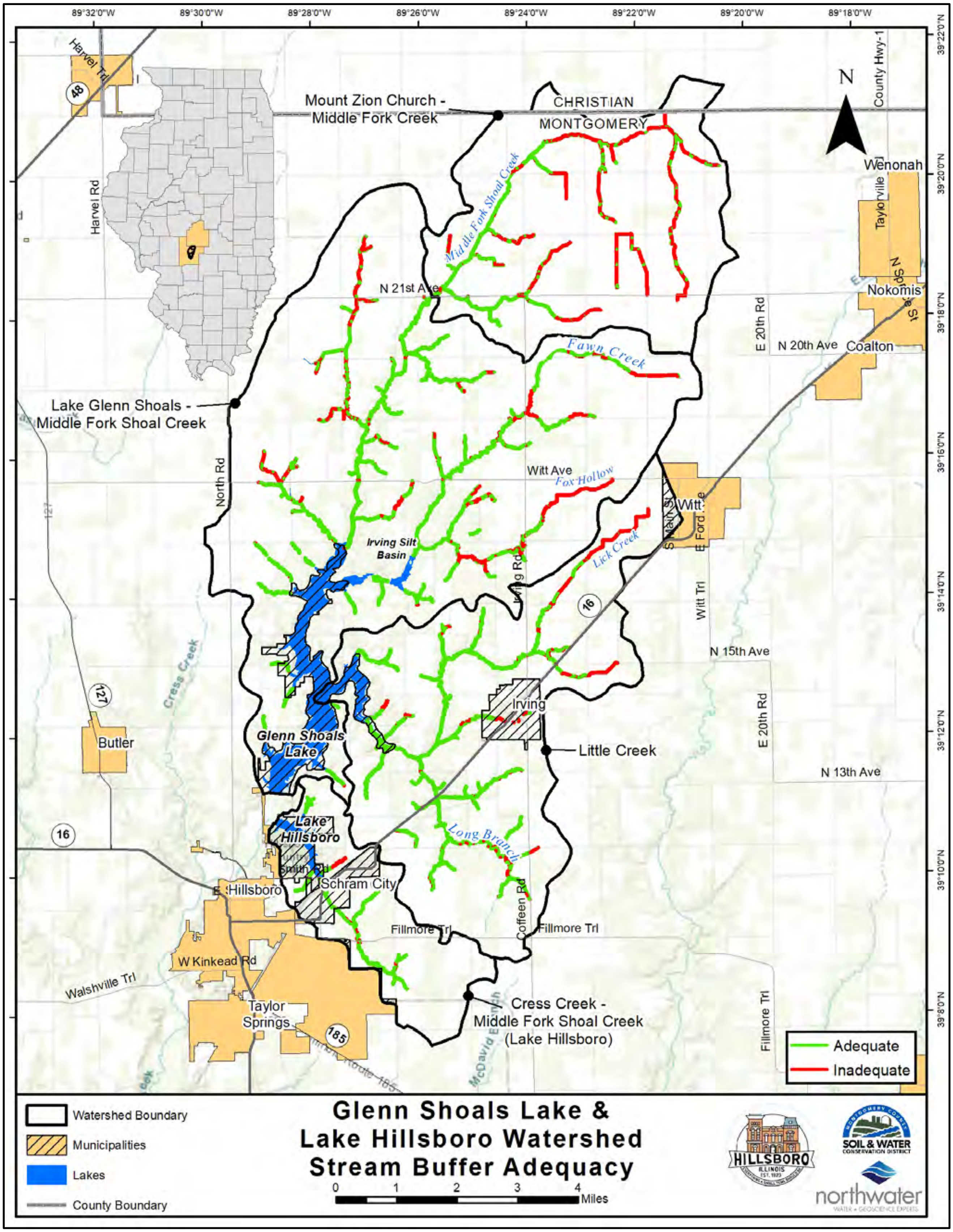


Figure 34 – Stream Buffers

Lake Buffers

Glenn Shoals Lake and Lake Hillsboro are both well buffered and contain large, contiguous riparian areas. Analysis shows that 87% (26 miles) of shoreline is adequately buffered, 89% of Glenn Shoals Lake and 79% of Lake Hillsboro (Table 24 and Figure 35). Across both lakes, forested areas account for 83%, open space 8.5%, and grasslands 2.7%. Forested buffers account for 86% of Glenn Shoals versus 70% for Lake Hillsboro.

Table 24 – Lake Buffer Adequacy

Lake Name	Total (ft)	Total (mi)	Adequate (mi)	Inadequate (mi)	Adequate (%)	Inadequate (%)
Glenn Shoals Lake	131,265	25	22	2.8	89%	11%
Lake Hillsboro	24,341	4.6	3.7	1	79%	21%
Grand Total	**155,606**	**29**	**26**	**3.7**	**87%**	**13%**

Well Buffered Lake Bank

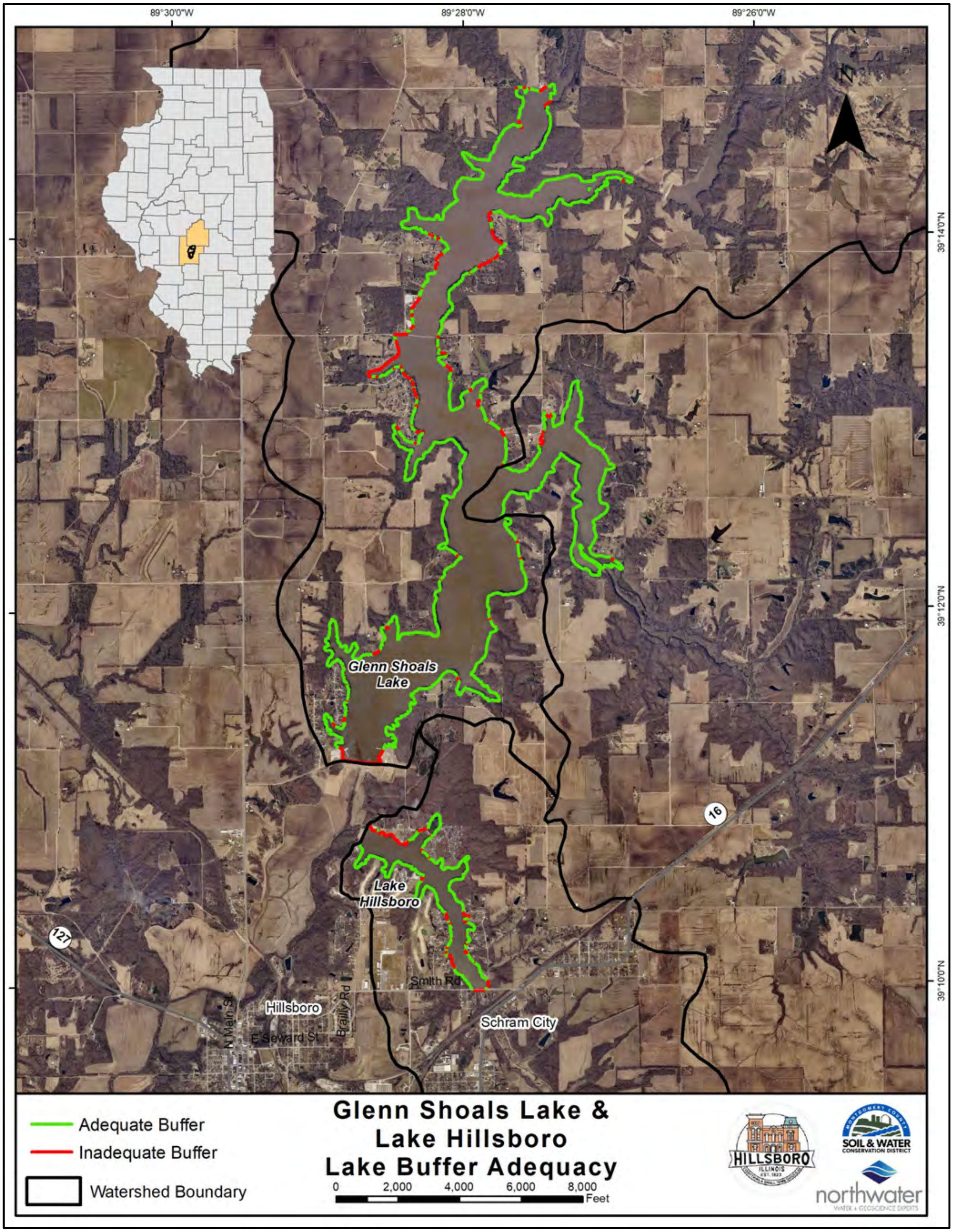


Figure 35 - Lake Buffers

3.13.5 Wetlands & Wetland Loss

Restored Wetland

Wetlands provide numerous valuable functions that are necessary for the health of a watershed. They play a critical role in protecting and moderating water quality through a combination of filtering and stabilizing processes. Wetlands remove pollutants through absorption, assimilation, and denitrification. This effective treatment of nutrients and physical stabilization leads to an increase in overall water quality. In addition, wetlands can increase stormwater detention capacity and attenuation, and moderate high flows. These benefits help to reduce flooding and erosion. Wetlands also facilitate groundwater recharge by allowing water to seep slowly into the ground, thus replenishing underlying aquifers. Groundwater recharge is also valuable to wildlife and stream biota during the summer months when precipitation is low, and the base flow of rivers/streams draw on the surrounding groundwater table.

Excluding stream, ponds, and lakes, the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) indicates there is a total of 484 acres (0.9%) of wetlands within the combined watershed. These are categorized as freshwater emergent and forested shrub wetlands. Results are shown in Table 25 and Figure 36.

Considering the outdated nature of the NWI dataset, an analysis of open water and forested wetlands was performed using 2023 aerial imagery to better understand their current extent. Results show 493 acres (0.9%) of wetlands in the watershed; 114 of the 493 acres can be considered emergent or open water. Comparing to NWI data indicates up to 109 acres of previously delineated emergent wetlands may have been drained or modified; therefore, opportunities exist to restore these areas.

Table 25 – Wetlands

Current Wetlands			NWI Wetlands		
Area (acres)	Emergent (acres)	Difference from NWI - Emergent	Emergent (acres)	Forested/Shrub (acres)	Total (acres)
493	114	65%	223	261	484

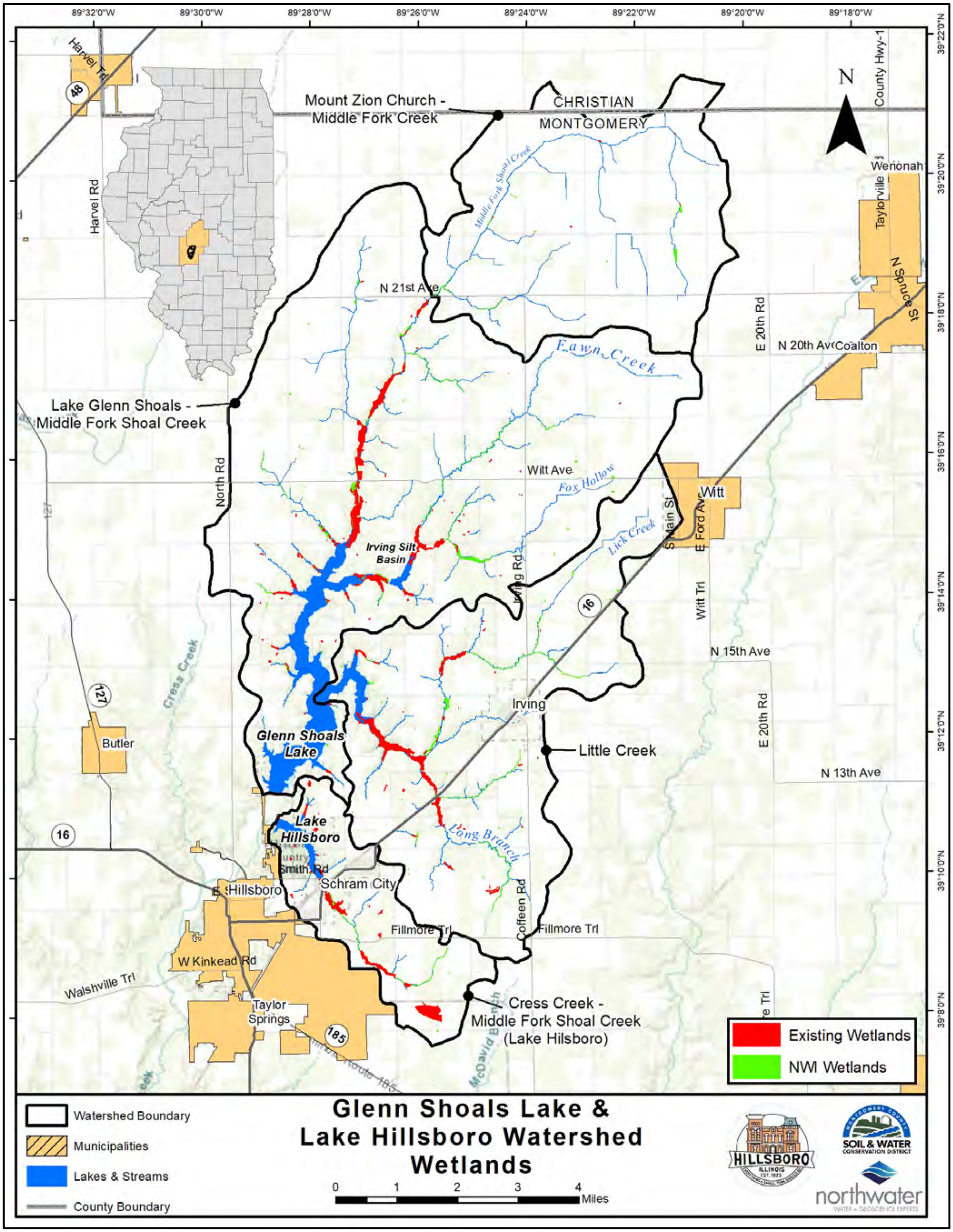


Figure 36 – Wetlands

3.13.6 Floodplain

A review and analysis of the most recent Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) indicates there is no official, mapped 100-year floodplain within the watershed. Flood hazard areas on the Flood Insurance Rate Map are identified as Special Flood Hazard Areas (SFHA). The SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year but are broken up into different zones based on severity of flood hazard risk. The 1-percent annual chance flood is also referred to as the base flood, or 100-year flood (FEMA, 2018). Despite the absence of SFHA maps, floodplains do exist. An old and outdated layer acquired through the State of Illinois indicates 238 acres of 100-year floodplain. Caution should be taken interpreting this data and Figure 37 is provided for informational purposes only.

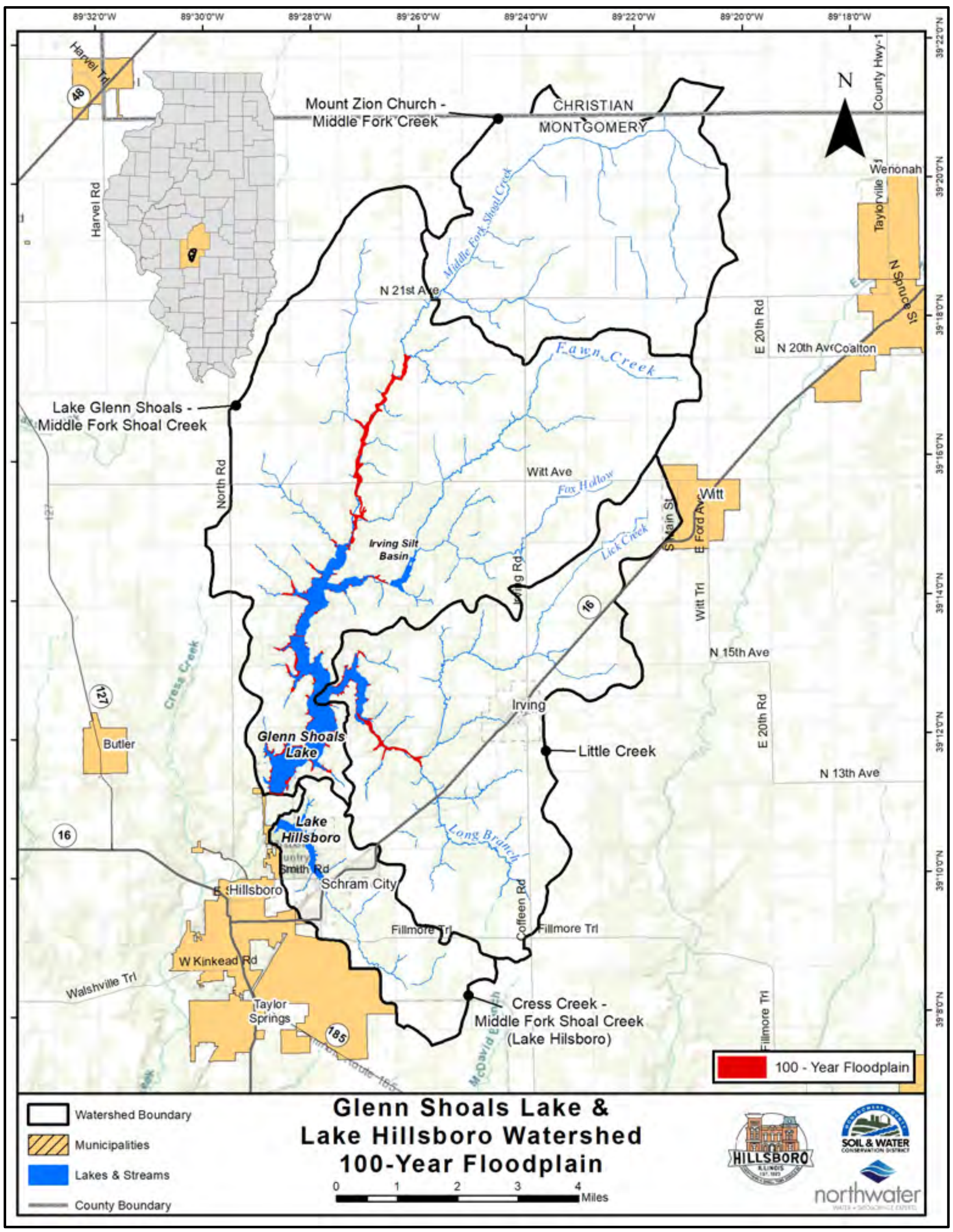


Figure 37 – 100 - Year Floodplain

3.14 Lake Shoreline & Streambank & Bed Erosion

Streambank/bed and lake shoreline erosion are sources of sediment and nutrients. An evaluation of the extent and severity of these sources was performed to quantify sediment, nitrogen and phosphorus loading. Streambank and bed erosion was estimated through direct observations during a windshield survey in the spring of 2023 followed by a more detailed assessment of high priority stream segments in the Glenn Shoals Lake watershed in December of 2023. During the windshield survey, data was captured with a GPS receiver at each road crossing to estimate average eroding bank height and annual recession rates. Results were extrapolated upstream and downstream from each crossing to the next observation point. Data was transferred into GIS to create a map layer representing general estimates of annual soil loss. The directly assessed segments included a stream walk with frequent measurements taken along each reach. Streambed erosion was only captured along these segments. A map book detailing results of the stream assessment is included in Appendix A.

Lake Hillsboro and Glenn Shoals Lake shoreline was assessed in the spring of 2023 by boat. The Irving Silt Basin was evaluated from shore. Erosion rates and bank heights were estimated and marked with a GPS receiver and transferred into a series of line files used to quantify soil loss and nutrient loading.

Annual sediment, nitrogen and phosphorus loads were calculated using equations below and adjusted to account for the trapping efficiency of BMPs. Eroding bank height, bank length and lateral recession rates (LRR) estimated in the field were transferred to GIS. Lake bank soil nutrient concentrations were estimated from soil cores obtained from representative areas within Glenn Shoals Lake. Soil nutrient concentrations for streambanks were derived from measured values from adjacent watersheds. The following equations were used to estimate total annual loads:

$$\boldsymbol{Sy = L \times LRR \times H \times yd \times SDR \times STF}$$

Sy – sediment yield in tons/yr
L – eroding bank length in feet
LRR – estimated lateral recession rate in feet per year
H – eroding bank height in feet
γd – Soil dry weight density (tons/ft^3)
SDR – Sediment Delivery Rate (1)
STF – Sediment Transport Factor (0.51 – 0.92)

$$\boldsymbol{TN = \left[Sy \times \frac{2000\ lbs}{1.0\ ton}\right] \times\ Nc\ x\ Cf}$$

TN – Total nitrogen load from lake banks and streambanks in lbs/yr
Sy – Sediment yield in tons/yr
Nc – Nitrogen concentration in soil (0.000643 lbs/lb, 0.000547 lbs/lbs for lakes)
Cf – Correction factor (1.0)

$$\boldsymbol{TP = \left[Sy \times \frac{2000\ lbs}{1.0\ ton}\right] \times\ Pc\ x\ Cf}$$

TP – Total phosphorus load from lake banks and streambanks in lbs/yr
Sy – Sediment yield in tons/yr
Pc – Phosphorus concentration in soil (0.000304 lbs/lb, 0.000435 lbs/lbs for lakes)
Cf – Correction factor (1.0)

3.14.1 Streambank Erosion

Streambank erosion is a natural process but the rate at which it occurs is often increased by human activities such as urbanization and agriculture. Bank erosion is typically a result of streambed incision and channel widening.

Streambank Erosion

Field observations indicate that the severity of streambank erosion is variable but, overall, moderate to high. Results indicate it is responsible for delivering 3,189 tons of sediment, 3,687 lbs of nitrogen, and 2,239 lbs of phosphorus annually to both lakes (Table 26 and Figure 38). This translates to 3,064 tons of sediment, 3,578 pounds of nitrogen, and 2,127 pounds of phosphorus to Glenn Shoals Lake and 124 tons of sediment, 110 pounds of nitrogen, and 112 pounds of phosphorus delivered to Lake Hillsboro annually. Streams in the watershed yield an average of 5.3 lbs of sediment per foot (Glenn Shoals 5.4 and Lake Hillsboro, 3.7). Many banks eroding at high rates are largely inaccessible, making localized stabilization difficult and costly. In many situations, the most effective treatments to limit delivery to the lake will involve reconnecting stream channels themselves to their natural floodplains. These practices are described in Section 6.

Table 26 – Streambank Erosion & Loading

Stream	Streambank Miles	Sediment Load (tons/year)	Sediment Load (lbs/ft of stream)	Nitrogen Load (lbs/year)	Phosphorus Load (lbs/year)
Glenn Shoals Lake					
Fawn Creek	15	405	10	516	250
Fox Hollow	10	62	2.2	56	54
Little Creek	19	558	11	667	376
Long Branch	8.1	198	9.2	240	131
Middle Fork Shoal Creek	30	382	4.8	454	260
Unnamed Tributary	133	1,459	4.2	1,644	1,056
Subtotal	***216***	***3,064***	***5.4***	***3,578***	***2,127***
Lake Hillsboro					
Unnamed Tributary	13	124	3.7	110	112
Grand Total	**229**	**3,189**	**5.3**	**3,687**	**2,239**

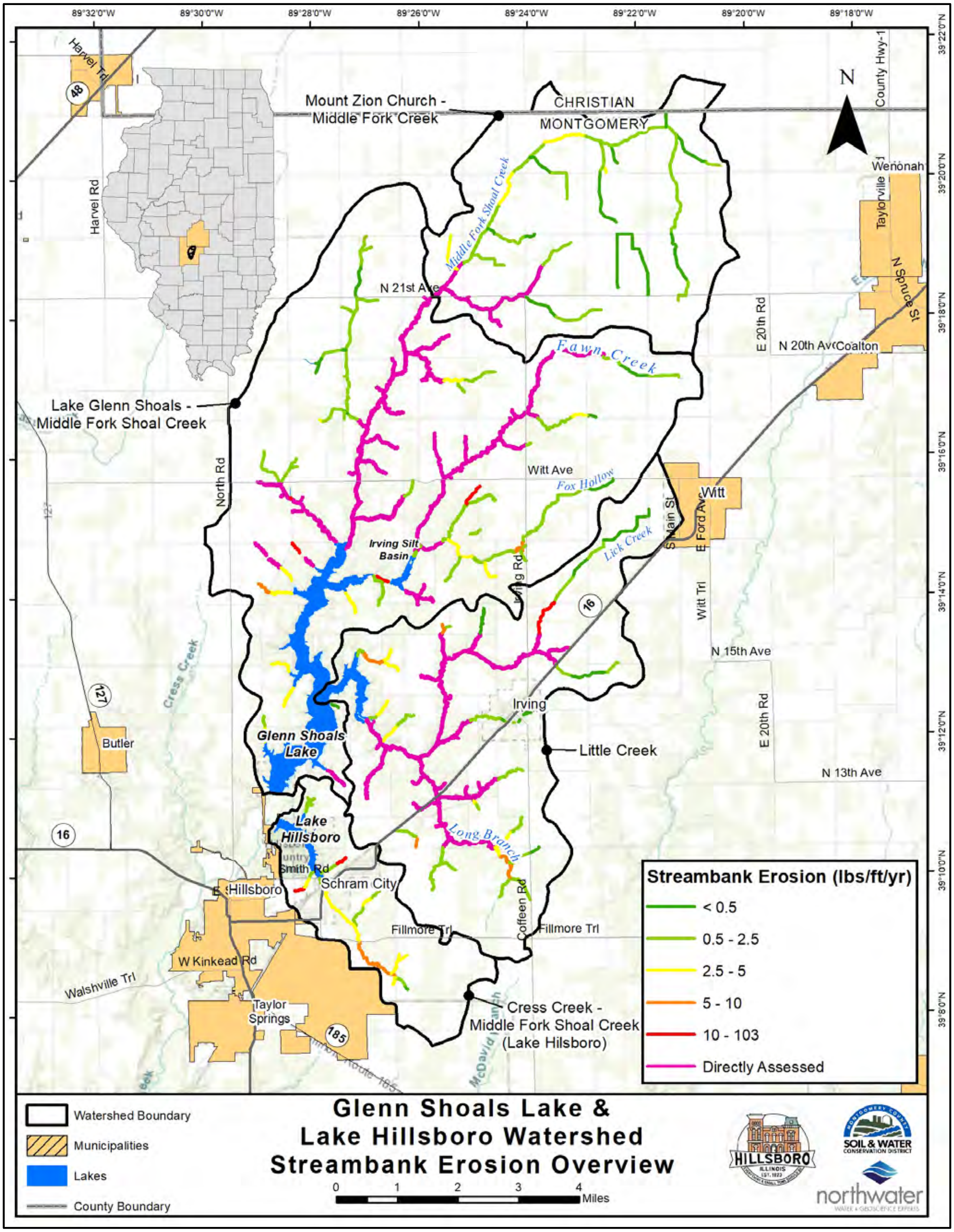


Figure 38 - Streambank Erosion

3.14.2 Streambed Erosion

Bed Erosion

Bed erosion, degradation or lowering, is a process by which the bed of the stream is eroded to a new lower level at a much faster rate than occurs naturally. This bed lowering is indicated by the presence of "knickpoints," or an abrupt change in a streams' longitudinal profile due to a change in base level, similar to a waterfall. Knickpoints migrate upstream and can be triggered by channel modification or changes in stream discharge. As knickpoints migrate upstream and the channel deepens, corresponding banks become steeper and more susceptible to failure. These features can be mitigated by installing stream riffles to stabilize grade.

A total of 48 knickpoints were observed in the Glenn Shoals Lake watershed, generally localized and concentrated along unnamed tributary segments. Most were observed to be slight with some exceptions, with one approximately 4 feet tall. Of note are the presence of numerous log jams observed during the stream assessment. Sixty-seven were recorded, mostly in Middle Fork Shoal Creek.

3.14.3 Lake Shoreline Erosion

A total of 170,095 ft, or 32.2 miles of Lake Hillsboro, Glen Shoals Lake and the Irving Silt Basin shoreline, was evaluated. Total annual sediment loading is 1,987 tons or an average of 23 lbs/ft with Glenn Shoals eroding an average of 28 lbs/ft versus Lake Hillsboro at 5.4 lbs/ft. Annual nitrogen loading is 2,176 lbs and phosphorus is 1,727 lbs (Table 27 and Figure 39). Overall, shoreline erosion is high due to Glenn Shoals Lake, the primary contributor. Lake Hillsboro and the Irving Silt Basin are only responsible for 4.8% of the total erosion. In Glenn Shoals, those banks eroding at more than 100 lbs/ft are responsible for 60% of the total sediment while only representing 6.5% of total shore length. Treating just these locations will eliminate most of the total sediment and nutrient load.

Table 27 – Lake Shoreline Erosion & Pollutant Loading

Lake Name	Bank Length (ft)	Average Eroding Bank Height (ft)	Average LRR (ft/yr)	Sediment Load (tons/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)
Glenn Shoals Lake	136,761	1.4	0.15	1,892	2,071	1,644
Lake Hillsboro	23,771	0.7	0.07	64	71	56
Irving Silt Basin	9,563	0.9	0.08	31	34	27
Total	**170,095**	**1.2**	**0.14**	**1,987**	**2,176**	**1,727**

Despite the high volume of sediment, a relatively high amount of shoreline is stabilized or eroding at very low rates. Seawalls and rock/concrete stabilization are common covering 24% of all shorelines in Glenn Shoals and Lake Hillsboro.

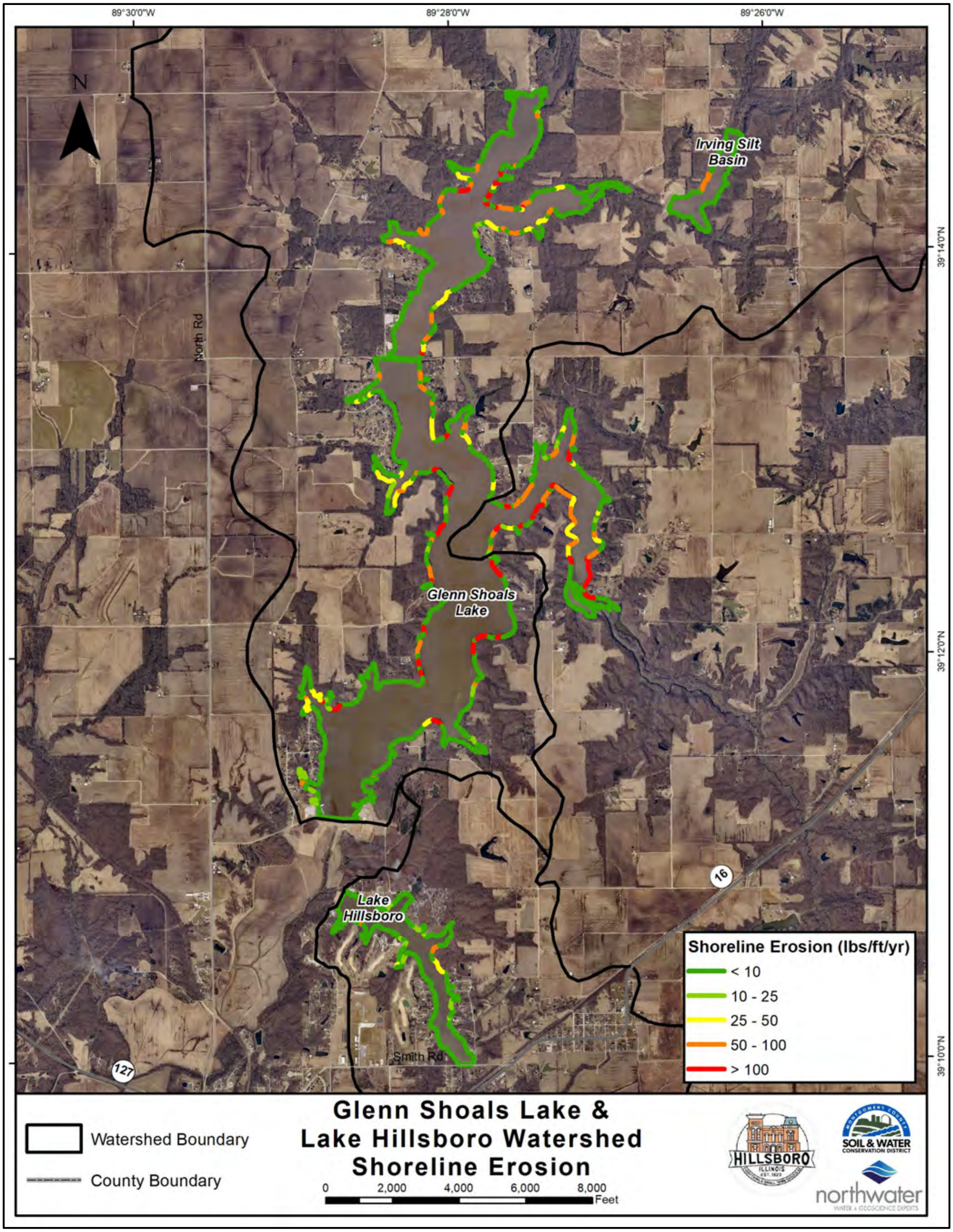


Figure 39 - Shoreline Erosion

3.15 Gully Erosion

Gully erosion is the removal of soil along drainage lines by surface water runoff. Once started, gullies will continue to move by headward erosion or by slumping of the side walls unless steps are taken to stabilize the disturbance. Gully erosion occurs when water is channeled across unprotected land and washes away the soil along the drainage lines. Under natural conditions, run-off is moderated by vegetation which generally holds the soil together, protecting it from excessive run-off and direct rainfall. To repair gullies, the objective is to divert and modify the flow of water moving into and through the gully so that scouring is reduced, sediment accumulates, and vegetation can establish. Stabilizing the gully head is important to prevent damaging water flow and headward erosion. In most cases, gullies can be prevented by good land management practices (Water Resources Solutions, 2014).

Gully erosion was evaluated during the watershed windshield survey, the stream assessment, individual landowner field visits, and estimated using GIS. Results presented in this section represent both ephemeral (those that form each year) and permanent (those that receive intermittent streamflow and expand over time such as a forested ditch or channel). For those ephemeral gullies not visible from a road or observed during the windshield survey, GIS was used to estimate their location and extent. Gullies were delineated using aerial imagery and high-resolution elevation data, and a conservative average estimated width, depth, and years eroding were applied. For gullies observed in the field, dimensions were directly measured and transferred to GIS for analysis.

Total net erosion in tons/year and estimates of nitrogen and phosphorus loading were calculated using the equations below. A distance-based delivery ratio was applied to account for distance to a receiving waterbody. Sediment trapping efficiency was accounted for, if the gully drained to a pond or other BMP. Soil nutrient concentrations were obtained from measured data in similar watersheds and the United States Environmental Protection Agency (USEPA) Spreadsheet Tool for the Estimation of Pollutant Load (STEPL). The following equations were applied to estimate gully erosion and nutrient yields:

$$Sy = \left\{\frac{L \times W \times H}{Y} \times \gamma d\right\} DPS^{0.2069}$$

Sy – sediment yield in tons/yr
L – gully length in feet
W – gully width in feet
D -gully depth in feet
Y – years eroding
γd – Soil dry weight density (tons/ft^3)
$DPS^{0.2069}$- Distance to lake or perennial stream or waterbody in feet, delivery ratio

$$TN = \left[Sy \times \frac{2000\ lbs}{1.0\ ton}\right] \times Nc\ x\ Cf$$

TN – Total nitrogen load from gully in lbs/yr
Sy – Sediment yield in tons/yr
Nc – Nitrogen concentration in soil (lbs/lb)
Cf – Correction factor, 1.0

$$TP = \left[Sy \times \frac{2000\ lbs}{1.0\ ton}\right] \times Pc\ x\ Cf$$

TP – Total phosphorus load from gully in lbs/yr
Sy – Sediment yield in tons/yr
Pc – Phosphorus concentration in soil (lbs/lb)
Cf – Correction factor, 1.0

Gully erosion in the watersheds occurs primarily at ephemeral water courses adjacent to major perennial drainage ways. It is also evident on crop ground, especially on long slopes where subsurface drainage is occurring. Conservation practices observed in the watershed, such as WASCBs or grassed waterways and other grade control structures, have been implemented to address this specific type of erosion.

Gully Erosion

Results indicate that there are 108 miles of eroding gullies (Figure 40), with an average depth of 1.2 ft and an average width of 1.7 ft (Table 28). Gullies are responsible for the annual delivery of 3,020 tons of sediment, 3,106 lbs of nitrogen and 1,257 lbs of phosphorus.

An analysis by land use type is also presented in Table 28. The highest sediment and nutrient loads from gully erosion originate from forested areas or 65% of the sediment, 32% of the nitrogen, and 58% of the phosphorus. Within both the Glenn Shoals Lake and Lake Hillsboro drainage areas, forested gully erosion is responsible for most of the sediment load, at 64% and 71% respectively. Cropland is responsible for 19% of the gully sediment load, 36% of the nitrogen, and 25% of the phosphorus. Forested areas contribute substantially more sediment due to high rates of delivery and proximity to receiving streams.

Table 28 – Gully Erosion & Pollutant Loading

Land Use Category	Gully Length (ft)	Gully Length (miles)	Average Gully Width (ft)	Average Gully Depth (ft)	Sediment (tons/yr)	Nitrogen (lbs/yr)	Phosphorus (lbs/yr)
Glenn Shoals Lake							
Forest	337,813	64	2	1.5	1,767	890	652
Row Crops	173,703	33	0.8	0.4	517	1,034	289
Grasslands	42,970	8.1	2	1.4	386	772	139
Pasture	12,586	2.4	1.8	1.4	59	118	46
Open Space	1,645	0.3	2	1.5	16	32	16
Dirt Driveway	59	0.01	2.8	1.8	0.6	1.1	0.6
Subtotal	***568,777***	***108***	***1.7***	***1.2***	***2,746***	***2,847***	***1,143***
Lake Hillsboro							
Forest	54,288	10.3	2	1.5	194	98	72
Row Crops	16,462	3.1	0.8	0.4	49	98	29
Grasslands	12,156	2.3	1.6	1.1	28	55	10
Pasture	749	0.1	1.7	1.3	2	4.1	1.7
Open Space	361	0.1	1.9	1.3	1.4	2.9	1.4
Golf Course	88	0.02	1	1	0.002	0.005	0.002
Dirt Driveway	23	0.005	3	1.5	0.06	0.2	0.06
Subtotal	***84,128***	***16***	***1.6***	***1.2***	***275***	***259***	***114***
Grand Total	**652,905**	**124**	**1.7**	**1.2**	**3,020**	**3,106**	**1,257**

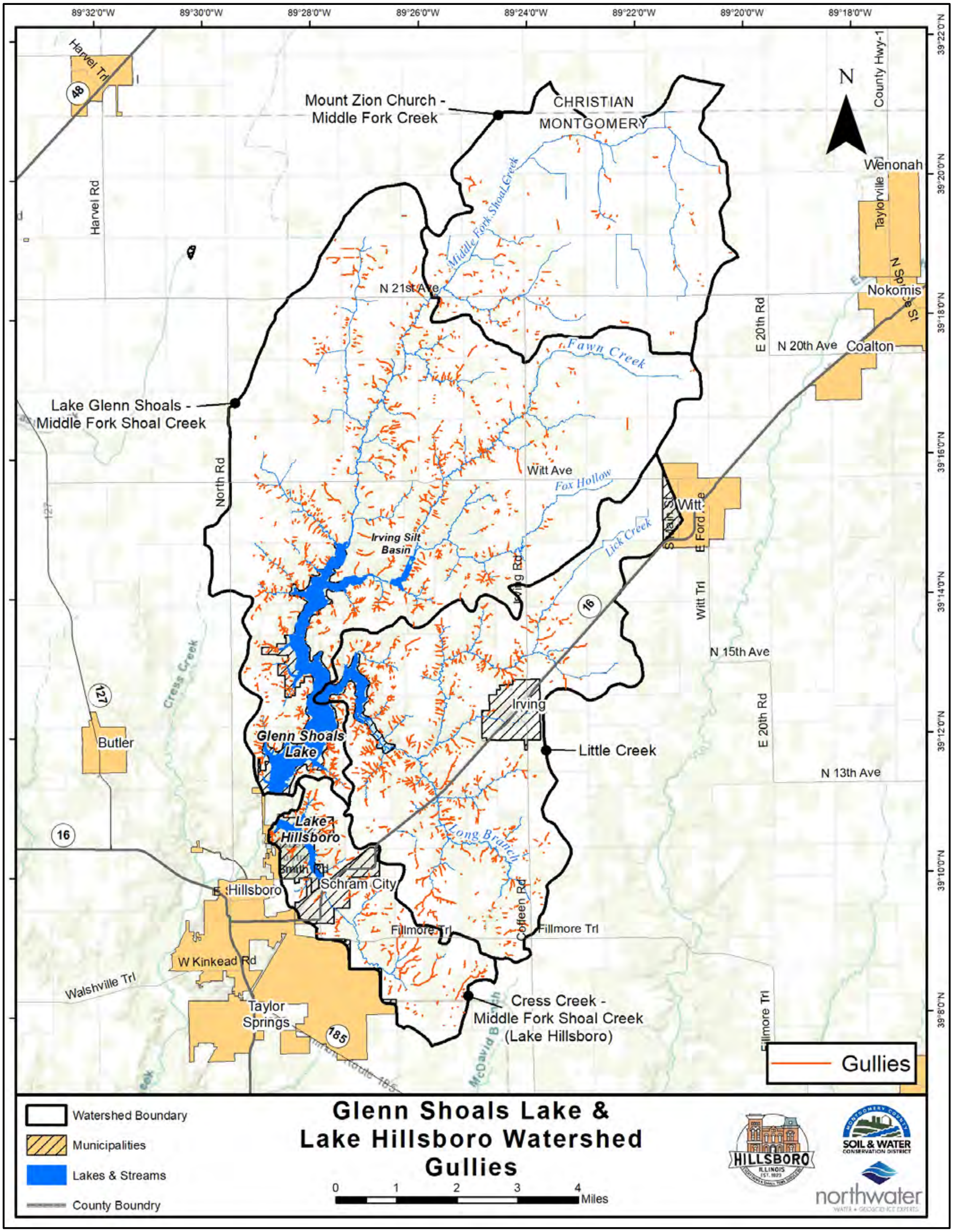


Figure 40 – Gully Erosion

3.16 Sheet & Rill Erosion

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. The extent of sheet and rill erosion in the watershed was calculated using the Universal Soil Loss Equation (USLE), which is widely used to estimate rates caused by rainfall and associated overland flow. This method relies on soil properties, precipitation, slope, cover types and conservation practices (if applicable). A map-based USLE model was developed for all cropped soils within the watershed and used to quantify sediment loading from agricultural ground and identify locations with the potential for excessive erosion.

Analysis shows sheet and rill erosion from cropland is responsible for the annual delivery of 42,913 tons of sediment or 1.14 tons/ac/yr delivered to Glenn Shoals Lake and 1.27 tons/ac/yr delivered to Lake Hillsboro (Table 29). Modeled results indicate that the majority originates from mulch-tilled fields and from HEL/PHEL soils (Section 5) and those fields closest to a stream or other waterbody.

Conventional tillage that, on average, delivers 0.89 ton/ac/yr, represents 3.5% of all cropland and is responsible for the annual delivery of 5.6% of the entire cropland sediment load. Although these fields yield the greatest per acre, mulch-till is responsible for 55% of the total delivered sediment (Table 29), primarily due to higher overall acreage. No-Till covers 28% of cropped acres, but only contributes 24% of cropland sediment. Cover crops represent 5.6% of all cropland and deliver only 2.3% of the sediment load at a yield of 0.46 tons/ac/yr.

Table 29 – Sheet & Rill Erosion Loading by Tillage Type

Tillage Type	Total Area (ac)	% Cropland	Sediment Load (tons/yr)	Sediment Load (tons/ac/yr)	% Total Sediment Load from Sheet & Rill Erosion
Glenn Shoals Lake					
Mulch-Till	17,807	49%	22,585	1.27	55%
No-Till	9,908	27%	9,568	0.97	23%
Reduced-Till	3,577	9.9%	5,128	1.43	12%
Cover Crop[1]	2,018	5.6%	946	0.47	2.3%
Hay\Wheat\Clover[1]	1,549	4.3%	516	0.33	1.3%
Conventional	1,183	3.3%	2,283	1.93	5.6%
Subtotal	***36,043***	***100%***	***41,026***	***1.14***	***100%***
Lake Hillsboro					
No-Till	612	41%	749	1.22	40%
Mulch-Till	547	37%	934	1.71	49%
Conventional	123	8.3%	109	0.89	5.8%
Cover Crop[1]	86	5.8%	28	0.33	1.5%
Reduced-Till	79	5.3%	63	0.79	3.3%
Hay\Wheat[1]	37	2.5%	3.7	0.1	0.2%
Subtotal	***1,484***	***100%***	***1,887***	***1.27***	***100%***
Grand Total	**37,527**	**100%**	**42,913**	**1.14**	**100%**

[1] – Not a tillage practice

3.17 Point Source Pollution

Point source pollution in the watershed comes from NPDES permitted dischargers. Septic systems, although typically considered to be a nonpoint source issue, exist in the watershed and may be contributing to nutrient loading in certain areas. Failing septic systems can leach wastewater into groundwater and surrounding waterways. Point source pollution is defined by the USEPA as “any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack” (Hill, 1997). The NPDES, a provision of the Clean Water Act, prohibits point source discharge of pollutants into waters of the U.S. unless a permit is issued by the USEPA or a state or tribal government. Individual permits are specific to individual facilities (e.g., water or wastewater treatment facilities), and general permits cover facilities with similar treatment types and effluent. Permits describe the allowed discharge of pollutant concentrations (mg/L) and loads (lbs/day). Permitted discharges contribute a measurable portion of annual nutrient load in the watershed.

3.17.1 NPDES Dischargers

The watershed contains two facilities permitted to discharge. One is the Hillsboro water treatment plant in the Lake Hillsboro watershed, and one is the Irving sewage treatment plant that discharges to Little Creek in the Glenn Shoals Lake drainage. Sediment and nutrient loading were calculated using data from the USEPA, and from NPDES permit documents. Data was partial for one. Accounting for delivery to both lakes, permitted NPDES dischargers are responsible for a total of 2.1 tons/yr sediment, 1,128 lbs/yr phosphorus, and 818 lbs/yr nitrogen (Table 30).

Table 30 – NPDES Facilities & Pollutant Loading

NPDES Permit Number	Current Permit Name	Permit Type	Nitrogen Load (lbs/yr)	Phosphorous Load (lbs/yr)	Sediment Load (tons/ yr)
IL0053881	Irving STP	Individual permit	818	1,128	1.8
ILG640236	Hillsboro WTP	General Permit Covered Facility	N/A[1]	N/A[1]	0.26
Total			**818**	**1,128**	**2.1**

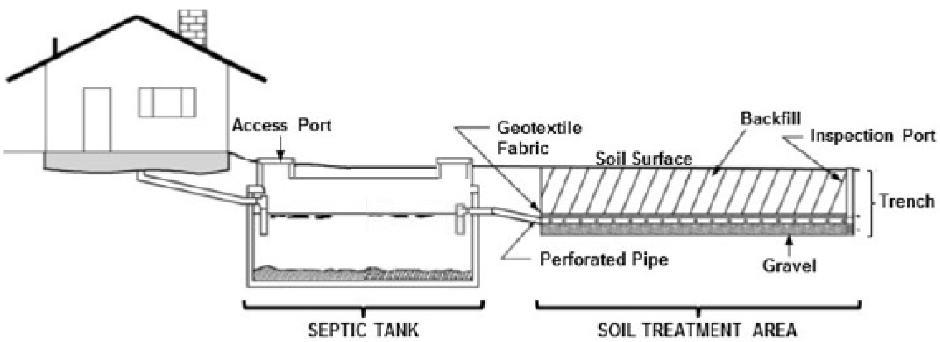
[1] - No monitoring data available

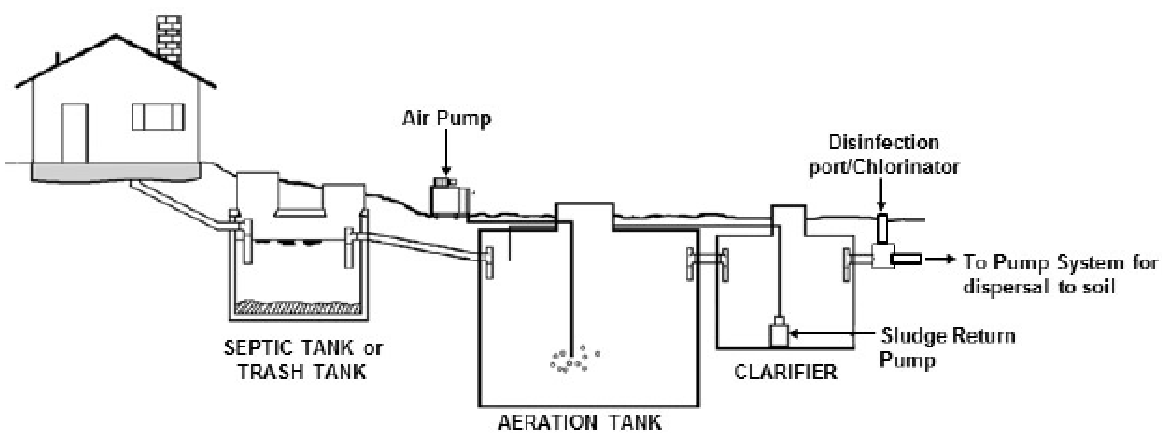
3.18 Septic Systems

Outside of sewered areas, septic systems provide treatment of wastewater from individual properties and structures. When failing, they can be an active source of pollutants. Faulty or leaking septic systems are sources of bacteria, nitrogen, and phosphorus. Typical national failure rates are 10-20% but vary widely depending on the local definition of failure; no rates are reported specifically for Illinois (USEPA, 2002). Fifteen percent was used for analysis, consistent with other watershed plans in Illinois and after confirming with the local county health department.

Every home and structure in the subwatershed not served by a sewer system were located and mapped using GIS to estimate the number of individual structures using septic systems. Corresponding nitrogen and phosphorus loads were estimated using STEPL.

There are an estimated 514 septic systems in the combined watershed. Assuming a rate of 15%, it is possible that 77 structures have failing septic systems. Due to the planning nature of this analysis, the exact number of systems is unknown. Potentially failing systems contribute an estimated 2,398 lbs/yr of nitrogen and 939 lbs/yr of phosphorous. For the purposes of this report, it is assumed that these loadings do make it to waterways, however, loading is a function of location to a waterway, and it is possible that some portion of septic water may be absorbed or filtered prior. Systems range from 16 to 4,995 ft from a receiving waterbody. Average distance is 626 ft, and the median is 292 ft. Approximately 82% of all systems are at or less than 1,000 ft from receiving waterbody. In the Glenn Shoals Lake watershed there are 424 systems, approximately 64 of which are likely failing, with 80% of all systems within 1,000 feet of a receiving waterbody. There are 90 systems in the Lake Hillsboro watershed area with approximately 14 likely failing, 91% of which are within 1,000 ft of a receiving waterbody.





Septic Systems: Conventional (above) and Aerobic Treatment (below)
Credit: OSU 2017

4.0 Pollutant Loading

4.1 Introduction

A watershed survey was completed to gain an understanding of conditions and features and to collect field-specific data. This included: tillage practices, cover types, existing project (BMP) locations and site suitability, and sources of sediment and gully erosion. This survey, combined with interpretation of aerial imagery, resulted in the identification of site-specific BMP locations. Drainage areas were then delineated for each and incorporated into the modeling detailed in this section.

A spatially explicit GIS-based pollution loading model (SWAMM) was developed to estimate loading from direct runoff and tile or subsurface flow. The model simulates surface runoff and loading using the curve number approach, local precipitation, the USLE, and Event Mean Concentrations (EMCs) specific to land use and soil types. In addition, field survey data was incorporated, such as tillage practices and existing BMPs. The model accounts for subsurface tile flow by allocating a percentage of annual rainfall. It was not directly calibrated due to a lack of watershed-specific measured water quality and streamflow data. Loads were compared to other adjacent watersheds and past studies to ensure results are in the correct range.

4.2 Pollutant Loading

Pollutant load estimates are presented in this section and are provided for septic systems, NPDES dischargers, surface runoff and tile flow, gully erosion, and streambank erosion. Gully and streambank erosion were observed in the field to the extent it was visible. Loading from septic systems was estimated based on those homes not connected to a wastewater treatment system, and NPDES discharge data were acquired from the USEPA and other sources. Results from the GIS-based direct surface runoff and tile flow pollution load model are illustrated in Figure 41, Figure 42, and Figure 43. Loading from direct, surface runoff and tile accounts for what is contributed from overland flow and tiles.

As presented in Table 31, total annual loading from all sources to both lakes is 553,466 lbs of nitrogen, 87,398 lbs of phosphorus, and 51,867 tons of sediment. Direct runoff and tile flow combined are responsible for 96% of the nitrogen load, 86% of the phosphorus, and 84% of the sediment load. Loading from tile flow is likely responsible for approximately 11% of the total nitrogen and 1.6% of the total phosphorus load. All other sources combined - failing septic systems, streambank and lake shoreline erosion, internal lake nutrient release, point source discharges, and gully erosion account for 4% of the nitrogen, 14% of the phosphorus, and 16% of the sediment load.

Glenn Shoals Lake receives 508,402 lbs/yr nitrogen, 79,828 lbs/yr phosphorus and 49,405 tons/yr sediment versus 45,064 lbs/yr nitrogen, 7,570 lbs/yr phosphorus and 2,463 tons/yr sediment for Lake Hillsboro.

Table 31 – Pollution Loading Summary

Pollution Source	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)	Nitrogen Load (% total)	Phosphorus Load (% total)	Sediment Load (% total)
Glenn Shoals Lake						
Surface Runoff & Tile Flow	488,468	68,851	41,671	96%	86%	84%
Streambank Erosion	3,577	2,127	3,064	0.7%	2.7%	6.2%
Gullies	2,847	1,143	3,064	0.6%	1.4%	5.6%
Lake Shoreline Erosion	2,105	1,672	1,923	0.4%	2.1%	3.9%
Septic Systems	1,978	774	N/A	0.4%	1%	N/A
NPDES	818	1,128	1.8	0.2%	1.4%	0.004%
In-Lake Loading	8,609	4,133	N/A	1.7%	5.2%	N/A
Subtotal	**508,402**	**79,828**	**49,405**	**100%**	**100%**	**100%**
Lake Hillsboro						
Surface Runoff & Tile Flow	42,145	6,417	1,999	88%	73%	81%
Streambank Erosion	110	112	124	0.2%	1.3%	5.1%
Gullies	259	114	275	6.6%	1.5%	11%
Lake Shoreline Erosion	71	56	64	0.1%	0.7%	2.6%
Septic Systems	420	164	N/A	0.9%	1.9%	N/A
NPDES	N/A	N/A	0.26	N/A	N/A	0.01%
In-Lake Loading	2,061	707	N/A	4.4%	8.3%	N/A
Subtotal	***45,064***	***7,570***	***2,463***	***100%***	***100%***	***100%***
Grand Total	**553,466**	**87,398**	**51,867**			

Modeled pollution loading from surface runoff and subsurface tile flow is reported in Table 32, and depicted in Figure 41, Figure 42, and Figure 43. Per-acre results are calculated by dividing the total annual load of a given land use category by the total number of acres. Results show that row crops have the highest per-acre sediment load. Row crops and livestock feed areas have the highest per-acre nitrogen load. Feed areas deliver the highest per-acre phosphorus loads.

In the combined watershed, cropland delivers 502,006 lbs/yr of nitrogen, or 13 lbs/ac/yr, 66,380 lbs/yr of phosphorus, or 1.8 lbs/ac/yr and 42,913 tons/ty, or 1.1 tons/ac/yr of sediment. Row crops draining to Glenn Shoals Lake deliver 467,847 lbs/yr of nitrogen, or 13 lbs/ac/yr, 62,335 lbs/yr of phosphorus, or 1.7 lbs/ac/yr and 41,026 tons/yr, or 1.1 tons/ac/yr of sediment, whereas Lake Hillsboro receives 34,159 lbs/yr of nitrogen, or 23 lbs/ac/yr, 4,045 lbs/yr of phosphorus, or 2.7 lbs/ac/yr and 1,887 tons/yr, or 1.3 tons/ac/yr of sediment. It is important to note that these results represent delivered loads for all fields combined. Individual fields deliver soil and nutrients at different rates based on tillage practices, soil and slope characteristics, proximity to a waterbody, and whether a BMP is in place.

Other land use categories, such as forest, open space and residential areas, are also relatively high contributors of nutrients and sediment. Although forest and open space have low per-acre values compared to other categories, the two lake watersheds contain a higher percentage and, therefore, cumulative loading is higher.

Table 32 – Pollution Loading from Surface & Subsurface Runoff by Land Use

Land Use Category	Area (ac)	Nitrogen Load		Phosphorus Load		Sediment Load	
		Lbs/ac	lbs/ac/yr	Lbs/ac	lbs/ac/yr	tons/ac	tons/ac/yr
Glenn Shoals Lake							
Row Crops	36,043	467,847	13	62,335	1.7	41,026	1.1
Forest	5,506	4,784	0.9	1,795	0.3	255	0.05
Grasslands	3,404	1,601	0.5	644	0.2	50	0.01
Open Space	1,404	1,917	1.4	382	0.3	42	0.03
Open Water Pond/Reservoir[2]	1,335	2,670	2	692	0.5	16	0.01
Pasture	606	4,381	7.2	1,393	2.3	104	0.2
Roads[1]	365	1,489	4.1	461	1.3	79	0.2
Open Water Stream[2]	204	1,463	7.2	356	1.7	3.9	0.02
Driveway	149	473	3.2	188	1.3	30	0.2
Farm Building	63	593	9.4	125	2	18	0.3
Residential	63	667	31	190	3	23	0.4
Wetlands	44	36	0.8	1.7	0.04	0.1	0.001
Parking Lot[1]	28	107	3.8	46	1.6	7.4	0.3
Railroad	26	52	2	19	0.7	3.2	0.1
Parks & Recreation	19	23	1.2	18	0.9	0.3	0.02
Feed Area	14	222	16	133	9.4	5	0.4
Cemetery	14	26	1.8	12	0.9	0.6	0.05
Junkyard	11	17	1.6	7.1	0.7	1.5	0.1
Confinement	9.4	75	8	42	4.4	1.7	0.2
Open Water Pond/Reservoir Non-Discharging	8.4	0.03	0.004	0.01	0.001	0.0001	0.00001
Utilities	1.7	5.6	3.3	2.9	1.7	0.3	0.2
Commercial	1.3	7	5.3	2.5	1.9	0.3	0.2
Warehousing	1.0	4.2	4.4	1.6	1.7	0.2	0.2
Campground	0.8	1.4	1.7	0.7	0.8	0.1	0.1
Institutional	0.7	3.9	5.5	1.5	2.1	0.2	0.3
Dry Detention Basin	0.7	0.6	0.9	0.1	0.2	0.02	0.02
Beach	0.6	1	1.8	0.3	0.6	0.02	0.03
Boat Ramp	0.2	0.8	3.2	0.4	1.8	0.02	0.1
Solar Farm	0.1	0.3	2.8	0.1	1.1	0.01	0.1
Glenn Shoals Lake Subtotal[3,4]	***49,323***	***488,468***	***10***	***68,851***	***1.4***	***41,671***	***0.8***

Land Use Category	Area (ac)	Nitrogen Load		Phosphorus Load		Sediment Load	
		Lbs/ac	lbs/ac/yr	Lbs/ac	lbs/ac/yr	tons/ac	tons/ac/yr
Lake Hillsboro							
Row Crops	1,484	34,159	23	4,045	2.7	1,887	1.3
Grasslands	970	786	0.8	342	0.4	11	0.01
Forest	810	1,656	2	484	0.6	29	0.04
Open Space	290	894	3.1	158	0.5	8	0.03
Open Water Pond/Reservoir[2]	130	600	4.6	107	0.8	1.1	0.01
Solar Farm	85	460	5.4	147	1.7	3.7	0.04
Wetlands	70	96	1.4	3.2	0.05	0.05	0.001
Roads[1]	68	616	9.1	180	2.6	15	0.2
Golf Course	56	242	4.3	128	2.3	1.9	0.03
Pasture	49	582	12	163	3.3	6.2	0.1
Parks & Recreation	44	119	2.7	80	1.8	0.6	0.01
Driveway	41	270	6.6	95	2.3	7.1	0.2
Residential	39	802	78	198	5.1	11	0.3
Railroad	22	92	4.1	35	1.6	2.7	0.1
Parking Lot[1]	21	167	7.8	65	3.1	4.9	0.2
Open Water Stream[2]	12	217	18	43	3.5	0.2	0.02
RV Park	11	168	15	76	6.9	3.9	0.4
Manufacturing	6.7	59	8.8	24	3.6	1.8	0.3
Farm Building	4.7	111	24	21	4.4	1.5	0.3
Commercial	3.1	30	10	12	3.8	0.6	0.2
Warehousing	1.9	18	9.3	8.1	4.2	0.5	0.3
Institutional	0.7	8.8	12	3.3	4.5	0.2	0.3
Dry Detention Basin	0.6	1.5	2.5	0.2	0.4	0.01	0.02
Feed Area	0.5	18	38	11	22	0.2	0.4
Open Water Pond/Reservoir Non-Discharging	0.3	0.003	0.01	0.0005	0.001	0.000003	0.00001
Utilities	0.02	0.2	7.5	0.1	3.3	0.004	0.2
Lake Hillsboro Subtotal[3,4]	***4,218***	***42,145***	***10***	***6,417***	***1.5***	***1,999***	***0.5***
Grand Total	**53,542**	**530,613**	**9.9**	**75,267**	**1.4**	**43,670**	**0.8**

[1] – Roads/parking lots yield high nutrient loads from rapid runoff and relatively high Event Mean Concentration values from existing literature.
[2] – High nutrient yields for streams and, to a lesser extent, ponds and reservoirs are the result of legacy nutrients from the watershed already in the water column and, therefore, high measured event concentrations. When combined with high runoff rates and rapid delivery of water through the system, yield results exceed other land use categories. This is a limitation of the model used for estimating surface runoff loading.
[3] - loading from the septic systems themselves is not included in this total. Table 31 quantifies septic system loading separately.
[4] – per acre values in this column represent total loading divided by the total watershed area and is an overall average.

Table 33 compares the loadings originating from direct runoff and tile flow with the watershed load from all sources. Row crops are the greatest contributor, responsible for 90% of the total nitrogen, 75% of total phosphorus, and 83% of the total sediment load. Direct runoff from cropland draining to Glenn Shoals

Lake contributes 91% of the total nitrogen, 78% of total phosphorus, and 83% of the total sediment load draining to Glenn Shoals Lake, whereas runoff from cropland draining to Lake Hillsboro contributes 72% of the total nitrogen, 48% of total phosphorus, and 77% of the total sediment load. Forests are the second highest contributor of sediment, albeit only 0.6%. Forests, pasture, and open water ponds are the next three highest contributors of surface runoff nitrogen loads, at 1.2%, 0.9% and 0.6%, respectively. Forests, pasture, and grasslands contribute 2.6%, 1.8% and 1.1% of total phosphorus, respectively.

Table 33 – Loading from Surface & Subsurface Runoff by Land Use as Percentage of Watershed Load

Land Use Category	Area (ac)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	% Total Load	lbs/yr	% Total Load	tons/yr	% Total Load
Glenn Shoals Lake							
Row Crops	36,043	467,847	91%	62,335	78%	41,026	83%
Forest	5,506	4,784	0.9%	1,795	2.2%	255	0.5%
Grasslands	3,404	1,601	0.3%	644	0.8%	50	0.1%
Open Space	1,404	1,917	0.4%	382	0.5%	42	0.1%
Open Water Pond/Reservoir	1,335	2,670	0.5%	692	0.9%	16	0.03%
Pasture	606	4,381	0.9%	1,393	1.7%	104	0.2%
Roads	365	1,489	0.3%	461	0.6%	79	0.2%
Open Water Stream	204	1,463	0.3%	356	0.4%	3.9	0.01%
Driveway	149	473	0.1%	188	0.2%	30	0.1%
Farm Building	63	593	0.1%	125	0.2%	18	0.04%
Residential	63	667	0.1%	190	0.2%	23	0.05%
Wetlands	44	36	0.01%	1.7	0.002%	0.1	0.0001%
Parking Lot	28	107	0.02%	46	0.1%	7.4	0.01%
Railroad	26	52	0.01%	19	0.02%	3.2	0.01%
Parks & Recreation	19	23	0.005%	18	0.02%	0.3	0.001%
Feed Area	14	222	0.04%	133	0.2%	5.0	0.01%
Cemetery	14	26	0.01%	12	0.02%	0.6	0.001%
Junkyard	11	17	0.003%	7.1	0.01%	1.5	0.003%
Confinement	9.4	75	0.01%	42	0.1%	1.7	0.003%
Open Water Pond/Reservoir Non-Discharging	8.4	0.03	0.00001%	0.01	0.00001%	0.0001	0.0000002%
Utilities	1.7	5.6	0.001%	2.9	0.004%	0.3	0.001%
Commercial	1.3	7	0.001%	2.5	0.003%	0.3	0.001%
Warehousing	1.0	4.2	0.001%	1.6	0.002%	0.2	0.0004%
Campground	0.8	1.4	0.000%	0.7	0.001%	0.1	0.0001%
Institutional	0.7	3.9	0.001%	1.5	0.002%	0.2	0.0004%
Dry Detention Basin	0.7	0.6	0.0001%	0.1	0.0002%	0.02	0.00003%
Beach	0.6	1	0.0002%	0.3	0.0004%	0.02	0.00004%

Land Use Category	Area (ac)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	% Total Load	lbs/yr	% Total Load	tons/yr	% Total Load
Boat Ramp	0.2	0.8	0.0002%	0.4	0.001%	0.02	0.00003%
Solar Farm	0.1	0.3	0.0001%	0.1	0.0001%	0.01	0.00002%
Subtotal	***49,323***	***488,468***	***97%***	***68,851***	86%	***41,671***	84%
Lake Hillsboro							
Row Crops	1,484	34,159	72%	4,045	48%	1,887	77%
Grasslands	970	786	1.7%	342	4%	11	0.4%
Forest	810	1,656	3.5%	484	5.7%	29	1.2%
Open Space	290	894	1.9%	158	1.9%	8	0.3%
Open Water Pond/Reservoir	130	600	1.3%	107	1.3%	1.1	0.04%
Solar Farm	85	460	1%	147	1.7%	3.7	0.2%
Wetlands	70	96	0.2%	3.2	0.04%	0.05	0.002%
Roads	68	616	1.3%	180	2.1%	15	0.6%
Golf Course	56	242	0.5%	128	1.5%	1.9	0.1%
Pasture	49	582	1.2%	163	1.9%	6.2	0.3%
Parks & Recreation	44	119	0.3%	80	0.9%	0.6	0.03%
Driveway	41	270	0.6%	95	1.1%	7.1	0.3%
Residential	39	802	1.7%	198	2.3%	11	0.4%
Railroad	22	92	0.2%	35	0.4%	2.7	0.1%
Parking Lot	21	167	0.4%	65	0.8%	4.9	0.2%
Open Water Stream	12	217	0.5%	43	0.5%	0.2	0.01%
RV Park	11	168	0.4%	76	0.9%	3.9	0.2%
Manufacturing	6.7	59	0.1%	24	0.3%	1.8	0.1%
Farm Building	4.7	111	0.2%	21	0.2%	1.5	0.1%
Commercial	3.1	30	0.1%	12	0.1%	0.6	0.03%
Warehousing	1.9	18	0.04%	8.1	0.1%	0.5	0.02%
Institutional	0.7	8.8	0.02%	3.3	0.0%	0.2	0.01%
Dry Detention Basin	0.6	1.5	0.003%	0.2	0.0%	0.01	0.0005%
Feed Area	0.5	18	0.04%	11	0.1%	0.2	0.01%
Open Water Pond/Reservoir Non-Discharging	0.3	0.003	0.00001%	0.0005	0.00001%	0.000003	0.0000001%
Utilities	0.02	0.2	0.0003%	0.1	0.001%	0.004	0.0002%
Subtotal	***4,218***	***42,145***	***89%***	***6,417***	***76%***	***1,999***	***81%***
Grand Total	**53,542**	**530,613**	**96%**	**75,267**	**87%**	**43,670**	**88%**

Note: Percentages do not add up to 100% because direct runoff is not the only source of loading in the watershed. Streambank and lake shoreline erosion, gully erosion, septic systems, and NPDES dischargers are responsible for the remaining percentage.

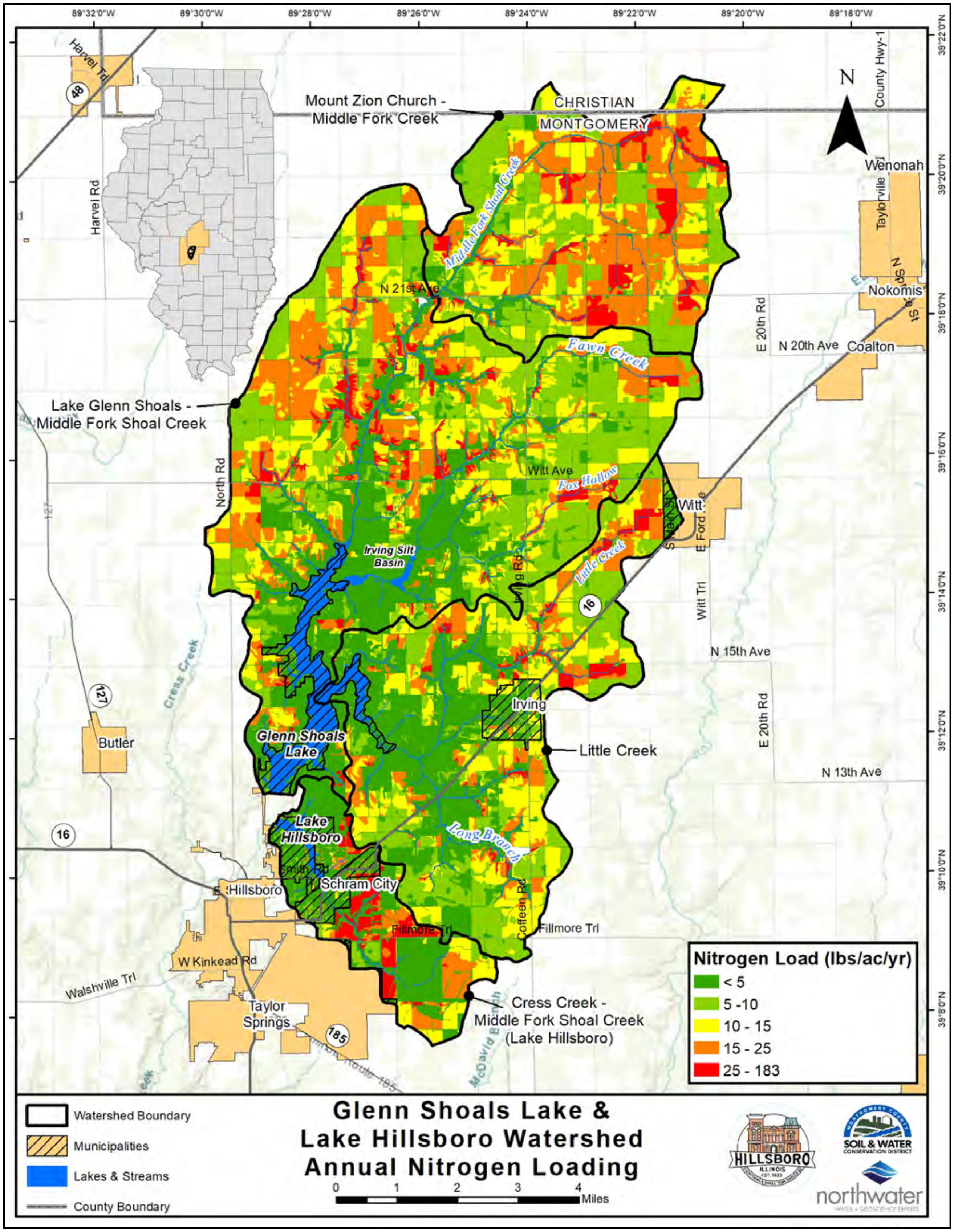


Figure 41 – Annual Nitrogen Loading Per Acre from Direct Surface & Subsurface Runoff

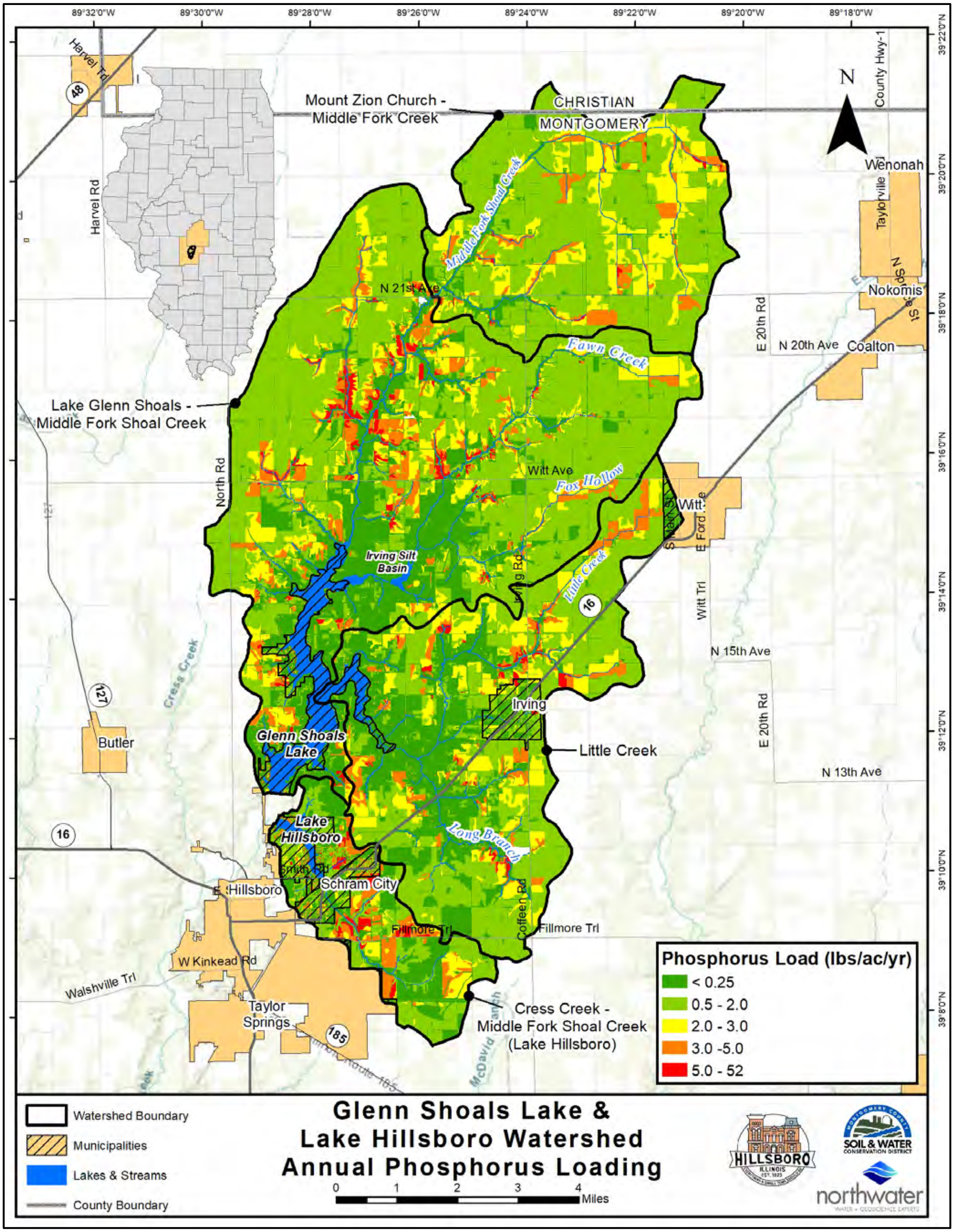


Figure 42 – Annual Phosphorus Loading Per Acre from Direct Surface & Subsurface Runoff

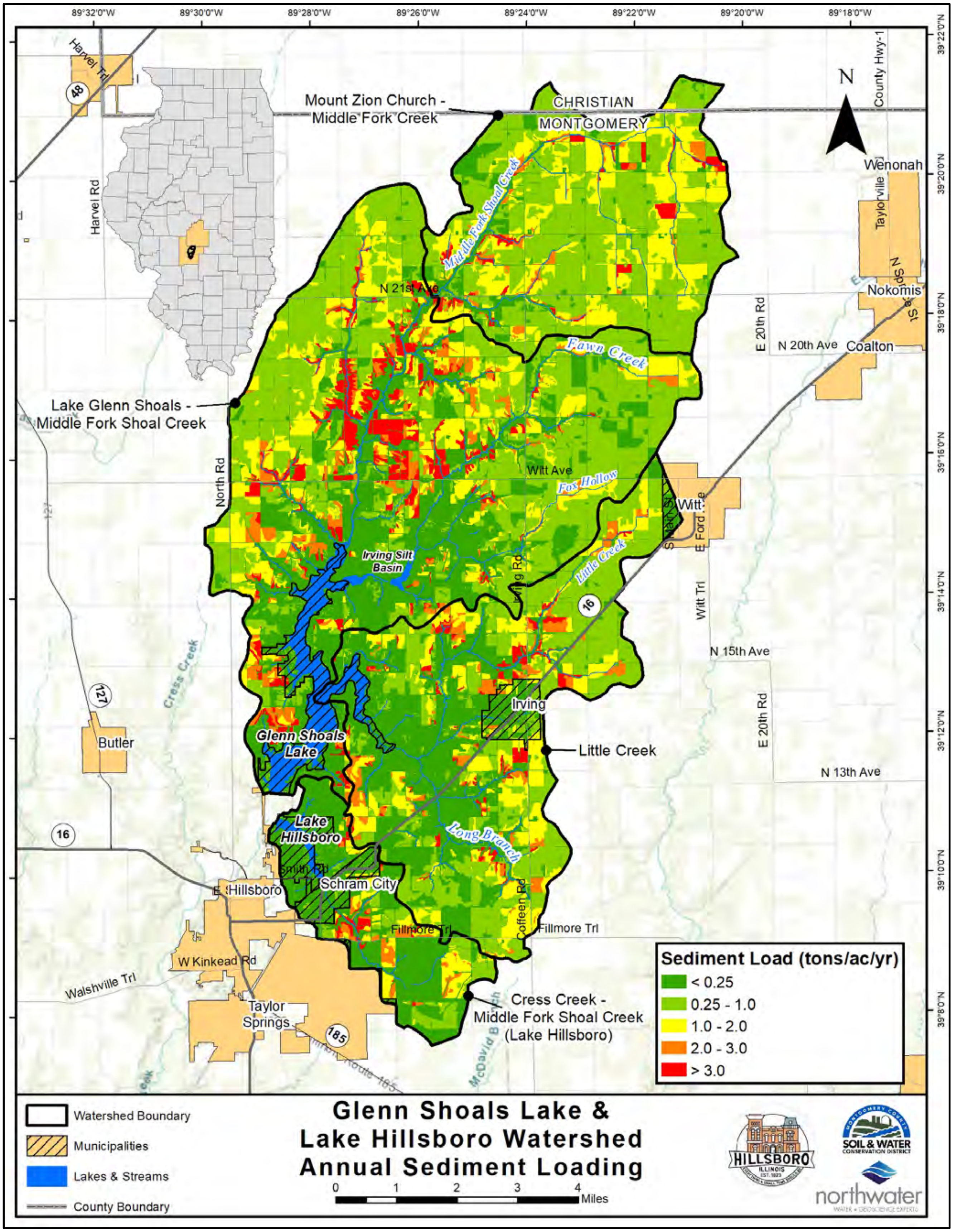


Figure 43 – Annual Sediment Loading Per Acre from Direct Surface Runoff

4.2.1 In-Lake Loading

Internal phosphorus and ammonia-nitrogen loading rates were calculated based on the extent and duration of anoxic conditions in the lakes using a limited set of historical and recent monitoring data. Release rates were estimated using the method described in Nürnberg (1984) where the total loading is equal to the anoxic area multiplied by the anoxic time multiplied by the release rate. For this analysis release rates based on review of literature and best professional estimates were used, though it is important to note that published rates vary widely. Extensive data collection and analysis on both lakes is necessary to refine the estimates. Recommendations for such monitoring are described in Section 13.

Limited depth profile data was available on which to base estimates, particularly in Glenn Shoals where depth profile monitoring does not capture the extent and duration of seasonal stratification well. Glenn Shoals was estimated to stratify at 15 ft for 122 days per year. Using bathymetric data to estimate the area of lake bottom of 15 ft or greater depth resulted in an anoxic area of 316 acres. Lake Hillsboro was estimated to stratify at 10 ft' for 137 days per year, resulting in an anoxic area of 48 acres.

A standard phosphorus release rate of 12 mg/($m^2 \cdot$ yr) based on Nürnberg (1984) was used for both lakes. The ammonia-nitrogen release rate was estimated based on Beutel (2006). The rates vary widely, and both lakes fall into the eutrophic to hypereutrophic category, with hypolimnion ammonia concentrations typically being higher in Lake Hillsboro. Thus, Glenn Shoals was estimated to have an ammonia-N release rate of 25 mg/($m^2 \cdot$ yr), and Lake Hillsboro was estimated to have a higher release rate of 35 mg/($m^2 \cdot$ yr).

Results, summarized in Table 34, show an estimated internal lake loading of 8,610 lbs/yr of nitrogen and 4,133 lbs/yr of phosphorus in Glenn Shoals Lake, and 2,062 lbs/yr of nitrogen and 707 lbs/yr of phosphorus released from Lake Hillsboro.

Table 34 - Estimated Internal Loading of Phosphorus & Nitrogen

Lake	Estimated Anoxic Depth (ft)	Estimated Anoxic Area (acres)	Estimated Days Anoxic	Estimated P Release Rate mg/($m^2 \cdot$ day)	Internal P Load (lbs/yr)	Estimated Ammonia-N Release Rate	Estimated Internal N Load (lbs/yr)
Glenn Shoals	15	316	122	12	4,133	25	8,610
Lake Hillsboro	10	48	137	12	707	35	2,062

5.0 Sources of Watershed Impairments


Cropland Surface Erosion

Watershed impairments originate from either NPS or point source pollution. A description of point source pollution is given in Section 3.17. Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source." Unlike pollution from point sources like industrial and sewage treatment plants, NPS pollution comes from many diffuse sources and is caused by rainfall or snowmelt moving over and through the ground. The runoff picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (USEPA, 2018).

In both lake watersheds, sources of sediment are thought to be originating from cropland, streambank, lake shoreline, and gully erosion and, to a lesser extent, non-crop land. Nutrients are thought to originate from cropland, release from lakebed sediments, leaking or improperly maintained septic systems, permitted point sources, streambanks, lake shorelines, and gullies.

The following section provides pollutant source descriptions identified at the significant subcategory level, along with estimates to the extent they are present. The section looks at the greatest contributions and spatial extent of loading by each major source.

5.1 Nitrogen & Phosphorus

The largest source of nitrogen in both lake watersheds is tile flow and surface runoff from cropland. Tile nitrogen is responsible for 11% and surface runoff 80% of the total nitrogen load. The largest source of phosphorus is surface runoff from cropland which is responsible for 74% of the total load. An additional 1.5% is believed to be originating from tile flow (Table 35). Other primary sources include eroding gullies (agricultural and non-agricultural), surface runoff from non-cropland, lake shoreline erosion, and in-lake nutrient release.

Table 35 – Primary Nutrient Loading Sources

Pollutant Source	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Nitrogen Load (% total)	Phosphorus Load (% total)
Glenn Shoals Lake				
Surface Runoff: Cropland	409,077	61,005	80%	76%
Surface Runoff: Non-Cropland	20,621	6,516	4.1%	8.2%
Tile Flow: Cropland	58,770	1,330	12%	1.7%
Gullies: Cropland	1,034	289	0.2%	0.4%
Gullies: Non-Cropland	1,813	853	0.4%	1.1%
Streambank Erosion	3,577	2,127	0.7%	2.7%
Lake Shoreline Erosion	2,105	1,672	0.4%	2.1%
Septic Systems	1,978	774	0.4%	1%
NPDES	818	1,128	0.2%	1.4%
In-Lake Loading	8,609	4,133	1.7%	5.2%
Subtotal	***508,402***	***79,827***	***100%***	***100%***
Lake Hillsboro				
Surface Runoff: Cropland	33,059	4,025	73%	53%
Surface Runoff: Non-Cropland	7,986	2,372	18%	31%
Tile Flow: Cropland	1,100	20	2.4%	0.3%
Gullies: Cropland	98	29	0.2%	0.4%
Gullies: Non-Cropland	160	85	0.4%	1.1%
Streambank Erosion	110	112	0.2%	1.5%
Lake Shoreline Erosion	71	56	0.2%	0.7%
Septic Systems	420	164	0.9%	2.2%
NPDES	N/A	N/A	N/A	N/A
In-Lake Loading	2,061	707	4.6%	9.3%
Subtotal	***45,064***	***7,570***	***100%***	***100%***
Grand Total	**553,466**	**87,398**	**-**	-

5.1.1 Cropland

The amount of nutrients originating from cropland depends on a whole host of complex factors and conditions including, but not limited to, weather, soil chemistry, nutrient application rates and timing, subsurface drainage or tiling, tillage practices, proximity to a receiving waterbody, or the presence or absence of conservation practices. To better understand the extent of nutrient loading from cropland, an analysis was performed on available and known watershed data. This includes an investigation of modeled loading from surface runoff versus tile flow, and tillage types.

Nitrogen – Excessive loading can be a challenge for the water treatment process if it exceeds the 10 mg/L nitrate-nitrogen drinking water standard in the lakes. It is believed that most of the nitrogen load is surface runoff from cropland, or 80% (Table 35). Fortunately, concentrations in the lakes remain low.

Phosphorus – Increased concentrations in a waterbody stimulates algae growth, which can lead to large populations, forming a bloom that can be harmful to water quality and aquatic life. It is believed that much of the load to both lakes is from surface runoff (74%) and closely tied to soil erosion from crop ground.

Tillage

The relatively small percentage of conventional till has the highest annual yield or per-acre loading of nutrients, followed by reduced-till. Although mulch-till yields less nutrients per acre, it covers the majority of crop ground at 49% and, therefore, contributes about 54% of the nitrogen and 53% of total phosphorus from cropland (Table 36). No-till is responsible for 27% of the nitrogen and 28% of the phosphorus and covers 28% of all cropland in the combined watershed.

Table 36 – Cropland Nutrient Loading by Tillage Type

Tillage Type	Area (% crop)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Nitrogen Load (% crop)	Phosphorus Load (% crop)	Nitrogen (lbs/ac/yr)	Phosphorus (lbs/ac/yr)
Glenn Shoals Lake							
Mulch-Till	49%	257,664	33,551	55%	54%	14	1.9
No-Till	27%	118,550	16,783	25%	27%	12	1.7
Reduced-Till	10%	54,393	6,662	12%	11%	15	1.9
Cover Crop[1]	5.6%	13,601	2,034	2.9%	3.3%	6.7	1
Clover/Hay/Wheat[1]	4.3%	5,461	907	1.2%	1.5%	3.5	0.6
Conventional	3.3%	18,178	2,399	3.9%	3.8%	15	2
Subtotal	***100%***	***467,847***	***62,335***	***100%***	***100%***	***13***	***1.7***
Lake Hillsboro							
No-Till	41%	15,680	1,890	46%	47%	26	3.1
Mulch-Till	37%	13,649	1,665	40%	41%	25	3
Conventional	8.3%	2,410	212	7.1%	5.2%	20	1.7
Cover Crop[1]	5.8%	1,022	113	3%	2.8%	12	1.3
Reduced-Till	5.3%	1,265	150	3.7%	3.7%	16	1.9
Hay/Wheat[1]	2.5%	133	16	0.4%	0.4%	3.6	0.4
Subtotal	***100%***	***34,159***	***4,045***	***100%***	***100%***	***23***	***2.7***
Grand Total	**100%**	**502,006**	**66,380**	**100%**	**100%**	**13**	**1.8**

[1] – not a tillage practice

5.1.2 Non-Cropland, Gullies, Streambanks, Lake Shoreline Erosion, In-Lake Loading, NPDES & Septic Systems

Non-cropland – forest, grasslands, open space, residential areas and other associated land use, primarily within proximity to tributary streams and the lakes contribute 10% of the total phosphorus and 5.2% of the total annual nitrogen load to both lakes. The percentage of the total annual load from non-cropland is significantly higher in the Lake Hillsboro drainage compared to Glenn Shoals Lake (Table 35).

Streambank erosion - streambank erosion delivers 2.6% of the phosphorus and only 0.7% of the total annual nitrogen with similar percentages for each lake. Streambank erosion is more relevant in terms of sediment loading.

Lake shoreline erosion – lake shoreline erosion delivers 2% of the phosphorus and only 0.4% of the total annual nitrogen. This percentage is measurably higher in Glenn Shoals Lake. Lake shoreline erosion is more relevant in terms of sediment loading.

Gully erosion – loading from gully erosion accounts for 1.4% of the phosphorus and 0.6% of the total annual nitrogen to both lakes. Non-cropland gullies contribute more than those from cropland. As with stream and lake bank erosion, this source is more relevant in terms of sediment.

In-Lake Loading – internal nutrient release accounts for 5.5% of the phosphorus and 1.9% of the combined watersheds' annual nitrogen load. Nutrient release is greater in Lake Hillsboro.

Septic systems - if failing, are a relatively minor contributor of phosphorus, accounting for 1% compared to 0.4% for nitrogen across both lake watersheds. Septic systems represent a higher percentage of Lake Hillsboro's annual loading compared to Glenn Shoals.

Permitted point sources (NPDES) – the two point sources located in the combined watershed are responsible for 1.3% of the phosphorus and 0.2% of the annual nitrogen. The one located in Glenn Shoals contributes the majority of the total NPDES load.

5.2 Sediment

The primary source of sedimentation in in the combined watershed is cropland sheet and rill erosion, responsible for 86% of the entire sediment load with a higher percentage generated in the Glenn Shoals Lake drainage (Table 37). Secondary sources include eroding gullies (primarily forest), streambank erosion, lake shoreline erosion, and, to a much less extent, surface runoff from non-croplands. Point sources contribute a negligible amount.

Table 37 – Sediment Loading from all Sources

Pollution Source	Sediment Load (tons/yr)	Sediment Load (% total)
Glenn Shoals Lake		
Surface Runoff: Cropland	41,026	83%
Surface Runoff: Non-Cropland	644	1.3%
Gullies: Cropland	517	1%

Pollution Source	Sediment Load (tons/yr)	Sediment Load (% total)
Gullies: Non-Cropland	2,228	4.5%
Streambank Erosion	3,064	6.2%
Lake Shoreline Erosion	1,923	3.9%
NPDES	1.8	0.004%
Subtotal	***47,234***	***100%***
Lake Hillsboro		
Surface Runoff: Cropland	1,887	77%
Surface Runoff: Non-Cropland	112	4.5%
Gullies: Cropland	49	2%
Gullies: Non-Cropland	226	9.2%
Streambank Erosion	124	5.1%
Lake Shoreline Erosion	64	2.6%
NPDES	0.26	0.01%
Subtotal	***2,463***	***100%***
Grand Total	**49,697**	**100%**

5.2.1 Cropland

The amount of sediment originating from cropland depends on tillage practices, proximity to a receiving waterbody, the presence or absence of conservation practices, and land slope. To better understand the extent of sediment loading from cropland, an analysis was performed to investigate the total and per-acre loading by tillage practices and soil HEL/PHEL designation. Results are presented in Table 38 and Table 39.

Tillage

Mulch-till fields contribute 55% of the annual cropland sediment to both lakes. This represents 47% of the total combined watershed load. Conventional tillage yields the highest per-acre or 1.8 tons/ac/yr. Despite only accounting for 3.5% of all cropland acres, conventional tillage delivers 5.6% of the entire sediment originating from farm ground and 4.8% of the total annual load. Reduced-till is also responsible for a relatively high percentage compared to total area. Cover crops and no-till combined are only responsible for 26% of the cropland sediment load, despite covering 34% of the land area draining to both lakes.

Table 38 – Cropland Sediment Loading by Tillage Type

Tillage Type	% Crop Land	Sediment Load (tons/yr)	Sediment Load (tons/ac/yr)	% Crop Sediment Load
Glenn Shoals Lake				
Mulch-Till	49%	22,585	1.3	55%
No-Till	27%	9,568	1.0	23%
Reduced-Till	10%	5,128	1.4	12%
Cover Crop[1]	5.6%	946	0.5	2.3%
Clover/Hay/Wheat[1]	4.3%	516	0.3	1.3%

Tillage Type	% Crop Land	Sediment Load (tons/yr)	Sediment Load (tons/ac/yr)	% Crop Sediment Load
Conventional	3.3%	2,283	1.9	5.6%
Subtotal	***100%***	***41,026***	***1.1***	***100%***
Lake Hillsboro				
No-Till	41%	749	1.2	40%
Mulch-Till	37%	934	1.7	49%
Conventional	8.3%	109	0.9	5.8%
Cover Crop[1]	5.8%	28	0.3	1.5%
Reduced-Till	5.3%	63	0.8	3.3%
Hay/Wheat[1]	2.5%	3.7	0.1	0.2%
Subtotal	***100%***	***1,887***	***1.3***	***100%***
Grand Total	**100%**	**42,913**	**1.1**	**100%**

[1] – not a tillage practice

Cropped HEL Soils

An analysis was performed to better understand the extent of sediment loading from sheet and rill erosion based on HEL and PHEL soils and tillage. Results are presented in Table 39.

Although HEL/PHEL soils make up 19% of watershed cropland area, they account for 15,794 tons or 37% of cropland sediment load and 14% of the entire sediment load. On average, cropped HEL soils deliver sediment at rates 67% higher than non-HEL.

No-till and mulch-till HEL fields combined contribute 30% of the annual cropland sediment followed by reduced-till and conventional. Conventional tillage of HEL/PHEL yields the highest per-acre, or 3.5 tons/ac/yr. Most cropped HEL/PHEL are being no-tilled, or 36%, and yield 1.9 tons/ac/yr. A fairly large percentage of cover crops are responsible for only 1.4% of the total cropland sediment load. With only 2.2% of the total HEL/PHEL area, conventional tillage is responsible for 1.4% of the entire sediment load coming from cropland and 3.6% of the total HEL/PHEL load. Cover crops planted on HEL soils lose far less soil, per acre, on an annual basis.

Table 39 – Cropland Sediment Loading by HEL/PHEL Soils & Tillage Type

Tillage Type	Area (ac)	% Crop HEL/PHEL	Sediment load (tons/yr)	Sediment load (tons/ac/yr)	% Total Cropland Sediment load
Glenn Shoals Lake					
No-Till	2,440	37%	4,804	2.0	12%
Mulch-Till	2,016	31%	6,321	3.1	15%
Clover/Hay/Wheat[1]	762	12%	374	0.5	0.9%
Cover Crop[1]	737	11%	567	0.8	1.4%
Reduced-Till	477	7.3%	2,096	4.4	5.1%
Conventional	112	1.7%	538	4.8	1.3%

Tillage Type	Area (ac)	% Crop HEL/PHEL	Sediment load (tons/yr)	Sediment load (tons/ac/yr)	% Total Cropland Sediment load
Glenn Shoals Lake Subtotal	***6,545***	***100%***	***14,700***	***2.2***	***36%***
Lake Hillsboro					
No-Till	276	43%	481	1.7	25%
Mulch-Till	199	31.1%	506	2.5	27%
Cover Crop[1]	61	9.5%	24	0.4	1.3%
Conventional	51	8.0%	37	0.7	2.0%
Reduced-Till	34	5.4%	43	1.2	2.3%
Hay/Wheat[1]	18	2.8%	3.0	0.2	0.2%
Lake Hillsboro Subtotal	***639***	***100%***	***1,094***	***1.7***	***58%***
Grand Total	**7,184**	**100%**	**15,794**	**2.2**	**37%**

[1] – not a tillage practice

5.2.2 Gullies, Lake Banks & Streambanks

Lake shoreline erosion and gully erosion from non-cropland are the next most significant sources of sediment, followed by cropland.

Streambank erosion - streambank erosion delivers 6.4% of the total sediment load to both lakes combined with a slightly higher percentage of the total load to Glenn Shoals Lake.

Lake shoreline erosion – lake shoreline erosion delivers 4% of the total sediment load and is primarily from Glenn Shoals Lake at 1,923 tons/yr versus 64 tons/yr in Lake Hillsboro.

Gully erosion - gully erosion, which is most prevalent in forested areas and non-cropland, delivers 6.4% of the total sediment load for both lake watersheds combined. Gully erosion on crop ground is only responsible for 1.1% of the total watershed load and 36% of all gully erosion. Much of the forested contribution can be attributed to delivery rates as a relatively high percentage are very close to a receiving stream. Contributions from crop ground are relatively low due to low delivery rates and the presence of BMPs that either trap or filter sediment before entering a receiving stream.

6.0 Nonpoint Source Management Measures & Load Reductions

This section details recommended BMPs for the watershed, their quantities and expected annual pollution load reductions. Although reductions presented below include nitrogen, phosphorus and sediment, special attention is given to sediment and phosphorus. As these are the most common water quality concerns for the lakes, practices that address phosphorus and sediment loading should receive priority.

Best Management Practices can be described as a practice or procedure to prevent or reduce water pollution and address stakeholder concerns. They typically include treatment requirements, operating procedures, and practices to control surface runoff and mitigate pollution loading. This section describes all BMPs needed to achieve measurable reductions in nitrogen, phosphorus and sediment.

Expected reductions are calculated using average pollutant reduction efficiency percentages based on the INLRS, existing literature, and local expertise. Ranges of efficiencies used can be found in Table 40 and Table 41. It should be noted that addressing nutrient and sediment loading will take a substantial amount of effort and resources. Water quality improvements will not happen overnight, and time will be needed to realize results. Years of work by Hillsboro, the MCSWCD, the county NRCS, landowners, growers, and others have generated many positive water quality benefits. Building off these efforts will help to accelerate improvements.

Table 40 – Pollutant Reduction Efficiency Ranges by BMP for Surface Runoff

BMP	Nitrogen Reduction	Phosphorus Reduction	Sediment Reduction
Cover Crop	30%	30%	40%
Nutrient Management - Deep Placement Phosphorus	0%	20%	0%
Field Border (Footprint)[1]	90%	80%	90%
Field Border (Drainage Area)	5 - 10%	10 - 40%	18 - 60%
Filter Strip (Footprint)[1]	90%	80%	90%
Filter Strip (Drainage Area)	3 - 10%	6 - 80%	7 - 90%
Field Border – Perennial (Drainage Area)	10 - 30%	20 - 50%	30 - 65%
Field Border – Perennial (Footprint)[1]	90%	80%	90%
Filter Strip – Perennial (Drainage Area)	10 – 25%	20 - 40%	40 - 65%
Filter Strip – Perennial (Footprint)[1]	90%	80%	90%
Floodplain Re-Connection	10 - 15%	12 - 22%	15 - 28%
Grass Conversion (Footprint)[1]	90%	80%	90%
Grass Conversion – Perennial (Footprint)[1]	90%	80%	90%
Grass Conversion – Perennial (Drainage Area)	5 - 45%	10 - 70%	20 - 65%
Grassed Waterway[1,2]	6 - 30%	3 - 22%	4 - 32%
Native Prairie Buffer	5%	30%	35%
In-Lake Dam	10 - 30%	12 - 40%	15 - 50%
Terrace/WASCB[1,2]	20%	60%	70%
Sediment Basin	10 - 20%	20 - 60%	30 - 70%
Permeable/Porous Pavement	45%	50%	80%
Rain Garden	40%	45%	50%
Grade Control[1]	1 – 5%	3 – 15%	5 – 20%
Streambed/Bank Stabilization (includes riffles and stone toe protection or STP)[3]	2 – 4%	5 – 8%	7 - 12%
Livestock Stream Fencing & Pasture Management	50%	55%	60%
Livestock Feed Area Treatment System	84%	83%	79%
Timber Stand Improvement (TSI)	5%	5%	5%
No-Till	10%	50%	70%
Strip-Till	10%	50%	70%
Pond	30 - 40%	40 - 65%	50 - 85%
Wetland Creation	10 - 38%	12 - 45%	16 - 60%

[1] - Controls 100% of gully erosion. [2] - Reduction percentage includes maintenance of existing structures. [3] – STP reduces 100% of bank erosion.

Table 41 – Pollutant Reduction Efficiency Ranges by BMP for Subsurface Runoff

BMP	Nitrogen Reduction	Phosphorus Reduction
Bioreactor	40%	40%
Cover Crop	38%	10%
Drainage Water Management	40%	10%
Saturated Buffer	55%	25%
Floodplain Re-Connection[1]	10 - 15%	12 - 22%
Grass Conversion (Footprint)	90%	80%
Grass Conversion – Perennial (Footprint)	90%	80%
Pond[1]	30 – 40%	40 - 65%
Nutrient Management – Spring Split Application of Nitrogen	20%	0%
Sediment Basin[1]	10 – 20%	20 – 60%
Wetland Creation[1]	10 - 38%	12 - 45%

[1] - Assumes tile flow is routed through BMP

6.1 Best Management Practices & Expected Load Reductions

Load reductions were calculated for each recommended BMP using the GIS-based loading model. Where applicable, a drainage area was delineated for each individual practice. Therefore, expected load reductions are spatially explicit and represent delivered pollutants. Agriculture subsections cover structural versus in-field practices. Urban BMPs are also included. Recommended practices do not include those currently being implemented or in place. To meet water quality targets, it is important that these existing practices continue. This is especially true for in-field practices such as no-till and cover crops that may be discontinued as economic conditions change or current funding support drops off.

Table 42 lists all proposed BMPs, quantities, area treated and expected annual reductions. Locations are shown in Figure 44, Figure 45, Figure 46, Figure 47, Figure 48, Figure 49, Figure 50, and Figure 51 that shows only in-lake management measures. Excluding dredging that removes sediment and nutrients already in the systems, the largest total expected reductions in annual nitrogen, phosphorus and sediment can be achieved from cover crops, tillage and nutrient management (specifically for phosphorus), perennial grass conversion, floodplain re-connection (with wetlands), and a select number of other structural practices. All practices will require willing landowners to implement and large investments by Hillsboro and other partners. Further information on BMP costs, reductions, critical practices, technical and financial assistance and implementation goals can be found in Sections 7–11.

Table 42 – Recommended BMPs & Load Reduction Summary

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
Glenn Shoals Lake						
In-Field Practices	Cover Crop	33,144 (ac)	33,144	153,750	17,647	15,516
	Cover Crop - Existing	2,052 (ac)	2,052	5,978	889	635
	Cover Crop – Partial[1]	9,227 (ac)	9,227	54,680	6,369	6,513

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
	Nutrient Management - Deep Placement Phosphorus	23,603 (ac)	23,603	n/a	8,535	n/a
	No-Till	5,181 (ac)	5,181	7,828	6,107	8,102
	Nutrient Management - Split Application Nitrogen	722 (ac)	722	2,328	n/a	n/a
	No-Till or Strip-Till	17,608 (ac)	17,608	20,907	14,974	13,102
Glenn Shoals Lake In-Field Practices Subtotal			***80,258***	***190,790***	***48,151***	***37,354***
Structural, Urban, and In-Lake Practices	Aerators	63 (aerators)	316	n/a	7,749	n/a
	Bioreactor	10 (locations), 20 (structures)	392	2,046	9.2	n/a
	Drainage Water Management	1 (locations), 39 (ac)	39	119	0.6	n/a
	Dredge[2]	*10 (locations), 1,509,788 (CY)*	*137*	*11,081,846*	*2,506,249*	*815,286*
	Feed Area Management System	12 (locations), 14 (ac)	7.6	113	62	2.2
	Field Border	76 (locations), 244 (ac)	2,478	2,261	1,054	904
	Field Border - Perennial	29 (locations), 512 (ac)	2,355	3,767	1,121	963
	Filter Strip	170 (locations), 381 (ac)	5,170	6,597	2,966	2,640
	Filter Strip - Perennial	5 (locations), 55 (ac)	276	484	187	149
	Floodplain Re-connection	8 (locations), 49 (riffles), 105 (ac wetland), 26 (structures)	62,807	87,435	13,932	10,851
	Grade Control – Rock Check	10 (locations), 34 (structures)	78	78	32	79
	Grade Control - Riffles	8 (locations), 15 (small riffles), 2 (medium riffles)	231	114	56	81
	Grass Conversion	66 (locations), 126 (ac)	126	1,325	187	153
	In-Lake Dam	4 (locations), 3,450 (ft)	34,818	33,547	6,238	4,952
	Livestock Fencing/ Management	6 (locations), 8,332 (ft fencing), 5 (crossings)	33	285	107	6.6
	Native Prairie Buffer	13 (locations), 4 (ac)	28	3.3	6.4	1

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
	Perennial Grasses	634 (locations), 8,384 (ac)	13,243	83,888	14,781	14,587
	Permeable Pavement	4 (locations), 222,968 (sq ft)	5	11	6.5	1.7
	Pond	130 (locations)	7,875	30,382	6,417	5,899
	Pond Repair	1 (locations)	3.7	1	0.6	0.1
	Rain Garden	62 (locations)	6.9	42	17	2.5
	Saturated Buffer	9 (locations), 5,400 (ft tile)	315	2,008	21	n/a
	Sediment Basin	17 (locations), 25 (basins)	314	549	232	309
	Streambed/Bank Stabilization	8 (locations), 12 (small riffles), 27 (medium riffles), 1,266 (ft STP)	1,058	705	404	494
	Shoreline Stabilization	82 (locations), 20,099 (ft)	n/a	1,717	1,364	1,569
	STP	38 (locations), 10,859 (ft STP)	n/a	714	338	559
	Terrace	18 (locations), 27,700 (ft tile), 12,630 (ft terrace)	237	806	380	407
	Timber Stand Improvement (TSI)	6 (locations), 75 (ac)	75	10	6.3	14
	WASCB	86 (locations), 232 (basins), 54,530 (ft tile)	662	2,172	1,025	1,123
	WASCB Maintenance	9 (locations), 19 (basins), 5,700 (ft tile)	83	226	101	105
	Waterway	30 (locations), 52 (ac), 39,022 (ft tile)	1,894	3,077	361	448
	Waterway Maintenance	18 (locations), 30 (ac), 7,086 (ft tile)	1,036	1,672	207	300
	Wetland Creation	66 (locations), 100 (ac wetland), 80 (structures)	4,224	9,686	2,113	1,887
Glenn Shoals Lake Structural Practices Subtotal			***140,188***	***275,841***	***61,479***	***48,485***
Glenn Shoals Lake Grand Total			**220,446**	**466,632**	**109,630**	**85,839**
In-Field Practices	Cover Crop	1,055 (ac)	1,055	7,746	885	560
	Cover Crop - Existing	52 (ac)	52	280	30	14
	Cover Crop – Partial[1]	540 (ac)	540	4,414	508	324
	Nutrient Management - Deep Placement Phosphorus	575 (ac)	575	n/a	281	n/a
	No-Till	429 (ac)	429	933	564	472

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
	No-Till or Strip-Till	123 (ac)	123	227	134	94
Lake Hillsboro In-Field Practices Subtotal			***2,722***	***13,320***	1,895	1,139
Structural, Urban, In-Lake Practices	Aerator	10 (aerators)	48	n/a	1,855	n/a
	Dredge[2]	*3 (locations), 120,353 (CY)*	*12*	*2,269,854*	*327,360*	*64,991*
	Field Border	5 (locations), 24 (ac)	144	215	88	57
	Field Border - Perennial	2 (locations), 20 (ac)	85	330	104	60
	Grade Control - Riffles	1 (locations), 5 (small riffles)	68	23	7.1	7.5
	Grass Conversion	2 (locations), 3 (ac)	3.2	23	1.9	0.5
	Native Prairie Buffer	3 (locations), 1 (ac)	6.6	2	5	0.2
	Perennial Grasses	46 (locations), 672 (ac)	706	15,255	1,669	1,007
	Permeable Pavement	3 (locations), 52,508 (sq ft)	1.2	6.4	2.9	0.4
	Pond	10 (locations)	554	2,909	661	319
	Pond - Urban	4 (locations)	107	117.3	63	16.4
	Rain Garden	17 (locations)	1.5	23	6.5	0.5
	Shoreline Stabilization	2 (locations)	n/a	14	11	13
	Terrace	3 (locations), 4,100 (ft tile), 2,150 (terrace)	32	190	66	39
	TSI	1 (locations), 3 (ac)	3.1	0.2	0.1	0.004
	WASCB	7 (locations), 23 (basins), 6,050 (ft tile)	67	359	132	94
	Waterway	2 (locations), 4 (ac), 3,093 (ft tile)	83	372	40	31
	Waterway Maintenance	2 (locations), 2 (ac), (ft tile)	61	292	26	18
	Wetland Creation	9 (locations), 34 (ac wetland), 15 (structures)	849	2,669	480	199
Lake Hillsboro Structural Practices Subtotal			***2,821***	***22,798***	**5,219**	***1,862***
Lake Hillsboro Grand Total			**5,542**	**36,119**	**7,114**	**3,001**

[1] *- Cover Crop – Cropped HEL soils only are not included in subtotals or totals as their reductions are already accounted for with cover crops.*
[2] *– Dredging not included in totals.*

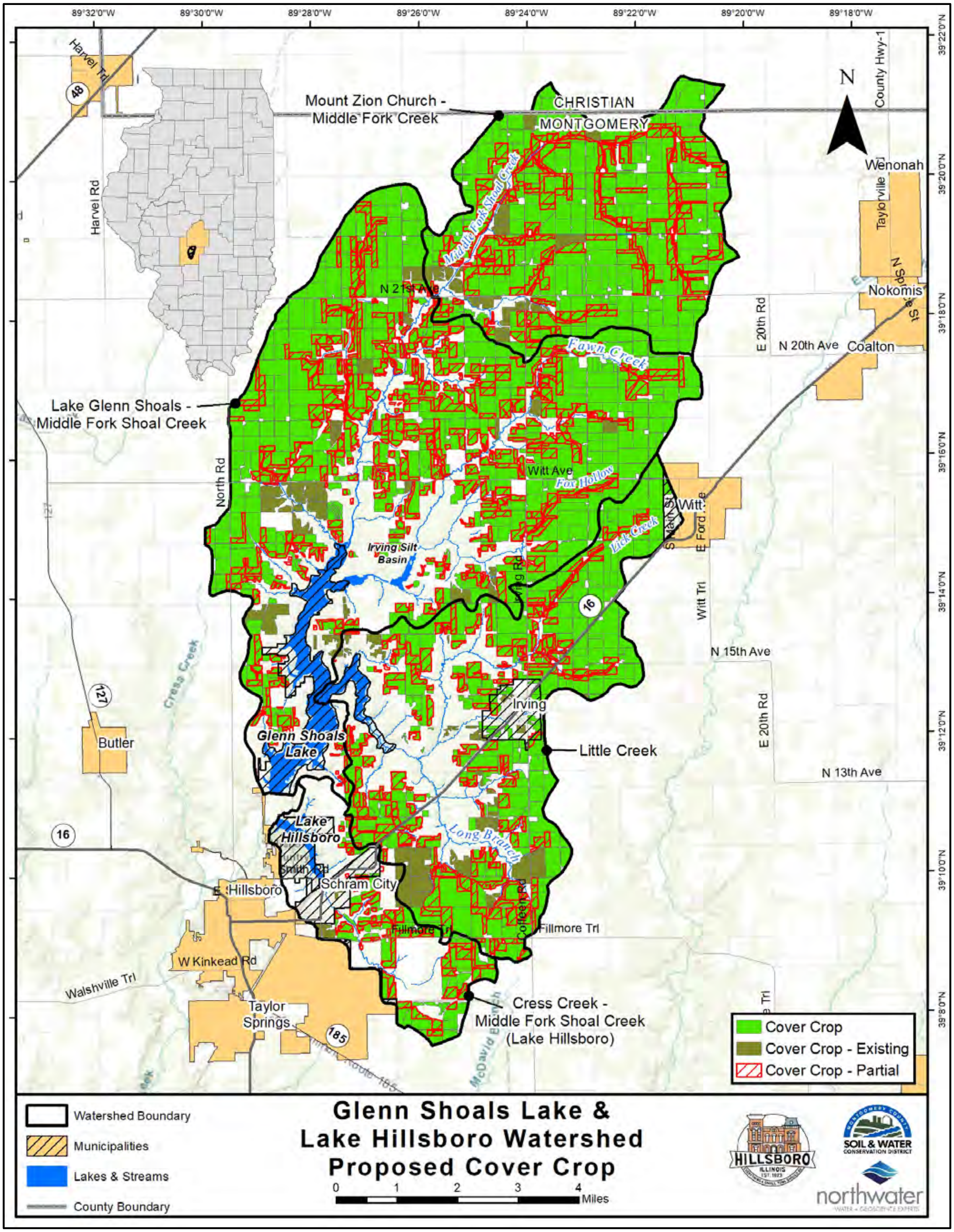


Figure 44 – Proposed BMPs – In-Field Cover Crop

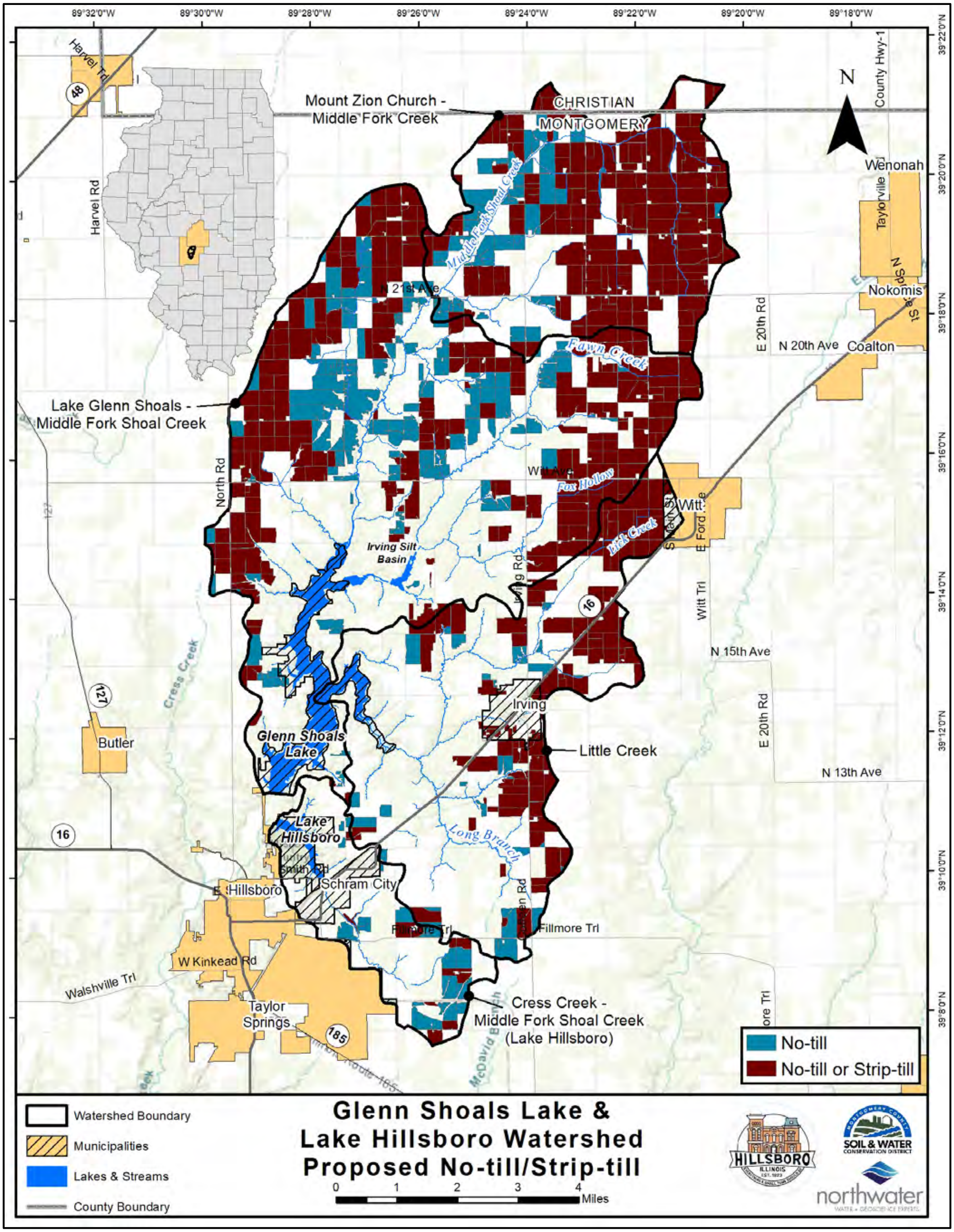


Figure 45 – Proposed BMPs - In-Field No-till/Strip-till

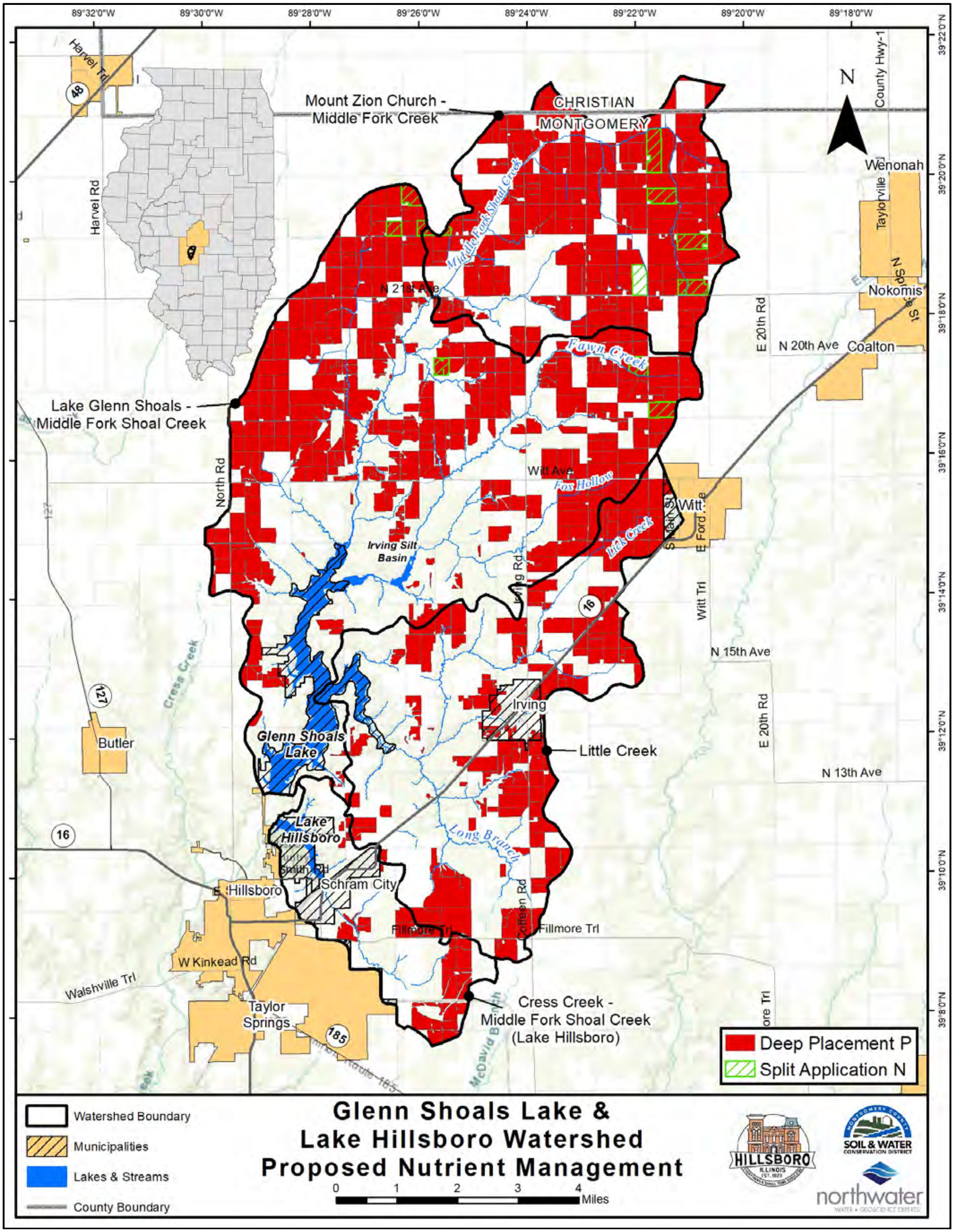


Figure 46 – Proposed BMPs - In-Field Nutrient Management

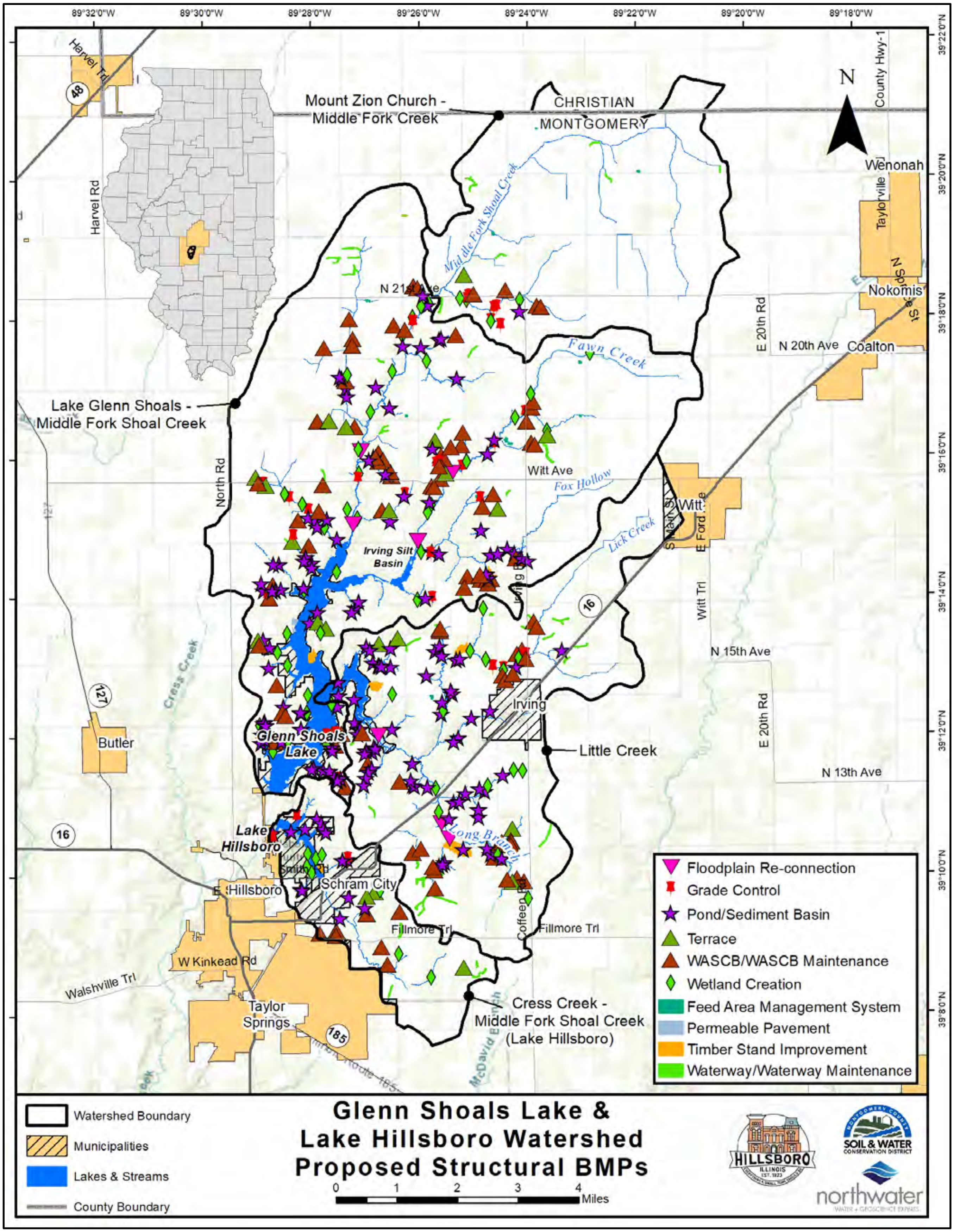


Figure 47 – Proposed Structural BMPs (1)

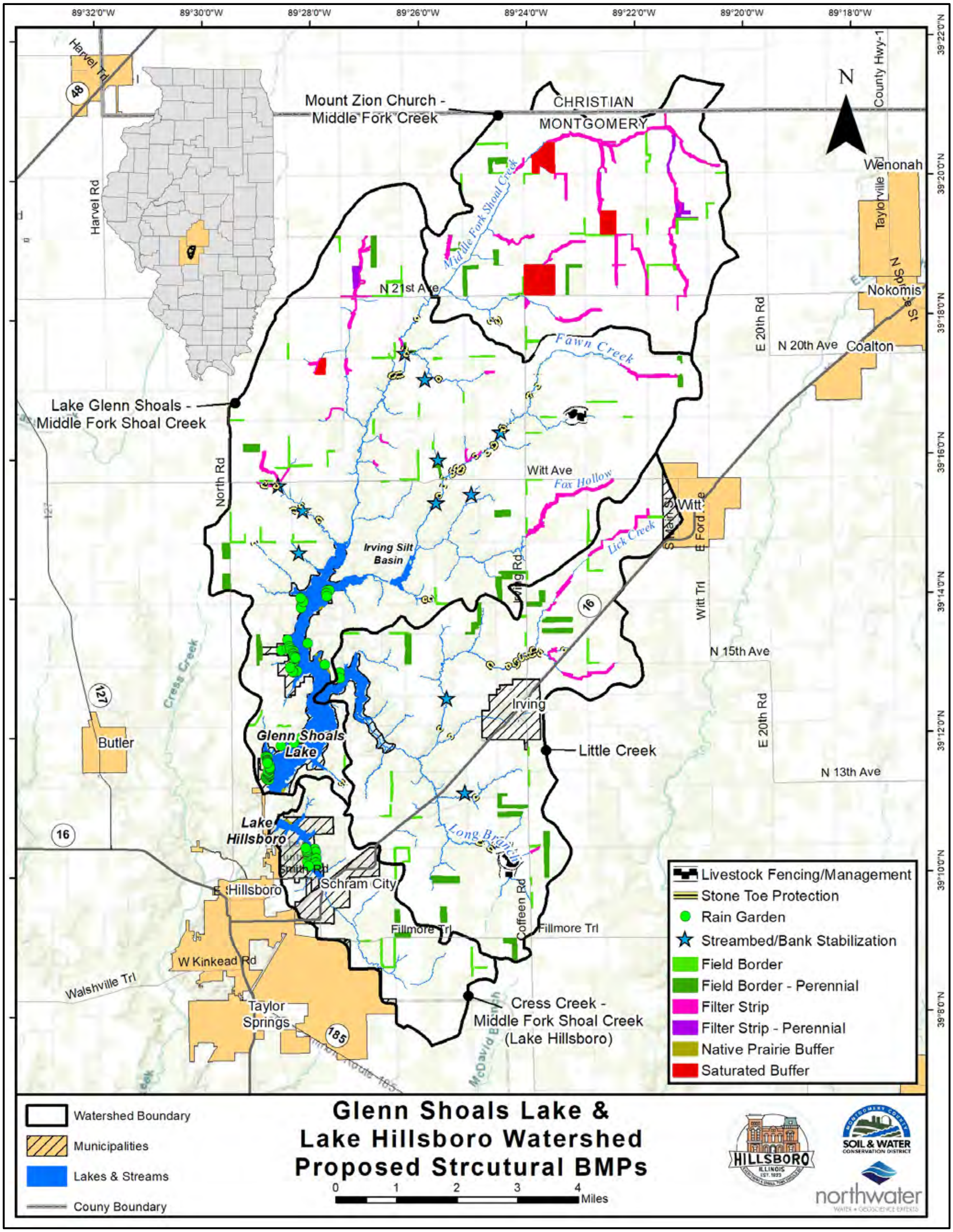


Figure 48 – Proposed Structural BMPs (2)

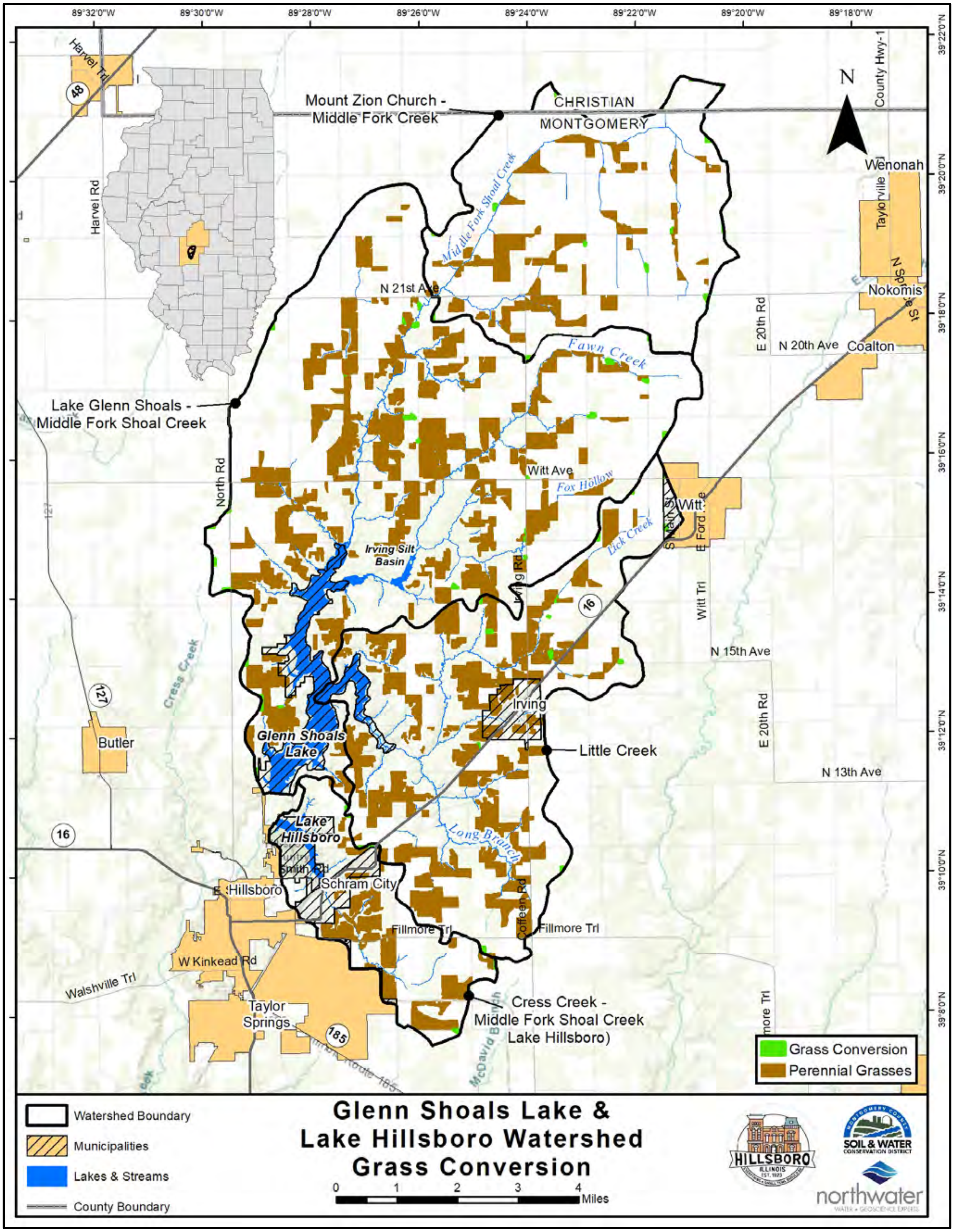


Figure 49 – Proposed Structural BMPs – Grass Conversion/Perennial Grasses

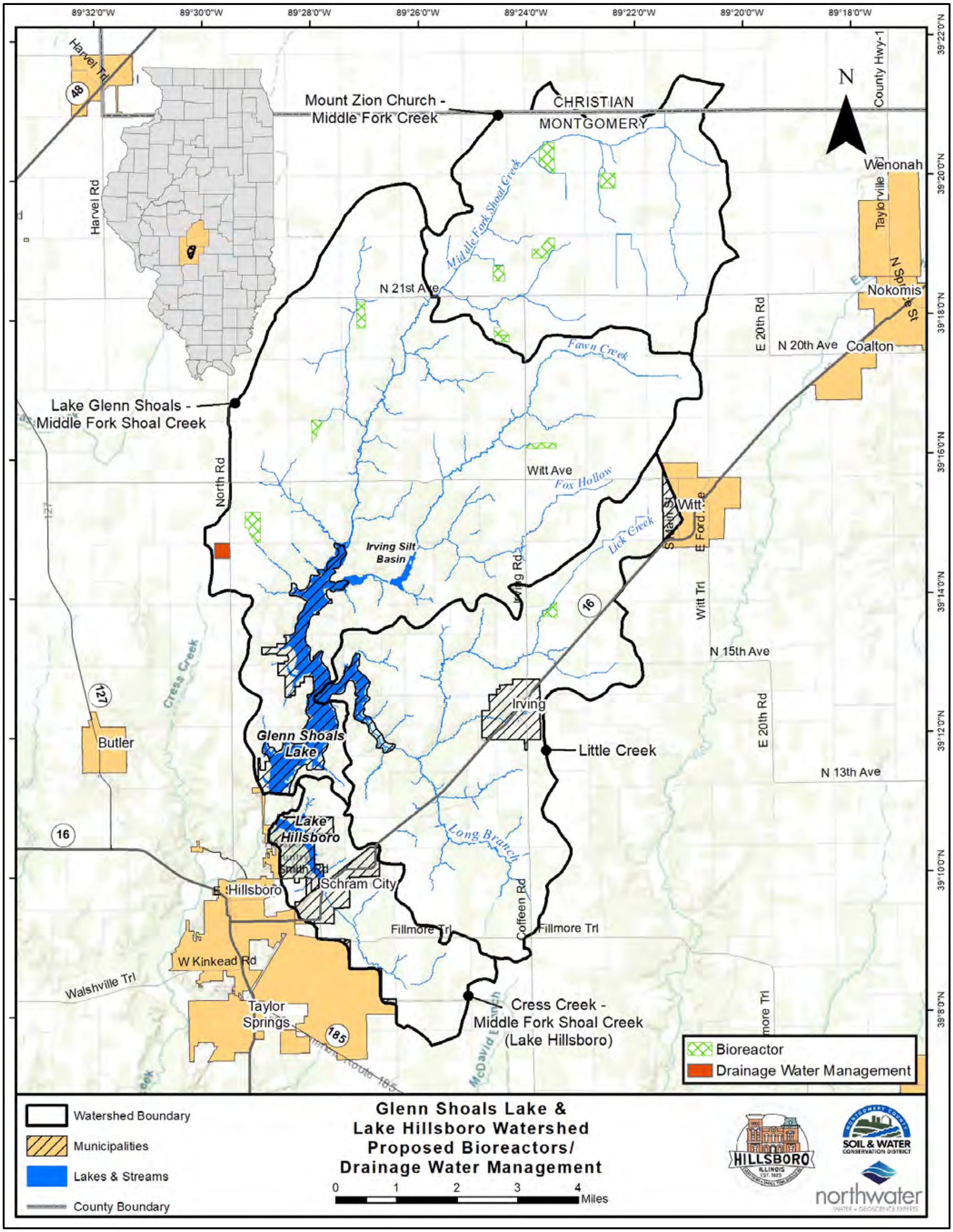


Figure 50 – Proposed Structural BMPs – Bioreactors & Agricultural DWM

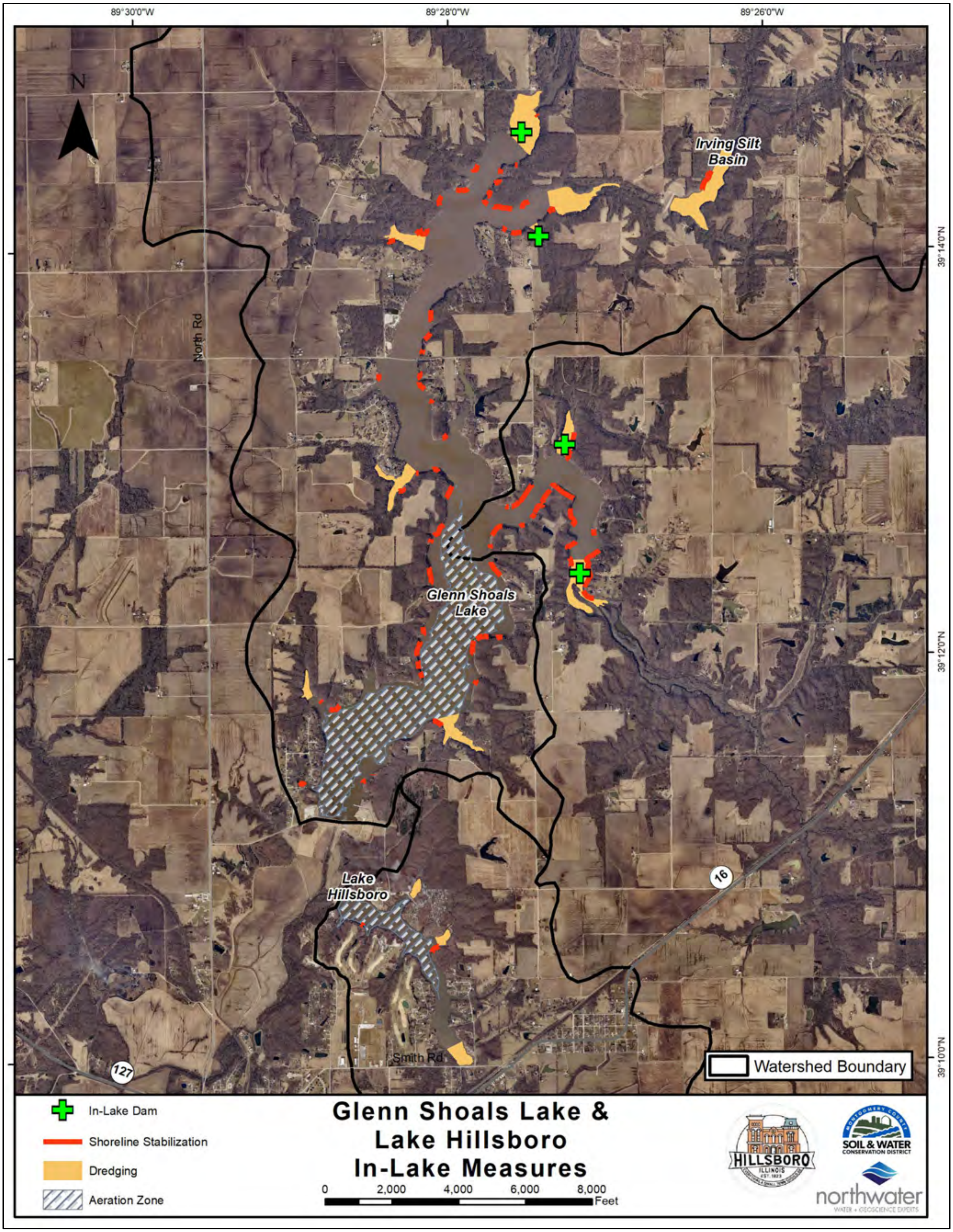


Figure 51 – Proposed In-Lake Management Measures

6.1.1 Agricultural - In-Field BMP Summary

In-field management measures are critical to achieving water quality targets. These measures focus on nutrient and sediment loading coming from cropland. As noted in previous sections, cropland is the primary contributor of sediment and nutrients. Recommendations presented in this section cover both lakes.

Cover Crops

A cover crop is a temporary vegetative cover that is grown to provide protection for the soil and improve soil conditions. Cover crops can be applied over a broad area in the watershed and are key to addressing nitrogen. There are many different types of cover crop; some species terminate in the winter, such as oats, and others that are terminated in the spring using herbicide or mechanical methods such as cereal rye.

Cover Crop

Cover crop - all fields greater than 5 acres not currently in cover crops were selected and are proposed for a total of 1,090 fields or 34,199 acres. If all acres are planted to cereal rye, the following annual load reductions are expected:

- 161,496 lbs nitrogen
- 18,532 lbs phosphorus
- 16,075 tons sediment

Cover crop - existing - fields currently in cover crops are recommended to be maintained so they can continue to provide water quality benefits. A total of 110 fields, or 2,104 acres, were selected. If all acres are maintained, the following annual load reductions are expected:

- 6,258 lbs nitrogen
- 919 lbs phosphorus
- 649 tons sediment

Cover crop – partial fields – cover crops on just a portion of a field can maximize reductions and at a lower total cost. This is true for HEL soils that generate the highest nutrient and sediment yields. Fields with HEL soils greater than one acre not currently being cover cropped are recommended. A total of 806 fields, or 9,767 acres, are recommended. If all acres are planted, the following annual load reductions are expected:

- 59,094 lbs nitrogen (37% of the reductions for all cover crops and 29% of the total watershed acreage)
- 6,877 lbs phosphorus (37% of the reductions for all cover crops and 29% of the total watershed acreage)
- 6,838 tons sediment (43% of the reductions for all cover crops and 29% of the total watershed acreage)

No-Till or Strip-Till

No-till can be defined as farming where the soil is left relatively undisturbed from harvest to planting. During the planting operation, a narrow seedbed is prepared, or holes are drilled in which seeds are planted. A switch from conventional tillage to no-till is often a prerequisite for the installation of cover crops. Strip-till is a good alternative to no-till, especially for those producers that are not willing to move to no-till.

Strip-till is a minimum tillage system that combines the soil drying and warming benefits of conventional tillage with the soil-protecting advantages of no-till by disturbing only the portion of the soil that is to contain the seed row.

No-till – is proposed for fields greater than 5 acres in size where conventional, reduced or mulch tillage is employed and where slopes are prohibitive to strip-till. A total of 256 fields are recommended covering 5,610 acres. If all acres are treated, the following annual reductions are expected:

- 8,761 lbs nitrogen
- 6,671 lbs phosphorus
- 8,573 tons sediment

Strip-till and/or no-till – is proposed on fields with less than 5% slopes. A total of 533 fields are recommended covering 17,731 acres. If all acres are treated, the following annual reductions are expected:

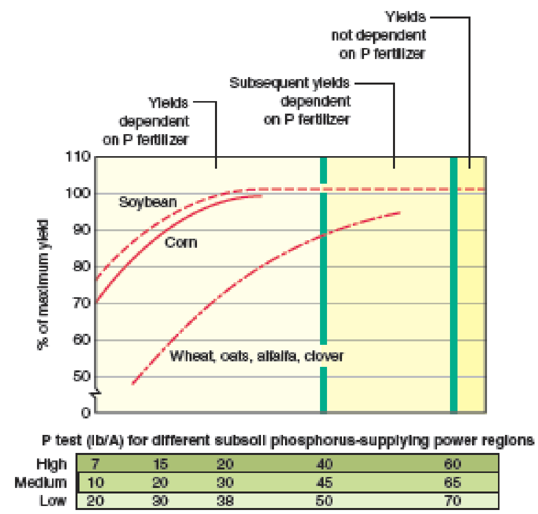
- 21,133 lbs nitrogen
- 15,108 lbs phosphorus
- 13,196 tons sediment

No-Till Field

Nutrient Management

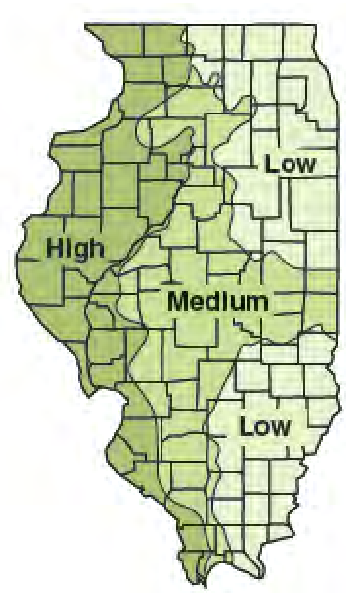
Nutrient management is the practice of using nutrients essential for plant growth, such as nitrogen and phosphorus fertilizers in proper quantities and at appropriate times, for optimal economic and environmental benefits. Nutrient management is a non-structural practice that can be applied to all fields in the watershed, primarily to address nitrogen; it is well-suited to the flat topography and productive nature of soils in the watershed although, if a field is being farmed, nutrient management should be practiced regardless of these factors. The nutrient management system now being promoted by agricultural organizations utilizes the approach commonly called the "4Rs":

- Right Source: Matches fertilizer type to crop needs.
- Right Rate: Matches amount of fertilizer to crop needs.
- Right Time: Makes nutrients available when crops need them.
- Right Place: Keeps nutrients where crops can use them.



Promoting smart soil testing is also important as the spatial variability of available nutrients in a field makes soil sampling the most common and greatest source of error in a soil test (University of Illinois, 2012). Proper soil testing is the foundation of good nutrient management as it relates to phosphorus.

As described in Chapter 8 of the Illinois Agronomy Handbook, regional differences in P-supplying power shown in the adjacent figure were broadly defined primarily by parent material and degree of weathering factors. Within a region, variability in parent material, degree of weathering, native vegetation, and natural drainage cause differences in the soil's P-supplying power. For example, soils developed under forest cover appear to have more available subsoil P than those developed under grass.



Minimum soil test levels required to produce optimal crop yields vary depending on the crop to be grown and the soil's P-supplying power (see adjacent figure). Near maximal yields of corn and soybeans are obtained when levels of available P are maintained at 30, 40, and 45 lbs/ac for soils in the high, medium, and low P-supplying regions, respectively. Since these are minimal values, to ensure soil P availability will not restrict crop yield, it is recommended that soil test results be built up to 40, 45, and 50 lbs/ac for soils in the high, medium, and low P-supplying regions, respectively. This is a practical approach because P is not easily lost from the soil, other than through crop removal or soil erosion.

Several methods described in Chapter 8 of the Illinois Agronomy Handbook can be used to manage crop nutrient loss: variable rate technology (VRT) and deep fertilizer placement. Variable rate technology can improve the efficacy of fertilization and promote more environmentally sound placement compared to single-rate applications derived from the conventional practice of collecting a composite soil sample to represent a large area of the field. Research has shown that this technology often reduces the amount of fertilizer applied over an entire field. However, one of the drawbacks of this placement method is the expense associated with these technologies. Also, VRT can only be as accurate as the soil test information used to guide the application rate (University of Illinois 2012).

Shifting the fall application of nitrogen fertilizer to split applications in the spring can reduce tile nitrate losses by 20% (David, 2008). Split applying nitrogen involves two or more fertilizer applications during the growing season rather than providing all of the crop's nitrogen requirements with a single treatment. This makes nutrient uptake more efficient and reduces the risk of denitrification, leaching or volatilization.

The MRTN calculator provides a method to calculate optimum nitrogen application and to find the maximum return to nitrogen or MRTN at selected prices of nitrogen and corn directly from recent research data. The MRTN approach is the regional approach suggested for developing corn nitrogen rate guidelines in individual states. Nitrogen rate trial data is provided for six states (Illinois, Iowa, Michigan, Minnesota, Ohio, and Wisconsin) where an adequate number of research trials (sites) were available for corn following soybean and corn following corn. These trials were conducted with spring, sidedress, or split preplant/sidedress applied, and sites not irrigated (IFCA, 2022).

Deep fertilizer placement is where any combination of nitrogen, phosphorus, and potassium can be injected at a depth of 4 to 8 inches. Subsurface applications may be beneficial (if the subsurface band application does not create a channel for water and soil movement) is when the potential for surface water runoff is high (University of Illinois, 2012).

Deep Placement – P Fertilizer

Fields greater than 5 acres in size were selected for the deep placement of phosphorus fertilizer. If applied to all 828 fields or 24,178 acres, expected annual load reductions are:

- 8,816 lbs phosphorus

Split Application – Nitrogen Fertilizer

Fields greater than 5 acres in size without a known nutrient management plan and expected to be tiled were selected for split application of nitrogen fertilizer. If applied to all 15 fields or 722 acres, expected annual load reductions are:

- 2,328 lbs nitrogen

6.1.2 Structural BMP Summary

This section provides a brief description of each structural BMP and their expected load reductions. Practices are primarily for agricultural areas but do include locations in urban and forested areas. For example, several wetlands and floodplain re-connections are recommended on tributaries and, in forested draws. Recommendations presented in this section cover both lakes.

Water and Sediment Control Basins (WASCB) / Terrace

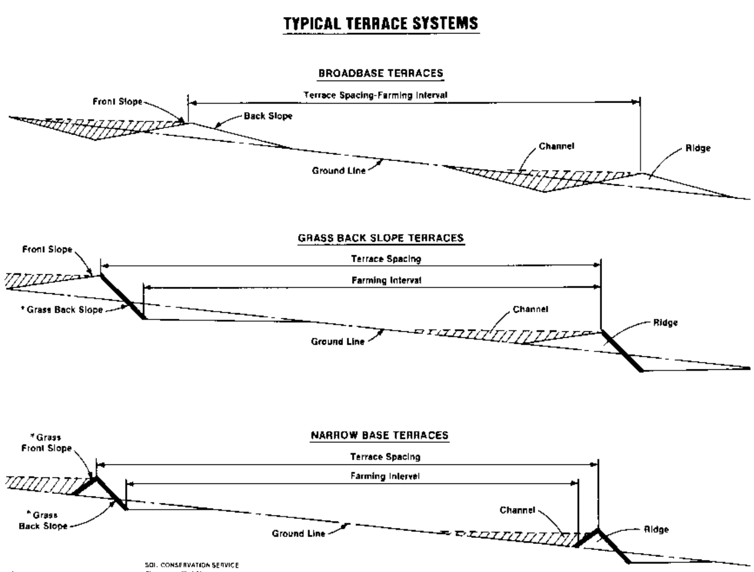
These practices are earth embankments constructed across a drainage channel or along contours of a slope to intercept runoff water and trap soil. They are often constructed to mitigate gully erosion where concentrated flow is occurring and where drainage areas are relatively small. Multiple basins are often placed along a flow line or at each site depending on drainage area and cropping systems. Locations to apply these practices are many due to the sloping nature of the watershed.

Water and sediment control basins are recommended at 102 locations, for a total of 274 individual basins and 66,280 feet of tile, including 9 locations for the repair of existing WASCBs. If all practices are installed, a total of 813 acres will be treated. Expected annual load reductions (including gully stabilization) will total:

- 2,758 lbs nitrogen
- 1,258 lbs phosphorus
- 1,321 tons sediment

Terraces can be applied at 21 locations totaling 31,800 feet of terrace. If all are installed, a total of 269 acres will be treated. Expected annual load reductions (including gully stabilization) will total:

- 996 lbs nitrogen
- 446 lbs phosphorus
- 446 tons sediment



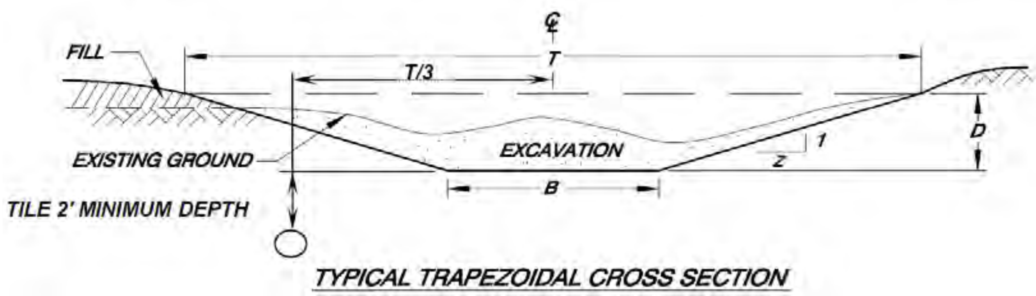
NRCS Detail – Terrace/WASCB

Grassed Waterways

A grass waterway is a grassed strip in a field that acts as an outlet for water to control silt, filter nutrients and limit gully formation. Grassed waterways are applicable in areas with very large drainage areas and low-moderate slopes.

Grassed waterways are recommended at 52 locations, for a total of 88 acres and 49,200 ft of tile, including 20 locations for the maintenance of existing waterways. If all are installed, a total of 3,074 acres will be treated. Expected annual load reductions (including gully stabilization) are:

- 5,412 lbs nitrogen
- 633 lbs phosphorus
- 798 tons sediment



NRCS Grassed Waterway Detail

Constructed Wetlands/Wetland Restoration

A constructed wetland is a shallow water area built by creating an earth embankment or excavation area. Constructed wetlands can include a water control structure and are designed to mimic natural hydrology, store sediment and filter nutrients. Wetland restoration, on the other hand, aims to improve existing structures or features by expanding their footprint. Wetlands have been identified in areas where soils support their establishment, where local topography does not allow for the construction of a pond, and where no substantial area of cropland is needed to be removed from production. Local watershed studies have shown that wetlands are reasonably efficient at treating nitrogen, especially from tile flow.

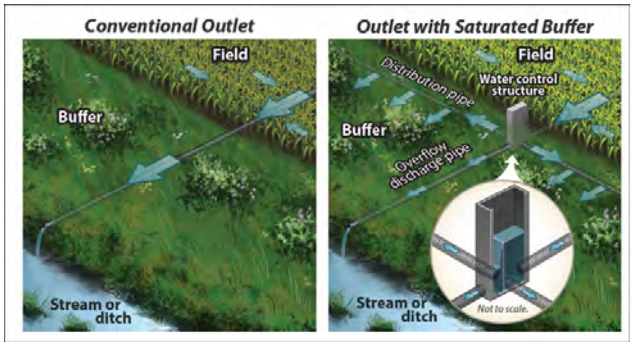
Constructed Wetland

Wetland creation is recommended at 75 locations, for a total of 134 acres. If all are implemented, they will treat 5,073 acres and the annual expected load reductions (including gully and streambank stabilization) are:

- 12,355 lbs nitrogen
- 2,593 lbs phosphorus
- 2,086 tons sediment

Saturated Buffers

A saturated buffer is a BMP in which drainage water is diverted as shallow groundwater flow through a grass buffer specifically for nitrate removal. A saturated buffer system can treat approximately 40 acres and consists of a control structure for diversion of drainage water from the outlet to lateral distribution lines that run parallel to the buffer. Areas adjacent to a stable stream segment or existing grass buffer where adequate slope and ideal soil characteristics are likely to exist were chosen. Saturated buffers only treat subsurface flow.



Saturated Buffer - *Credit: USDA*

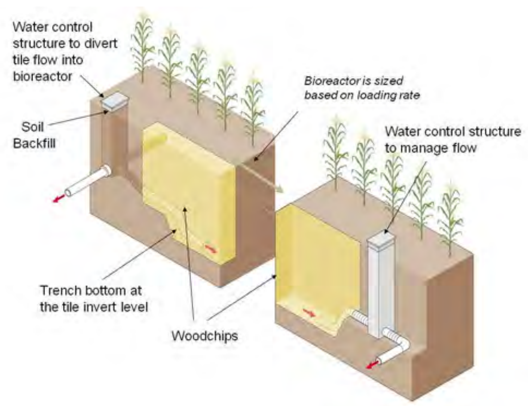
A total of 9 systems or sites are recommended, representing a treatment area of 315 acres and 5,400 ft of tile. Annual expected load reductions if all sites are implemented total:

- 2,008 lbs nitrogen
- 21 lbs phosphorus

Denitrifying Bioreactor

A denitrifying bioreactor is a structure containing a carbon source, usually woodchips, installed to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification. One bioreactor system will treat approximately 50 acres. Locations were identified by direct observation during the watershed windshield survey and by interpretation of aerial imagery and soils.

Twenty bioreactors at 10 locations can likely be applied effectively and will treat 392 acres. Annual load reductions expected if all are implemented total:



Bioreactor

- 2,046 lbs nitrogen
- 9 lbs phosphorus

Drainage Water Management

Drainage water management (DWM), also known as controlled drainage, is the practice of managing water table depths in such a way that nutrient transport from agricultural tile drains is reduced during the fallow season and plant water availability is maintained during the growing season. Sites were selected by direct observation during the watershed windshield survey, by interpretation of aerial imagery and soils. One location is recommended to treat a total of 39 acres. Annual expected load reductions total:

Drainage Water Control Structure

- 119 lbs nitrogen
- 0.6 lbs phosphorus

Filter Strips, Field Borders, Grass Conversion, & Harvestable Perennial Grasses

Field Border

A filter strip is a band of grass or other permanent vegetation used to reduce sediment, nutrients, pesticides, and other contaminants. Only those areas directly adjacent to an openly flowing ditch or stream where existing buffer areas are either inadequate or nonexistent were selected for the placement of filter strips. Field borders are like filter strips but are located along field edges or adjacent to timbered areas; they can range in width from 30 – 120 feet. Grass conversion or conservation cover plantings consist of removing land from production and planting native vegetation. Grass conversion to harvestable perennial grasses for uses including bioenergy, feedstock and livestock bedding are also recommended as an option.

Field borders - are recommended at 81 locations for a total of 268 acres. If all borders are planted, they will treat 2,622 acres. Expected annual load reductions (including gully stabilization) are:

- 2,476 lbs nitrogen
- 1,142 lbs phosphorus
- 962 tons sediment

Field borders – harvestable perennial grass - are recommended at 31 locations for a total of 532 acres. If all borders are planted, they will treat 2,440 acres. Expected annual load reductions (including gully stabilization) are:

- 4,097 lbs nitrogen
- 1,225 lbs phosphorus
- 1,023 tons sediment

Filter Strip

Filter strips - are recommended at 31 locations for a total of 36 acres. If all strips are planted, they will treat 2,440 acres. Expected annual load reductions (including gully stabilization) are:

- 4,097 lbs nitrogen
- 1,225 lbs phosphorus
- 1,023 tons sediment

Filter strips – harvestable perennial grass - are recommended at 5 locations for a total of 55 acres. If all strips are planted, they will treat 276 acres. Expected annual load reductions (including gully stabilization) are:

- 484 lbs nitrogen
- 187 lbs phosphorus
- 149 tons sediment

Grass conversion - or conservation cover consisting of native grasses on small fields is recommended at 68 locations totaling 129 acres. If all are planted, expected annual load reductions (including gully stabilization) are:

- 1,348 lbs nitrogen
- 189 lbs phosphorus
- 153 tons sediment

Conversion to harvestable perennial grasses (full field) - planting to perennial grass is recommended at 680 locations totaling 9,056 acres of planting. If all are planted, expected annual load reductions (including gully stabilization) are:

- 99,142 lbs nitrogen
- 16,450 lbs phosphorus
- 15,593 tons sediment

Grade Control Structures

A grade control structure consists of a constructed berm or a rock/modular block structure designed to address gully erosion and control vertical downcutting. Grade control can also include "rock checks" or rock riffles, a practice used to stabilize streambed erosion and are described in the streambank stabilization section. Grade control structures are recommended at locations where slopes are very steep, and gully erosion is considered very severe; areas where other practices are just not feasible. A total of 56 structures are proposed at 19 locations. Expected annual load reductions are:

- 215 lbs nitrogen
- 95 lbs phosphorus
- 168 tons sediment

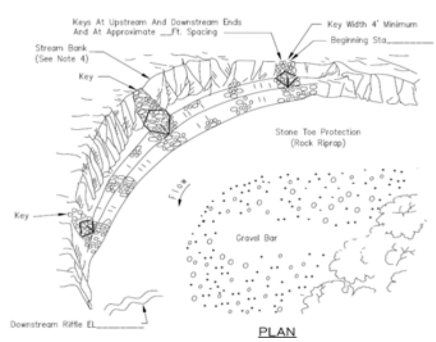
Streambank/Bed Stabilization: Stone-Toe Protection & Riffle

Streambank stabilization consists of both the placement of rock riffles and the installation of stone-toe protection (STP) to stabilize eroding streambanks and control stream grade, if necessary. Stream channel incision or deepening can lead to bank erosion and, oftentimes, grade control or rock riffles are needed in combination with STP. Thirty-nine stream riffles and 12,125 ft of STP are recommended at 46 locations. Locations were selected based on sediment load, accessibility and cost effectiveness.

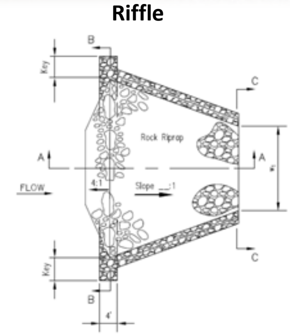
Riffle

If all sites are addressed, annual expected load reductions are:

- 1,419 lbs nitrogen
- 742 lbs phosphorus
- 1,052 tons sediment

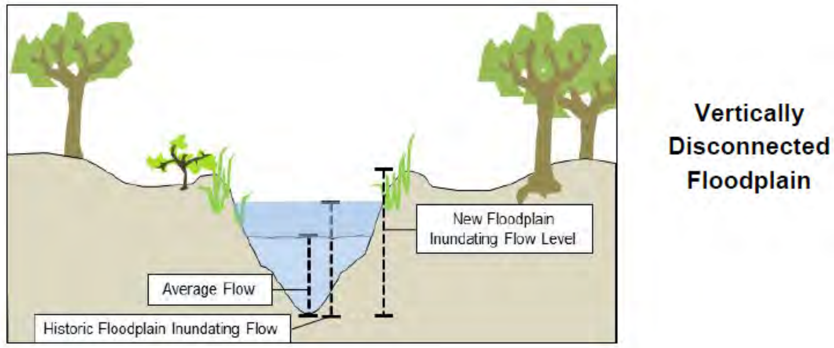


NRCS STP Detail



NRCS Riffle Detail

Floodplain Re-Connection



Source: American Rivers

Re-connecting rivers with their historical floodplains focuses on installing grade control measures to raise a stream's bed elevation. The river will re-establish its natural course over time, eventually reconnecting it to its historical floodplain, or creating a new one. Doing this increases the river's channel capacity for floodwater, resulting in shallower water moving at a reduced speed, reducing the risk of erosion and flooding. Denitrification occurs within these floodplain wetlands, reducing nitrogen loads in downstream waterbodies and increasing water quality (UNEP-DHI Partnership, 2017). Recommended locations also include wetland restoration in the floodplain to maximize sediment and nutrient trapping efficiency.

Re-connecting to the floodplain is recommended at eight locations utilizing 46 large grade control structures (riffles), three medium grade control structures, and 105 acres of wetland restoration. If all are installed, 62,807 acres will be treated, resulting in expected load reductions of:

- 87,435 lbs/yr nitrogen
- 13,932 lbs/yr phosphorus
- 10,851 tons/yr sediment

Ponds & Sediment Basins

A pond is a water impoundment made by constructing an earthen dam. A sediment basin is similar but designed to trap sediment and only hold water for a limited period. A total of 140 ponds, including one repair to an existing pond, and 17 sediment basins are recommended to treat 8,747 acres. These structures will trap sediment and nutrients from runoff and will control gully erosion in steep forested draws.

Pond

If all ponds and sediment basins are installed, annual expected load reductions (including gully stabilization) are:

- 33,840 lbs nitrogen
- 7,310 lbs phosphorus
- 6,527 tons sediment

Pasture Management & Stream Fencing


Stream Fencing

Pasture management consists of stream fencing to exclude livestock from the stream, appropriate stream crossings for cattle use and an alternate water supply (if needed). Stream fencing is placed back from the stream edge to allow for a vegetated buffer to filter runoff.

Stream fencing is recommended at 6 pasture locations. Five locations include stream crossings. A total of 8,332 ft of fence is recommended.

If each system is installed, 33 acres would be treated. Expected annual load reductions are:

- 285 lbs nitrogen
- 107 lbs phosphorus
- 6.6 tons sediment

Livestock Feed Area Treatment System

Once a site has been identified in the watershed, an integrated system can be constructed to manage livestock waste. The feed area 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. Twelve systems are recommended to treat 7.6 acres. If these systems are implemented, the following annual load reductions are expected:

- 113 lbs nitrogen
- 6.2 lbs phosphorus
- 2.2 tons sediment

6.1.3 In-Lake Management Measures

In-lake management measures are those practices or actions that can be implemented to address nutrient and sediment loads generated within each lake or from the entire watershed. Shoreline stabilization, aeration, and dredging in a select number of areas are recommended.

Selective Dredging

Removing accumulated sediment will reduce nutrient release and soft sediment remobilization, increase storage capacity, improve water quality and recreational access. Ten locations are recommended on Glenn Shoals Lake totaling 1,509,788 cubic yards and 3 totaling 120,353 cubic yards on Lake Hillsboro to improve recreational access and prevent the migration of deposited sediment to the main body of the lakes. If implemented, this sediment removal will increase water volume by approximately 329 million gallons.

Nutrient reductions were calculated based on a 2007 Clean Lakes Study. They are not included in the reduction totals from all other recommended practices as the sediment has already been deposited. Although available for resuspension and a potential internal loading source, removal does not necessarily reflect a reduction to the lake for the purposes of this plan. If selective dredging is performed, expected one-time load reductions are:

Glenn Shoals Lake:

- 11,081,958 lbs nitrogen
- 2,506,249 lbs phosphorus
- 815,286 tons sediment

Lake Hillsboro:

- 2,269,854 lbs nitrogen
- 327,359 lbs phosphorus
- 64,991 tons sediment

In-Lake Dam

In-lake sediment and nutrient control basins, consisting of a low-head dam structure, could be constructed to trap and treat nutrients and allow sediment to be deposited upstream of each. Since an in-lake structure would temporarily increase the upstream lake elevation by several feet, the final design would need to control the maximum water surface elevation to reduce flooding potential and impacts to properties and structures. Low flows pass through an opening within the dam structure which could allow small boats to pass upstream. Larger flows would be temporarily impounded allowing sediment and nutrients to be deposited and retained. These structures can be challenging and costly from a permitting standpoint, however they should be considered.

Low-flow/in-lake dam; Otter Lake, Illinois

Four structures are recommended on Glenn Shoals Lake totaling 3,450 ft in length. If implemented, they are expected to reduce 33,547 lbs/yr nitrogen, 6,238 lbs/yr phosphorus, and 4,952 tons/yr sediment from entering the main body of the lake.

Lake Shoreline Stabilization

Stabilizing sections of shoreline to reduce in-lake sediment delivery should be targeted to those areas with the highest rates of erosion. This can be accomplished by installing rip-rap or another form of armoring at the base of each bank. Shoreline stabilization is recommended at 84 locations or 20,465 ft. These areas are presented in Figure 51. Annual load reductions expected if all sites are implemented total:

Glenn Shoals Lake:

- 1,717 lbs nitrogen
- 1,363 lbs phosphorus
- 1,569 tons sediment

Lake Hillsboro:

- 14 lbs nitrogen
- 11 lbs phosphorus
- 12 tons sediment

Aeration

Artificial aeration or circulation of pond and lake water during the summer thermal stratification period is a practice commonly used to improve water quality conditions and limit nutrient release from bottom sediments. The two primary methods of aeration/circulation include artificial circulation and hypolimnetic aeration. Any system that is designed to completely mix or circulate the entire lake or provide aeration without maintaining the normal thermal structure is classified as an artificial circulation technique. Systems within this category include compressed air and/or mechanical devices capable of lifting anoxic hypolimnetic water and circulating oxic surface waters in order to evenly distribute oxygenated water throughout the lake. A compressed air system is typically used to initiate rising air bubbles sufficient to reach the surface and fan out horizontally. The cold, dense water eventually sinks to a level of equal density and eventually establishes a whole lake mixing if the system is sufficiently sized and designed. Hypolimnetic aeration is a method of providing dissolved oxygen to the bottom waters of a lake without disrupting the normal pattern of thermal stratification, thereby maintaining the cooler temperatures that are desirable for cool and cold-water fisheries.

A total of 73 aerators are recommended, with 63 in Glenn Shoals Lake to treat 316 acres and 10 in Lake Hillsboro to treat 48 acres. If the appropriate aeration system is installed in both lakes to address the entire anoxic area, expected annual reductions are:

Glenn Shoals Lake:

- 7,749 lbs phosphorus

Lake Hillsboro:

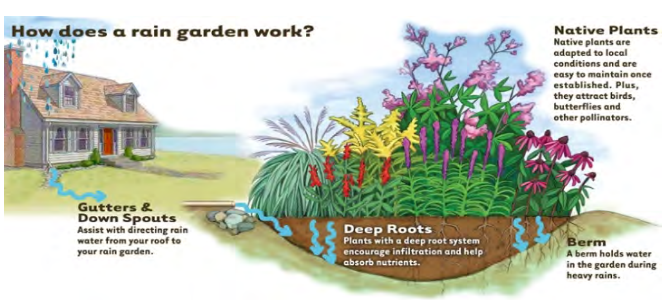
- 1,855 lbs phosphorus

6.1.4 Urban BMPs & Habitat Improvements

Urban BMPs are those specific to residential areas or within city limits. This includes residential rain gardens, an urban detention basin or pond, and permeable pavement. Habitat practices include native prairie buffers and timber stand improvement (TSI).

Residential Rain Gardens & Permeable Pavement

Rain gardens are recommended in residential areas surrounding the lakes. A rain garden is 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.



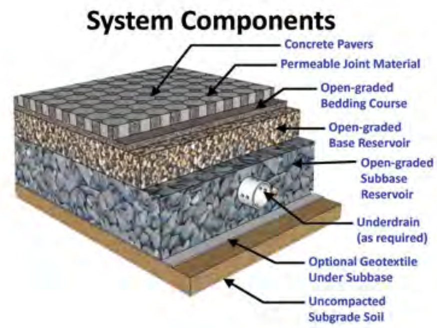
Source: London Master Gardeners

Porous/permeable pavement is a method of paving that allows stormwater to seep into the ground rather than run off into storm drains and waterways. Permeable pavements function similarly to sand filters as they filter the water by forcing it to pass through different aggregate sizes and a 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. Rain gardens are recommended at 79 locations to treat 8.4 acres of residential area in close proximity to both lakes. Annual load reductions expected if all are installed are:

- 65 lbs nitrogen
- 23 lbs phosphorus
- 3 tons sediment

Permeable pavement retrofits are recommended at seven locations or 6.3 acres of existing parking lots. Annual load reductions expected if all are installed are:

- 4.5 lbs nitrogen
- 9.4 lbs phosphorus
- 2 tons sediment



Source: CA Department of Transportation

Urban Wet Detention/Pond

Naturalized wet detention basins or ponds are designed to provide greater water quality and habitat benefits relative to standard dry-bottom (turfgrass) detention basins. They are stormwater control facilities that are planted with native vegetation to help improve stormwater quality. A total of 5 are recommended to treat 107 acres. If implemented, annual expected load reductions are: 117 lbs nitrogen, 63 lbs phosphorus, and 16 tons sediment.

Naturalized Wet Detention Basin or Pond

Native Prairie Buffers

Native vegetative buffers and prairie restoration can help to filter sediment and nutrients more efficiently, provide habitat where little exists and are aesthetically pleasing. Native buffers are recommended adjacent to each lake and where feasible. A total of 4.2 acres at 13 locations are proposed on Glenn Shoals Lake and 1.3 over 3 locations on Lake Hillsboro to treat 34 combined acres. Annual load reductions expected are:

Glenn Shoals Lake:

- 3.3 lbs nitrogen
- 6.4 lbs phosphorus
- 1 ton sediment

Lake Hillsboro:

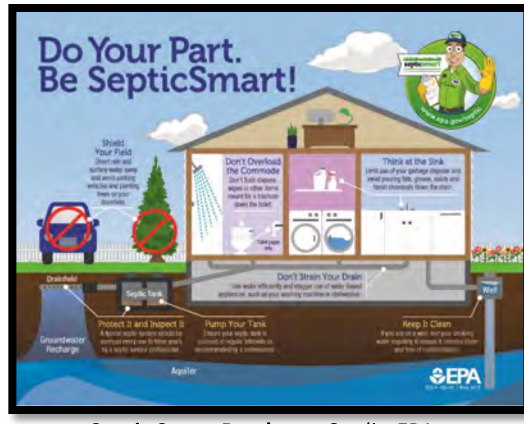
- 2 lbs nitrogen
- 5 lbs phosphorus
- 0.2 tons sediment

Timber Stand Improvement

Timber Stand Improvement (TSI) involves actions that improve the function and value of forests. Such activities include invasive species removal, selective harvesting to improve health and promote growth of desirable species, prescribed fire, and planting. A total of 78 acres of TSI are recommended at 7 sites, 1 owned by the City of Hillsboro. Modest annual load reductions are expected: 11 lbs nitrogen, 6.4 lbs phosphorus, and 14 tons sediment.

Floodplain Forest

Septic Systems



Septic Smart Brochure: *Credit: EPA*

Failing septic systems are likely a source of nutrients to the lakes. It is not known which specific ones are failing and, therefore, actions taken by stakeholders and municipal leaders to address them should focus first on connecting systems to an existing sewer system followed by education programs for systems outside of City limits. The EPA, for example, has implemented a SepticSmart program (https://www.epa.gov/septic) consisting of tips for maintenance and educational materials that can be distributed or promoted to those homes in the subwatershed that are not on sewers. Reducing the number of failing systems will benefit water quality, however, the cost of connecting all residences to a sewer network far outweighs the water quality benefits.

6.1.5 City-Owned BMP Summary

Practices specific to Hillsboro-owned property are summarized in Table 43. This includes wetlands, floodplain re-connection (with wetlands), in-lake aeration, in-lake dams, permeable pavement, shoreline stabilization, dredging, grade control structures, ponds, and habitat improvements. Table 43 also includes columns indicating if the practice can be funded either entirely or partially through grants versus those that will require the city to fund independently. If implemented, these practices will achieve 22% of the total expected nitrogen load reductions from all BMPs, 17% of the phosphorus and 19% of the sediment. Additional reductions will be realized by dredging. Most of the benefits are achieved by re-connecting streams to their floodplains. Shoreline stabilization should be considered first due to large sediment reductions achieved and low complexity in terms of engineering, permitting and construction.

Table 43 - City of Hillsboro Owned BMP Summary

BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)	Grant Funded	City Funded
Dredging	1,630,141 (cy)	149	13,351,812[1]	2,833,608[1]	880,277[1]	No	Yes
Aeration	73 (units)	n/a	n/a	9,604	n/a	No	Yes
Shoreline Stabilization	20,465 (ft)	n/a	1,731	1,374	1,581	Yes	Yes
In-Lake Dam	4 (locations), 3,450 (ft length)	34,818	33,547	6,238	4,952	Yes	Yes
Floodplain Re-connection	4 (locations), 26 (rock riffles), 71 (ac wetland)	48,978	74,092	11,655	9,126	Yes	Yes
Grade Control	2 (locations), 8 (structures)	15	16	8.5	20	Yes	Yes
Permeable Pavement	5 (locations), 5.1 (sq ft)	5.1	12	6.9	6.9	Yes	Yes
Pond	26 (locations)	405	1,001	365	377	Yes	Yes
Native Prairie Buffer	14 (locations), 5.3 (ac)	33	4.9	10	1.2	Yes	Yes
TSI	1 (location), 9.4 (ac)	9.4	0.42	0.19	0.03	Yes	Yes
Wetland Creation	15 (locations), 27.4 (ac)	1,101	2,469	586	535	Yes	Yes
Grand Total		**85,513**	**112,874**	**20,244**	**16,600**	-	

[1] – Reductions not included in totals

7.0 Cost Estimates

Costs are determined based on professional judgment and expertise, 2024 USDA-NRCS scenario rates, and unit costs used in other watershed plans. Several estimates are based on field visits and known quantities for a given practice. Costs should be considered as estimates only and revisited during final design and budgeting, as required. Totals include some level of planning and/or engineering and a contingency for future increases. Maintenance costs are not included. Land acquisition/rental costs are included for select BMPs.

7.1 Unit Costs

Unit estimates and assumptions are presented in the following table:

Table 44 - Unit Costs & Assumptions

BMP	Unit Cost	Unit	Notes/Assumptions
Aerator	$8,631	each	Based on professional judgement.
Bioreactor	$24,686.16	each	Based on USDA-NRCS rates of $91.90 per cubic yard to install, including labor and materials. Based on 222 cubic yards for a system with a liner and soil cover sized to treat 50 acres. An additional 20% contingency was applied.
Cover Crop	$103.08	acre	Based on USDA-NRCS rates. Assumes 1 year of multiple species including spring termination.
Drainage Water Management	$267.54	acre	Per acre for installation to retrofit an existing tile system, using estimates obtained from the Agricultural Watershed Institute in Macon County. An additional 20% contingency was applied.
Dredging	$17.00	cubic yard	Based on professional judgement.
Field Border	$904.42	acre	Based on USDA-NRCS rates for native species. Costs include land preparation, materials and seeding. An additional 10% contingency was applied. Estimates do not include any reoccurring annual rental payments or land acquisition.
Filter Strip	$904.42	acre	Based on USDA-NRCS rates for native species. Costs include land preparation, materials and seeding. An additional 10% contingency was applied. Estimates do not include any reoccurring annual rental payments or land acquisition.
Floodplain Reconnection	$34,470	each	Based on professional judgement and 1.75 times the USDA rates for "large" riffles, plus 20% for engineering and permitting. An additional 20% contingency was applied.
Floodplain Reconnection	$28,000	acre	Includes earthwork, tree removal (if needed) and seeding. Based on professional judgement and USDA-NRCS rates.
Floodplain Reconnection	$4,320	each	For water control structure and tile. Based on professional judgement and USDA-NRCS rates. An additional 20% contingency was applied.

BMP	Unit Cost	Unit	Notes/Assumptions
Grade control structure – Riffles, Large Stream	$16,117.42	each	Based on professional judgement and USDA-NRCS rates for “large” riffles. An additional 20% contingency was applied.
Grade control structure – Riffles, Medium Stream/Gully	$12,968.68	each	Based on professional judgement and USDA-NRCS rates for “small” riffles. An additional 20% contingency was applied.
Grade control structure – Riffles, Small Stream/Gully	$5,880.71	each	Based on professional judgement and USDA-NRCS rates for “small” riffles. An additional 20% contingency was applied.
Grade Control Structure - Rock Check	$4,567.75	each	Assumes 32 yd^3, based on USDA-NRCS cost share prices. An additional 20% contingency was applied.
Grass Conversion	$919.00	acre	Based on USDA-NRCS rates for Critical Area Planting with moderate grading. Includes land prep and seeding. An additional 10% contingency was applied. Estimates do not include any annual rental payments or land acquisition costs.
Grass Waterway	$7,533.95	acre	Based on USDA-NRCS rates for shaping and seeding, checks and crop season construction. An additional 20% contingency was applied.
Grass Waterway	$7.75	foot	Based on USDA-NRCS rates for waterway tile. Maintenance of existing waterways does not include tile. An additional 10% contingency was applied.
Livestock Waste or Feed Area Treatment System	$82,800	each	Based on professional judgement. Includes basins, diversions (if needed) and seeding.
Native Prairie Restoration	$1,104	acre	Costs include land preparation, materials and seeding. Estimates do not include any annual rental payments or land acquisition costs.
No-till/Strip-Till	$22.74	acre	Based on USDA-NRCS rates per acre for 1 year.
Nutrient Management – Deep placement P	$85.94	acre	Includes soil testing. Based on USDA-NRCS rates per acre for 1 year.
Nutrient Management – Split/Precision Application	$68.64	acre	Based on USDA-NRCS rates per acre for 1 year including soil testing.
Nutrient Management Plan	$19.00	acre	Based on USDA-NRCS rates up to a maximum of $5,407.
Pasture Stream Crossing	$13,166.71	each	Based on professional judgement and USDA-NRCS rates. 30’ x 50’ ft. An additional 20% contingency was applied.
Pasture Stream Fencing	$3.87	foot	Based on USDA-NRCS rates for permanent woven wire. An additional 10% contingency was applied.
Perennial Field Border	$1,209.12	acre	Based on USDA-NRCS rates for native species. Costs include land preparation, materials and seeding. Estimate includes a $277 annual rental payment. An additional 10% contingency was applied.
Perennial Filter Strip	$1,209.12	acre	Based on USDA-NRCS rates for native species with forgone income. Costs include land preparation, materials and seeding. Estimate includes a $277 annual rental payment. An additional 10% contingency was applied.

BMP	Unit Cost	Unit	Notes/Assumptions
Perennial Grass Conversion	$1,232.70	acre	Based on USDA-NRCS rates for Critical Area Planting with moderate grading. Includes land prep and seeding. Estimate includes a $277 annual rental payment. An additional 10% contingency was applied.
Pond	$82,800	each	Based on professional judgement and average 10,000 yd^3 soil. Cost can range depending on the size of the berm and primary spillway pipe, the extent of clearing needed, and size of rock at outfall structures. An additional 20% contingency was applied.
Porous/permeable pavement	$14.85	square foot	Based on professional judgement. Final costs are dependent on the surface type used.
Residential rain garden	$6,400	each	Based on professional judgement.
Saturated Buffer	$21.22	foot	Based on USDA-NRCS rates for saturated buffer with automated control structure. An additional 20% contingency was applied.
Sediment Basin	$20,556	each	Based on NRCS rates of $6.85 per yd^3 and 2,500 yd^3. An additional 20% contingency was applied.
Shoreline Stabilization	$125	foot	Based on professional judgement for breakwater stabilization
Streambank Stabilization (STP)	$130	foot	Based on professional judgement, includes some engineering and permitting.
Terrace	$8.08	foot	Based on USDA rates for farmable terraces, crop season construction. An additional 20% contingency was applied.
Terrace	$7.75	foot	Terrace tile. Based on NRCS rates for 8 inch tile. An additional 20% contingency was applied.
Timber Stand Improvement	$750.00	acre	Based on professional judgement. Includes manual invasive species removal, and prescribed fire.
Water and Sediment Control Basin	$3,408.29	each	Per basin and an average of 700 yd^3 soil. Based on professional judgement and USDA-NRCS rates for crop season construction. An additional 20% contingency was applied.
Water and Sediment Control Basin	$7.75	foot	Water and sediment control basin tile. Based on NRCS rates for 8 inch tile. An additional 20% contingency was applied.
Wetland Creation	$28,000.00	acre	Includes earthwork, tree removal (if needed) and seeding. Based on professional judgement and USDA-NRCS rates.
Wetland Creation – Control Structure	$4,320.00	each	For water control structure and tile. Based on professional judgement and USDA-NRCS rates. An additional 20% contingency was applied.
Wetland Restoration (existing wetland)	$13,764.00	acre	Based on USDA-NRCS rates for vernal pool wetland. An additional 20% contingency was applied.

7.2 Total Cost

Table 45 below provides a detailed breakdown of cost estimates for each BMP type and the cost per unit of loading reduced. The total of implementing all BMPs, except for dredging projects, is estimated to be $60,878,042 in Lake Glenn Shoals and $5,130,904 in Lake Hillsboro (Table 45). Excluding per unit practices that exceed $10,000 per unit reduced, the average per pound of nitrogen removed is $858 and $832, phosphorus $1,462 and $1,301, and the average cost for a ton of sediment is $1,179 and $2,012, for Lake Glenn Shoals and Lake Hillsboro, respectively.

Based on annual per pound of nitrogen reduction, conversion to no-till or strip-till, cover crops, continuing the application of existing cover crops, split application of nitrogen, floodplain re-connection, are the most effective followed by field borders and filter strips, and saturated buffers. Conversion to no-till or strip-till, floodplain reconnection, lake aerators, cover crops, are the most cost effective for phosphorus reduction, followed by filter strips and field borders. Conversion to no-till or strip-till, filter strips, field borders, and cover crop are the most effective for reducing sediment delivery and can be used on a large percentage of the watershed. Those structural practices that treat larger drainage areas, such as wetlands, ponds and floodplain re-connection, will generate higher volume reductions. Shoreline and streambank stabilization address problem areas needing attention and are very cost-effective, especially over their entire lifespan.

Costs are for establishment of the practice and cover crops, nutrient management, no-till, and strip-till are for 1 year. Structural practices have a high initial cost but provide reductions over their effective lifespan. Table 46 compares costs over a ten-year period with in-field practices requiring expenditures annually versus structural incurring as a one-time investment. Amortizing over ten years substantially reduces unit costs for structural practices, however, locations where they can be built are somewhat limited and water quality targets, in most cases, cannot be achieved with them alone. Furthermore, structural BMPs require maintenance, sometimes annually, adding to their cost over time.

In addition to the costs presented in this section for BMPs, there will be those associated with outreach and addressing septic systems through education campaigns. It is estimated that education and outreach could range from $30,000 – $70,000 per year, including staff time to contact and educate landowners, organize workshops, and develop grant applications.

Table 45 - Cost Summary by BMP Type

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
Glenn Shoals Lake						
In-Field Practices	Cover Crop	33,144 (ac)	$3,416,498.01	$22.22	$193.60	$220.20
	Cover Crop - Existing	52 (ac)	$211,553.60	$35.39	$238.06	$333.24
	Cover Crop - Partial	9,227 (ac)	$951,113.80	$17.39	$149.35	$146.02

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
	Nutrient Management - Deep Placement Phosphorus	23,603 (ac)	$2,478,216.70	n/a	$290.37	n/a
	No-Till	5,181 (ac)	$117,813.82	$15.05	$19.29	$14.54
	Nutrient Management - Split Application Nitrogen	722 (ac)	$63,287.95	$27.18	n/a	n/a
	No-Till or Strip-Till	17,608 (ac)	$400,402.45	$19.15	$26.74	$30.56
Glenn Shoals Lake In-Field Practices Subtotal			***$6,687,772.51***	***$22.73***	***$179.62***	***$148.91***
Structural, Urban, and In-Lake Practices	Aerator	63 (aerators)	$543,753.00	n/a	$70.17	n/a
	Bioreactor	10 (locations), 20 (structures)	$493,723.20	$241.32	$53,805.46	n/a
	Drainage Water Management	1 (locations), 39 (ac)	$10,471.69	$87.71	$16,153.29	n/a
	Feed Area Management System	12 (locations), 14 (ac)	$1,117,800.00	$9,855.88	$17,905.37	$497,958.81
	Field Border	76 (locations), 244 (ac)	$236,561.76	$104.64	$224.51	$261.60
	Field Border - Perennial	29 (locations), 512 (ac)	$619,057.61	$164.32	$552.19	$642.76
	Filter Strip	170 (locations), 381 (ac)	$344,755.17	$52.26	$116.24	$130.58
	Filter Strip - Perennial	5 (locations), 55 (ac)	$66,403.53	$137.25	$356.05	$447.15
	Floodplain Reconnection	8 (locations), 49 (riffles), 105 (ac wetland), 26 (structures)	$4,727,350.00	$54.07	$339.31	$435.67
	Grade Control	10 (locations), 34 (structures)	$155,303.50	$1,993.89	$4,851.11	$1,977.61
	Grade Control - Riffles	8 (locations), 15 (small riffles), 2 (medium riffles)	$146,382.85	$1,284.34	$2,634.76	$1,799.07
	Grass Conversion	66 (locations), 126 (ac)	$115,871.44	$87.45	$619.73	$759.20
	In-Lake Dam	4 (locations), 3,450 (ft)	$6,250,500.00	$186.32	$1,001.97	$1,262.33
	Livestock Fencing/ Management	6 (locations), 8,332 (ft fencing), 5 (crossings)	$98,077.55	$343.63	$918.35	$14,784.82
	Native Prairie Buffer	13 (locations), 4 (ac)	$4,682.84	$1,416.32	$729.78	$4,611.19
	Perennial Grasses	634 (locations), 8,384 (ac)	$10,317,719.43	$122.99	$698.03	$707.34
	Permeable Pavement	4 (locations), 222,968 (sq ft)	$3,311,081.97	$306,986.32	$509,385.71	$1,988,799.07

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
	Pond	130 (locations)	$14,454,080.23	$475.75	$2,252.62	$2,450.21
	Pond Repair	1 (locations)	$82,800.00	$86,017.13	$139,000.11	$1,056,702.02
	Rain Garden	62 (locations)	$460,800.00	$10,997.45	$27,907.55	$181,551.41
	Saturated Buffer	9 (locations), 5,400 (ft tile)	$114,588.00	$57.07	$5,440.24	n/a
	Sediment Basin	17 (locations), 25 (basins)	$513,900.00	$936.84	$2,214.54	$1,662.94
	Streambed/Bank Stabilization	8 (locations), 12 (small riffles), 27 (medium riffles), 1,266 (ft STP)	$558,171.27	$791.50	$1,382.66	$1,130.92
	Shoreline Stabilization	82 (locations), 20,099 (ft)	$2,512,411.94	$1,463.08	$1,842.27	$1,601.57
	STP	38 (locations), 10,859 (ft STP)	$1,530,833.68	$2,142.80	$4,532.15	$2,740.43
	Terrace	18 (locations), 27,700 (ft tile), 12,630 (ft terrace)	$321,698.50	$398.94	$846.58	$790.10
	TSI	6 (locations), 75 (ac)	$56,089.37	$5,445.70	$8,872.01	$4,080.53
	WASCB	86 (locations), 232 (basins), 54,530 (ft tile)	$1,011,199.49	$465.49	$986.35	$900.79
	WASCB Maintenance	9 (locations), 19 (basins), 5,700 (ft tile)	$16,812.37	$74.23	$166.13	$160.50
	Waterway	30 (locations), 52 (ac), 39,022 (ft tile)	$478,935.73	$155.65	$1,327.42	$1,068.47
	Waterway Maintenance	18 (locations), 30 (ac), 7,086 (ft tile)	$281,854.03	$168.62	$1,364.82	$938.27
	Wetland Creation	66 (locations), 100 (ac wetland), 80 (structures)	$3,236,600.00	$334.16	$1,531.77	$1,715.33
Glenn Shoals Lake Structural Practices Subtotal			$54,190,270.15	$710.60	$1,764.30	$1,403.24
Glenn Shoals Lake Grand Total[1, 2]			$60,878,042.66	$858.19	$1,462.16	$1,179.25
Lake Hillsboro						
In-Field Practices	Cover Crop	1,055 (ac)	$108,780.60	$14.04	$122.91	$194.36
	Cover Crop - Existing	052 (ac)	$5,348.24	$19.08	$177.01	$372.62
	Cover Crop - Partial	540 (ac)	$55,617.81	$12.60	$109.42	$171.49
	Nutrient Management - Deep Placement Phosphorus	575 (ac)	$60,376.66	n/a	$214.87	n/a
	No-Till	429 (ac)	$9,747.41	$10.45	$17.27	$20.67
	No-Till or Strip-Till	123 (ac)	$2,797.43	$12.33	$20.80	$29.85

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
Lake Hillsboro In-Field Practices Subtotal			***$187,050.34***	***$13.70***	***$110.38***	***$157.80***
Structural, Urban, and In-Lake Practices	Aerator	10 (aerators)	$86,310.00	n/a	$46.53	n/a
	Dredge	3 (locations), 120,353 (CY)	$2,045,997.56	$0.90	$6.25	$31.48
	Field Border	5 (locations), 24 (ac)	$21,495.57	$99.94	$244.64	$374.67
	Field Border - Perennial	2 (locations), 20 (ac)	$23,930.87	$72.55	$229.48	$399.23
	Grade Control - Riffles	1 (locations), 5 (small riffles), (medium riffles)	$29,403.55	$1,278.81	$4,152.17	$3,895.35
	Grass Conversion	2 (locations), 3 (ac)	$2,897.11	$128.51	$1,492.40	$5,383.15
	Native Prairie Buffer	3 (locations), 1 (ac)	$1,470.13	$743.24	$293.94	$7,308.96
	Perennial Grasses	46 (locations), 672 (ac)	$827,995.75	$54.28	$496.12	$822.32
	Permeable Pavement	3 (locations), 52,508 (sq ft)	$779,742.73	$122,612.26	$266,619.55	$2,030,061.93
	Pond	10 (locations)	$1,258,560.02	$432.68	$1,904.14	$3,946.62
	Pond - Urban	4 (locations)	$530,000.01	$4,520.16	$8,353.48	$32,263.42
	Rain Garden	17 (locations)	$108,800.00	$4,792.10	$16,780.49	$233,115.22
	Shoreline Stabilization	2 (locations)	$45,823.48	$3,357.85	$4,228.21	$3,675.73
	Terrace	3 (locations), 4,100 (ft fencing), 2,150 (crossings)	$49,790.50	$262.22	$751.20	$1,290.56
	TSI	1 (locations), 3 (ac)	$2,291.48	$10,542.07	$33,000.82	$579,827.37
	WASCB	7 (locations), 23 (basins), 6,050 (ft tile)	$104,408.52	$290.64	$791.25	$1,112.31
	Waterway	2 (locations), 4 (ac), 3,093 (ft tile)	$37,466.76	$100.73	$944.66	$1,197.74
	Waterway Maintenance	2 (locations), 2 (ac)	$16,106.92	$55.22	$609.65	$910.99
	Wetland Creation	9 (locations), 34 (ac wetland), 15 (structures)	$1,017,360.00	$381.14	$2,118.89	$5,110.78
Lake Hillsboro Structural Practices Subtotal			$4,943,853.40	$1,104.67	$1,777.12	$2,725.26
Lake Hillsboro Total [1, 2]			$5,130,903.73	$831.93	$1,300.91	$2,012.08

[1] - Cover Crop – Partial are not included in subtotals or totals as their reductions are already accounted for with cover crops
[2] – Excludes high cost BMPs.

Table 46 – Amortized Cost Over Ten Years

BMP Class	BMP	Total Cost Over 10 Years	Amortized Yearly Cost Over 10 Years	Cost/lb Nitrogen Reduction Yearly	Cost/lb Phosphorous Reduction Yearly	Cost/ton Sediment Reduction Yearly
Glenn Shoals Lake						
In-Field Practices	Cover Crop	$34,164,980.05	$3,416,498.01	$22.22	$193.60	$220.20
	Cover Crop - Existing	$2,115,535.97	$211,553.60	$35.39	$238.06	$333.24
	Cover Crop - Partial	$9,511,138.02	$951,113.80	$17.39	$149.35	$146.02
	Nutrient Management - Deep Placement Phosphorus	$24,782,166.96	$2,478,216.70	n/a	$290.37	n/a
	No-Till	$1,178,138.20	$117,813.82	$15.05	$19.29	$14.54
	Nutrient Management - Split Application Nitrogen	$632,879.45	$63,287.95	$27.18	n/a	n/a
	No-Till or Strip-Till	$4,004,024.46	$400,402.45	$19.15	$26.74	$30.56
Structural, Urban, and In-Lake Practices	Aerators	$543,753.00	$54,375.30	n/a	$7.02	n/a
	Bioreactor	$493,723.20	$49,372.32	$24.13	$5,380.55	n/a
	Drainage Water Management	$10,471.69	$1,047.17	$8.77	$1,615.33	n/a
	Feed Area Management System	$1,117,800.00	$111,780.00	$985.59	$1,790.54	$49,795.88
	Field Border	$236,561.76	$23,656.18	$10.46	$22.45	$26.16
	Field Border - Perennial	$619,057.61	$61,905.76	$16.43	$55.22	$64.28
	Filter Strip	$344,755.17	$34,475.52	$5.23	$11.62	$13.06
	Filter Strip - Perennial	$66,403.53	$6,640.35	$13.72	$35.60	$44.71
	Floodplain Reconnection	$4,727,350.00	$472,735.00	$5.41	$33.93	$43.57
	Grade Control	$155,303.50	$15,530.35	$199.39	$485.11	$197.76
	Grade Control - Riffles	$146,382.85	$14,638.29	$128.43	$263.48	$179.91
	Grass Conversion	$115,871.44	$11,587.14	$8.75	$61.97	$75.92
	In-Lake Dam	$6,250,500.00	$625,050.00	$18.63	$100.20	$126.23
	Livestock Fencing/Management	$98,077.55	$9,807.75	$34.36	$91.83	$1,478.48
	Native Prairie Buffer	$4,682.84	$468.28	$141.63	$72.98	$461.12
	Perennial Grasses	$10,317,719.43	$1,031,771.94	$12.30	$69.80	$70.73
	Permeable Pavement	$3,311,081.97	$331,108.20	$30,698.63	$50,938.57	$198,879.91
	Pond	$14,454,080.23	$1,445,408.02	$47.57	$225.26	$245.02
	Pond Repair	$82,800.00	$8,280.00	$8,601.71	$13,900.01	$105,670.20
	Rain Garden	$460,800.00	$46,080.00	$1,099.74	$2,790.76	$18,155.14
	Saturated Buffer	$114,588.00	$11,458.80	$5.71	$544.02	n/a
	Sediment Basin	$513,900.00	$51,390.00	$93.68	$221.45	$166.29
	Streambed/Bank Stabilization	$558,171.27	$55,817.13	$79.15	$138.27	$113.09
	Shoreline Stabilization	$2,512,411.94	$251,241.19	$146.31	$184.23	$160.16
	STP	$1,530,833.68	$153,083.37	$214.28	$453.22	$274.04
	Terrace	$321,698.50	$32,169.85	$39.89	$84.66	$79.01

BMP Class	BMP	Total Cost Over 10 Years	Amortized Yearly Cost Over 10 Years	Cost/lb Nitrogen Reduction Yearly	Cost/lb Phosphorous Reduction Yearly	Cost/ton Sediment Reduction Yearly
	TSI	$56,089.37	$5,608.94	$544.57	$887.20	$408.05
	WASCB	$1,011,199.49	$101,119.95	$46.55	$98.63	$90.08
	WASCB Maintenance	$98,961.42	$9,896.14	$43.69	$97.79	$94.48
	Waterway	$478,935.73	$47,893.57	$15.56	$132.74	$106.85
	Waterway Maintenance	$281,854.03	$28,185.40	$16.86	$136.48	$93.83
	Wetland Creation	$3,236,600.00	$323,660.00	$33.42	$153.18	$171.53
Lake Hillsboro						
In-Field Practices	Cover Crop	$108,780.60	$10,878.06	$1.40	$12.29	$19.44
	Cover Crop - Existing	$5,348.24	$534.82	$1.91	$17.70	$37.26
	Cover Crop - Partial	$55,617.81	$5,561.78	$1.26	$10.94	$17.15
	Deep Placement P	$60,376.66	$6,037.67	n/a	$21.49	n/a
	No-Till	$9,747.41	$974.74	$1.04	$1.73	n/a
	No-Till or Strip-Till	$2,797.43	$279.74	$1.23	$2.08	$2.99
Structural, Urban, and In-Lake Practices	Field Border	$21,495.57	$2,149.56	$9.99	$24.46	$37.47
	Field Border - Perennial	$23,930.87	$2,393.09	$7.26	$22.95	$39.92
	Grade Control - Riffles	$29,403.55	$2,940.36	$127.88	$415.22	$389.54
	Grass Conversion	$2,897.11	$289.71	$12.85	$149.24	$538.31
	Native Prairie Buffer	$1,470.13	$147.01	$74.32	$29.39	$730.90
	Perennial Grasses	$827,995.75	$82,799.58	$5.43	$49.61	$82.23
	Permeable Pavement	$779,742.73	$77,974.27	$12,261.23	$26,661.95	$203,006.19
	Pond	$1,258,560.02	$125,856.00	$43.27	$190.41	$394.66
	Pond - Urban	$530,000.01	$53,000.00	$452.02	$835.35	$3,226.34
	Rain Garden	$108,800.00	$10,880.00	$479.21	$1,678.05	$23,311.52
	Shoreline Stabilization	$45,823.48	$4,582.35	$335.79	$422.82	$367.57
	Terrace	$49,790.50	$4,979.05	$26.22	$75.12	$129.06
	TSI	$2,291.48	$229.15	$1,054.21	$3,300.08	$57,982.74
	WASCB	$104,408.52	$10,440.85	$29.06	$79.13	$111.23
	Waterway	$37,466.76	$3,746.68	$10.07	$94.47	$119.77
	Waterway Maintenance	$16,106.92	$1,610.69	$5.52	$60.96	$91.10
	Wetland Creation	$1,017,360.00	$101,736.00	$38.11	$211.89	$511.08

8.0 Water Quality Targets

This section describes water quality targets and those implementation actions required to meet them. The primary constituents of concern in Glenn Shoals Lake and Lake Hillsboro are sediment and phosphorus. Targets of an 85% reduction in phosphorus and sediment and a 45% reduction in nitrogen are consistent with existing TMDL plans and the INLRS and have been applied to both lakes. The 85% sediment target is set to match the Glenn Shoals and Lake Hillsboro TMDL and reflects Hillsboro's desire to achieve substantial reductions.

Table 47 compares BMPs to targets. Results indicate that widespread and overlapping in-field and structural BMP implementation will meet or exceed targets. It should be noted that reductions do not account for the cumulative effect of upstream practices and, therefore, the totals achieved will likely be somewhat lower if all recommended practices are considered as a "system." It is estimated that this situation could reduce estimates by up to 30%. Despite this, it is still reasonable to assume that targets can be met or exceeded.

Cover crops, conversion to no-till or strip-till, and floodplain reconnection will likely provide the greatest potential for reductions. Combined, in-field practices will achieve moderately greater reductions in nitrogen, phosphorus, and sediment (Table 47). In-field management is less costly on an annual basis but requires a long-term commitment and landowner buy-in to ensure benefits are realized over multiple consecutive years.

The importance of lake and watershed management is even greater today as Hillsboro looks to ensure a resilient source of water that can support future economic development. This watershed plan details actions designed to reduce the sources of sediment and nutrients to levels that could eliminate or reduce the need for major water treatment/supply expenditures such as large-scale dredging and prolong recent investments. Furthermore, focusing on source water or watershed protection will provide additional benefits, such as improved recreational opportunities. Considerations for the lake and watershed approach include:

1. Future savings to costly treatment/supply infrastructure and reduce frequency of dredging. Dollars spent in the watershed will yield substantial reductions in nutrient and sediment loads, potentially at a lower cost.
2. Leveraging of funds. Watershed improvements are eligible for a wide array of state and federal funding where relatively small investments from the city can generate substantial amounts of funding.
3. Recreational and quality of life benefits. Improving lake water quality will attract visitors and businesses who then invest in the local economy.

Table 47 – Water Quality Targets & Load Reductions

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (% Total Load)	Phosphorus Reduction (% Total Load)	Sediment Reduction (% Total Load)
Glenn Shoals Lake						
In-Field	Cover Crop	33,144 (ac)	33,144	30%	22%	31%
	Cover Crop - Existing	2,052 (ac)	2,052	1.2%	1.1%	1.3%
	Cover Crop – Partial[1]	9,227 (ac)	9,227	11%	8%	13%
	Nutrient Management - Deep Placement Phosphorus	23,603 (ac)	23,603	n/a	11%	n/a
	No-Till	5,181 (ac)	5,181	1.5%	8%	16%
	Nutrient Management - Split Application Nitrogen	722 (ac)	722	0.5%	n/a	n/a
	No-Till or Strip-Till	17,608 (ac)	17,608	4.1%	19%	27%
Glenn Shoals Lake In-Field Practices Subtotal			**80,258**	***38%***	***61%***	***79%***
Structural, Urban, and In-Lake Practices	Aerators	63 (aerators)	316	n/a	9.7%	n/a
	Bioreactor	10 (locations), 20 (structures)	392	0.4%	0.01%	n/a
	Drainage Water Management	1 (locations), 39 (ac)	39	0.02%	0.001%	n/a
	Feed Area Management System	12 (locations), 14 (ac)	7.6	0.02%	0.1%	0.005%
	Field Border	76 (locations), 244 (ac)	2,478	0.4%	1.3%	1.8%
	Field Border - Perennial	29 (locations), 512 (ac)	2,355	0.7%	1.4%	1.9%
	Filter Strip	170 (locations), 381 (ac)	5,170	1.3%	3.7%	5.3%
	Filter Strip - Perennial	5 (locations), 55 (ac)	276	0.1%	0.2%	0.3%
	Floodplain Reconnection	8 (locations), 49 (riffles), 105 (ac wetland), 26 (structures)	62,807	17%	17%	22%
	Grade Control	10 (locations), 34 (structures)	78	0.02%	0.04%	0.2%
	Grade Control - Riffles	8 (locations), 15 (small riffles), 2 (medium riffles)	231	0.02%	0.1%	0.2%
	Grass Conversion	66 (locations), 126 (ac)	126	0.3%	0.2%	0.3%
	In-Lake Dam	4 (locations), 3,450 (ft)	34,818	6.6%	7.8%	10%
	Livestock Fencing/Management	6 (locations), 8,332 (ft fencing), 5 (crossings)	33	0.1%	0.1%	0.01%
	Native Prairie Buffer	13 (locations), 4 (ac)	28	0.001%	0.01%	0.002%

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (% Total Load)	Phosphorus Reduction (% Total Load)	Sediment Reduction (% Total Load)
	Perennial Grasses	634 (locations), 8,384 (ac)	13,243	17%	19%	30%
	Permeable Pavement	4 (locations), 222,968 (sq ft)	5.1	0.002%	0.01%	0.003%
	Pond	130 (locations)	7,875	6%	8%	12%
	Pond Repair	1 (locations)	3.7	0.0002%	0.001%	0.0002%
	Rain Garden	62 (locations)	6.9	0.01%	0.02%	0.01%
	Saturated Buffer	9 (locations), 5,400 (ft tile)	315	0.4%	0.03%	n/a
	Sediment Basin	17 (locations), 25 (basins)	314	0.1%	0.3%	0.6%
	Streambed/Bank Stabilization	8 (locations), 12 (small riffles), 27 (medium riffles), 1,266 (ft STP)	1,058	0.1%	0.5%	1%
	Shoreline Stabilization	82 (locations), 20,099 (ft)	n/a	0.3%	1.7%	3.2%
	STP	38 (locations), 10,859 (ft STP)	n/a	0.1%	0.4%	1.1%
	Terrace	18 (locations), 27,700 (ft tile), 12,630 (ft terrace)	237	0.2%	0.5%	0.8%
	TSI	6 (locations), 75 (ac)	75	0.002%	0.01%	0.03%
	WASCB	86 (locations), 232 (basins), 54,530 (ft tile)	662	0.4%	1.3%	2.3%
	WASCB Maintenance	9 (locations), 19 (basins), 5,700 (ft tile)	83	0.04%	0.1%	0.2%
	Waterway	30 (locations), 52 (ac), 39,022 (ft tile)	1,894	0.6%	0.5%	0.9%
	Waterway Maintenance	18 (locations), 30 (ac), 7,086 (ft tile)	1,036	0.3%	0.3%	0.6%
	Wetland Creation	66 (locations), 100 (ac wetland), 80 (structures)	4,224	1.9%	2.6%	3.8%
Lake Glenn Shoals Structural Practices Subtotal			***140,188***	**54%**	**77%**	**98%**
Glenn Shoals Lake Grand Total			**220,446**	**62 - 92% (target exceeded)[2]**	**100% (target exceeded)[3]**	**100% (target exceeded)[4]**
Lake Hillsboro						
In-Field Practices	Cover Crop	1,055 (ac)	1,055	17%	12%	23%
	Cover Crop - Existing	52 (ac)	52	0.6%	0.4%	0.6%
	Cover Crop – Partial[1]	540 (ac)	540	9.8%	6.7%	13%

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (% Total Load)	Phosphorus Reduction (% Total Load)	Sediment Reduction (% Total Load)
	Nutrient Management - Deep Placement Phosphorus	575 (ac)	575	n/a	3.7%	n/a
	No-Till	429 (ac)	429	2.1%	7%	19%
	No-Till or Strip-Till	123 (ac)	123	0.5%	1.8%	3.8%
Lake Hillsboro In-Field Practices Subtotal			***2,722***	***30%***	***18%***	***27%***
Structural, Urban, and In-Lake Practices	Aerator	10 (aerators)	48	n/a	25%	n/a
	Field Border	5 (locations), 24 (ac)	144	0.5%	1.2%	2.3%
	Field Border - Perennial	2 (locations), 20 (ac)	85	0.7%	1.4%	2.4%
	Grade Control - Riffles	1 (locations), 5 (small riffles)	68	0.1%	0.1%	0.3%
	Grass Conversion	2 (locations), 3 (ac)	3.2	0.05%	0.03%	0.02%
	Native Prairie Buffer	3 (locations), 1 (ac)	6.6	0.004%	0.1%	0.01%
	Perennial Grasses	46 (locations), 672 (ac)	706	34%	22%	41%
	Permeable Pavement	3 (locations), 52,508 (sq ft)	1.2	0.01%	0.04%	0.01%
	Pond	10 (locations)	554	6.5%	8.7%	13%
	Pond - Urban	4 (locations)	107	0.3%	0.8%	0.7%
	Rain Garden	17 (locations)	1.5	0.1%	0.1%	0.02%
	Shoreline Stabilization	2 (locations)	n/a	0.03%	0.1%	0.5%
	Terrace	3 (locations), 4,100 (ft fencing), 2,150 (crossings)	32	0.4%	0.9%	1.6%
	TSI	1 (locations), 3 (ac)	3.1	0.0005%	0.001%	0.0002%
	WASCB	7 (locations), 23 (basins), 6,050 (ft tile)	67	0.8%	1.7%	3.8%
	Waterway	2 (locations), 4 (acres), 3,093 (ft tile)	83	0.8%	0.5%	1.3%
	Waterway Maintenance	2 (locations), 2 (ac), (ft tile)	61	0.6%	0.3%	0.7%
	Wetland Creation	9 (locations), 34 (ac wetland), 15 (structures)	849	5.9%	6.3%	8.1%
Lake Hillsboro Structural Practices Subtotal			***2,821***	***51%***	***69%***	***76%***
Lake Hillsboro Grand Total			**5,542**	**50% -80% (target exceeded)[2]**	**64% - 94% (target likely met)[2]**	**73% -100% (target met)[2,5]**

[1] - Cover Crop – Partial not included in totals. [2] – A range is provided to account for the cumulative effects of BMPs implemented as a "system". [3] - Summed total phosphorus reductions are 137% of the total load when considered individually. [4]- Summed total sediment reductions are 130% when considered individually. [5] – Summed total sediment reductions are 174% when considered individually

9.0 Critical Areas

Critical areas are those BMP locations and individual fields throughout the watershed where implementation activities should be prioritized. This includes locations targeted for in-field and structural practices. In-field management practices will provide the greatest "bang-for-the-buck" and benefits to water quality. They will improve soil structure and health, and overall farm profitability. Structural practices, although more costly upfront, will prove benefits over multiple years and address locations where other measures are infeasible. Critical areas focus on maximizing reductions primarily in sediment and phosphorus. Those that address phosphorus also maximize sediment reductions.

9.1 In-Field Management Measures

In-field practices recommended are nutrient management, no-till/strip-till, and cover crops. Critical areas are primarily based on expected sediment and nutrient load reductions. Specific selection criteria are provided by management practice type and are discussed in the following subsections.

9.1.1 Nutrient Management

Critical areas for nutrient management were selected based on the practices with lowest cost per pound reduced. As listed in Table 48 and depicted in Figure 52, critical areas for nitrogen management are expected to achieve 51% of the total nitrogen in the Glenn Shoals watershed while only encompassing 31% of recommended acres. For phosphorus management, 30% of the total phosphorus reductions in Glenn Shoals and 69% in Lake Hillsboro can likely be achieved while only encompassing 16% of the recommended acres.

Deep placement of phosphorus fertilizer – fields that cost less than $200 per lb phosphorus reduced. This represents a total of 3,911 acres, or 199 fields.

Split application of nitrogen fertilizer - fields that cost less than $20 per pound nitrogen reduced. This represents a total of 227 acres, or 3 fields.

Table 48 - Critical Areas - Nutrient Management

Critical Practice	Quantity (acres)	Total Nitrogen Reduction (lbs/yr)	Total Phosphorus Reduction (lbs/yr)	Percent of Total Practice Load Reduction - Nitrogen	Percent of Total Practice Load Reduction - Phosphorus
Glenn Shoals Lake					
Nutrient Management - Deep Placement Phosphorus	3,650	n/a	2,557	n/a	30%
Nutrient Management - Split Application Nitrogen	227	1,194	n/a	51%	n/a
Lake Hillsboro					
Nutrient Management - Deep Placement Phosphorus	261	n/a	193	n/a	69%

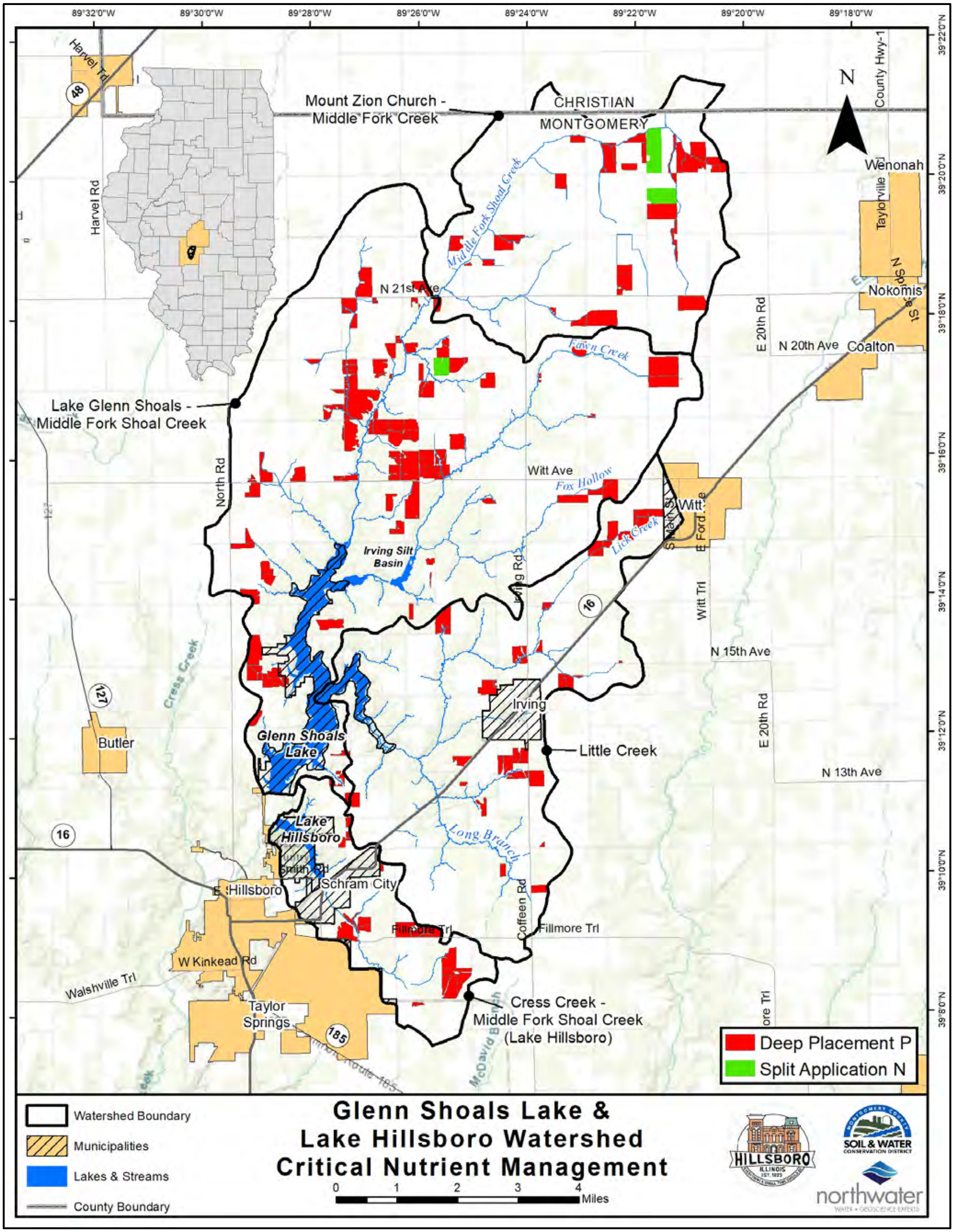


Figure 52 - Critical Areas - In-Field Nutrient Management

9.1.2 No-till & Strip-Till

No-till critical areas were selected as those fields costing less than $10 per ton sediment reduced. A total of 67 fields, or 894 acres, were selected. If implemented, annual reductions of 2,389 lbs of nitrogen, 2,065 lbs of phosphorus, and 3,760 tons of sediment are expected. No-till or strip-till critical areas were also selected as those fields costing less than $20 per ton sediment reduced. A total of 99, or 2,333 acres, were selected. If implemented, annual reductions of 4,560 lbs of nitrogen, 3,545 lbs of phosphorus, and 3,985 tons of sediment are expected. As listed in Table 49 and depicted in Figure 53, critical areas for no-till or strip-till are expected to achieve 22% of the total nitrogen, 23% of the total phosphorus, and 30% of the total sediment reductions associated with these practices, while only encompassing 13% of the total recommended acres in the combined watershed.

9.1.3 Cover Crops

Cover crop - critical areas were selected as those fields costing less than $125 per ton sediment reduced. A total of 192 fields, or 4,008 ac, were selected. If implemented, annual reductions of 27,391 lbs of nitrogen, 4,176 lbs of phosphorus, and 5,517 tons of sediment are expected. As listed in Table 49 and depicted in Figure 54, critical areas for cover crops are expected to achieve 17% of the total nitrogen, 23% of the total phosphorus and 34% of the total sediment reductions associated with these practices, while only encompassing 12% of the total recommended acres.

Maintaining of existing cover crop - critical areas were selected as those fields costing less than $200 per ton sediment reduced. A total of 28 fields, or 313 ac, were selected. If implemented, annual reductions of 6,258 lbs of nitrogen, 919 lbs of phosphorus, and 649 tons of sediment are expected.

Cover crop on HEL only soils - critical areas were selected as those fields costing less than $75 per ton sediment reduced. A total of 121 fields, or 882 ac, were selected. If implemented, annual reductions of 7,710 lbs of nitrogen, 1,292 lbs of phosphorus, and 2,085 tons of sediment are expected.

Table 49 – Critical Areas – Tillage & Cover Crop

Practice	Quantity (acres)	Total Nitrogen Reduction	Total Phosphorus Reduction	Total Sediment Reduction	% Total Practice Load Reduction Nitrogen	% Total Practice Load Reduction Phosphorus	% Total Practice Load Reduction Sediment
Glenn Shoals Lake							
Cover Crop	3,895	26,003	4,006	5,345	17%	23%	34%
Cover Crop - Existing	310	1,364	234	245	23%	26%	39%
Cover Crop - Partial	844	7,194	1,225	2,009	13%	19%	31%
No-Till	862	2,252	1,978	3,649	29%	32%	45%
No-Till or Strip-Till	2,323	4,508	3,513	3,953	22%	23%	30%
Glenn Shoals Subtotal		***41,322***	***10,955***	***15,202***	-	-	-
Lake Hillsboro							
Cover Crop	114	1,388	171	172	18%	19%	31%

Practice	Quantity (acres)	Total Nitrogen Reduction	Total Phosphorus Reduction	Total Sediment Reduction	% Total Practice Load Reduction Nitrogen	% Total Practice Load Reduction Phosphorus	% Total Practice Load Reduction Sediment
Cover Crop - Existing	3.7	23	3.3	1.9	8.3%	11%	13%
Cover Crop - Partial	38	516	67	76	12%	13%	23%
No-Till	32	137	88	110	15%	16%	23%
No-Till or Strip-Till	11	52	32	32	23%	24%	34%
Lake Hillsboro Subtotal		***2,116***	***361***	***392***	-	-	-

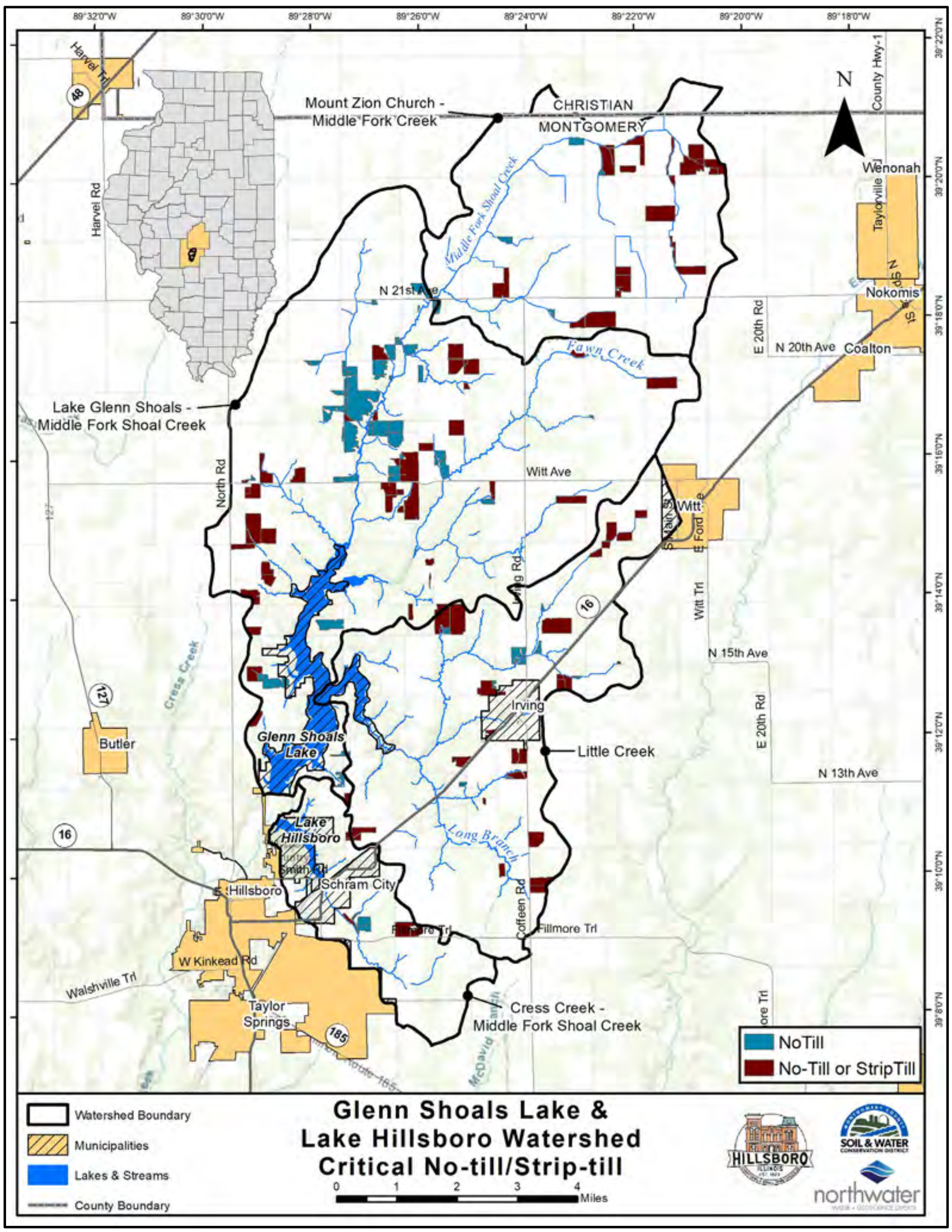


Figure 53 - Critical Areas - In-Field No-Till/Strip-Till

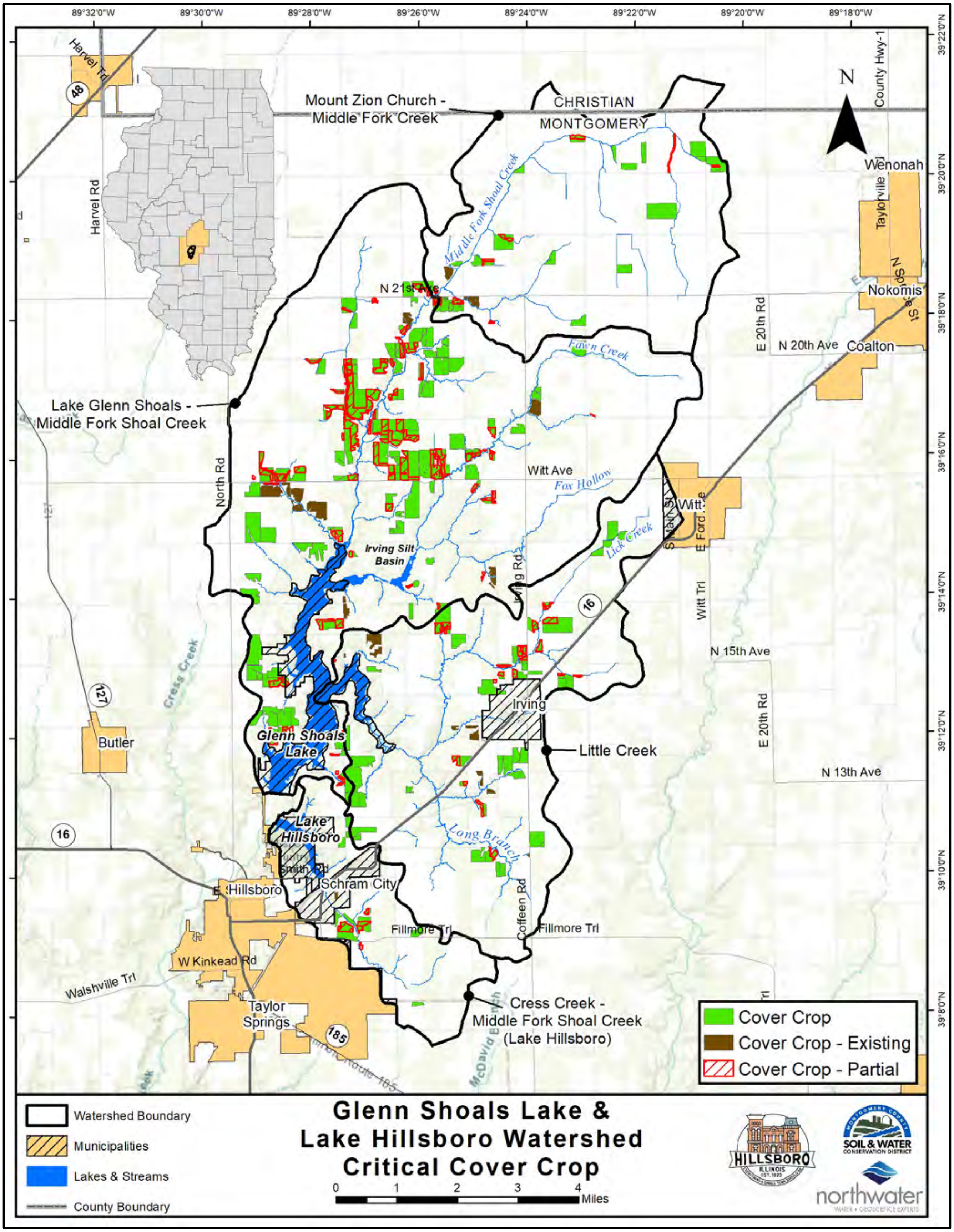


Figure 54 - Critical Areas - In-Field Cover Crop

9.2 Structural BMPs

A selection of critical structural practices were prioritized for implementation throughout the watershed and lake. See Table 50, Figure 55, Figure 56, Figure 57 and Figure 58 for site locations. Selection criteria included cost/benefit, or the amount of sediment or nutrients reduced per dollar of expenditures, greatest total expected load reductions and feasibility for implementation. If all critical structural practices are implemented, 36% of the total nitrogen, 31% of the phosphorus, and 43% of the sediment reductions associated with all recommended structural practices will be achieved.

Aerator – all 63 in-lake aerators to treat nutrient release from lakebed sediments are critical to mitigate the formation of algal blooms.

Critical bioreactors – those that are expected to achieve the greatest nitrogen reductions were selected. Two sites were selected for a total of 5 structures to treat approximately 105 acres.

Critical DWM – only one site is recommended and therefore critical to treat 39 acres.

Critical livestock feed area treatment – the site with the greatest potential for reductions was selected as critical.

Critical livestock fencing and management – the site with the greatest phosphorus reductions was selected.

Critical field borders and filter strips – for field borders, those that cost less than $200 per ton sediment reduced. Twenty-seven locations were selected for a total of 62 acres to treat 937 acres. For filter strips, those that cost $100 or less per ton of sediment reduced. A total of 48 sites were selected, or 72 acres to treat 1,587 acres.

Critical field border harvestable perennial grasses – nine sites that cost under $500 per ton sediment reduced were selected for a total of 137 acres to treat 1,029 acres.

Critical filter strip harvestable perennial grasses – the one site, 15 acres in size that is expected to generate the greatest sediment reductions was selected to treat 75 acres.

Critical floodplain re-connection – the site with the highest potential for sediment reductions was selected as critical. If implemented, it will treat 19,004 acres.

Critical grade control – three sites with the highest potential for sediment reductions were selected as critical. One contains rock checks and the other two, a series of riffles. If implemented, they will treat 171 acres.

Critical grass conversion – ten small fields in the Glenn Shoals Lake watershed with the highest expected sediment reductions. Combined, these total 11 acres.

Critical in-lake dam – one in Glenn Shoals Lake was selected that will reduce the most sediment and treat 21,340 acres.

Critical livestock stream fencing and pasture management – one that reduces the greatest sediment, and phosphorus was selected protecting 1,957 feet of streambanks.

Critical native prairie buffer – one immediately adjacent to each lake was selected and expected to generate the greatest sediment and nutrient reductions for a total of 1.6 acres.

Critical harvestable perennial grass conversion – are those sites that cost less than $400 per ton sediment reduced. A total of 980 acres across 102 locations were selected to treat 1,841 acres.

Critical permeable pavement – one in each lake watershed was selected and expected to generate the greatest sediment and nutrient reductions for a total of 275,476 square feet.

Critical ponds – the 17 costing less than $1,800 per ton of sediment reduced were selected. If constructed, these sites are expected to treat 4,872 acres.

Critical rain gardens – ten adjacent to each lake were selected with the most expected load reductions. Nine are on Glenn Shoals Lake and one on Lake Hillsboro.

Critical saturated buffers – one with the highest total nitrogen reduction. The selected practice will treat 66 acres.

Critical sediment basins – two basins were selected representing the highest total sediment reduction and will treat 163 acres.

Critical streambank/bed stabilization – one system consisting of riffles and STP was selected and is expected to generate the highest sediment reductions at the lowest unit cost.

Critical lake shoreline stabilization – all 30 segments (6,311 ft) located in Glenn Shoals Lake will reduce most of the sediment load from bank erosion.

Critical streambank stabilization – thirteen locations (3,503 ft) consisting of just STP will achieve over half of the sediment reduced by this practice overall.

Critical terraces – five critical sites were chosen, all in the Glenn Shoals Lake watershed, and expected to generate sediment reductions at a cost under $550/ton. These locations, if implemented, will treat 59 acres.

Critical Timber Stand Improvement - one site in each lake watershed was selected and are expected to generate the greatest sediment and nutrient reductions for a total of 14 acres treated.

Critical WASCB – critical sites were chosen for having a price per ton of sediment reduced that is less than $600. Twenty-one locations were chosen. If implemented, these critical practices will treat 165 acres.

Critical WASCB maintenance – two sites in the Glenn Shoals Lake watershed were chosen as critical due to high sediment reductions. These two locations, if implemented, will treat 48 acres.

Critical grass waterway – five locations in the Glenn Shoals Lake watershed were selected for having a price per ton of sediment reduced that is less than $700. These waterways total 5 acres and will treat 248 acres.

Critical grass waterway maintenance – four sites in the Glenn Shoals Lake watershed were selected for having a price per ton of sediment reduced that is less than $710. These four locations, if implemented, will treat 134 acres.

Critical wetland creation – eleven locations costing less than $900 per ton sediment reduced were selected as critical. Five locations (17 ac), all in the Glenn Shoals Lake watershed, will treat 1,125 acres.

Table 50 - Critical Areas - Structural Practices

Practice	Quantity	Total Nitrogen Reduction	Total Phosphorus Reduction	Total Sediment Reduction	% Total Practice Load Reduction Nitrogen	% Total Practice Load Reduction Phosphorus	% Total Practice Load Reduction Sediment
Glenn Shoals Lake							
Aerators	63 (aerators)	n/a	7,749	n/a	n/a	100%	n/a
Bioreactor	2 (locations), 105 (structures)	905	4.7	n/a	44%	51%	n/a
Drainage Water Management	1 (location), 39 (ac)	119	0.6	n/a	100%	100%	n/a
Livestock Feed Area Management System	1 (location), 1 (ac)	19	10	0.3	17%	16%	15%
Field Border	26 (locations), 61 (ac)	976	462	469	43%	44%	52%
Field Border - Perennial	8 (locations), 126 (ac)	1,721	492	499	46%	44%	52%
Filter Strip	48 (locations), 72 (ac)	2,094	956	1,028	32%	32%	39%
Filter Strip - Perennial	1 (location), 15 (ac)	121	54	41	25%	29%	27%
Floodplain Re-connection	1 (location), 6 (riffles), 20 (ac wetland), 4 (structures)	29,719	4,481	3,614	34%	32%	33%
Grade Control	1 (location), 3 (structures)	38	10	27	49%	33%	34%
Grade Control - Riffles	1 (location), 2 (medium riffles)	57	29	32	50%	53%	40%
Grass Conversion	10 (location), 11 (ac)	243	42	57	18%	23%	37%
In-Lake Dam	1 (location), 1,700 (ft)	21,921	3,983	3,408	65%	64%	69%
Livestock Fencing/Management	1 (location), 1,957 (ft fencing), 1 (crossing)	114	44	2.8	40%	41%	42%
Native Prairie Buffer	1 (location), 1 (ac)	0.6	1.2	0.2	19%	19%	20%

Practice	Quantity	Total Nitrogen Reduction	Total Phosphorus Reduction	Total Sediment Reduction	% Total Practice Load Reduction Nitrogen	% Total Practice Load Reduction Phosphorus	% Total Practice Load Reduction Sediment
Perennial Grasses	96 (location), 931 (ac)	17,997	3,503	5,029	21%	24%	34%
Permeable Pavement	1 (location), 80,978 (sq ft)	4.5	2.8	0.7	42%	43%	45%
Pond	16 (locations)	20,028	3,572	3,355	66%	56%	57%
Rain Garden	9 (locations)	10	4	0.6	24%	24%	24%
Saturated Buffer	1 (location), 900 (ft tile)	604	6.3	0	30%	30%	n/a
Sediment Basin	2 (locations)	247	97	124	45%	42%	40%
Streambed/Bank Stabilization	1 (location), 5 (medium riffles), 350 (ft STP)	162	147	161	23%	37%	33%
Shoreline Stabilization	30 (locations), 6,311 (ft)	1,061	843	969	62%	62%	62%
Stone Toe Protection	13 (locations), 3,503 (ft STP)	396	187	308	55%	55%	55%
Terrace	5 (locations), 5,700 (ft tile), 3,080 (ft terrace)	265	130	196	33%	34%	48%
TSI	1 (location), 11 (ac)	6.3	4.3	11	61%	69%	81%
WASCB	20 (locations), 41 (basins), 10,275 (ft tile)	770	356	490	35%	35%	44%
WASCB Maintenance	2 (locations), 8 (basins), 2,200 (ft tile)	143	65	65	63%	65%	62%
Waterway	5 (locations), 5 (ac), 3,956 (ft tile)	680	92	143	22%	25%	32%
Waterway Maintenance	4 (locations), 3 (ac), 822 (ft tile)	333	46	89	20%	22%	29%
Wetland Creation	11 (locations), 13 (ac wetland), 14 (structures)	2,838	602	629	29%	28%	33%
Glenn Shoals Lake Subtotal		***103,593***	***20,228***	***20,747***	***38%***	***33%***	***43%***

Practice	Quantity	Total Nitrogen Reduction	Total Phosphorus Reduction	Total Sediment Reduction	% Total Practice Load Reduction Nitrogen	% Total Practice Load Reduction Phosphorus	% Total Practice Load Reduction Sediment
Lake Hillsboro							
Aerators	10 (locations)	n/a	1,855	n/a	n/a	100%	n/a
Field Border	1 (location), 1 (ac)	21	7.9	5.6	10%	9%	10%
Field Border - Perennial	1 (locations), 11 (ac)	253	83	49	77%	79%	81%
Grade Control - Riffles	1 (locations), 5 (small riffles)	23	7.1	7.5	100%	100%	100%
Native Prairie Buffer	1 (location), 1 (ac)	1	3.5	0.1	50%	70%	44%
Perennial Grasses	6 (locations), 49 (ac)	1,920	229	214	13%	14%	21%
Permeable Pavement	1 (location), 33,599 (sq ft)	3.9	1.8	0.2	62%	62%	60%
Pond	1 (location)	718	124	74	25%	19%	23%
Rain Garden	1 (location)	2.1	0.6	0.04	9.2%	9.2%	9.3%
TSI	1 (location), 3 (ac)	0.2	0.1	0.004	100%	100%	100%
WASCB	1 (location), 8 (basins), 2,300 (ft tile)	179	66	51	50%	50%	54%
Wetland Creation	1 (locations), 4 (ac wetland), 1 (structure)	673	104	46	25%	22%	23%
Lake Hillsboro Subtotal		***3,794***	***626***	***449***	***17%***	***12%***	***24%***
Grand Total		**107,387**	**20,854**	**21,195**	**-**	**-**	**-**

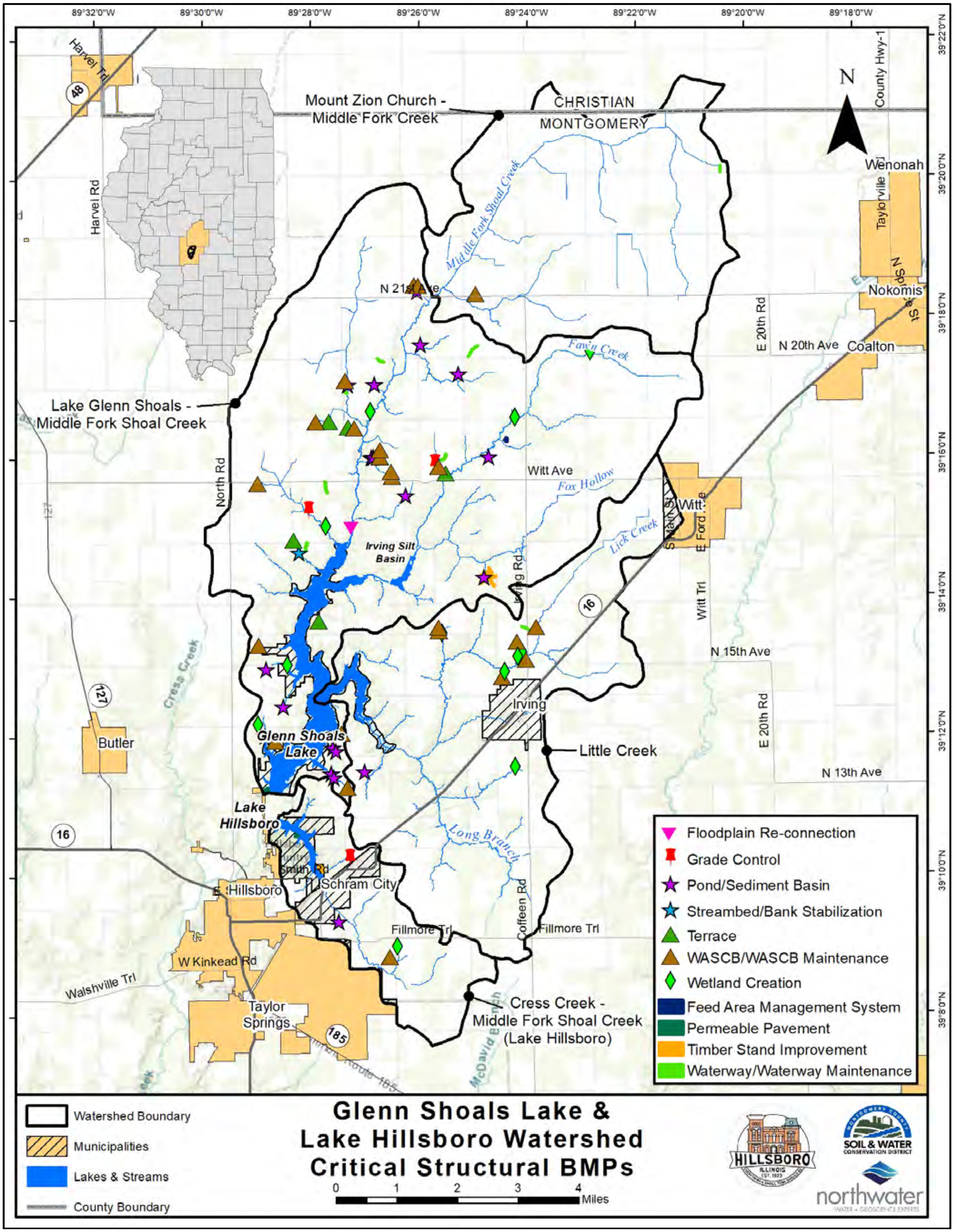


Figure 55 – Critical Areas – Structural Practices (1)

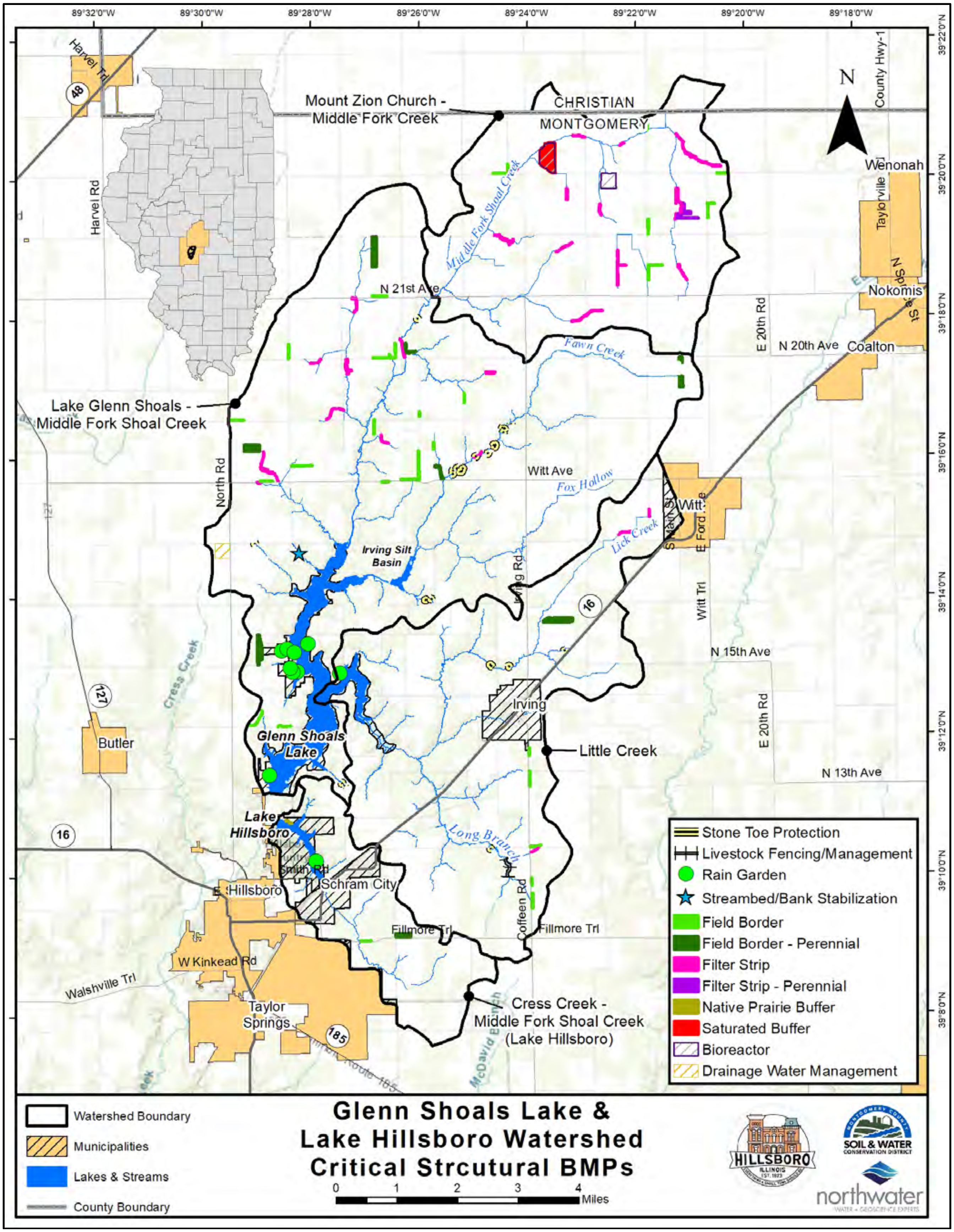


Figure 56 – Critical Areas – Structural Practices (2)

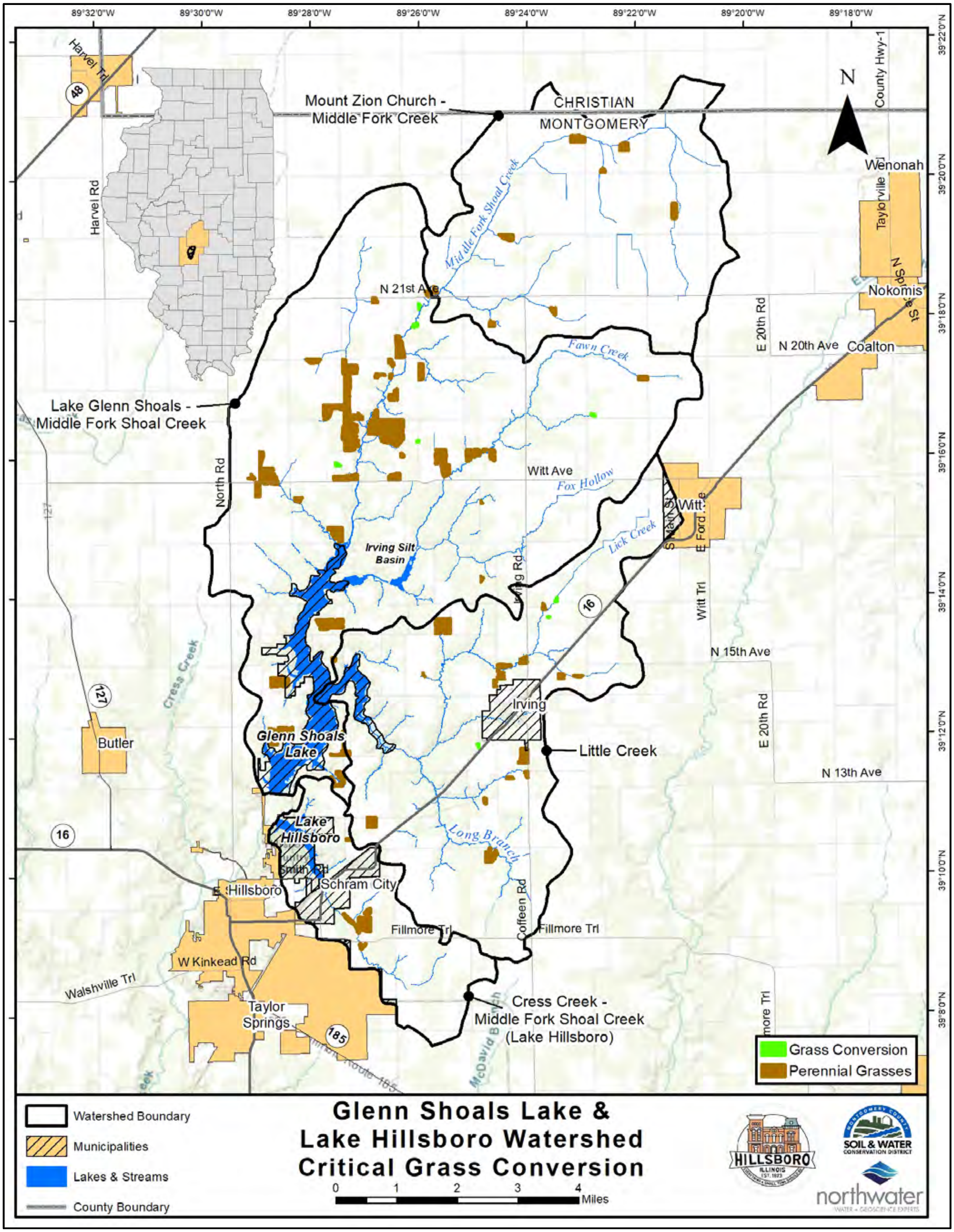


Figure 57 - Critical Grass Conversion/Perennial Grasses

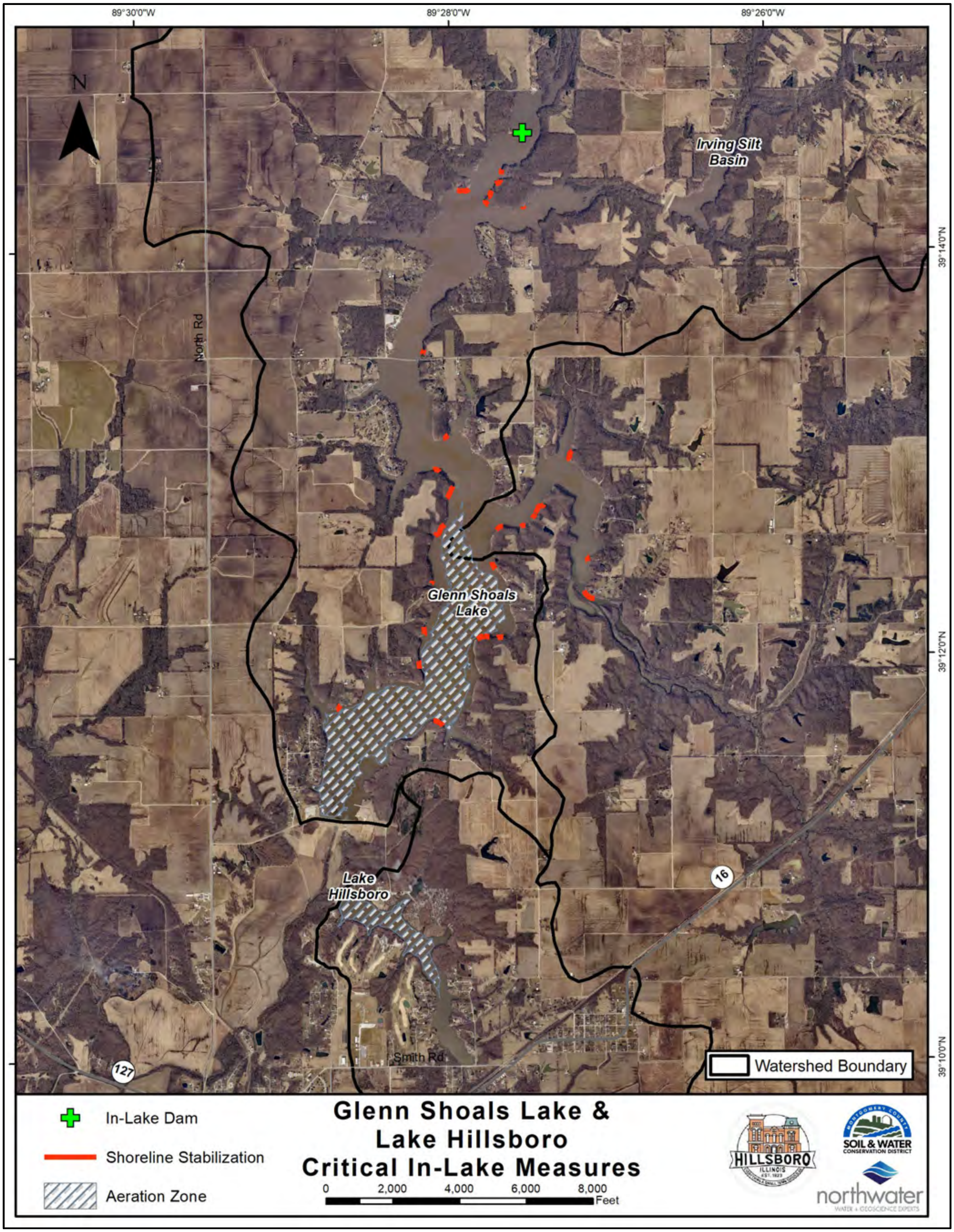


Figure 58 - Critical In-Lake Management Measures

10.0 Technical & Financial Assistance

Entities listed below are potentially available for plan implementation and funding. For those that can provide funding specific to the watershed, descriptions of the programs or financial assistance mechanisms are provided, with a separate section of those that may be able to provide funding or in-kind contributions to watershed efforts. Entities that may not have a direct avenue to a funding apparatus or a formal grant program are listed under Section 10.2, Technical Assistance. With implementation, primary responsibility lies with the owner of the land first. Any agency or entity providing a role in implementation will need to work with willing landowners but do not have the primary decision-making authority. All actions are completely voluntary.

10.1 Financial Assistance

City of Hillsboro – the City will take a leadership role in the implementation of this plan, will provide financial assistance and is the primary beneficiary of improvements in lake water quality. The City currently funds staff and provides matching funds for grants.

Farmers/Landowners - there are varying business arrangements on who farms the land and makes important conservation decisions. If the farmer is the landowner, then the farmer/landowner is considered the primary responsible party. If the person/entity who owns the land is an absentee owner, then it could be either the farmer/tenant, farm manager or the absentee landowner who is responsible. In some cases, the conservation practice decisions are made together in a collaborative fashion by the tenant, farm manager and landowner. Frequently, farm lease terms determine who makes conservation decisions.

> **Financial Assistance:** Private funds can come from many sources including foundations, trusts, individual farmers, and landowners and can be used as cash match for grants or as private contributions to other conservation initiatives.

United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) - the USDA has local offices in most Illinois counties which include the NRCS. The Montgomery County field offices services the watershed and provides both conservation technical assistance and financial assistance. One program frequently used is the Environmental Quality Incentive Program (EQIP) which provides cost sharing for approved conservation program practices. The farmer/landowner applies for conservation funds and is assisted by NRCS staff to complete the application process, certify the practices and make payments. Five additional programs administered by the NRCS are also discussed below: The Regional Conservation Partnership Program (RCPP), the National Water Quality Initiative (NWQI), the Conservation Stewardship Program (CSP), the Conservation Innovation Grant (CIG) program, and the Watershed and Flood Prevention Operations Program.

> **Financial Assistance:**
>
> **NRCS EQIP** - is a cost-share program for farmers and landowners to share the expenses of implementation and maintenance of approved soil and water conservation practices on farmland for qualified entities and is a dedicated source of funding available in the watershed.

NRCS/USDA RCPP – a primary program where funding is being sought, RCPP promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. The NRCS assists producers through partnership agreements and through program contracts or easement agreements. Assistance is delivered in accordance with the rules of other NRCS programs. The RCPP encourages partners to join in efforts with producers to increase restoration and sustainable use of soil, water, wildlife, and related natural resources on regional or watershed scales. Through RCPP, NRCS and its partners help producers install and maintain conservation activities in selected project areas. This program is becoming a more robust program, and funds are prioritized for public water supplies.

Within the RCPP are Alternative Funding Arrangements (AFA) that support projects that take innovative and non-traditional approaches to conservation solutions at the local, regional and landscape scales.

NRCS NWQI - as USDA's premiere water quality initiative, NWQI provides a way to accelerate voluntary, on-farm conservation investments and focused water quality monitoring and assessment resources where they can deliver the greatest benefits for clean water. The NWQI is a partnership among NRCS, state water quality agencies and the U.S. EPA to identify and address impaired water bodies through voluntary conservation. Targeted funding is provided for financial and technical assistance in small watersheds most in need and where farmers can use conservation practices to make a difference. Conservation systems include practices that promote soil health, reduce erosion and lessen nutrient runoff, such as filter strips, cover crops, reduced tillage and manure management. State water quality agencies and other partners contribute additional resources for watershed planning, monitoring, implementation and outreach. Source water protection and public water supplies are now a priority and component of NWQI.

NRCS CSP - through CSP, NRCS provides conservation program payments and is a very popular program in the Lake Decatur watershed. Conservation Stewardship Program participants receive an annual land use payment for operation-level environmental benefits they produce. Under CSP, participants are paid for conservation performance: the higher the operational performance, the higher their payment.

USDA Watershed Protection and Flood Prevention Program - helps units of federal, state, local and tribal government (project sponsors) protect and restore watersheds up to 250,000 acres. This program provides for cooperation between the Federal government and the states and their political subdivisions/tribes to work together to prevent erosion; floodwater and sediment damage; to further the conservation development, use and disposal of water; and to further the conservation and proper use of land in authorized watersheds. This program may be an option for larger infrastructure projects.

USDA Conservation Innovation Grant Program (CIG) - is a competitive program that supports the development of new tools, approaches, practices, and technologies to further natural resource conservation on private lands. Through creative problem solving and innovation, CIG partners work to address our nation's water quality, air quality, soil health and wildlife habitat challenges, all while improving agricultural operations. This program may be available to assist with new and emerging BMPs and other unique conservation practices.

Illinois Environmental Protection Agency (Illinois EPA) - the Illinois EPA Bureau of Water's Watershed Management Section provides program direction and financial assistance for water quality protection in Illinois through the Clean Water Act Section 319 program.

Financial Assistance: Administered by the Illinois EPA, the Section 319 program provides funds for addressing NPS pollution. The purpose is to work cooperatively with units of local government and other organizations toward the mutual goal of protecting the water quality in Illinois through the control of NPS pollution. The program includes providing funding to these groups to implement projects that utilize cost-effective BMPs on a watershed scale.

Projects may include structural BMPs, such as detention basins, non-structural BMPs, such as construction erosion control ordinances, and setback zones to protect community water supply wells. Technical assistance and information and education programs are also eligible. Funds are reimbursable and require a match of either cash or in-kind services, or a combination of both.

The Illinois EPA also administers the Green Infrastructure Grant Opportunities program for Stormwater Management, or GIGO. It is funded through the Rebuild Illinois Capital Plan. The program focusses on projects to construct green infrastructure BMPs that prevent, eliminate, or reduce water quality impairments by decreasing stormwater runoff into rivers, streams, and lakes.

The Illinois EPA Water Pollution Control Loan Program (WPCLP) that falls under the State Revolving Loan Fund is designed to provide low interest loans and other forms of assistance for water resource protection and improvement projects. This program could be utilized to fund more costly green infrastructure projects recommended in this plan such as floodplain reconnection or large-scale wetland creation.

The federal EPA also administers grant programs that can be pursued. This includes environmental education grants, research grants, and the Farmer-to-Farmer program.

Illinois Department of Agriculture (IDOA) - The IDOA's Bureau of Land and Water Resources distributes funds to Illinois' 98 soil and water conservation districts for programs aimed at reducing soil loss and protecting water quality. It also helps to organize the state's soil survey every two years to track progress toward the goal of reducing soil loss on cropland to tolerable levels. Annual funding can be directed to the watershed and grants can be pursued for streambank stabilization, education, outreach, and research.

Financial Assistance: Partners for Conservation (PFC) program monies can be used for four purposes: to promote sustainable agriculture, stabilize eroding streambanks, fund a cost-share program for construction of soil conservation practices and assist Illinois' SWCD's. The Streambank Stabilization and Restoration Program, or SSRP, is designed to demonstrate effective, inexpensive vegetative and bio-engineering techniques for limiting stream bank erosion. The sustainable agriculture grants program funds sustainable agricultural research, education and demonstration through conferences, training, on-farm research, and educational outreach. The IDOA also offers up to $5 per acre off the following year's crop insurance premium through their Fall Covers for Spring Savings incentive program.

Farm Service Agency (FSA) - located in USDA local offices are officials of the FSA who also provide some conservation-oriented programs; specifically, they provide the administrative structure for the federal Conservation Reserve Program (CRP) and also support the state Conservation Reserve and Enhancement Program.

Financial Assistance:

USDA/FSA Conservation Reserve Program (CRP) - is a land conservation program administered by the FSA. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. Land in the watershed is already enrolled in CRP and additional, eligible land is available for enrollment.

USDA/FSA Conservation Reserve and Enhancement Program (CREP) - CREP is an offshoot of the CRP. Administered on the federal level by the FSA, CREP targets high-priority conservation issues identified by local, state, or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers and agricultural landowners are paid an annual rental rate. Participation is voluntary, and the contract period is typically 10–15 years, along with other federal and state incentives as applicable per agreement. In Illinois, the CREP administrative agency is the Illinois Department of Natural Resources (IDNR) which provides additional and generous financial incentives on top of a FSA contract, including payments for additional 15–35-year contract extensions; IDNR also offers a permanent easement option. Farmers and landowners locally apply for support through a SWCD.

US Fish and Wildlife Service (USFWS) - provides technical assistance to local watershed groups. It also administers several grant and cost-share programs that fund habitat restoration. The USFWS also administers the federal Endangered Species Act and supports a program called Endangered Species Program Partners, which features formal or informal partnerships for protecting endangered and threatened species. These partnerships include federal partners, as well as states, tribes, local governments, nonprofit organizations, and individual landowners.

Financial Assistance:

The **USFWS Partners program** restores, improves, and protects fish and wildlife habitat on private lands through alliances between the USFWS, other organizations and individuals, while leaving the land in private ownership. Opportunities may exist within the watershed to utilize financial assistance from the partners program for wetland or prairie restoration.

Other Funding Programs – in addition to financial incentives through carbon trading programs, other private sector entities are currently offering a range of payments to growers for practices such as cover crops, nutrient management and tillage. One of particular relevance to the watershed is the Archer Daniels Midland re:generations program (https://admadvantage.com/regen/programs/).

10.2 Technical Assistance & Strategic Partners

A series of potential partners and stakeholders were engaged to assist or contribute to lake and watershed management efforts. Many have already committed to the program and are actively working in the larger watershed. The intent is to leverage current partners and continue engaging new ones to help with the implementation of this plan.

10.2.1 Government

Units of government will play key roles in watershed management. Descriptions of roles and responsibilities for primary governmental bodies include:

1. **City of Hillsboro** – in addition to financial support, the city will provide project management, and overall guidance. It can forward conservation on city-owned land, conduct monitoring efforts, and invest in lake and municipal water quality projects such as shoreline stabilization. It will apply for funding to supplement expenditures and engage the community and local businesses and forward significant projects.
2. **Municipalities/Counties** – outside of Hillsboro, watershed municipalities and county government can provide general support and participation in mutually beneficial urban water quality practices. The other municipalities are Irving, Schram City, and Wilt.
3. **Montgomery County SWCD** – the MCSWCD administers a complementary cost-share program, directs state resources to the watershed, conducts targeted landowner outreach, participates in education events, provides technical assistance for design, and can assist with planning. A program championed by the Champaign County SWCD is also relevant to the watershed - Saving Tomorrow's Agricultural Resources, or S.T.A.R., is an evaluation system which assigns points for each cropping, tillage, nutrient application and soil conservation activity used on individual fields. The practices selected and the point values assigned are determined by a group of scientists and researchers, including some farmers who are involved in research. The total points are used in a scale to determine a rating of 1-5 stars for each field. The purpose is to motivate those making cropping decisions to use conservation management practices that will ultimately meet the goals of the INLRS.
4. **Federal government** – primary technical assistance will occur through the USDA NRCS County office to execute projects and programs on private farm ground. Other federal agencies will assist with funding, monitoring, additional technical assistance, and permitting.

10.2.2 Agricultural & Trade Organizations

Agricultural trade organizations, such as the state and county Farm Bureau, are critical to watershed management. A selection of strategic groups relevant to the watershed include:

1. **State and County Farm Bureau** – Illinois Farm Bureau is a non-profit, membership organization directed by farmers who join through their county Farm Bureau. Based in Bloomington, Illinois, Farm Bureau serves a voting membership of more than 74,000. It represents three out of four Illinois farmers. One County Farm Bureau operates in the watershed, Montgomery being the

primary office. The State and County Farm Bureau will engage landowners and growers and conduct outreach, provide general support and perform education, host field days and coordinate with agribusiness.

2. **Illinois Fertilizer and Chemical Association (IFCA)** – IFCA was formed to assist and represent the crop production supply and service industry, while promoting sound stewardship and utilization of agricultural inputs. The IFCA influences legislative and regulatory policies for the crop production supply and service industry at the state level, and it coordinates national efforts with national industry associations, including The Fertilizer Institute, Agricultural Retailers Association and Crop Life America. It participates in agricultural policy development and cooperates with other ag organizations to assure that the crop production input industry is well represented. The IFCA can coordinate with ag retailers, conduct targeted landowner outreach and execute on-the-ground conservation.

3. **Illinois Land Improvement Contractors of America (LICA)** – LICA is a national association dedicated to encouraging high standards of workmanship in resource management, land improvement practices and to promote enterprises in the area of land improvement contracting. For over 60 years, Illinois LICA has been bringing people with similar interests and passions for improving natural resources together. Its contractors throughout the state are educated and committed to the professional conservation of soil and water resources. Illinois LICA can be a key technical assistance partner aiding in outreach and on-the-ground execution of program components.

10.2.3 Private Sector

The private sector is uniquely positioned to both leverage substantial financial and technical resources and execute on-the-ground conservation in a timely fashion. Numerous public-sector partners have been tapped to help with the watershed management program and can be of assistance. A selection is described in more detail below:

1. **Deer Run Coal Mine** – can provide technical and financial resources and connections with watershed landowners. The coal mine is a major employer in Hillsboro and surrounding areas, the largest non-potable water user and has a substantial footprint in the watershed. It will likely play a major role moving forward.

2. **Ag Retailers -** major ag retailers in the watershed, such M&M Service Company, help their farmer-owners and customers by providing products and technology. This includes harvesting and selling crops, custom fertility and crop protection solutions, soil testing, nutrient management, cover crop seed, variable rate fertilizer application, and can assist with outreach. Retailers will be key strategic partners moving forward and will provide agronomic technical assistance, education, and outreach to forward key actions related to nutrient management and erosion control.

3. **Crop advisors** – several locally based crop advisory companies exist and can provide technical assistance, landowner outreach and on-the-ground delivery of cost-share dollars.

4. **Agricultural engineering firms and drainage consultants** – a team of consultants operate in and near the watershed and can provide technical assistance for practice design and conduct targeted outreach.

5. **Farm Managers** - a modest amount of land in the subwatershed is bank managed. These entities can provide leveraged services related to the promotion and installation of conservation practices.

6. **Farmer Peer-to-Peer Network** – a farmer network will be established to reach landowners and conduct training and outreach including the transition to new management systems and program promotion.

10.2.4 Non-Governmental Organizations

Numerous NGOs operate in the watershed and work with the farming community and others to promote and forward conservation. Several key partnerships have been formed or are being pursued to leverage staff resources and technical assistance.

1. **American Farmland Trust (AFT)** – the mission of AFT is to protect farmland, promote sound farming practices, and keep farmers on the land. The AFT advocates for programs and policies that protect farmland, food, and the environment, and conduct education and outreach and promote conservation. Technical assistance will include landowner outreach, program coordination and management, training, and collaboration on grant applications.

2. **Illinois Stewardship Alliance (ISA)** - is a membership-based organization whose mission is to promote environmentally sustainable, economically viable, socially just, local food systems through policy development, advocacy, and education. Most relevant to the watershed is ISA's work to promote cover crops and educate producers on their benefits. Staff can assist with landowner outreach and education programs related to conservation.

3. **The Wetlands Initiative (TWI)** – a non-profit incorporated in 1994 that designs, restores, and creates wetlands. They innovate, collaborate, and employ sound science to improve water quality, habitat for plants and wildlife, and our climate. Hillsboro is currently working with TWI to explore State Revolving Funding for some of the large wetland restoration projects recommended in this plan.

4. **Glenn Shoals Lake Club** – a group of residents who live and recreate on the lake. The organization hosts recreational events, conducts lake cleanups and advocates for clean water. The lake club has collaborated on at least one grant application and will participate in lake improvement initiatives and education and outreach.

5. **Illinois Corn Growers (ICG)** – established in 1972, it is a grassroots membership organization with approximately 5,000 members. Corn Growers run the Precision Conservation Management Program (PCM), which is a farmer-led effort developed to address natural resource concerns on a field-by-field basis by identifying conservation practices that effectively address environmental issues in a financially viable way. Staff work with farmers to identify conservation needs and use data from agronomic management practices, economic models, and sustainability metrics to

develop customized solutions. PCM is active in the county with staff specialists that can provide technical assistance and outreach.

6. **The Nature Conservancy (TNC)** - founded in the U.S. through grassroots action in 1951, TNC has grown to become one of the most effective and wide-reaching environmental organizations in the world. Thanks to more than a million members and the dedicated efforts of a diverse staff and over 400 scientists, it impacts conservation in 72 countries and territories: 38 by direct conservation impact and 34 through partners. TNC is very active in Illinois and will be an important technical assistance and financial resource partner.

10.2.5 Institutional

Institutions and other research-based entities will provide valuable in-kind services to help measure outcomes of the larger watershed program. They may allocate existing research programs and resources to expand the current water quality monitoring program.

1. **Illinois State Water Survey** (ISWS) – the ISWS is a division of the Prairie Research Institute at the University of Illinois. The Water Survey's scientists conduct state-of-the-art research and collect, analyze, archive, and disseminate high-quality, objective data and technical information. The Water Survey's data, services, and expertise provide a sound technical basis for the citizens and policymakers of Illinois to make decisions. It conducts water quality monitoring and leverages/directs other outside funding and will be approached about contributing to watershed monitoring efforts.
2. **National Great Rivers Research and Education Center (NGRREC)** – a division of Lewis and Clark Community College, is dedicated to the study of great river systems and the communities that use them. The center aspires to be a leader in scholarly research, education, and outreach related to the interconnectedness of large rivers, their floodplains, watersheds, and their associated communities. NGRREC was founded in 2002 through a collaborative partnership between the University of Illinois at Urbana-Champaign, the Illinois Natural History Survey and Lewis and Clark Community College. It will be approached to assist with monitoring.
3. **University of Illinois** – numerous academic researchers at the University work throughout Illinois on agricultural related initiatives and studies. One program is quantifying the state-wide contribution of sediment and phosphorus from streambank erosion and several sites are in the watershed. Other research related to the establishment and use of harvestable perennial crops is also relevant and being pursued.

11.0 Implementation Milestones, Objectives & Schedule

Implementation milestones and goals are intended to be measured by USDA-NRCS program contracts, Illinois EPA Section 319 and City and SWCD-funded cost-share measures. The goals are meant to be both measurable and realistic. Targeted outreach and on-farm visits with landowners are vital to the success of future activities and will be a component of every effort to ensure the adoption of the BMPs listed below. Communication and outreach will also help to ensure practices are maintained over time.

An implementation schedule is presented in Table 51 (short term, 1-2 years), Table 52 (medium term, 3-5 years), and Table 53 (long term, 6-10 years). The milestones or objectives presented are intended to be achievable and realistic over each time period, though actual implementation will depend on interested landowners and funding availability. The schedule takes into consideration agency and Hillsboro staff capacity and incorporates acres and practices necessary to achieve water quality targets. A reasonable number of critical in-field and structural BMPs (Section 9.0) are considered prioritized for implementation within 5 years. The plan and milestones should be revisited and updated after 10 years. Consistent throughout each period is the need for outreach, communication, partnerships, grant applications, water quality monitoring, and tracking of progress.

Table 54 summarizes BMP milestones or objectives, those responsible entities and the primary technical/financial assistance available. The implementation milestones or objectives needed to begin to meet water quality targets are those that are realistic within a 10-year period. Given the high cost and limited resources available, it is anticipated that more than 10 years will be required to fully meet water quality targets and maintain them over time. This plan, milestones and objectives will be revisited and updated after 10 years.

In the first 5 years of plan implementation, priorities focus on critical areas or those locations and practices in the Glenn Shoals Lake and Lake Hillsboro watershed where management measures will achieve the greatest nutrient reductions at the lowest unit cost.

Table 51 – Years 1-2 - Implementation Milestones

Timeframe	Milestone
Years 1–2	1. Initiate targeted outreach and one-one-one communication with producers; engage farmer peer-to-peer network. 2. Apply for program funding. 3. Plant 2,000 acres of critical cover crops. Focus on HEL soils. 4. Convert conventional or other tillage to strip-till or no-till on 1,000 critical acres. 5. Complete split application of nitrogen fertilizer on 227 critical acres. 6. Complete 500 critical acres of deep placement P fertilizer. 7. Install aeration system capable of reducing anoxic zone in both lakes by up to 50%. 8. Install 10 critical filter strips. 9. Install 1 critical harvestable perennial filter strip. 10. Install 9 critical field borders. 11. Install 5 critical harvestable perennial grass field borders. 12. Complete grass conversion on 5 critical fields. 13. Complete 20 critical harvestable perennial grass conversions. 14. Install 2 critical waterways.

Timeframe	Milestone
	15. Complete maintenance of 2 critical waterways. 16. Install 3 critical ponds. 17. Install 1 critical sediment basin. 18. Install 1 critical grade control project. 19. Install 10 critical WASCB systems. 20. Install 2 critical terrace systems. 21. Install 1 critical DWM system. 22. Install 1 critical bioreactor. 23. Install 1 critical saturated buffer system. 24. Install 2 critical wetlands. 25. Complete 1 critical streambank/bed stabilization project. 26. Install STP at 3 critical locations. 27. Complete 950 ft of critical shoreline stabilization. 28. Begin site-level planning, permitting, and engineering/design of 1 one critical floodplain re-connection. 29. Begin site-level planning, permitting, and engineering/design of 1 critical in-lake dam. 30. Initiate expanded water quality monitoring program.

In years 3-5 of plan implementation, priorities continue with a focus on critical areas or those locations and practices where management measures will achieve the greatest nutrient reductions. Initiate a modest number of urban rain gardens.

Table 52 – Years 3-5 - Implementation Milestones

Timeframe	Milestone
Years 3–5	1. Continue targeted outreach and one-one-one communication with producers. 2. Apply for program funding as needed. 3. Complete aeration system capable of reducing remaining anoxic zones in both lakes. 4. Plant 2,009 acres of critical cover crops. Focus on HEL soils. 5. Convert conventional or other tillage to strip-till or no-till on 1,334 critical acres. 6. Complete split application of nitrogen fertilizer on 500 acres. 7. Complete 500 critical acres of deep placement P fertilizer. 8. Install 10 critical filter strips. 9. Install 2 harvestable perennial filter strips. 10. Install 9 critical field borders. 11. Install 5 critical harvestable perennial grass field borders. 12. complete grass conversion on 5 critical fields. 13. Complete 20 critical harvestable perennial grass conversions. 14. Install 1 critical native prairie buffer on each lake. 15. Install 3 critical waterways. 16. Complete maintenance of 2 critical waterways. 17. Install 2 critical grade control projects. 18. Install 5 critical ponds. 19. Install 1 critical sediment basin. 20. Install 2 critical terrace systems. 21. Install 11 critical WASCB systems. 22. Complete maintenance of 1 critical WASCB system. 23. Install 1 critical livestock fencing/pasture management system. 24. Install 2 critical wetlands. 25. Install 2 critical rain gardens.

Timeframe	Milestone
	26. Complete 1 critical TSI project. 27. Complete 2,000 ft of critical shoreline stabilization. 28. Complete 1 streambank/bed stabilization project. 29. Install STP at 3 critical locations. 30. Complete floodplain re-connection planning/design and permitting and complete construction. 31. Complete in-lake dam planning/design and permitting and complete construction. 32. Continue water quality monitoring.

In years 6-10, priorities continue to be on critical in-field management measures and critical structural practices.

Table 53 – Years 6-10 - Implementation Milestones

Timeframe	Milestone
Years 6–10	1. Continue targeted outreach and one-one-one communication with producers. 2. Plant 7,000 acres of cover crops. 3. Convert conventional or other tillage to strip-till or no-till on 4,000 acres. 4. Complete 1,000 critical acres of deep placement P fertilizer. 5. Install 10 critical filter strips. 6. Install 2 harvestable perennial filter strips. 7. Install 9 critical field borders. 8. Install 5 harvestable perennial grass field borders. 9. Complete 30 critical harvestable perennial grass conversions. 10. Install 5 waterways. 11. Complete maintenance of 5 waterways. 12. Install 2 grade control projects. 13. Install 5 critical ponds. 14. Install 5 terrace systems, 1 being critical. 15. Install 20 WASCB systems. 16. Complete maintenance of 1 critical WASCB system. 17. Install 2 sediment basins. 18. Install 5 critical wetlands. 19. Complete 3,361 ft of critical shoreline stabilization. 20. Complete 2 streambank/bed stabilization projects. 21. Install STP at 7 critical locations. 22. Complete 1 critical TSI project. 23. Continue monitoring.

Beyond 10 years, broad implementation and monitoring should continue, and the watershed plan and milestones should be revisited and updated to accommodate changes over time.

Table 54 – Implementation Objectives, Responsible Parties & Technical Assistance

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
Watershed BMPs/Education and Outreach (1–10 years)		
BMP: Cover Crops **Objective:** Plant 11,009 acres	Landowner/NRCS/ MCSWCD/City/Ag Retailers/Farm Managers	**Technical Assistance**: NRCS/MCSWCD/AFT/PCM/ TNC/Ag Retailers/Farmer Peer-to-Peer/ISA **Funding Mechanism**: RCPP/Private Funds/IDOA Fall Covers for Spring Savings/other NRCS and State Programs/City/re:generations
BMP: No-Till/Strip-Till **Objective**: Convert 6,334 acres	Landowner/NRCS/ MCSWCD/City/Ag Retailers/Farm Managers	**Technical Assistance**: NRCS/MCSWCD/AFT/PCM/ TNC/Ag Retailers/Farmer Peer-to-Peer/ISA **Funding Mechanism**: RCPP/Private Funds/other NRCS and State Programs/City/re:generations
BMP: Split Application N Fertilizer **Objective**: Complete 727 acres	Landowner/NRCS/ MCSWCD/City/Ag Retailers/Farm Managers	**Technical Assistance**: NRCS/MCSWCD/PCM/Ag Retailers/IFCA **Funding Mechanism**: RCPP/Private Funds/other NRCS and State Programs/re:generations
BMP: Deep Placement P Fertilizer **Objective**: Complete 2,000 acres	Landowner/NRCS/ MCSWCD/City/Ag Retailers/Farm Managers	**Technical Assistance**: NRCS/MCSWCD/PCM/Ag Retailers/IFCA **Funding Mechanism**: RCPP/Private Funds/other NRCS and State Programs
BMP: Grassed Waterway/ Waterway Maintenance **Objective:** Install 19	Landowner/NRCS/ MCSWCD/City/Ag Retailers/Farm Managers	**Technical Assistance**: NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/319 Grant/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Wetlands **Objective:** Install 9	Landowner/City	**Technical Assistance**: NRCS/Consultants/ TNC/LICA/ TWI/USFWS **Funding Mechanism**: 319 Grant/City Funds/WPCLP/ USFWS
BMP: Filter strips **Objective:** Install at 30 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/319 Grant/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Harvestable Perennial Filter Strips **Objective:** Install at 5 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/319 Grant/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Field Borders **Objective:** Install at 27 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/319 Grant/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Harvestable Perennial Field Borders **Objective:** Install at 15 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/319 Grant/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Bioreactor **Objective:** Install 1 system	Landowner/NRCS/ MCSWCD/ Farm Managers	**Technical Assistance:** NRCS/ Consultants/LICA/TWI **Funding Mechanism**: 319 Grant/RCPP/LICA/ISA/TNC
BMP: Drainage Water Management **Objective:** Install 1 system	Landowner/NRCS/ MCSWCD/ Farm Managers	**Technical Assistance:** NRCS/ Consultants/LICA/TWI **Funding Mechanism**: 319 Grant/RCPP/LICA/ISA/TNC
BMP: Saturated Buffer **Objective:** Install 1 system	Landowner/NRCS/ MCSWCD/ Farm Managers	**Technical Assistance:** NRCS/ Consultants/LICA/TWI **Funding Mechanism**: 319 Grant/RCPP/LICA/ISA/TNC
BMP: Grass Conversion **Objective:** Install at 10 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/Private Funds /City Funds/CRP/other NRCS and State Programs
BMP: Perennial Grass Conversion **Objective:** Install at 70 locations	Landowner/NRCS/ MCSWCD/City/ Farm Managers	**Technical Assistance:** NRCS/MCSWCD/FSA/Consultant **Funding Mechanism**: RCPP/Private Funds /City Funds/CRP/other NRCS and State Programs

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
BMP: Native Prairie Buffer **Objective:** Install at 2 locations (one on each lake)	City of Hillsboro/Lake Property Owners/ Glenn Shoals Lake Club	**Technical Assistance:** MCSWCD/Consultant **Funding Mechanism**: City Funds/Private Funds /Glenn Shoals Lake Club
BMP: Rain Garden **Objective:** Install 2	City of Hillsboro/Lake Property Owners/ Glenn Shoals Lake Club	**Technical Assistance:** MCSWCD/Consultant **Funding Mechanism**: City Funds/Private Funds /Glenn Shoals Lake Club/GIGO
BMP: TSI **Objective:** Complete 2	City of Hillsboro/Landowner	**Technical Assistance:** Consultant **Funding Mechanism**: City Funds/Private Funds
BMP: Pond **Objective:** Install 13	Landowners/ City/MCSWCD	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds
BMP: WASCB and WASCB Maintenance **Objective:** Install 43 systems	Landowners/ City/MCSWCD	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds
BMP: Terrace **Objective:** Install 9 systems	Landowners/ City/MCSWCD	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds
BMP: Sediment basin **Objective:** Install 4	Landowners/ City/MCSWCD	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds
BMP: Grade Control **Objective:** Install 5	Landowners/ City/MCSWCD	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds
BMP: Livestock Fencing/Pasture Management **Objective:** Install 1	Landowners/MCSWCD	**Technical Assistance:** NRCS/Consultants/ISA **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds/ other NRCS programs
BMP: Streambank/Bed Stabilization **Objective:** Install 4	Landowners/ City/MCSWCD	**Technical Assistance:** Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds/ other NRCS and State Programs
BMP: Stone Toe Protection **Objective:** Install at 13 locations	Landowners/ City/MCSWCD	**Technical Assistance:** Consultants **Funding Mechanism:** 319 Grant/City Funds/ RCPP/ Private Funds/ other NRCS and State Programs
BMP: Lake Shoreline Stabilization **Objective:** Install 6,311 ft	City of Hillsboro/Lake Property Owners	**Technical Assistance:** Consultants **Funding Mechanism:** 319 Grant/City Funds/Private Funds
BMP: Floodplain Re-Connection **Objective:** Connect 1 stream	City of Hillsboro	**Technical Assistance**: Consultants/TWI/TNC/LICA **Funding Mechanism**: 319 Grant/City Funds/WPCLP/ USFWS
BMP: Aeration **Objective:** Eliminate anoxic zones	City of Hillsboro	**Technical Assistance**: Consultants **Funding Mechanism**: City Funds
BMP: In-Lake Dam **Objective:** Install 1	City of Hillsboro	**Technical Assistance**: Consultants/LICA **Funding Mechanism**: 319 Grant/City Funds/WPCLP
BMP: Education and Outreach **Objective:** Stakeholder engagement	MCSWCD/City of Hillsboro	**Technical Assistance:** MCSWCD/AFT/Farm Bureau/ISA/Farmer Peer-to-Peer **Funding Mechanism:** RCPP/City Funds/AFT/ISA

12.0 Information & Education

The City Hillsboro, the MCSWCD and other partners conducted education and outreach during the planning process. This included presentations to the public and stakeholders, field days hosted by the SWCD and others, and a series of individual farmer and landowner meetings. The intent moving forward is to accelerate outreach and one-on-one landowner engagement to propel watershed management forward, engage additional partners, and host and participate in future education events, field days and workshops. These actions will aid implementation of this plan and management of lakes. Effective education and outreach are crucial to a plan's success since many problems and solutions result from human actions.

As described in a 2017 report compiled by McLean County SWCD and TNC, traditional, broad-scale outreach materials, including newsletter articles, fact sheets, newspaper stories, and online content were useful for helping to concisely describe conservation opportunities and promote them to local landowners. However, their outreach most effectively led to practice adoption and implementation when it was targeted to specific individuals, when messages were delivered from trusted advisors, and when messengers demonstrated an understanding of how the practices being promoted fit within the context of an individual producer's management system. In many cases, an iterative approach, including conversations over many months, was required for adoption of long-term practices. Furthermore, it was generally recognized that achieving meaningful water quality improvements in Illinois requires a multi-practice, multi-partner program with on-the-ground, local outreach as a key component (Lemke and Mclean County SWCD, 2017).

The Glenn Shoals Lake and Lake Hillsboro watershed information and education program will be guided based on goals and actionable objectives described below. Target audiences, communication strategies and anticipated costs are also included.

12.1 Information & Education Program

A successful program first raises awareness among stakeholders of water quality and watershed issues, challenges and opportunities. The next step is to provide them with information on implementation actions that will address issues, challenges and opportunities. The MCSWCD will be the lead entity responsible for the execution of this program.

12.1.1 Goals & Objectives

Goals were established for the watershed based on stakeholder input, guidance from the City of Hillsboro, the MCSWCD, and outreach needs of the broader watershed management effort. The goals are intended to be general in nature and objectives specific. It is expected that future funding opportunities will require targeted education and outreach components to be adapted and/or customized. Goals and objectives are intended to be a guide to educational topics and provide a focus of messages in relation to implementation goals so that future progress can be assessed, and outreach can be modified as needed. An expected start and end date or schedule is provided for each objective.

Goal 1: Build stakeholder awareness of the greater watershed program and targeted implementation (i.e., critical areas) through education and stewardship while increasing communication and coordination among stakeholders.

Objectives:

1. Establish a stakeholder committee with a shared interest in protecting and improving water quality in the lakes (January 2025 – June 2025).
2. Engage in targeted outreach and one-on-one communication with agricultural landowners and growers with critical area practices identified in this plan (January 2025 - January 2034).
3. Establish a farmer peer-to-peer network to assist with communication and provide technical assistance. The MCSWCD will lead the formation of the group with assistance from AFT (January 2025 – March 2025).
4. Increase environmental stewardship opportunities and encourage stakeholders to participate in plan implementation and restoration campaigns to increase activism in the watershed (February 2025 - December 2034).
5. Inform public officials of the benefits of conservation within both the agricultural and urban settings and the functions and benefits of healthy watersheds (January 2025 - January 2034).
6. Approach and secure strategic partnerships from local businesses and corporations (February 2025 – February 2027).
7. Develop clear and concise outreach materials that address practice benefits, costs, and economic incentives associated with conservation incentive programs such as the RCPP (January 2025 – January 2026).
8. Work with local media outlets to promote the plan and its implementation. Provide regular updates to media contacts on progress (January 2025 – January2029).
9. Provide regular updates to local stakeholder groups, including the Glenn Shoals Lake Club (January 2025 – January 2028).
10. Present data showing sources of sediment and nitrate export into the Lakes and practice effectiveness at reducing nutrient loss and erosion. Utilize existing in-stream and edge-of-field monitoring network and partnerships when in place (November 2025 – November 2030).
11. Publicize farmer efforts to improve water quality among municipal water rate payers. This promotes agriculture and builds greater understanding of farmers' efforts among downstream water users (May 2025 – May 2030).
12. Provide educational workshops, field days and events to the public that encourage environmental stewardship, promote conservation practices and the connection to the lakes and watershed (March 2025 – December 2029).

Goal 2: Encourage agricultural techniques and soil conservation practices that will protect and conserve soil, improve soil health, and reduce sediment and nutrient loading to Glenn Shoals Lake and Lake Hillsboro.

Objectives:

1. Utilize practice demonstrations using formal field days, informal site tours, and farmer-led discussions and workshops (March 2025 – August 2029).

2. Educate and inform landowners about private sector, federal and state cost-share programs, which provide incentives to enroll in conservation programs and implement conservation practices. Focus will be on the USDA and Illinois EPA programs (January 2025 – February 2028).
3. Encourage landowners to utilize existing programs and agencies such as NRCS, SWCD, FSA, etc. to install conservation practices that protect soil loss and water quality (January 2025 – December 2034).
4. Utilize existing watershed partners to assist in promoting and implementation of in-field practices such as cover crops and no-till. This could include groups like Illinois Corn Growers or the Illinois Soybean Association (March 2025 - December 2034).
5. Increase support for and develop additional financial assistance programs targeted at specific efforts within the watershed to increase the installation of conservation practices (March 2025 - December 2029).
6. Encourage landowners and farmers to follow the principles of soil health and/or regenerative agriculture on their land through in-field practices (March 2025 - December 2034).
7. Encourage landowners and farmers to install edge-of-field and structural practices such as filter strips or grassed waterways (March 2025 - December 2034).

Goal 3: Promote water quality improvement projects in urban areas and surrounding Glenn Shoals Lake and Lake Hillsboro.

Objectives:

1. Educate urban stakeholders about the greater watershed program, trends in water quality and progress being made on agricultural land (January 2025 - December 2029).
2. Educate and encourage landowners and businesses to install practices such as rain gardens and utilize native plants in yards and gardens, consistent with the watershed plans (March 2025 - December 2034).
3. Develop public-private partnerships to advance regionally significant and in-lake projects such as treatment wetlands or floodplain reconnections on tributaries immediately adjacent to the lakes (January 2025 - January 2030).

12.1.2 Target Audiences, Communication Strategies & Outcomes

The recommended target audience for each education campaign is selected based on the ability to advance objectives. The target audience is a group of people with ties to the lakes and watershed who are intended to be reached by a specific message. This includes people of all demographics, locations, occupations, and watershed roles. There can be multiple target audiences depending on which topic is being presented. Overall, this includes residential and agricultural landowners, homeowners, general public, local government, elected officials, businesses, educational institutions, trade groups, and non-governmental organizations. Once the target audience is identified for a specific education campaign, existing programs and communication vehicles should be leveraged to help distribute messages.

Recommended communications strategies and outcomes:

1. Strategy - engage local media and continuously promote the watershed program and any awarded grants. Outcomes:
    a. The public is aware of watershed planning and management efforts.
    b. Landowners learn about different avenues to access funding/program support.
2. Strategy - increase communication with, and outreach to, individual landowners and stakeholders, especially in critical or targeted areas. Utilize meetings, written publications and online platforms, including a dedicated City of Hillsboro website. Outcomes:
    a. Stakeholders understand the importance of a healthy watershed and water quality.
    b. Formation of an effective farmer peer-to-peer network.
    c. Accelerated practice adoption.
3. Strategy - develop key farmer and urban stakeholder workshops and demonstrations in partnership with other organizations. Outcomes:
    a. Stakeholders understand the importance of a healthy watershed and water quality.
    b. Accelerated conservation practice adoption.
    c. Stakeholders understand how different conservation practices work and how they can function to improve water quality and help reach watershed goals.
    d. Landowners/stakeholders learn about specific practices and can visualize them on their property, leading to increased implementation.
4. Strategy - expand partnerships especially with the private sector and corporations through direct communication. Outcomes:
    a. Additional private/corporate participation in watershed program including financial and technical support.

12.1.3 Cost Estimates & Tracking

Costs associated with information and education will vary based on the strategy deployed, ability to leverage other partners and resources, and the type of communication. For example, broad-scale, one-on-one outreach is time and labor intensive versus an open meeting format that is relatively easy to organize and promote. Tracking or measurement of outcomes achieved is also an important element to ensure information and education programs are reaching the desired audiences and leading to a positive change in attitudes and improvements to water quality. Table 55 lists proposed education and information items and quantities, estimated lumpsum cost and criteria for measurement over a 5-year period. Costs include labor and hard costs such as meeting space rental and promotion. Items listed represent those most likely to be utilized to support the watershed management program and not inclusive of all objectives and strategies described in previous sections.

Table 55 - Information & Education Program & Costs

Item	Quantity	Lump Sum Cost	Measurement Criteria
Farmer peer-to-peer network and one-on-one outreach	• 1 peer-to-peer network. • 75 individual landowner/ farmer meetings.	$60,000	• Number of farmers reached. • Hours of technical assistance provided. • Number of practices implemented in target areas.
Farmer field days, workshops, group meetings and demonstrations	• 5 field days. • 3 workshops/ demonstrations. • 5 group meetings.	$30,000	• Number of attendees. • Number of outreach materials distributed. • Measurable increase in watershed practice adoption.
Urban stakeholder field days, workshops, group meetings and demonstrations	• 2 field days. • 2 workshops/ demonstrations. • 3 group meetings.	$25,000	• Number of attendees. • Number of outreach materials distributed. • Number of urban BMPs implemented in the watershed.
News/radio interviews and content	• 20 interviews (watershed partners and City of Hillsboro).	$25,000	• Measurable increase in watershed practice adoption. • Increased awareness of watershed issues and solutions.
Corporate/ private business outreach (meetings and coordination)	• Approach 1 new business per year.	$2,500	• 1 new partnership developed each year. • Increase in available funding to support watershed program.
Develop standalone watershed program website	• 1 web page dedicated to housing watershed program information. • Configured to allow for interested landowners to sign-up for incentive programs.	$40,000	• Visitor count. • Time spent on page. • Source of visitors. • Number of practices implemented.

13.0 Monitoring & Tracking Strategy

13.1 Programmatic Monitoring

Tracking watershed investments is one of the simplest and most effective means to monitor progress towards achieving plan goals. Keeping track of projects across diverse partners and stakeholders can be as simple as an organized system where each agency or responsible implementation entity monitors and reports what is happening related to their programs or expenditures. For example, the MCSWCD could track and report state cost-share expenditures or practices funded through grant awards. Communicating and reporting progress towards goals is equally as important as tracking them in the first place.

The following recommendations are included to help monitor progress and achieve goals with plan implementation.

- Engage a stakeholder committee at least quarterly to discuss activities and progress towards goals. A list of completed, proposed and in-progress actions should be tracked.
- This plan should be evaluated every five years to assess the progress made as well as to revise, if appropriate, based on the progress achieved. It should also undergo a comprehensive review and update after 10 years. As milestones are accomplished and additional information is gathered, efforts may need to be shifted to issues of higher priority.
- A stakeholder committee or the MCSWCD could request that each agency or project partner in the watershed provide an annual update, which could be in the form of a "scorecard" that tracks progress towards goal objectives via measurable milestones presented in Section 11. The scorecard system is an easy and effective way to compile and track progress and evaluate the effectiveness of achieving short, medium, and long-term goals. They are an effective way to identify what needs attention and what stakeholders should focus on in the next year.
- Invest in customized watershed management software or maintain a GIS database or spreadsheet of proposed BMPs recommended in this plan to track those that have been implemented along with their expected load reductions.

Regardless of the specific methodologies or programs applied, it is pertinent to establish a system of working with watershed partners and stakeholders to monitor actions and their water quality benefits.

13.2 Water Quality Monitoring

Water quality monitoring is an effective means to evaluate the current health of Glenn Shoals Lake and Lake Hillsboro, and to directly measure effectiveness of plan implementation and progress towards water quality goals over the long term. Monitoring data also supports science and research, enabling practitioners to better understand the watershed and lake dynamics to guide future investments and interventions.

Example of Monitoring Station Equipment

Historic water quality data is scarce on tributaries to Glenn Shoals Lake and Lake Hillsboro, aside from some historic data in 2001 and 2002, and the City of Hillsboro's effort that began in 2024. The lack of flow data in the watershed is a major deficiency in accurately estimating current and historic nutrient and sediment loads to the lakes, as well as tracking progress in reducing future inputs. The proposed strategy is to build upon current and historical monitoring efforts in the lakes and tributaries to fill knowledge gaps. Currently there are three active monitoring sites in Glenn Shoals Lake, and two in Lake Hillsboro. There are five recently re-established monitoring sites on tributaries to Glenn Shoals Lake and one on the main tributary to Lake Hillsboro.

The monitoring strategy and recommendations include three sections (i) lake monitoring, (ii) tributary monitoring, (iii) management practice monitoring.

13.2.1 Lake Monitoring

Enhanced water quality monitoring is necessary to track lake health and parameters of concern in a consistent and on-going basis as watershed treatments are implemented. Lake monitoring will support an improved understanding of impairments, and rates and sources of sediment accumulation.

Lake Water Quality - Table 56 outlines the current monitoring and recommended improvements. In 2024, the City of Hillsboro initiated a program with frequent data collection to enhance periodic monitoring by Illinois EPA. Aside from continuing this program, the primary recommendations are to establish a new site on the deepest section of Glenn Shoals that better captures the duration and timing of seasonal stratification, and to establish a lake stage / spillway discharge rating curve to track the outflow each lake. This data, along with water chemistry, allows for tracking of loads of sediment and nutrients leaving the reservoirs.

Table 56 – Glenn Shoals Lake & Lake Hillsboro Monitoring Recommendations

Monitoring Program	Entity	Current Configuration	Recommendations
Lake Water Quality	City of Hillsboro & Illinois EPA	Three sites on Glenn Shoals, two on Lake Hillsboro, as described in Section 3.3: • Illinois EPA Ambient Lakes: o Approximately every 3 years. o Water chemistry and toxics. • City of Hillsboro: o Twice monthly, May through October. o Water chemistry of shallow and deep lake water.	• In Glenn Shoals, add station or move ROL-1 to deepest part of lake, still near the dam to better capture timing and strength of seasonal stratification. • Work with Illinois EPA to utilize its laboratory to analyze chemistry. • Continue frequent water chemistry measurements (2x per month) May through October, to enable long term tracking of changes. • Parameters should include at minimum: TP, Nitrate + Nitrite, Ammonia-N, DO (profile), TSS.

Monitoring Program	Entity	Current Configuration	Recommendations
Lake Stage	City of Hillsboro	• Periodic lake stage measurements	• Daily manual recording of lake stage or implementation of automatically recording lake stage instrumentation. • Establish discharge rating curve for spillway outflows. • Manage lake stage data so that it can be easily plotted and analyzed.

Lake Sedimentation Monitoring - Lake bathymetry and sediment accumulation monitoring is important to track the loss of reservoir storage capacity, both spatially and temporally. It also serves to estimate sediment yields and track progress towards reducing loading. A baseline survey-grade bathymetric map should be completed on both lakes, followed by periodic surveys every 2-5 years to track changes. In addition, a study of historic sediment deposition since the establishment of the lakes may provide detailed insight into the past extent and rate of reservoir capacity loss and how to mitigate sedimentation moving forward.

Lake Monitoring Estimated Costs

Projected monitoring costs are estimates only due to the extent of what is monitored, the equipment purchased, and frequency.

Lake stage - one time setup of $20,000 - $40,000 depending on technology. Annual maintenance of $7,500.

Additional lake water quality site - nominal setup with ongoing costs ranging from $2,500 - $15,000/yr including lab costs and labor.

Lake bathymetry - $35,000 per survey for both lakes.

13.2.2 Best Management Practice Monitoring

Monitoring of BMP effectiveness is an important consideration and will assist in ensuring limited management practice implementation funds are being spent cost effectively. Monitoring will also help identify changes in practices that may be needed. In addition, monitoring ensures that BMPs are working as intended and will identify if routine maintenance is needed.

For example, sediment traps are prevalent in the watershed. Regular monitoring of these structures to identify maintenance needs (i.e. sediment removal) is critical, otherwise they may become ineffective or even become sources of nutrients and sediment. Other examples of monitoring include special studies of smaller or ephemeral drainages before and after the implementation of large or multiple BMPs within. One specific example of a BMP monitoring study would be capturing storm event data at site ROL-T3 and upstream of the sediment trap located there.

13.2.3 Lake Tributary Monitoring

Monitoring of Glenn Shoals Lake and Lake Hillsboro tributaries has historically been intermittent and lacked important contextual data such as flow. Enhancing the monitoring at the existing sites will provide long term datasets and a baseline that can be used to track nutrient and sediment inputs to the lakes and changes in inputs over time as management practices are implemented in the watershed. At each site, continuous stage monitoring coupled with development of a discharge rating curve and regular collection of phosphorus, nitrogen and sediment data is recommended. Several options could be utilized based on the City of Hillsboro's objectives, capacity and resources, and are described in Table 57.

Table 57 - Tributary Monitoring Program Recommendations

Monitoring Program Type	Recommended Activity	Notes
Tributary Water Quality and Stage – Discharge Rating Curve	• At each monitoring site develop a stage-discharge rating curve: o Establish stage reference. o Collect stage data with each water quality measurement. o Collect flow measurements across wide range of stages.	• Stage-discharge rating curve allows for calculation of water quality constituent loads. • Allows for precise tracking of nutrient and sediment reduction progress over time and targeting of management practices.
Option 1: Real-Time Continuous Stage with Telemetry	• Establish stage measuring device and datalogger with real-time telemetry at each tributary site, or a subset of sites.	Pros: • Provides real-time instantaneous data and continuous record. • Can enhance site monitoring with water quality instrumentation. • Can integrate auto sampling equipment to capture samples during storm events in flashy creeks. • Can provide immediate insight useful for protecting source water and managing withdrawals. • Can provide automated remote alerts based on observed conditions. • Data management can be easily automated. Cons: • Costly. • High level of technical expertise needed for setup and troubleshooting. • May provide more data than is necessary.

Monitoring Program Type	Recommended Activity	Notes
Option 2: Stage Sensor with Manual Data Retrieval	• Establish continuous stage monitoring instrumentation at each tributary site using level loggers or other appropriate technology with manual data collection	Pros: • Provides continuous record of stage. • Can enhance site monitoring with water quality instrumentation. • Depending on instrumentation may be able to integrate auto sampling equipment to capture water samples during storm events in flashy creeks. • Less costly to set up and potentially less expensive to maintain. Cons: • Must physically visit site to collect data. • Depending on sensor type, there may be high risk for inappropriate shifting of data due to sensor movement. • Data management may be cumbersome. • No ability to view in real-time. • No ability to be notified of sampling triggers or other conditions of interest.

Tributary Monitoring Estimated Costs

A typical range of estimated costs is presented below. Some elements could be accomplished for less than the range depending on the situation. One time equipment costs depend on sonde and sensors attached, possible autosamplers, and additional site infrastructure such as sonar stage equipment and cellular uplinks. Ongoing yearly costs depend on frequency of monitoring, discharge measurements, and lab costs.

Option 1 (per site) - $30,000 to $110,000 one-time equipment and setup costs. An additional $20,000 to $50,000 per year in labor, lab costs, and technology fees.

Option 2 (per site) - $15,000 to $60,000 one-time equipment and setup costs. An additional $20,000 to $60,000 in annual labor, lab costs, and technology fees.

13.2.4 Lake Outlet / Downstream Monitoring

Illinois EPA has intermittently monitored the Middle Fork Shoal Creek below Glenn Shoals and Lake Hillsboro, at sites IL_EPA-OIL-02 and IL_EPA-OIL-03. In addition, the City of Hillsboro has recent monitoring data on the Middle Fork Shoal Creek downstream of the lakes but upstream of the city's wastewater treatment plant outfall. Regular monitoring downstream of the lakes will provide another measure of progress by providing data to understand the nutrient and sediment loads leaving Glenn Shoals and Lake Hillsboro. Using estimates of inputs and outputs, a net estimate of sediment and nutrients that become trapped in the lakes, or released from the lakes would be possible. Estimated cost is similar to those presented in the previous section.

13.2.5 Database

A relational database for all monitoring data is strongly recommended. This can also be used to import historical data and support an efficient means to evaluate trends and watershed improvements over time. A database system is essential with a high volume of information being collected and will force standardization and quality control. This will also make data usage and analysis significantly more efficient and affordable.

A 'champion' of the database is necessary to ensure it is used and all data is regularly entered. If in-house expertise and capacity is limited, it may be necessary for external support in its management and utilization. Figure 59 shows a screenshot of an environmental database system that is being applied for monitoring programs elsewhere in Illinois.

In addition, consider submitting data to US EPA Water Quality Exchange (WQX). Uploaded data may be included in publicly available portal and may aid in scientific research. Conversion from local database format to WQX schema can be automated and relatively easy if database is set up with this schema in mind. The one-time cost to set up the initial database is estimated at $10,000 - $20,000. Annual maintenance and data entry is estimated at $15,000.

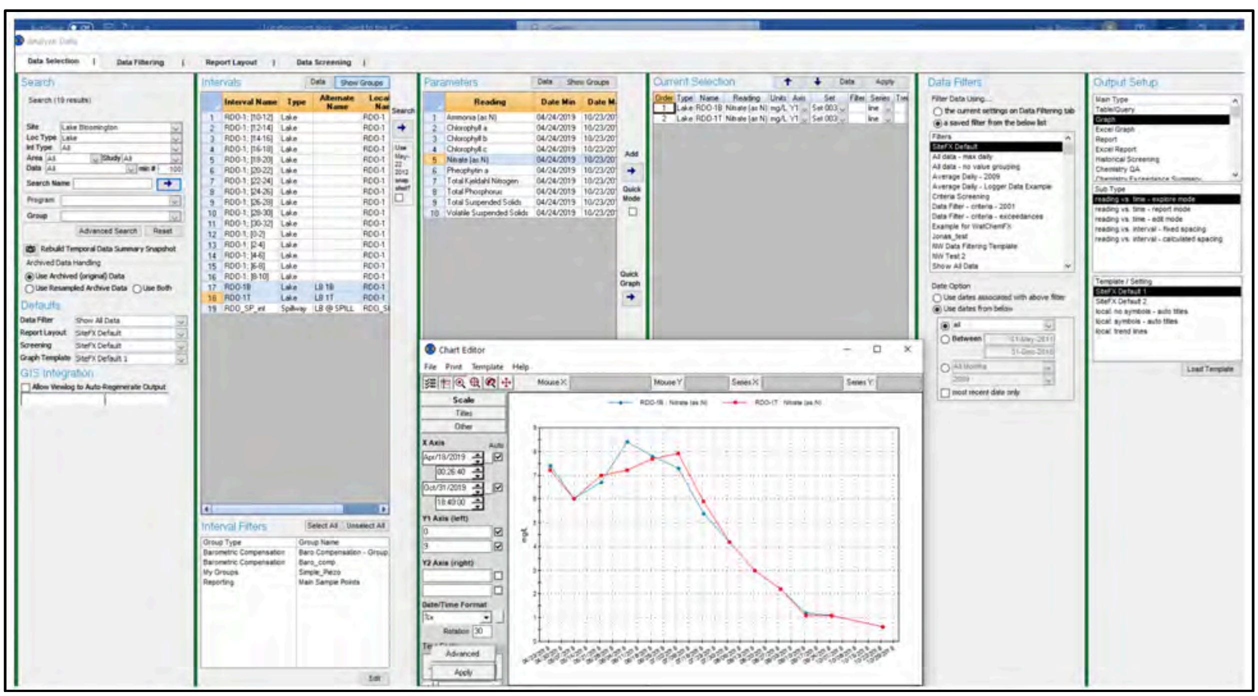


Figure 59 – Screenshot of Database System for Monitoring Data

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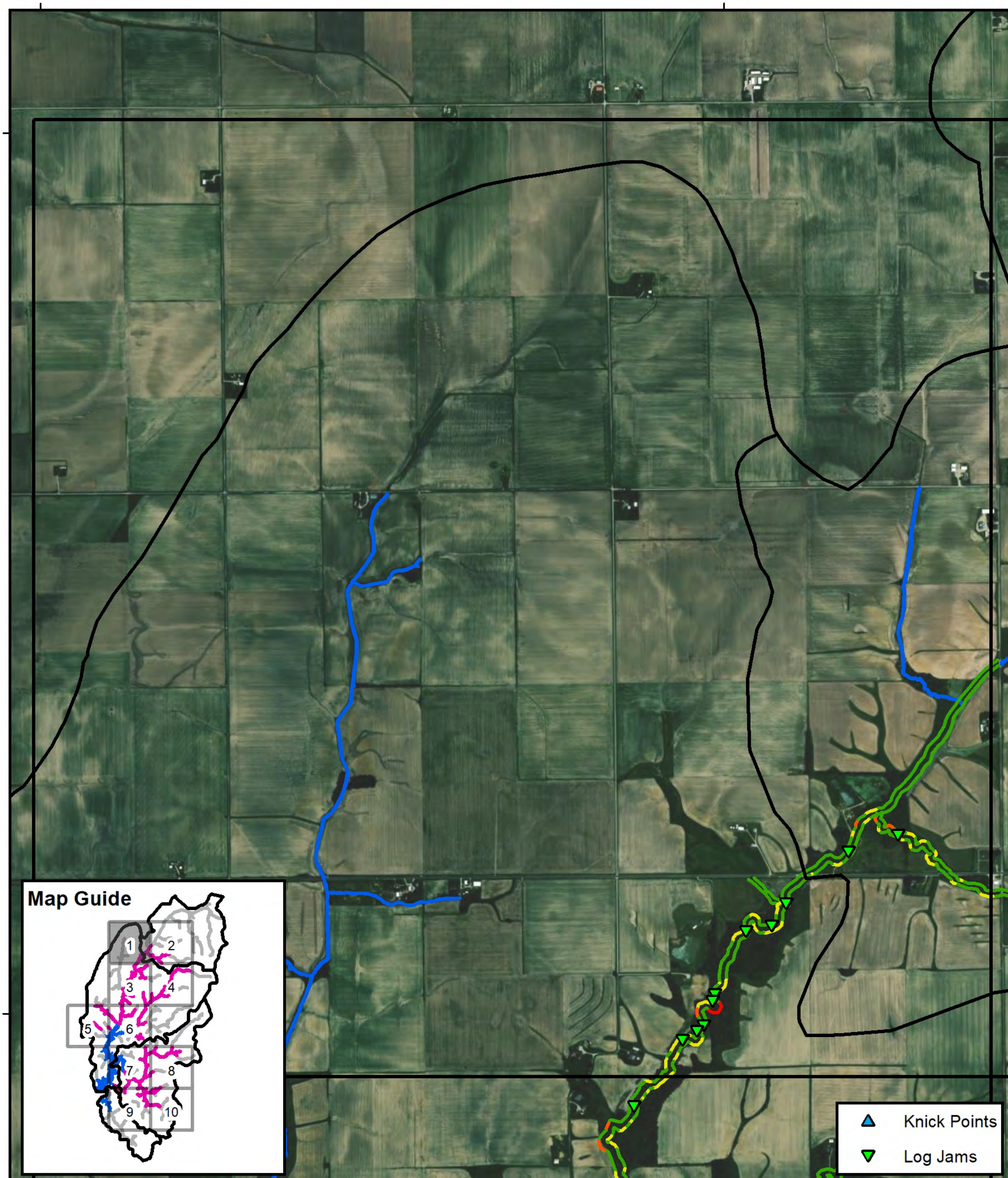
Appendix A: Streambank Assessment Map Book



Assessed Streams (lbs/ft/yr)

< 10

50 -100

10 - 50

> 100

Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 1 of 10

0 1,000 2,000 3,000 4,000 Feet

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MONTGOMERY COUNTY SOIL & WATER CONSERVATION DISTRICT

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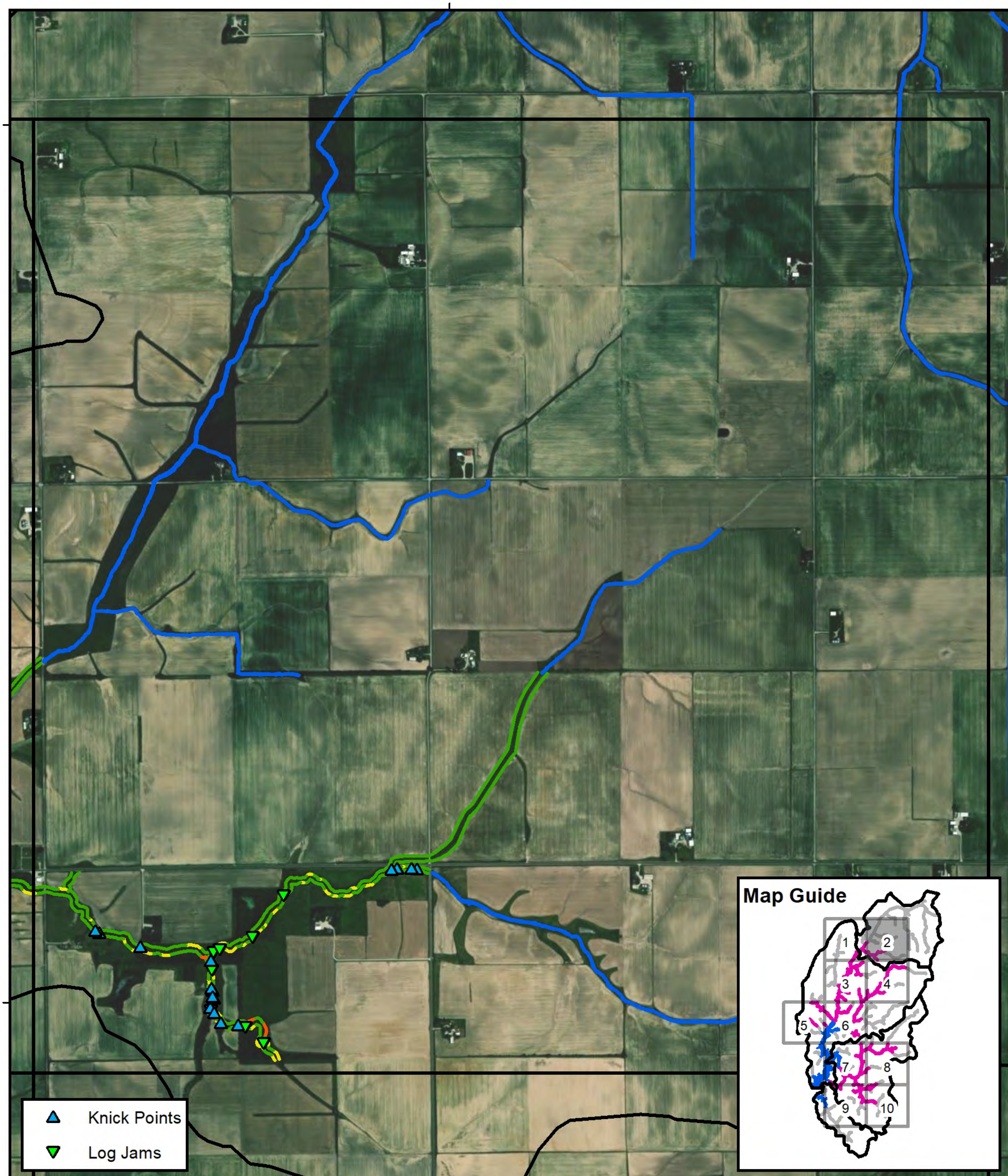

Assessed Streams (lbs/ft/yr)

- < 10
- 10 - 50
- 50 -100
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 2 of 10

0 1,000 2,000 3,000 4,000 Feet

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MONTGOMERY COUNTY SOIL & WATER CONSERVATION DISTRICT

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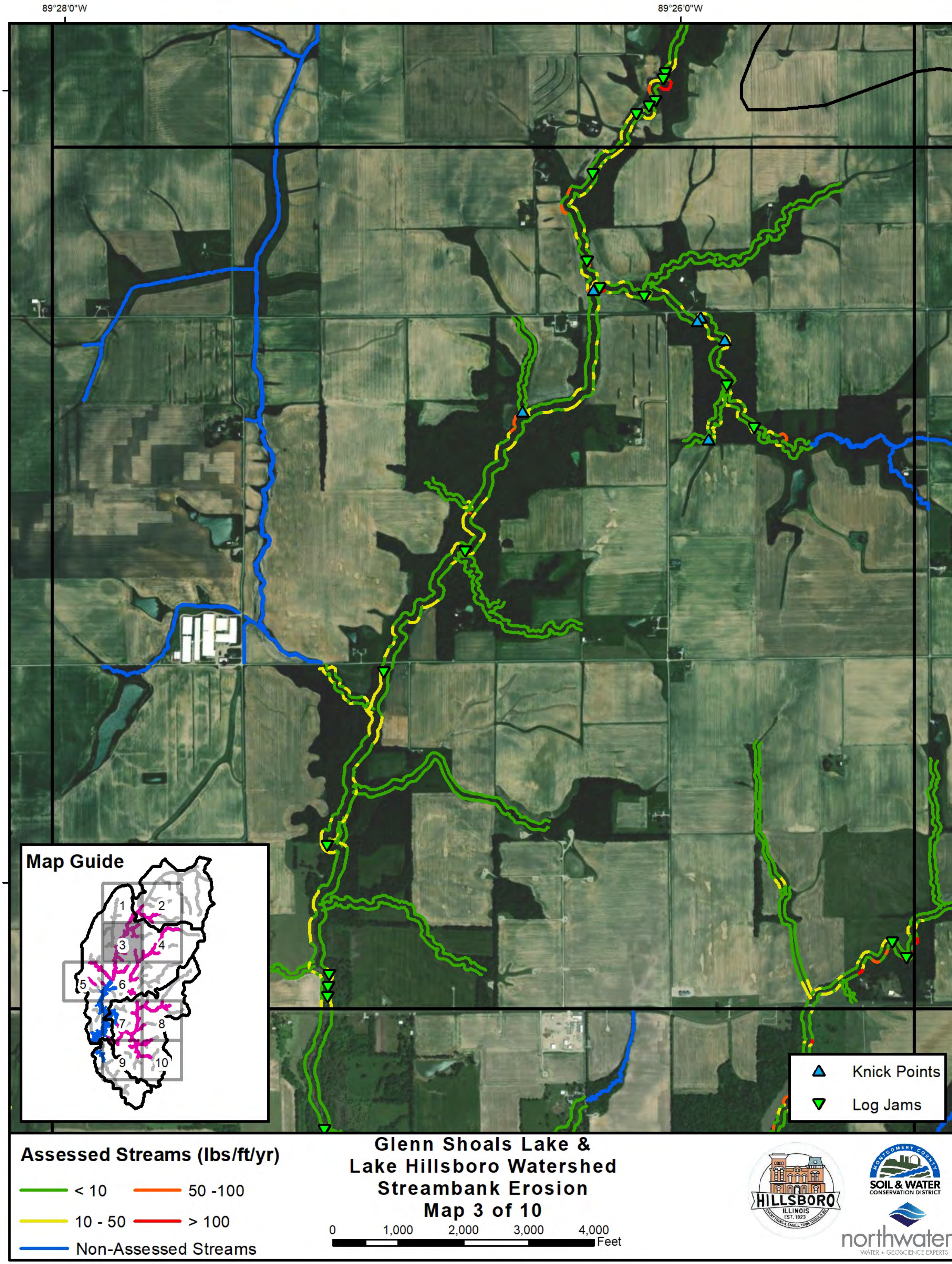

89°28'0"W
89°26'0"W
39°18'0"N
39°16'0"N
Map Guide
1
2
3
4
5
6
7
8
9
10
Knick Points
Log Jams
Assessed Streams (lbs/ft/yr)
< 10
50 -100
10 - 50
> 100
Non-Assessed Streams
Glenn Shoals Lake &
Lake Hillsboro Watershed
Streambank Erosion
Map 3 of 10
0
1,000
2,000
3,000
4,000
Feet
HILLSBORO
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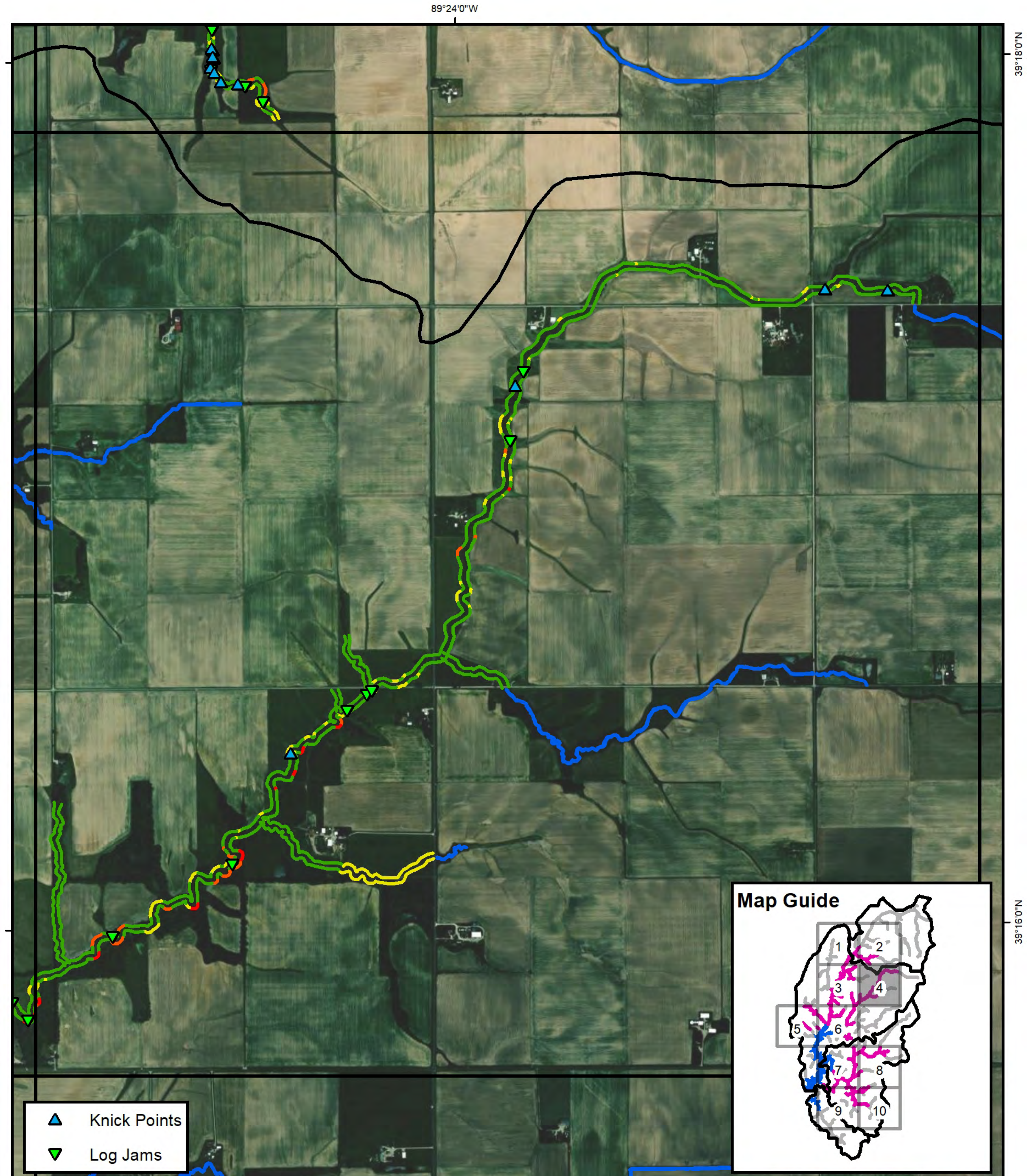

Assessed Streams (lbs/ft/yr)

< 10
50 -100
10 - 50
> 100
Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 4 of 10

0 1,000 2,000 3,000 4,000 Feet

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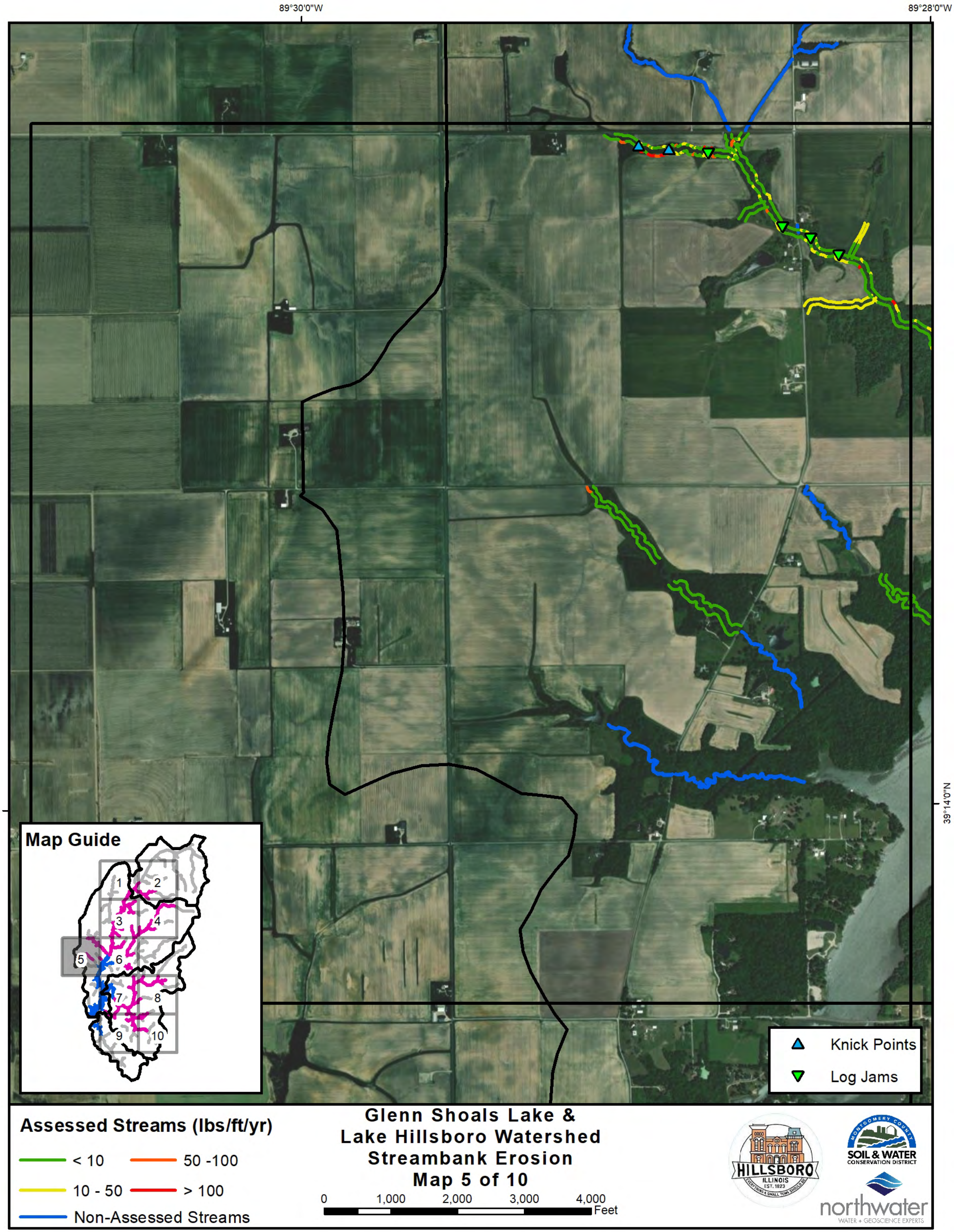
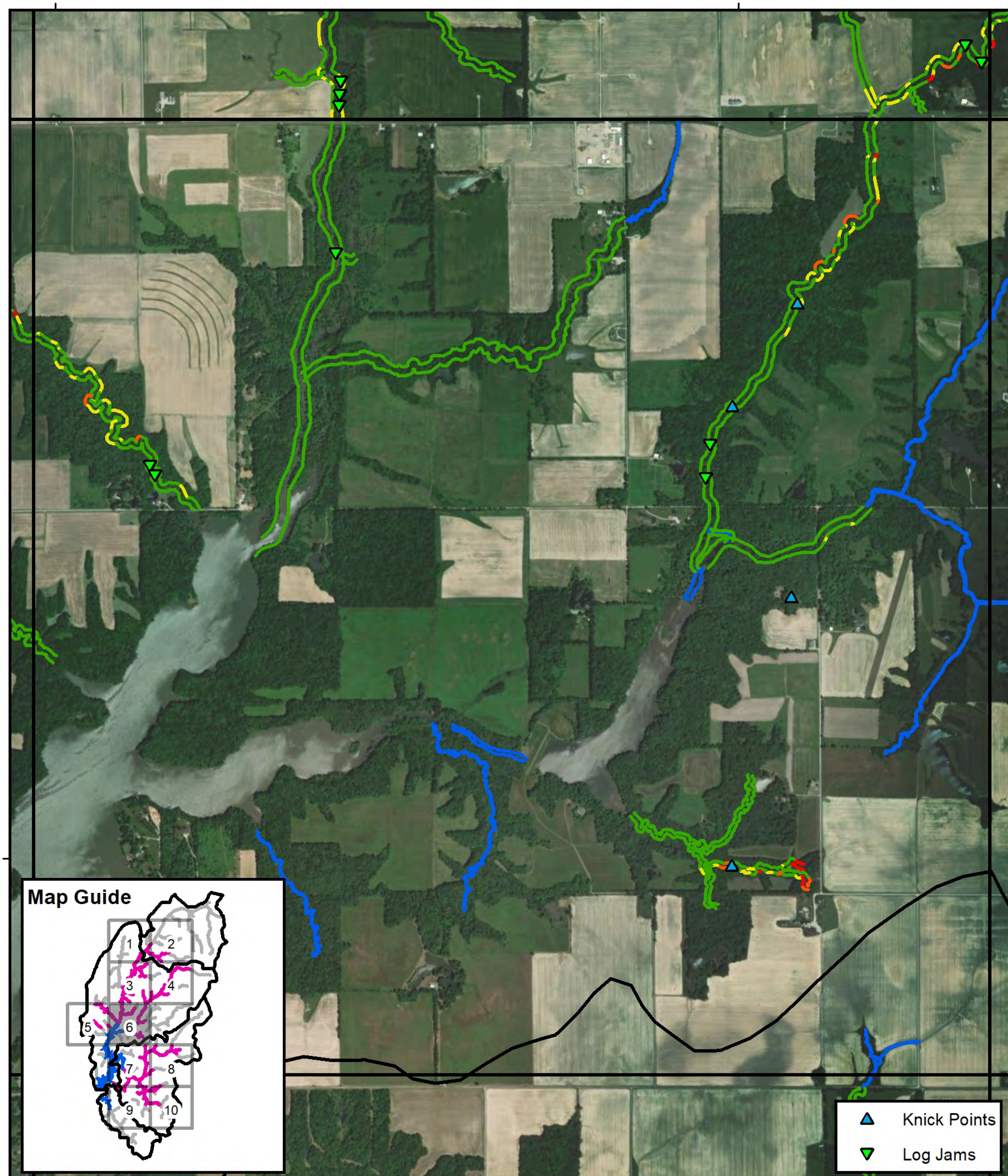


Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 5 of 10



Assessed Streams (lbs/ft/yr)

- < 10
- 10 - 50
- 50 -100
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 6 of 10

0 1,000 2,000 3,000 4,000 Feet

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MONTGOMERY COUNTY SOIL & WATER CONSERVATION DISTRICT

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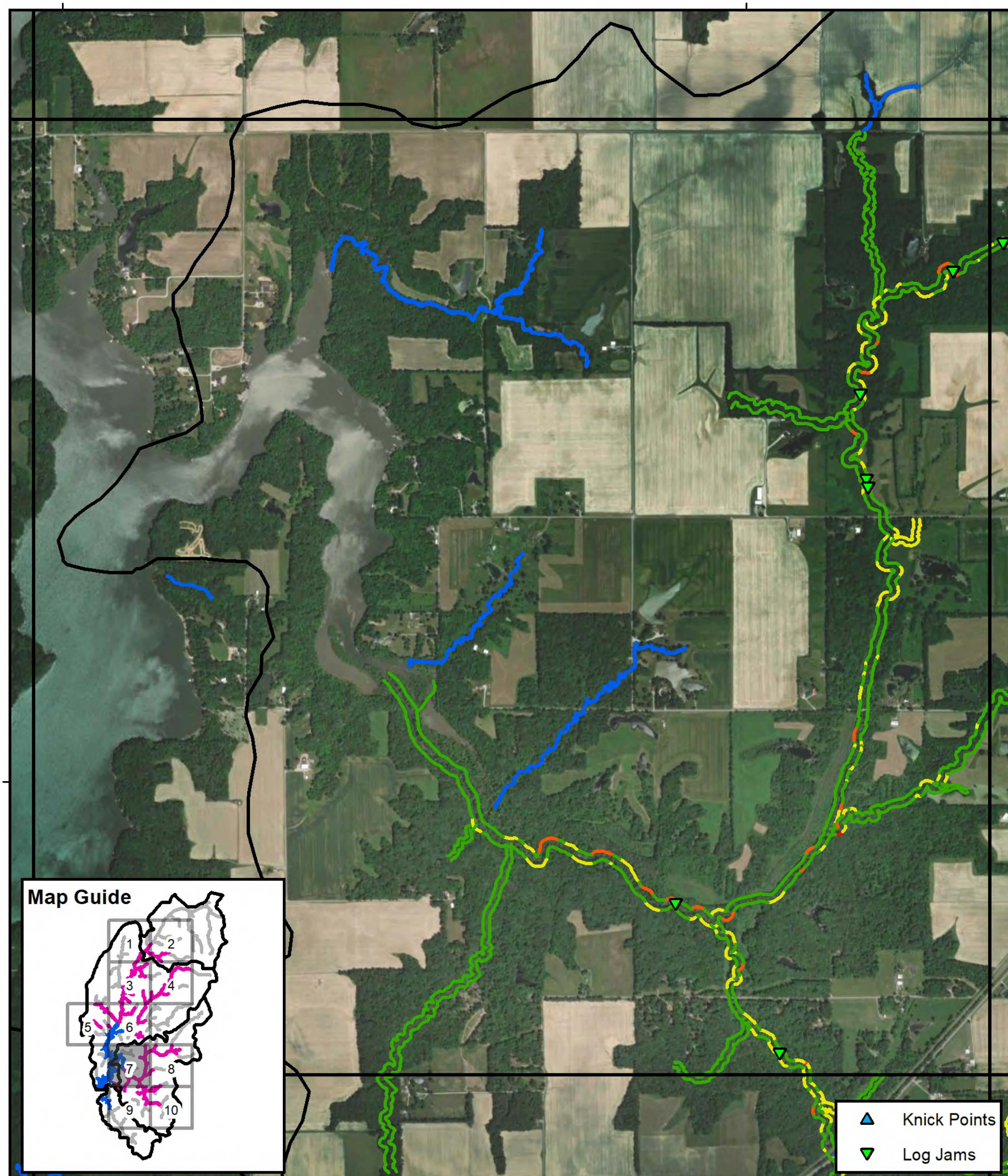
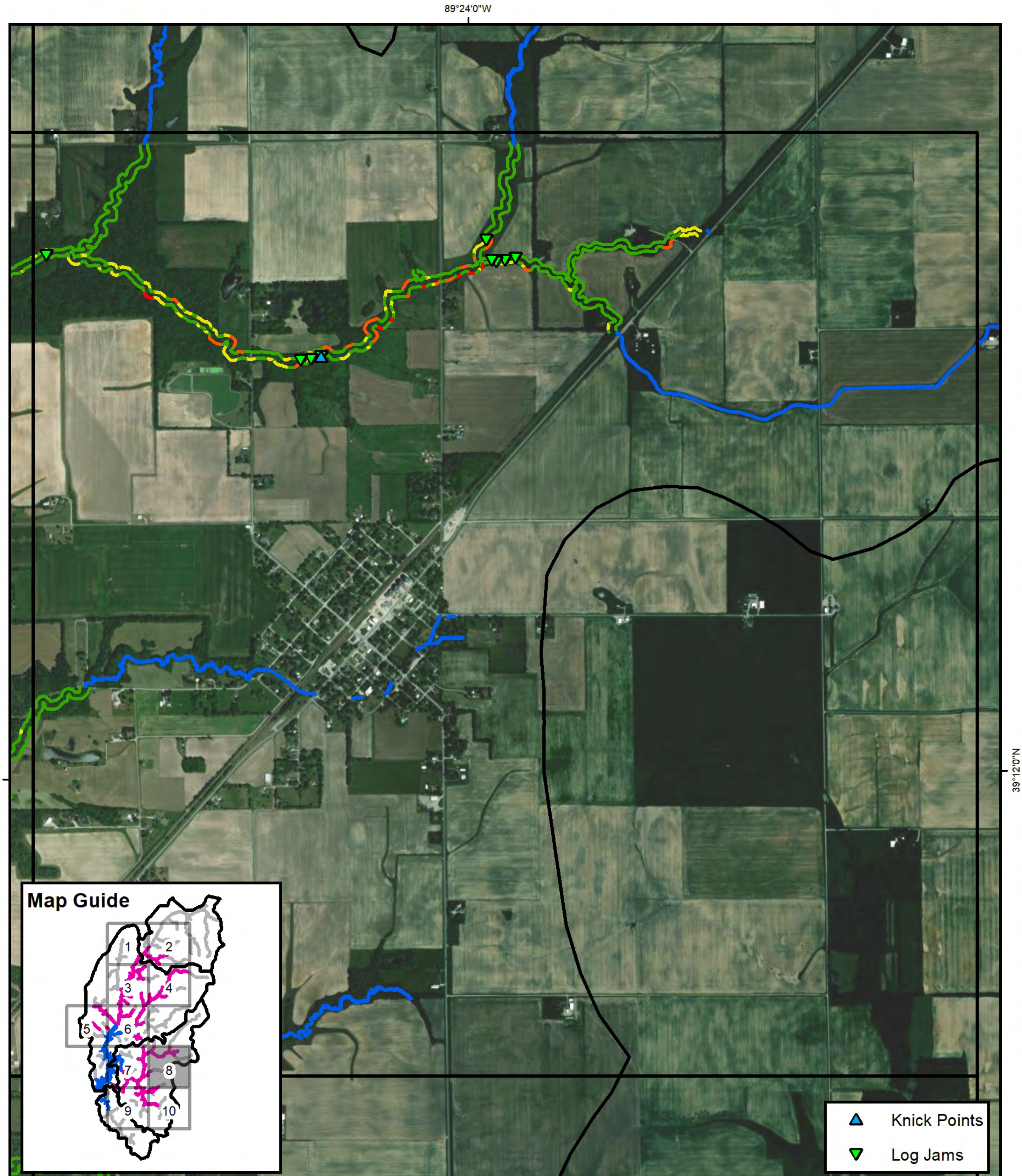


Assessed Streams (lbs/ft/yr)

- < 10
- 10 - 50
- 50 - 100
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 7 of 10

0 1,000 2,000 3,000 4,000 Feet



Assessed Streams (lbs/ft/yr)

- < 10
- 50 - 100
- 10 - 50
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 8 of 10

0 1,000 2,000 3,000 4,000 Feet

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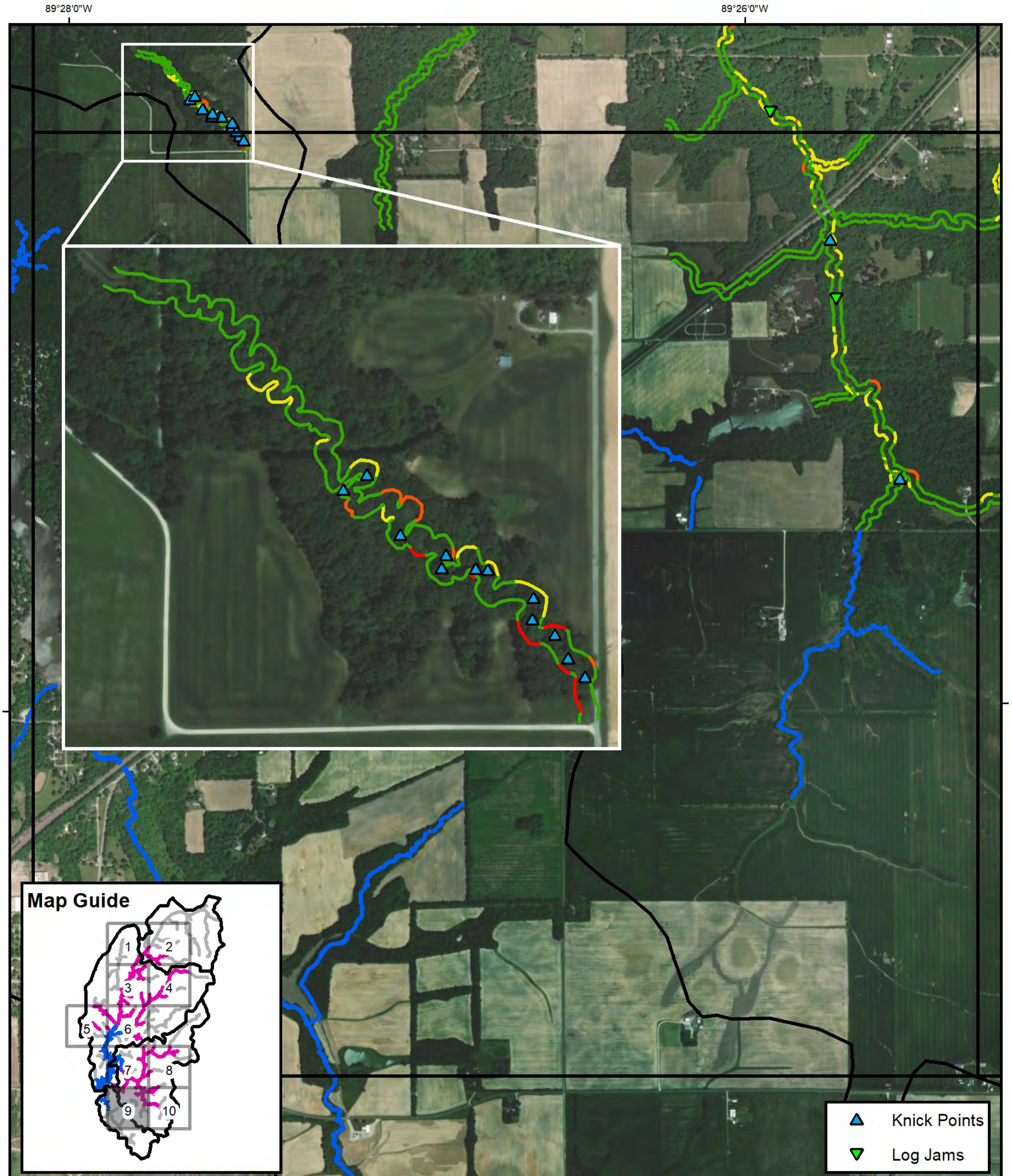


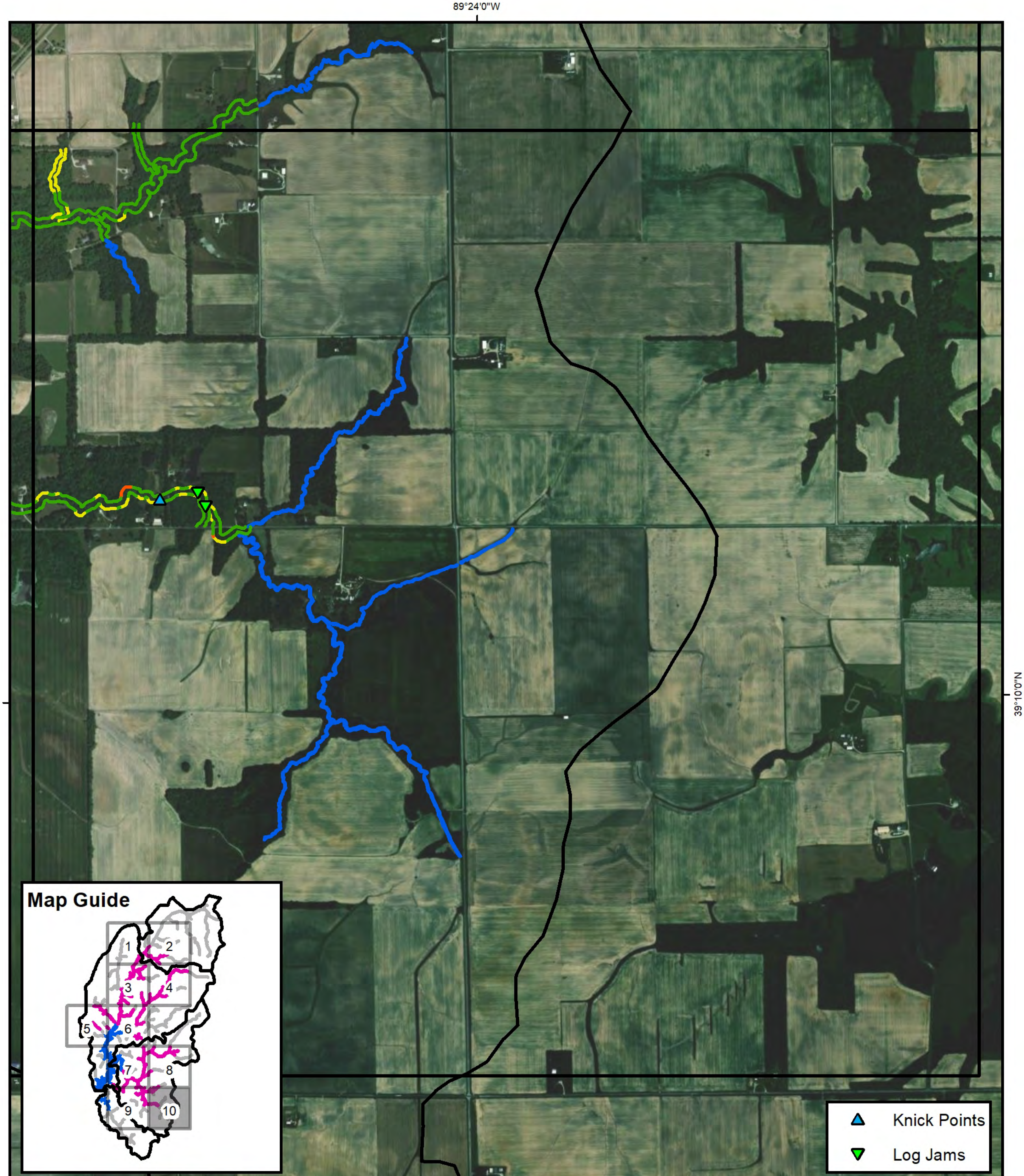
Assessed Streams (lbs/ft/yr)

- < 10
- 50 - 100
- 10 - 50
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion

Map 9 of 10

0 1,000 2,000 3,000 4,000 Feet



Assessed Streams (lbs/ft/yr)

- < 10
- 50 -100
- 10 - 50
- > 100
- Non-Assessed Streams

Glenn Shoals Lake & Lake Hillsboro Watershed Streambank Erosion Map 10 of 10

0 1,000 2,000 3,000 4,000 Feet

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