Friends Creek Subwatershed Plan Update & Addendum

Macon, Piatt & DeWitt County, Illinois

Funded by:
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Acronyms

1. BMP – Best Management Practice
2. DWM - Drainage Water Management
3. EMC – Event Mean Concentration
4. GIS – Geographic Information System
5. HEL – Highly Erodible Soil
6. HUC – Hydrologic Unit Code
7. Illinois EPA – Illinois Environmental Protection Agency
8. INLRS – Illinois Nutrient Loss Reduction Strategy
9. INSAC – Illinois Nutrient Science Advisory Committee
10. ISWS – Illinois State Water Survey
11. LTS – Long Term Strategy
12. NGRREC - National Great Rivers Research & Education Center
13. NO3 – Nitrate
14. NPS – Nonpoint Source Pollution
15. NRCS – Natural Resource Conservation Service
16. PHEL – Potentially Highly Erodible Soil
17. RCPP – Regional Conservation Partnership Program
18. STP – Stone Toe Protection
19. SSC - Suspended Sediment Concentration
20. TMDL – Total Maximum Daily Load
21. TN – Total Nitrogen
22. TP – Total Phosphorus
23. TSS – Total Suspended Solids
24. USDA – U.S. Department of Agriculture
25. USEPA – U.S. Environmental Protection Agency
26. USGS – United States Geological Survey
27. USLE – Universal Soil Loss Equation
28. VLMP – Volunteer Lake Monitoring Program
29. VRT - Variable Rate Technology
30. NVSS – Nonvolatile Suspended Solids
31. VSS – Volatile Suspended Solids
32. WASCB – Water and Sediment Control Basin

1.0 Introduction

The focus of this plan update is the 82,850-acre Friends Creek subwatershed, located in Macon, Piatt and DeWitt Counties, Illinois. The area of four United States Geological Survey (USGS) Hydrologic Unit Code (HUC)-12 subwatersheds make up the project area: Friends Creek Ditch (HUC12 – 071300060301), Shiloh Chapel – Friends Creek (HUC12 – 071300060302), Town of Argenta – Friends Creek (HUC12 – 071300060304), and Kickapoo Creek (HUC12 - 071300060303. Friends Creek makes up 14% of the entire 592,665-acre Lake Decatur watershed which is within the Upper Sangamon River HUC8 basin (07130006) and tributary to the Illinois River. Figure 1 shows the location of the subwatershed.

This update expands upon the 2019 Friends Creek Watershed Resource Inventory and Plan (Appendix A) to include more specifics on water quality and pollution sources, management measures and implementation, costs, targets, and critical areas. Its intent is to define an achievable implementation strategy to address water quality concerns, specifically, sediment and nutrients. It also summarizes and unites ongoing City-led efforts to "supersize" watershed management by identifying, prioritizing, and planning new projects, following decades of collaborative conservation activities and in-lake management. The update, therefore, will provide a road map to achieve water quality targets, as well as City and stakeholder goals for an area surrounding Lake Decatur. It will be used to guide a recently awarded $9.8 million Regional Conservation Partnership Program (RCPP) grant from the United States Department of Agriculture (USDA), as well as other future grants, and a City cost-share program.

Lake Decatur has a history of water quality impairments, as does Friends Creek more recently. Sediment and nutrient reduction is critically important to the long-term resiliency of the reservoir, as well as the recreational benefits it provides. Therefore, sediment, nitrogen, and phosphorus reduction are the primary drivers of this plan. Water quality targets of a 75% reduction in sediment and phosphorus and a 28% reduction in nitrogen are consistent with the existing Total Maximum Daily Load (TMDL) for Lake Decatur and the Illinois Nutrient Loss Reduction Strategy (INLRS). The 75% sediment target is set to match the phosphorus TMDL and reflects the City's desire to achieve substantial reductions in it. If all recommended projects are implemented and constructed, nitrogen, phosphorus and sediment reduction targets will be met or exceeded. This report includes only certain elements of a Watershed-Based Plan and is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Water Quality
- Section 3 – Pollutant Loading
- Section 4 – Sources of Watershed Impairments
- Section 5 – Nonpoint Source Management Measures & Load Reductions
- Section 6 – Cost Estimates
- Section 7 – Water Quality Targets
- Section 8 – Critical Areas
- Section 9 – Monitoring & Tracking Strategy

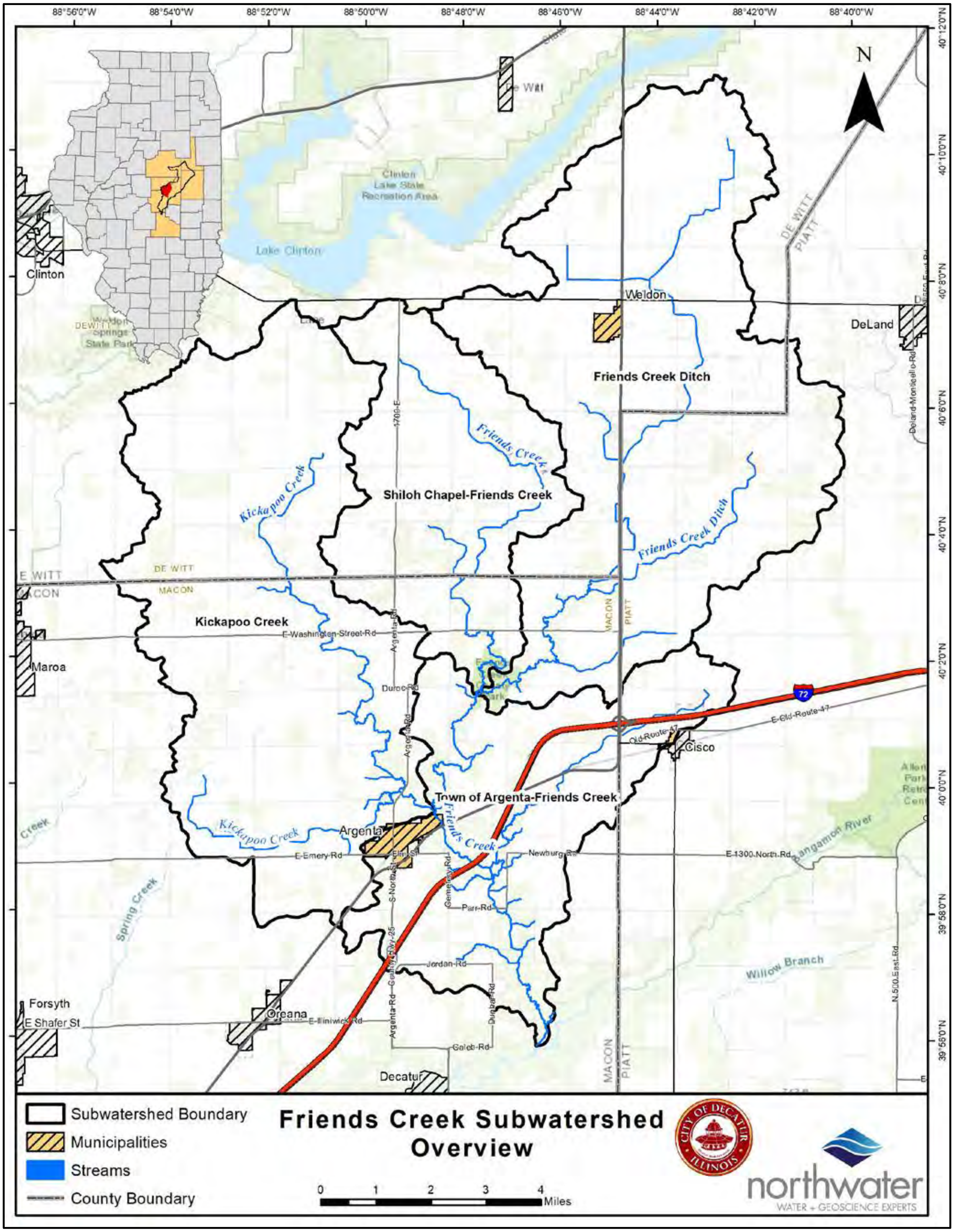


Figure 1 – Friends Creek Subwatershed

1.1 Lake Decatur Long-Term Strategy

Established in 2021, the LTS was developed to guide planning and management with the objective to reduce sediment and nutrients entering the lake. It represents an overarching plan for the entire Lake Decatur watershed. The Friends Creek subwatershed and plan is a vital component.

On an annual basis, up to $1M of sediment (based on dredging costs) enters the lake. According to the Illinois State Water Survey (ISWS), 15% of the watershed area nearest the lake contributes the majority of the sediment. The ISWS also estimates over 13M lbs/year of nitrate loading to the watershed. Nitrate loading per unit area is higher in proximity to the lake and decreases as drainage area increases. Nitrate loading causes the lake to periodically exceed drinking water standards, requiring approximately $200,000 in annual treatment costs. The LTS represents a guiding vision for the lake and watershed and is focused on two goals:

1. Achieve measurable reductions in sediment loading from a baseline to maximize the life of dredging investments.
2. Achieve measurable reductions in nitrate loading and reduce exceedances of the 10 mg/L drinking water standard.

The strategy is based upon four foundations of watershed planning:

1. Leadership and coordination.
2. Leveraging of opportunities.
3. **Subwatershed plan sequencing.**
4. Impactful launch and continuity.

Subwatershed Sequencing: beginning with the Bluffs in 2021, sequencing plans at a subwatershed scale rather than deploying a single plan for the entire 592,665-acre watershed is important. By 2026, detailed and actionable subwatershed plans will encompass the entire Lake Decatur watershed.

1. Criteria for sequencing include proximity to the lake, nutrient and sediment yields, and opportunity for greatest lake impacts.
2. Subwatershed scale plans are necessary to secure implementation funding, especially through the Illinois EPA.
3. A synthesized and cohesive plan will continue to grow as subwatershed plans are completed. These plans hold the site-level detail and specifics needed to guide cost-effective implementation.

Although the subwatershed plans will be independent, the objective is to synthesize them into a consistent management framework as they become completed, and implementation occurs. Table 1 presents all the subwatersheds and the sequencing chronology.

Table 1 - Lake Decatur Watershed Plan Sequencing Summary & Progress

Subwatersheds	HUC 12s	Initiation Year	Planning History / Notes
Bluffs	Lake Decatur Bluffs	2020	Plan completed in 2021 and on-the-ground implementation is underway.
Sand Creek	Sand Creek	2022	Plan completed in 2023 and on-the-ground implementation is underway.
Wildcat/Willow	Wildcat Creek	2022	Plan completed in 2023 and on-the-ground implementation is underway.
	Willow Branch		
Friends Creek	Friends Creek	2022	An Illinois EPA approved plan exists. The current plan required an update to include more details and site-specific recommendations. Plan update completed in 2023.
	Shiloh Chapel Friends Creek		
	Friends Creek Ditch		
	Kickapoo Creek		
Middle Upper Sangamon 1	Goose Creek	2023 - 2024	Planning is underway for Camp Creek and the South Fork of Camp Creek.
	Madden Creek		
	Camp Creek		
	Spring Lake		
	South Fork Camp Creek		
	Lake of the Woods		
Big Ditch	Big Ditch	2024-2025	Current Illinois EPA approved plan expires in 2024
Big / Long Creek	Big & Long Creek	2024-2025	Current Illinois EPA approved plan expires in 2024
Middle Upper Sangamon 2	Long Tree Creek	2026	No current or detailed plan exists. The Heart of the Sangamon River Partnership established watershed management goals in 1999.
	Owl Creek	2026	
	Wildcat Slough	2026	
	Hillsbury Slough	2026	
Finley Creek	Finley Creek	2026	No current or detailed plan exists.
Upper Sangamon	Dickerson Slough	2027	No current or detailed plan exists. The Heart of the Sangamon River Partnership established watershed management goals in 1999.
	Corn Valley Creek	2027	
	West Branch Drummer Creek	2027	
	Town of Arrowsmith Sangamon River	2027	

2.0 Water Quality, Impairments & Standards

This section provides an overview of applicable and relevant water quality standards, pollutants of concern and impairments in the Friends Creek's subwatershed. 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 time 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.

2.1 Water Quality Impairments

Friends Creek (Illinois EPA ID – IL_EV-02) has one impairment listed in the 2022 303 (d) list - Dissolved Oxygen for Aquatic Life. Lake Decatur (Illinois EPA ID IL_REA) and a short segment of the Sangamon River (Illinois EPA ID IL_E-95) downstream from Friends Creek are also listed. Both impairments are related to fish consumption and include Chlordane, Polychlorinated Biphenyls (PCBs), and Mercury (Table 2). In Lake Decatur, nitrogen, phosphorus, sediment, and DO persisted until completion of a 2007 Total Maximum Daily Load (TMDL) and metals related to fish consumption have been impairments since 2002. The Sangamon was impaired for metals in 2008, 2016, 2018 and 2022 (Table 2).

Table 2 – Current & Historical 303(d) Impaired Waterbodies

Assessment ID	Waterbody	Designated Use	Cause
2002			
REA	Lake Decatur	Overall, Aquatic Life, Primary and Secondary Contact, Fish Consumption	Priority Organics, Polychlorinated Biphenyls (PCBs), Unspecified Metals, Unspecified Nutrients, Phosphorus, Total Nitrogen, Siltation, organic enrichment/low Dissolved Oxygen, suspended solids, excessive algal growth/chlorophyll α
2004			
REA	Lake Decatur	Overall, Aquatic Life, Primary and Secondary Contact, Fish Consumption, Drinking Water Supply	Unspecified Metals, Unspecified Nutrients, Total Nitrogen, Nitrogen – Nitrate, Sedimentation/Siltation, Dissolved Oxygen, Total Suspended Solids, Chlordane, Polychlorinated Biphenyls (PCBs)
2006			
REA	Lake Decatur	Aquatic Life, Aesthetic Quality, Fish	Total Phosphorus, Total Nitrogen, Nitrogen – Nitrate, Sedimentation/Siltation, Dissolved Oxygen, Total

Assessment ID	Waterbody	Designated Use	Cause
		Consumption, Drinking Water Supply	Suspended Solids, Chlordane, Polychlorinated Biphenyls (PCBs), Silver
2008			
REA	Lake Decatur	Aquatic Life, Fish Consumption	Chlordane, Polychlorinated Biphenyls (PCBs), Silver, Mercury
E-95	Sangamon River	Fish Consumption	Mercury
2010, 2012, 2014			
REA	Lake Decatur	Aquatic Life, Fish Consumption	Turbidity, Chlordane, Polychlorinated Biphenyls (PCBs), Mercury
2016			
REA	Lake Decatur	Fish Consumption	Chlordane, Polychlorinated Biphenyls (PCBs), Mercury
E-95	Sangamon River	Fish Consumption	Mercury
2018			
REA	Lake Decatur	Fish Consumption	Chlordane, Polychlorinated Biphenyls (PCBs), Mercury
E-95	Sangamon River	Fish Consumption	Mercury
2022			
EV-02	Friends Creek	Aquatic Life	Dissolved Oxygen
REA	Lake Decatur	Fish Consumption	Chlordane, Polychlorinated Biphenyls (PCBs), Mercury
E-95	Sangamon River	Fish Consumption	Mercury

2.2 Relevant Standards & Guidelines

Standards and guidelines relevant to Friends Creek and achieving overall Lake Decatur watershed planning goals are nitrogen, phosphorous and sediment. Continued data collection and monitoring of Friends Creek will support an improved understanding of the proportion of sediment and nutrient inputs to the lake from this subwatershed and track successes from watershed improvement efforts.

Nitrogen: Nitrate-Nitrogen (NO3-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 applicable to Lake Decatur is 10 mg/L.

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.

Total Phosphorus (TP) includes dissolved and particulate fractions and is often stored in aquatic biota such as algae. Dissolved factions are more readily available and can stimulate processes that are harmful to water quality and aquatic life. Phosphorus sources in the watershed context include fertilizers and, to a lesser extent, human and animal waste.

- 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.

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), organic materials, such as algae, and decomposing organic matter and nonvolatile suspended solids (NVSS), which includes non-organic "mineral" substances (Illinois EPA, 1998). As referenced in this plan, Suspended Sediment Concentration (SSC) is another analytical method of estimating solid materials in water. The method measures the dry weight of all the sediment in a known volume of water-sediment mixture and is more reliable for surface water estimates.

- There are no regulatory TSS or SSC 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.

2.3 Water Quality Data

As described in the previous section, the single impairment is relative to the dissolved oxygen, however, the historical dataset collected by the Illinois State Water Survey did not pass quality control and was discarded. Sedimentation is a historical impairment relative to Lake Decatur and continues to be a primary stakeholder concern. This section focuses on sediment, nitrate and total phosphorus.

As part of a recently implemented City of Decatur monitoring program, three permanent stations have been established/re-established for sediment and nutrient monitoring. Locations are on the Upper Sangamon River, Long Creek and Friends Creek and capture nearly 80% of the lakes' watershed. The Friends Creek Station (Table 3) includes the following:

- Station 102 (Friends Creek at IL Route 48)
  - River stage collected at 15-minute increments with an Ott Radar-Level Sensor mounted on IL Route 48 (commissioned in October 2022).
  - A stage/discharge rating curve developed the ISWS applied to derive flow estimates.

- o ISCO auto-sampler and regular grab samples

Table 3 – Friends Creek Water Quality Monitoring Station

Station Code	Latitude (dd)	Longitude (dd)	Waterbody	Period of Data	Parameters
102	39.98941	-88.80558	Friends Creek	2020 - Present	Nitrate, TP, SSC) Stage and Flow, Dissolved Oxygen (discarded)

2.3.1 Phosphorus

Phosphorus monitoring at the Friends Creek's station was implemented in August 2021. Figure 2 and Table 4 present TP concentrations along with flow data. Of the 30 samples collected, the average concentration was 0.11 mg/L with a range of 0.04 to 0.438 mg/L. The lake water quality standard of 0.05 mg/L was exceeded on 60% of the samples.

Loading estimates are presented in Table 5. For the water years 2020-2021 and 2021-2022, loading is estimated at 58,500 and 44,000 lbs, respectively. With an estimated yield of 0.6 to 0.8 lbs/ac/year, Friends Creek appears to be a significant contributor of phosphorus to Lake Decatur.

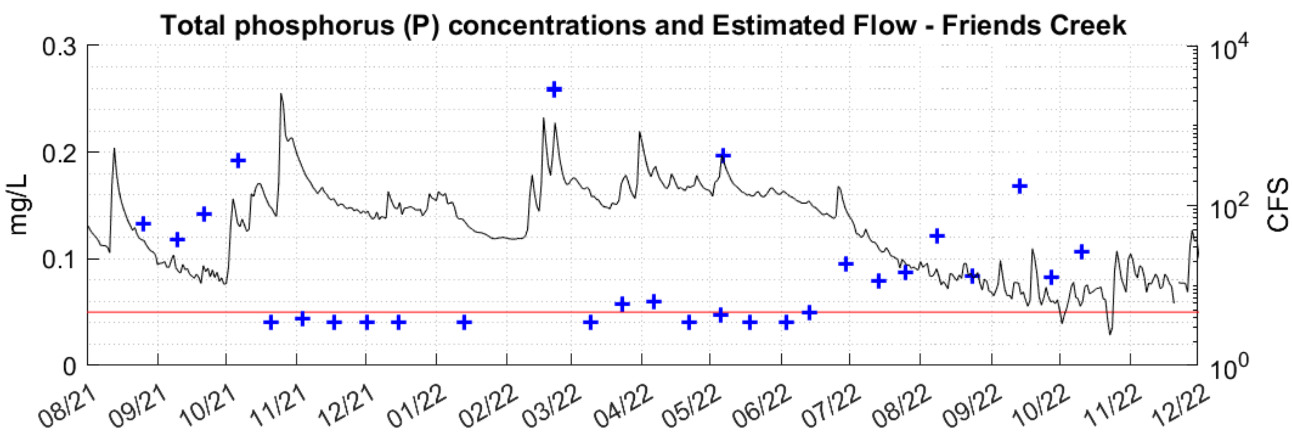


Figure 2 – Measured Phosphorus Concentrations

Table 4 – Summary statistics of TP Concentrations - 2021-2022

Period	# of Samples	Avg.	Min	Median	95th Percentile	Max	# Above Standard*	% Above Standard*
08/25/2021 – 10/24/2022	30	0.110	0.04	0.081	0.369	0.438	18	60%

** Illinois Lake water quality standard of 0.05 mg/L*

Table 5 – Estimated Phosphorus Loading - 2020-2022

Station	2020-2021		2021-2022	
Subwatershed	**TP (lbs/ac/yr)**	**TP (lbs/yr)**	**TP (lbs/ac/yr)**	**TP (lbs/yr)**
Friends Creek (102)	0.8	58,500	0.6	44,000

2.3.2 Nitrogen

Figure 3 and Table 6 present flow and nitrate concentration data for Friends Creek. Nitrate concentration patterns are similar to the logarithmic variation of flow. Of the 21 samples collected during the 2020-2021 water year, the average nitrate concentration was 4.25 mg/L and ranged from 0.04 to 12.08 mg/L. During the 2021-2022 water year, 25 samples were collected and presented significantly higher concentrations with an average of 6.75 mg/L and a range from 0.55 mg/L to 11.46 mg/L. One sample in 2020-2021 and two in 2021-2022 exceeded the drinking water standard of 10 mg/L.

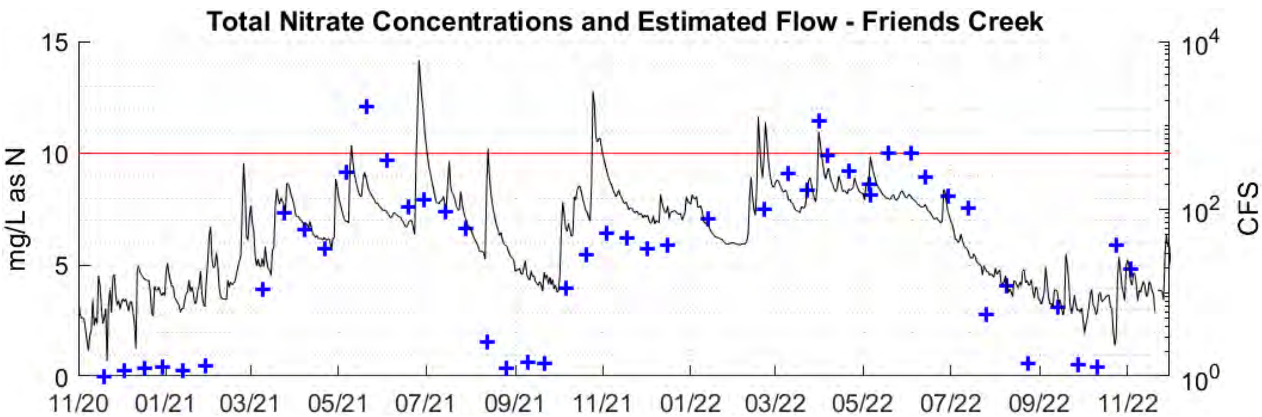


Figure 3 - Nitrate Concentrations & Flow

Table 6 – Summary Statistics of Nitrate Concentrations

Period	# Samples	Avg.	Min	Median	95th Percentile	Max	# Above Standard	% Above Standard
11/20/2020 – 09/21/2021	21	4.25	0.04	3.92	10.75	12.08	1	5%
10/06/2021– 09/27/2022	25	6.75	0.55	7.52	10.39	11.46	2	8%

For the water years 2020-2021 and 2021-2022, loading is estimated at 1,455,00 lbs and 2,350,000 lbs, respectively (Table 7). With an estimated annual yield per acre of 20.3 lbs and 32.8 lbs, Friends Creek is a significant contributor of nitrogen to Lake Decatur.

Table 7 – Nitrate Loading Estimates

Station	2020-2021		2021-2022	
Subwatershed	**(lbs/ac/yr)**	**(lbs/yr)**	**(lbs/ac/yr)**	**(lbs/yr)**
Friends Creek (102)	20.3	1,455,000	32.8	2,350,100

2.3.3 Sediment

Figure 4 and Table 8 present flow and SSC concentration data for Friends Creek. Of the 39 samples collected during the 2020-2021 water year, the average SSC concentration was 100 mg/L and ranged from 12.4 to 262 mg/L. During the 2021-2022 water year, 25 samples were collected and presented similar concentrations with an average of 105 mg/L and a range from 12.4 mg/L to 167 mg/L.

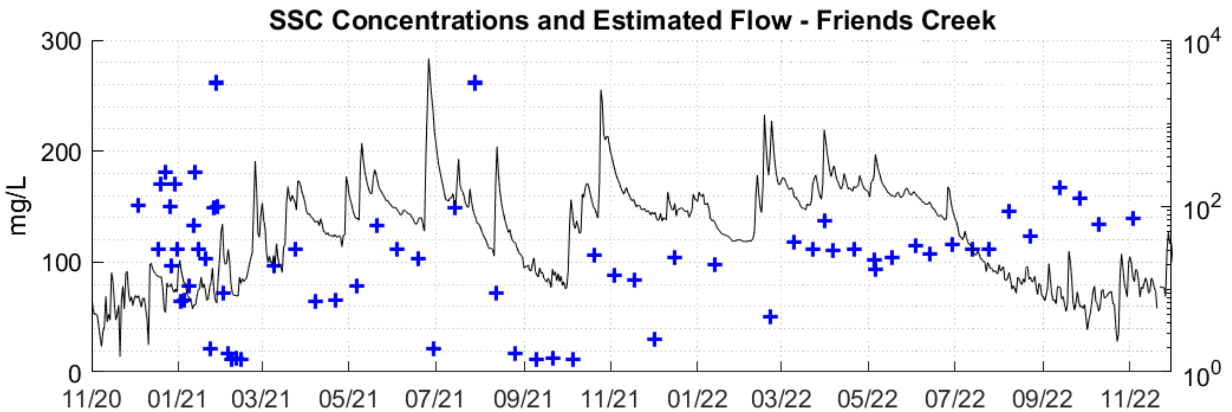


Figure 4 – SSC Concentrations & Flow

Table 8 – Summary Statistics of SSC Results

Period	# of Samples	Average	Min	Median	95th Percentile	Max
12/03/2020 – 09/21/2021	39	100	12.4	103	226	262
10/05/2021 – 09/27/2022	25	105	12.4	110	160	167

Loading estimates are presented in Table 9. For the water years 2020-2021 and 2021-2022, loading is estimated at 15,400 tons and 19,900 tons, respectively. Yield is relatively low at 0.24 and 0.31 lb/ac/year. Future monitoring, particularly during storm events, will greatly improve loading estimates since higher flow events deliver a greater proportion of the overall sediment load.

Table 9 – Estimate of Sediment Loading

Station	2020-2021		2021-2022	
Subwatershed	**(tons/ac/yr)**	**(tons/yr)**	**(tons/ac/yr)**	**(tons/yr)**
Friends Creek (102)	0.24	15,400	0.31	19,900

3.0 Pollutant Loading

3.1 Introduction

A subwatershed survey was completed to gain an understanding of more recent conditions and features and to collect field-specific data to support the Friends Creek plan update. 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.

A spatially explicit Geographic Information System (GIS)-based pollution loading model (SWAMM) was developed to estimate loading more accurately from direct runoff and tile or subsurface flow. The model simulates surface runoff and loading using the curve number approach, local precipitation, the Universal Soil Loss Equation (USLE), and Event Mean Concentrations (EMCs) specific to landuse and soil types. A custom landuse map layer was created for the subwatershed to support modeling and practice recommendations. 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 directly calibrated to Friends Creek measured water quality and streamflow data.

3.2 Pollutant Loading

Pollutant load estimates are presented in this section and are provided for septic systems, surface runoff and tile flow, gully erosion, and streambank erosion. Although there are two permitted discharges in the subwatershed, they do not contribute any nutrients or sediment to total annual loading. Gully erosion was observed in the field to the extent it was visible and estimated from recent aerial imagery and elevation data. Streambank erosion was quantified using data from the 2019 plan and observations during a watershed windshield survey. Loading from septic systems was estimated based on those homes not connected to a wastewater treatment system. Methods used for gullies, streambanks and septic systems are detailed in other Lake Decatur subwatershed plans, including the Bluffs, Willow Branch, Wildcat Creek and Sand Creek. Results from the GIS-based direct surface runoff and tile flow pollution load model are illustrated in Figure 5, Figure 6, and Figure 7. Loading from direct, surface runoff and tile accounts for what is contributed from overland flow and tiles.

As presented in Table 10, total annual loading from all sources is 2,310,500 lbs of nitrogen, 54,859 lbs of phosphorus, and 29,020 tons of sediment. Direct runoff and tile flow combined are responsible for 99.6% of the nitrogen load, 88% of the phosphorus, and 78% of the sediment load. Loading from tile flow is likely responsible for approximately 33% of the total nitrogen and 18% of the total phosphorus load. All other sources combined - failing septic systems, streambank erosion, and gully erosion - account for 0.43% of the nitrogen, 12% of the phosphorus, and 22% of the sediment load.

Table 10 – 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)
Surface Runoff & Tile Flow	2,300,750	48,246	22,646	99.6%	88%	78%
Streambank Erosion	4,646	4,768	5,280	0.2%	8.7%	18.2%
Gully Erosion	1,746	530	1,094	0.08%	0.97%	3.8%
Septic Systems	3,358	1,315	0	0.15%	2.4%	0%
Grand Total	**2,310,500**	**54,859**	**29,020**	**100%**	**100%**	**100%**

Modeled pollution loading from surface runoff and subsurface tile flow is reported in Table 11, and depicted in Figure 5, Figure 6, and Figure 7. Per-acre results are calculated by dividing the total annual load of a given landuse category by the total number of acres. Results show that row crops have the highest per-acre sediment load. Row crops and feed areas have the highest per-acre nitrogen load. Feed areas deliver the highest per-acre phosphorus loads.

Cropland delivers 2,279,299 lbs/yr of nitrogen, or 31 lbs/ac/yr; 46,247 lbs/yr of phosphorus, or 0.63 lbs/ac/yr; 22,536 tons, or 0.31 tons/ac/yr of sediment. It is important to note that these results represent delivered loads for all fields in the watershed 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 landuse categories, such as roads, grasslands, open space, and residential areas, are also relatively high contributors of nutrients and sediment. Although forest, grasslands, and open space have low per-acre values compared to other categories, the subwatershed contains a higher percentage and, therefore, cumulative loading is higher.

Table 11 – Pollution Loading from Surface & Subsurface Runoff by Landuse

Landuse Category	Area (acres)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	lbs/ac/yr	lbs/yr	lbs/ac/yr	lbs/yr	tons/ac/yr
Row Crops	73,832	2,279,299	31	46,247	0.63	22,536	0.31
Roads[1]	779	5,080	6.5	601	0.77	41	0.05
Open Space	1,858	3,295	1.8	191	0.10	9.5	0.01
Pasture	296	2,767	9.3	234	0.79	9.5	0.03
Forest	2,271	2,550	1.1	204	0.09	18	0.01
Open Water Stream[2]	200	2,029	10	145	0.72	1.2	0.01
Grasslands	2,835	1,706	0.6	170	0.06	9.2	0.003
Farm Building	124	1,351	11	99	0.80	5.7	0.05
Residential[3]	188	892	4.7	124	0.66	5.8	0.03
Driveway	105	512	4.9	66	0.63	4.0	0.04
Feed Area	15	330	22	59	3.9	1.1	0.07
Parking Lot	35	191	5.5	29	0.82	1.6	0.05

Landuse Category	Area (acres)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	lbs/ac/yr	lbs/yr	lbs/ac/yr	lbs/yr	tons/ac/yr
Open Water Pond/Reservoir[2]	88	122	1.4	4	0.05	0.05	0.001
Parks & Recreation	67	112	1.7	16	0.24	0.16	0.002
Institutional	12	81	6.8	11	0.9	0.57	0.05
Wetlands	60	77	1.3	0.6	0.01	0.01	0.0002
Cemetery	21	71	3.3	7	0.33	0.20	0.01
Warehousing	11	64	5.6	10	0.91	0.51	0.04
Commercial	9	61	6.7	8.6	0.95	0.42	0.05
Railroad	17	50	2.9	7.4	0.43	0.46	0.03
Campground	10	37	3.6	3.6	0.35	0.18	0.02
Industrial	5.2	27	5.3	4.4	0.85	0.24	0.05
Orchards & Nurseries	4.8	20	4	1.1	0.23	0.05	0.01
Utilities	3.1	13	4.3	2.1	0.68	0.10	0.03
Well Scrubbing Basin	2.6	9	3.4	0.33	0.13	0.03	0.01
Junkyard	0.90	3	3.3	0.45	0.5	0.03	0.04
Dry Detention Basin	0.90	1.4	1.5	0.05	0.06	0.003	0.004
Grand Total[4]	**82,850**	**2,300,750**	**28 (avg)**	**48,246**	**0.58 (avg)**	**22,646**	**0.27 (avg)**

[1] – Roads yield high nutrient loads due to rapid rates of runoff and relatively high Event Mean Concentration values found in existing literature.
[2] – Very 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 landuse 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 36 quantifies septic system loading separately.
[4] – per acre values in this column represent total loading divided by the total subwatershed area and is an overall average.

Table 12 compares the loadings originating from direct runoff with the subwatershed to total load from all sources. Row crops are the greatest contributor, responsible for 98.7% of the total nitrogen, 84% of total phosphorus, and 78% of the total sediment load. Roads are the second highest contributor of sediment, albeit only 0.14%. Roads, open space, pasture and forests are the next four highest contributors of surface runoff nitrogen loads, at 0.22%, 0.14%, 0.12%, and 0.11%, respectively. Roads, pasture and forest contribute 1.1%, 0.43% and 0.37% of total phosphorus, respectively.

Table 12 – Loading from Surface & Subsurface Runoff by Landuse as Percentage of Watershed Load

Landuse Category	Area (acres)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	% Total Watershed Load	lbs/yr	% Total Watershed Load	tons/yr	% Total Watershed Load
Row Crops	73,832	2,279,299	98.7%	46,247	84.3%	22,536	77.7%
Roads	779	5,080	0.22%	601	1.1%	41	0.14%
Open Space	1,858	3,295	0.14%	191	0.35%	9.5	0.03%
Pasture	296	2,767	0.12%	234	0.43%	9.5	0.03%
Forest	2,271	2,550	0.11%	204	0.37%	18	0.06%
Open Water Stream	200	2,029	0.09%	145	0.26%	1.2	0.004%
Grasslands	2,835	1,706	0.07%	170	0.31%	9.2	0.03%

Landuse Category	Area (acres)	Nitrogen Load		Phosphorus Load		Sediment Load	
		lbs/yr	% Total Watershed Load	lbs/yr	% Total Watershed Load	tons/yr	% Total Watershed Load
Farm Building	124	1,351	0.06%	99	0.18%	5.7	0.02%
Residential	188	892	0.04%	124	0.23%	5.8	0.02%
Driveway	105	512	0.02%	66	0.12%	4.0	0.01%
Feed Area	15	330	0.01%	59	0.11%	1.1	0.00%
Parking Lot	35	191	0.01%	29	0.05%	1.6	0.01%
Open Water Pond/Reservoir	88	122	0.01%	4.0	0.01%	0.05	0.0002%
Parks & Recreation	67	112	0.005%	16	0.03%	0.16	0.001%
Institutional	12	81	0.003%	11	0.02%	0.57	0.002%
Wetlands	60	77	0.003%	0.6	0.00%	0.01	0.000%
Cemetery	21	71	0.003%	7.0	0.01%	0.20	0.001%
Warehousing	11	64	0.003%	10	0.02%	0.51	0.002%
Commercial	9	61	0.003%	8.6	0.02%	0.42	0.001%
Railroad	17	50	0.002%	7.4	0.01%	0.46	0.002%
Campground	10	37	0.002%	3.6	0.01%	0.18	0.001%
Industrial	5.2	27	0.001%	4.4	0.01%	0.24	0.001%
Orchards & Nurseries	4.8	20	0.001%	1.1	0.002%	0.05	0.0002%
Utilities	3.1	13	0.001%	2.1	0.004%	0.10	0.0003%
Well Scrubbing Basin	2.6	9.0	0.0004%	0.33	0.001%	0.03	0.0001%
Junkyard	0.90	3.0	0.0001%	0.45	0.001%	0.03	0.0001%
Dry Detention Basin	0.90	1.4	0.0001%	0.05	0.0001%	0.003	0.00001%
Grand Total	82,850	2,300,750	99.58%	48,246	88%	22,646	78%

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

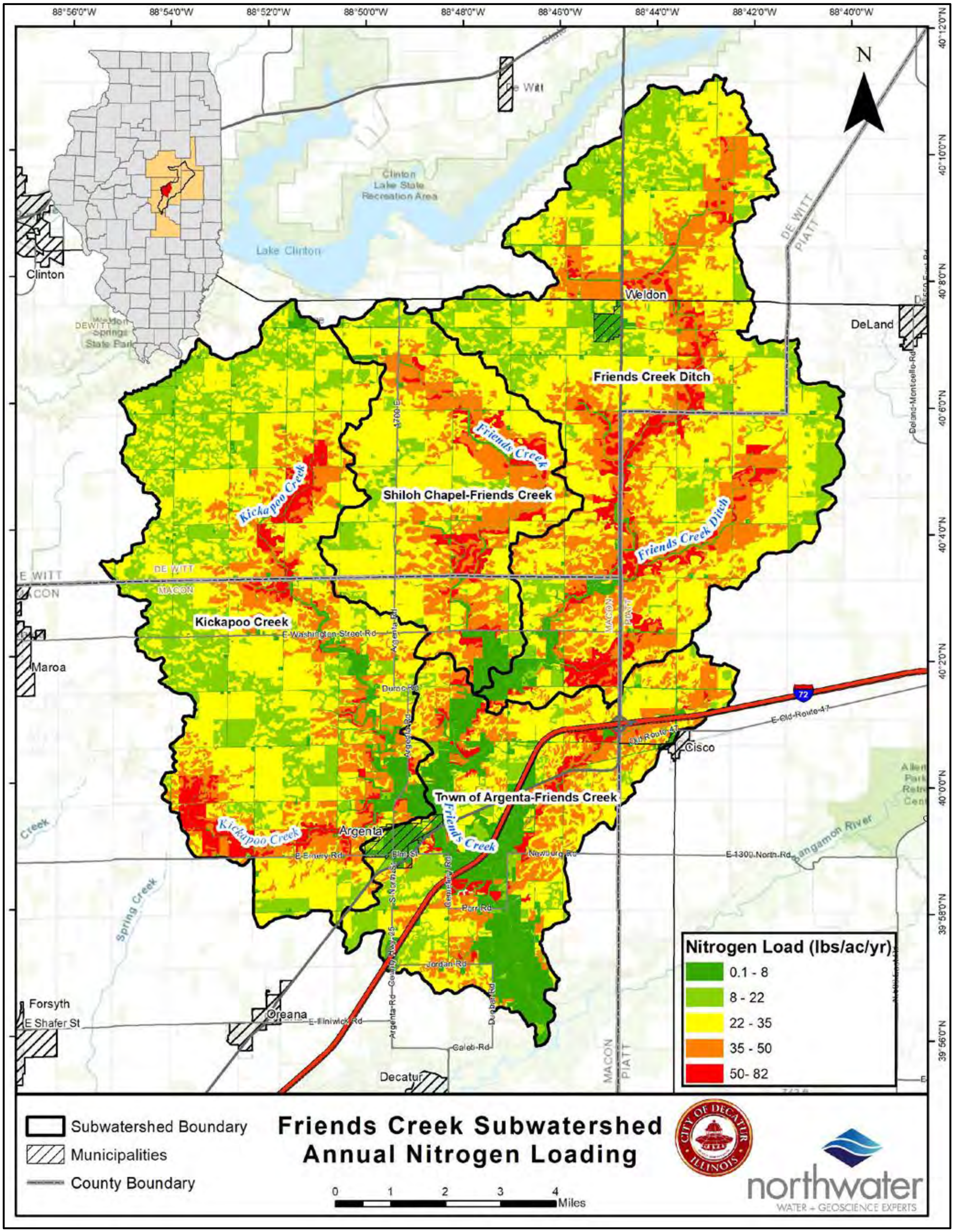


Figure 5 – Annual Nitrogen Loading Per Acre from Direct Surface & Subsurface Runoff

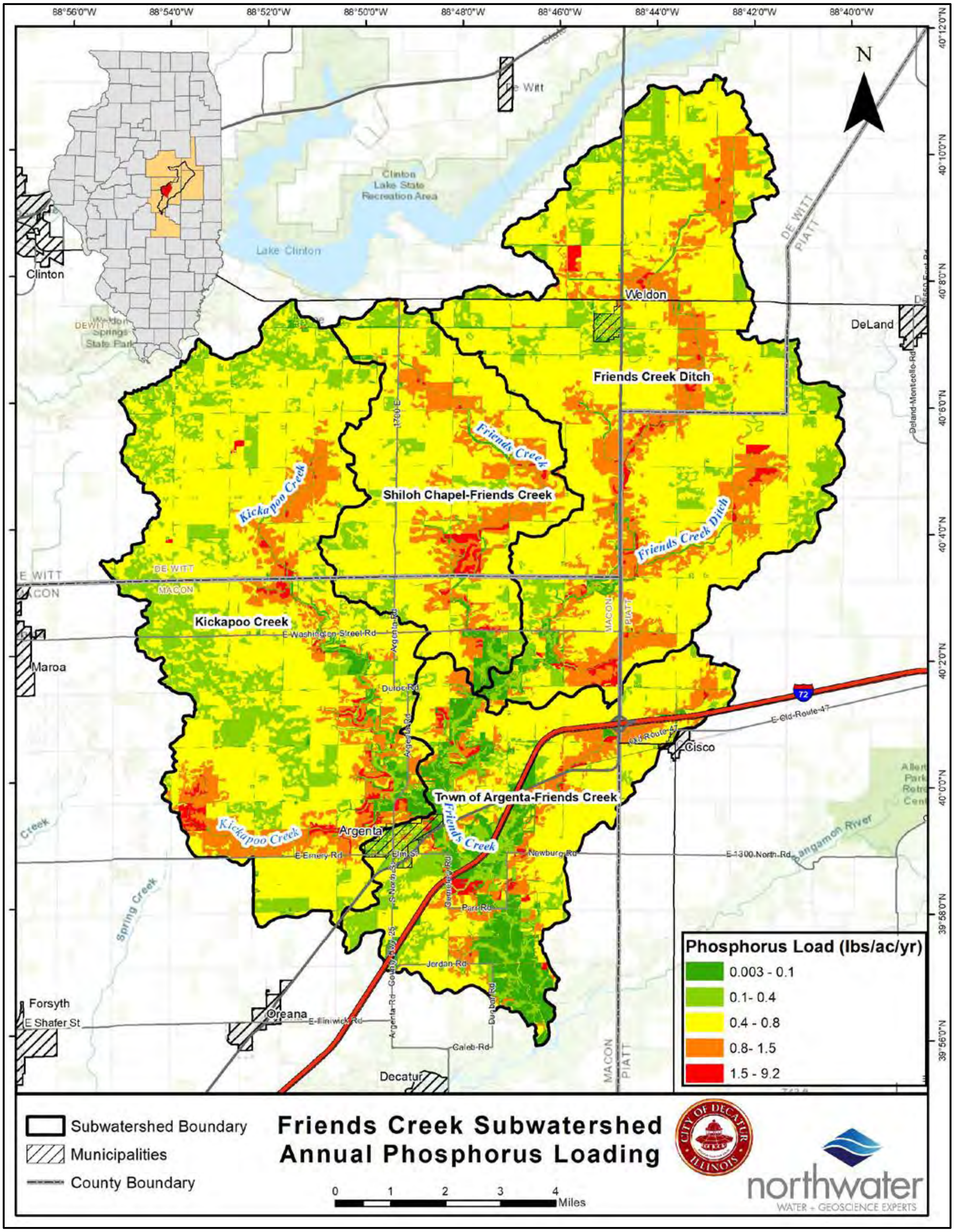


Figure 6 – Annual Phosphorus Loading Per Acre from Direct Surface & Subsurface Runoff

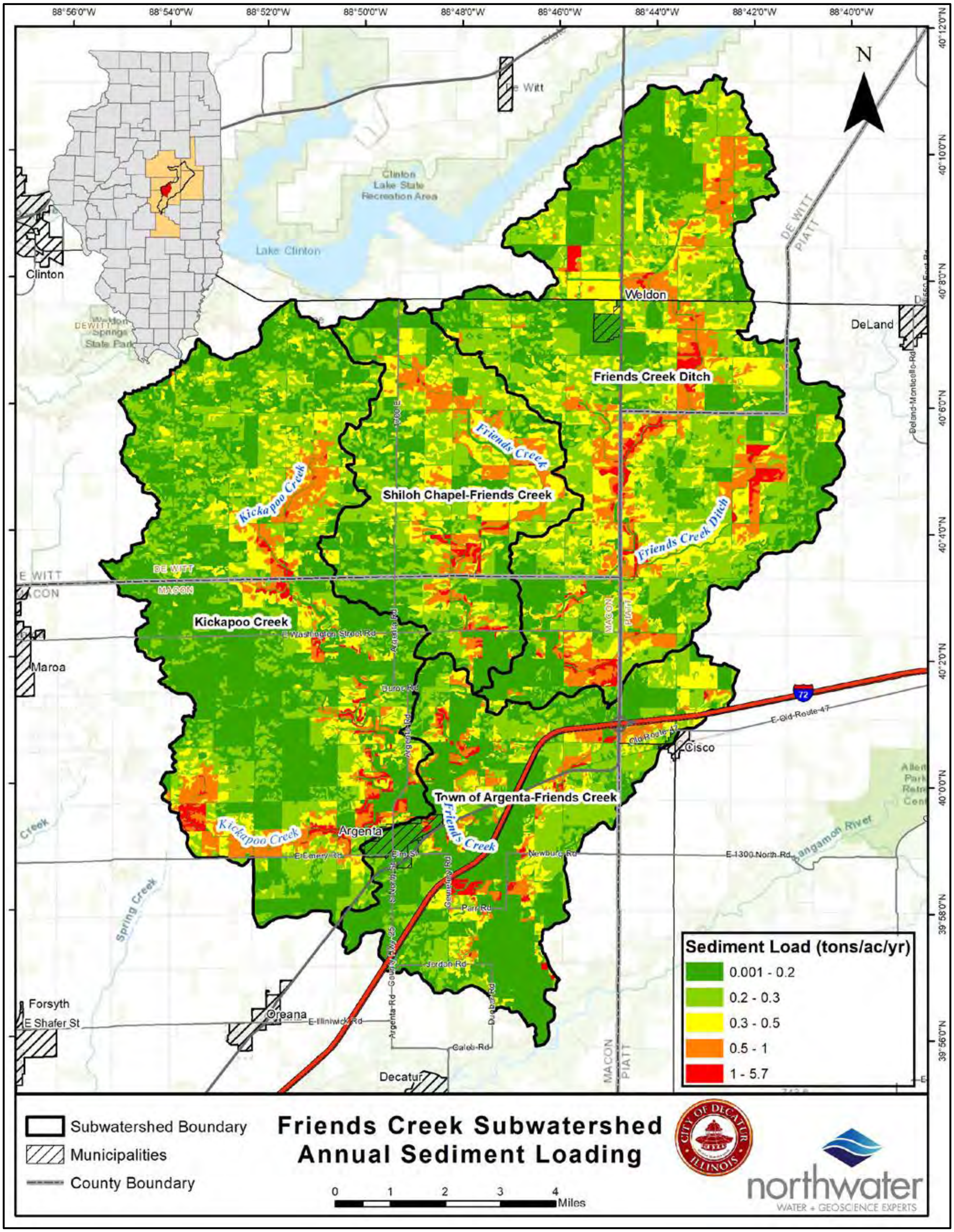


Figure 7 – Annual Sediment Loading Per Acre from Direct Surface Runoff

4.0 Sources of Watershed Impairments

Cropland Surface Erosion

Watershed impairments originate from either nonpoint source (NPS) or point source pollution. A description of point source pollution is given in Section 3.15. 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 the Friends Creek subwatershed, sources of sediment are thought to be originating from cropland, streambank and gully erosion and, to a much lesser extent, developed areas. Nutrients are thought to be originating from cropland, leaking or improperly maintained septic systems, streambanks, and gullies. Permitted point source discharges exist in the watershed, however, their contributions to water quality impairments are non-existent. Gullies, septic systems, and streambank erosion are depicted in Figure 8.

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.

4.1 Nitrogen & Phosphorus

The largest source of nitrogen in the subwatershed is tile flow and surface runoff from cropland. Tile nitrogen is responsible for 33% and surface runoff from cropland 66% of the total nitrogen load. The largest source of phosphorus is surface runoff from cropland which is also responsible for 66% of the total load. An additional 18% is believed to be originating from tile flow (Table 13). Other primary sources include eroding gullies (agricultural and non-agricultural), surface runoff from non-cropland, streambank erosion, and septic systems.

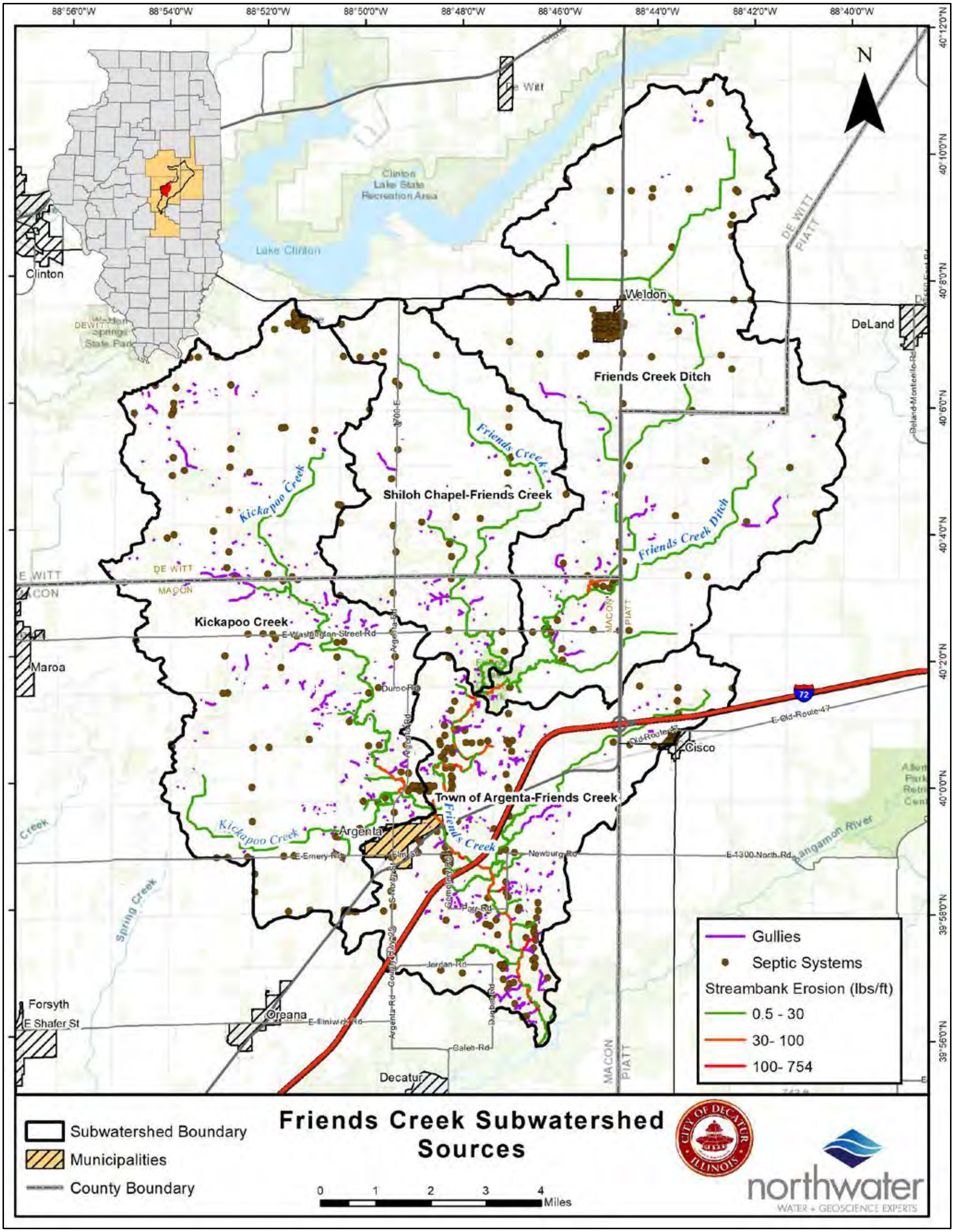


Figure 8 - Sources - Gullies, Septic Systems, & Streambank Erosion

Table 13 – Primary Nutrient Loading Sources

Pollutant Source	Nitrogen Load (lbs/ac)	Phosphorus Load (lbs/yr)	Nitrogen Load (% total)	Phosphorus Load (% total)
Surface Runoff: Cropland	1,525,122	36,447	66%	66%
Tile Flow: Cropland	754,178	9,800	33%	18%
Surface Runoff: Non-cropland	21,450	1,999	0.93%	4%
Gully Erosion: Cropland	1,477	399	0.06%	0.73%
Gully Erosion: Non-cropland	269	131	0.01%	0.24%
Septic Systems	3,358	1,315	0.15%	2.4%
Streambank Erosion	4,646	4,768	0.2%	9%
Grand Total	**2,310,500**	**54,859**	**100%**	**100%**

4.1.1 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 subwatershed data. This includes an investigation of modeled loading from surface runoff versus tile flow, and tillage types.

Nitrogen – Excessive loading is a challenge for the City and adds complexities and cost to its water treatment process and ability to meet the 10 mg/L drinking water standard. It is believed that most of the nitrogen load is surface runoff and tile flow from cropland, or 99%. (Table 13).

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 subwatershed load is from surface runoff and closely tied to soil erosion from crop ground, at 66% (Table 13).

Tillage

The relatively small percentage of conventional and strip-till has the highest annual yield or per-acre loading of nutrients, followed by mulch-till. Although mulch-till yields slightly less nutrients per acre, it covers the majority crop ground and, therefore, contributes about 58% of the nitrogen and 57% of total phosphorus from cropland (Table 14). No-till is responsible for 14% of the nitrogen and 13% of the phosphorus and covers 14% of subwatershed cropland.

Table 14 – Cropland Nutrient Loading by Tillage Type

Tillage Type	Area (% crop)	Nitrogen Load (lbs/yr)	Nitrogen Load (lbs/ac/yr)	Nitrogen Load (% crop)	Phosphorus Load (lbs/yr)	Phosphorus Load (lbs/ac/yr)	Phosphorus Load (% crop)
Mulch-Till	58%	1,310,948	32	58%	26,372	0.65	57%
Reduced-Till	23%	533,800	31	23%	11,055	0.65	24%
No-Till	14%	314,295	26	14%	6,064	0.51	13%
Conventional	3.8%	87,123	39	3.8%	2,104	0.94	4.5%
Cover Crop[1]	0.7%	15,869	16	0.7%	307	0.31	0.66%
Strip-Till	0.71%	16,116	39	0.7%	300	0.73	0.65%
Hay[1]	0.05%	1,149	3.6	0.1%	46	0.14	0.1%
Total	**100%**	**2,279,299**	**31**	**100%**	**46,247**	**0.63**	**100%**

[1] – cover type, not a tillage practice

4.1.2 Non-Cropland, Gullies, Streambanks, & Septic Systems

Septic systems - if failing, are a relatively modest contributor of phosphorus, accounting for 2.5% compared to 0.15% for nitrogen.

Non-Cropland – urban or developed areas and all non-cropland including forest and grasslands, contribute 4% of the total phosphorus and 0.9% of the total annual nitrogen load.

Streambank Erosion - Streambank erosion delivers 9% of the phosphorus and only 0.2% of the total annual nitrogen. Streambank erosion is more relevant in terms of sediment loading.

Gully Erosion – phosphorus loading from gully erosion is slightly more significant from cropland accounting for 0.73% of the phosphorus load and, to a much lesser extent, nitrogen. Gullies on non-cropland account for 0.24% of the phosphorus. As with streambank erosion, this source is more relevant in terms of sediment.

4.2 Sediment

The primary source of sedimentation in the watershed is cropland sheet and rill erosion, responsible for 68% of the entire sediment load (Table 15). Secondary sources include streambank erosion, eroding gullies (primarily cropland and forest) and, to a much lesser extent, surface runoff from non-croplands.

Table 15 – Sediment Loading from all Sources

Pollutant Source	Sediment Load (tons/yr)	Sediment Load (% total)
Surface Runoff: Cropland	22,536	78%
Surface Runoff: Non-cropland	110	0.38%
Gullies: Cropland	738	2.5%
Gullies: Non-cropland	356	1.2%
Streambank Erosion	5,280	18%
Total	**29,020**	**100%**

4.2.1 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 erodibility designation. Results are presented in Table 16 and Table 17.

Tillage

Mulch-till fields contribute 57% of the annual cropland sediment. This represents 44% of the total subwatershed load. Conventional tillage yields the highest per-acre or 0.69 tons/ac/yr. Despite only accounting for 3.8% of all cropland acres, conventional tillage delivers 7% of the entire sediment originating from farm ground and 5.4% of the total watershed load. Reduced-till and mulch-till is also responsible for a relatively high percentage of the sediment load compared to total area. Cover crops and no-till combined are only responsible for 10.3% of the cropland sediment load, despite covering 15% of it.

Table 16 – Cropland Sediment Loading by Tillage Type

Tillage Type	Area (ac)	Area (% Cropland)	Sediment Load (tons/yr)	Sediment Load (tons/ac/yr)	% Crop Sediment Load
Mulch-Till	40,847	58%	12,904	0.32	57%
Reduced-Till	17,107	23%	5,686	0.33	25%
No-Till	11,910	14%	2,181	0.18	10%
Conventional	2,249	3.8%	1,555	0.69	7%
Cover Crop[1]	990	0.7%	74	0.07	0.3%
Strip-Till	410	0.7%	113	0.28	1%
Hay[1]	319	0.1%	23	0.07	0.1%
Total	**73,832**	**100%**	**22,536**	**0.31 (avg)**	**100%**

[1] – cover type, not a tillage practice

Cropped Highly Erodible Soils

An analysis was performed to better understand the extent of sediment loading from sheet and rill erosion based on highly erodible (HEL) and potentially highly erodible (PHEL) soils and tillage. Results are presented in Table 17.

Although HEL/PHEL soils make up 6.9% of watershed cropland area, they account for 5,081 tons, or 23%, of cropland sediment load and 17.5% of the entire sediment load. On average, cropped HEL soils deliver sediment at rates 61% higher than non-HEL.

Reduced-till and mulch-till HEL/PHEL fields combined contribute 9% of the annual cropland sediment followed by no-till. Conventional tillage of HEL/PHEL yields the highest per-acre or 1.12 tons/ac/yr. Most cropped HEL/PHEL are mulch-tilled or 43% and yield 0.59 tons/ac/yr. A small percentage of cover crops are responsible for only 0.06% of the total cropland sediment load. Cover crops planted on HEL soils lose far less soil, per acre, on an annual basis.

Table 17 – 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
Mulch-Till	2,173	43%	1,290	0.59	5.7%
Reduced-Till	1,114	22%	731	0.66	3.2%
No-Till	1,338	26%	558	0.42	2.5%
Conventional	133	2.6%	149	1.12	0.66%
Cover Crop[1]	110	2.2%	13	0.12	0.06%
Strip-Till	37	0.72%	8.9	0.24	0.04%
Hay[1]	176	3.5%	15	0.08	0.06%
Total	**5,081**	**100%**	**2,765**	**0.54 (avg)**	**12%**

[1] – cover type, not a tillage practice

4.2.2 Gullies & Streambanks

Gully erosion and streambank erosion are the next most significant sources of sediment, followed by non-cropland.

Streambank Erosion - Streambank erosion delivers 18% of the total subwatershed sediment load.

Gully Erosion - Gully erosion, which is most prevalent on cropland, delivers 2.5% of the total sediment load and 67% of the entire gully contribution. Gully erosion from forested areas is responsible for 1% of the total subwatershed load and 27% of all gully erosion. Contributions from crop ground are greater due to higher densities near a receiving stream. Much of the forested contribution can be attributed to delivery rates as a relatively high percentage are also very close to a receiving stream.

5.0 Nonpoint Source Management Measures & Load Reductions

This section details recommended Best Management Practices (BMPs) for the subwatershed, their quantities and expected annual pollution load reductions. Although reductions presented below include nitrogen, phosphorus and sediment, special attention is given to sediment and nitrogen. As these are the most common water quality concerns for the lake, practices that address nitrogen 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 18 and Table 19. 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 the City and others have generated many positive water quality benefits. Building off these efforts will help to accelerate improvements.

Table 18 – 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)	1 - 40%	5 - 55%	5 - 65%
Filter Strip (Footprint)[1]	90%	80%	90%
Filter Strip (Drainage Area)	2 - 30%	3 - 50%	4 - 65%
Floodplain Re-Connection	2 - 28%	4 - 35%	5 - 40%
Grass Conversion (Footprint)[1]	90%	80%	90%
Grass Conversion – Perennial (Footprint)[1]	90%	80%	90%
Grass Conversion – Perennial (Drainage Area)	8 - 50%	15 - 60%	20 - 75%
Grassed Waterway / Grassed Waterway Maintenance [1]	2 - 28%	1 - 23%	1 - 30%
Terrace/WASCB[1,2]	20%	50 - 60%	60 - 70%
Sediment Basin	10 - 20%	30 - 50%	40 - 60%
Grade Control[1]	1%	3 – 4%	3 – 5%
Livestock Stream Fencing & Pasture Management	20%	25%	30%
Livestock Feed Area Treatment System	84%	83%	79%
No-Till	10%	50%	70%
Strip-Till	10%	50%	70%
Pond	35 - 38%	50 - 60%	55 - 80%
Wetland Creation	22 - 38%	30 - 45%	35 - 55%

[1] - Controls 100% of gully erosion.

Table 19 – 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]	2 - 28%	4 - 35%
Grass Conversion (Footprint)	90%	80%
Grass Conversion – Perennial (Footprint)	90%	80%
Pond[1]	35 - 38%	50 - 60%
Nutrient Management – Spring Split Application of Nitrogen	20%	0%
Wetland Creation[1]	22 - 38%	30 - 45%

[1] = Assumes tile flow is routed through BMP

5.1 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 in the watershed. 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 20 lists all proposed BMPs, quantities, area treated, and expected annual reductions. Locations are shown in Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13. The largest total expected reductions can be achieved from cover crops, filter strips, field borders, grass conversion, tillage, nutrient management, and a select number of structural practices. All practices will require willing landowners to implement and large investments by the City and other partners. Further information on BMP costs, reductions, and critical practices can be found in Sections 6–8.

Table 20 – Recommended BMPs & Load Reduction Summary

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
In-field	Cover Crop	71,046 (ac)	71,046	880,176	12,243	9,089
	Cover Crop – Existing to be Maintained	990 (ac)	990	6,792	131	49
	Cover Crop – Cropped HEL Soils Only[1]	8,108 (ac)	8,108	150,441	2,084	1,696
	Nutrient Management - Deep Placement Phosphorus	59,505 (ac)	59,505	0	6,253	0
	Nutrient Management –Split Application Nitrogen	16,078 (ac)	16,078	62,808	0	0
	No-till	20,285 (ac)	20,285	47,864	6,050	5,888
	No-till or Strip-till	39,219 (ac)	39,219	79,892	9,583	8,523
In-Field Practices Subtotal		***n/a***	**207,123**	**1,077,532**	**34,260**	**23,549**
Structural	Bioreactor	52 (locations), 106 (structures)	2,244	14,761	24	0
	Drainage Water Management	43 (locations), 2,650 (ac)	2,650	15,917	78	0
	Feed Area Treatment	8 (locations), 7 (ac)	7	187	33	0.7
	Field Border	148 (locations), 802 (ac)	47,745	659,305	14,133	9,305

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
	Filter Strip	121 (locations), 357 (ac)	7,346	219,791	5,103	3,860
	Floodplain Re-connection (with wetlands)	4 (locations), 21 (riffles), 15 (ac wetland)	32,341	31,685	1,435	1,033
	Grade Control – Rock Riffles	2 (locations), 6 (riffles)	828	409	118	112
	Grass Conversion	12 (locations), 10 (ac)	10	210	5.2	4.1
	Grass Conversion - Perennial	170 (locations), 1,724 (ac)	n/a	88,725	2,649	2,006
	Grass Waterway	30 (locations), 63,020 (ft tile), 75 (ac)	20,581	29,066	642	782
	Grass Waterway Maintenance	3 (locations), 1 (ac)	98	363	21	49
	Livestock Fencing	1 (location), 1,020 (ft fencing)	10	23	3.6	1.7
	Pond	11 (locations)	1,112	14,388	601	492
	Saturated Buffer	41 (locations), 29,000 (ft tile)	3,594	30,928	192	0
	Sediment Basin	8 (locations)	240	1,730	96	60
	Streambank/Bed Stabilization	3 (locations), 4,200 (ft STP), 13 (riffles)	n/a	485	498	551
	Terrace	5 (locations), 7,080 (ft terrace), 3,550 (ft tile)	51	283	26	25
	WASCB	24 (locations), 41,095 (ft tile), 74 (basins)	419	2,337	203	191
	Wetland Creation	9 (locations), 19 (ac)	3,478	26,637	678	344
Structural Practices Subtotal			**122,757**	**1,137,232**	**26,538**	**18,817**
Grand total			**329,880**	**2,214,764**	**60,798**	**42,367**

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

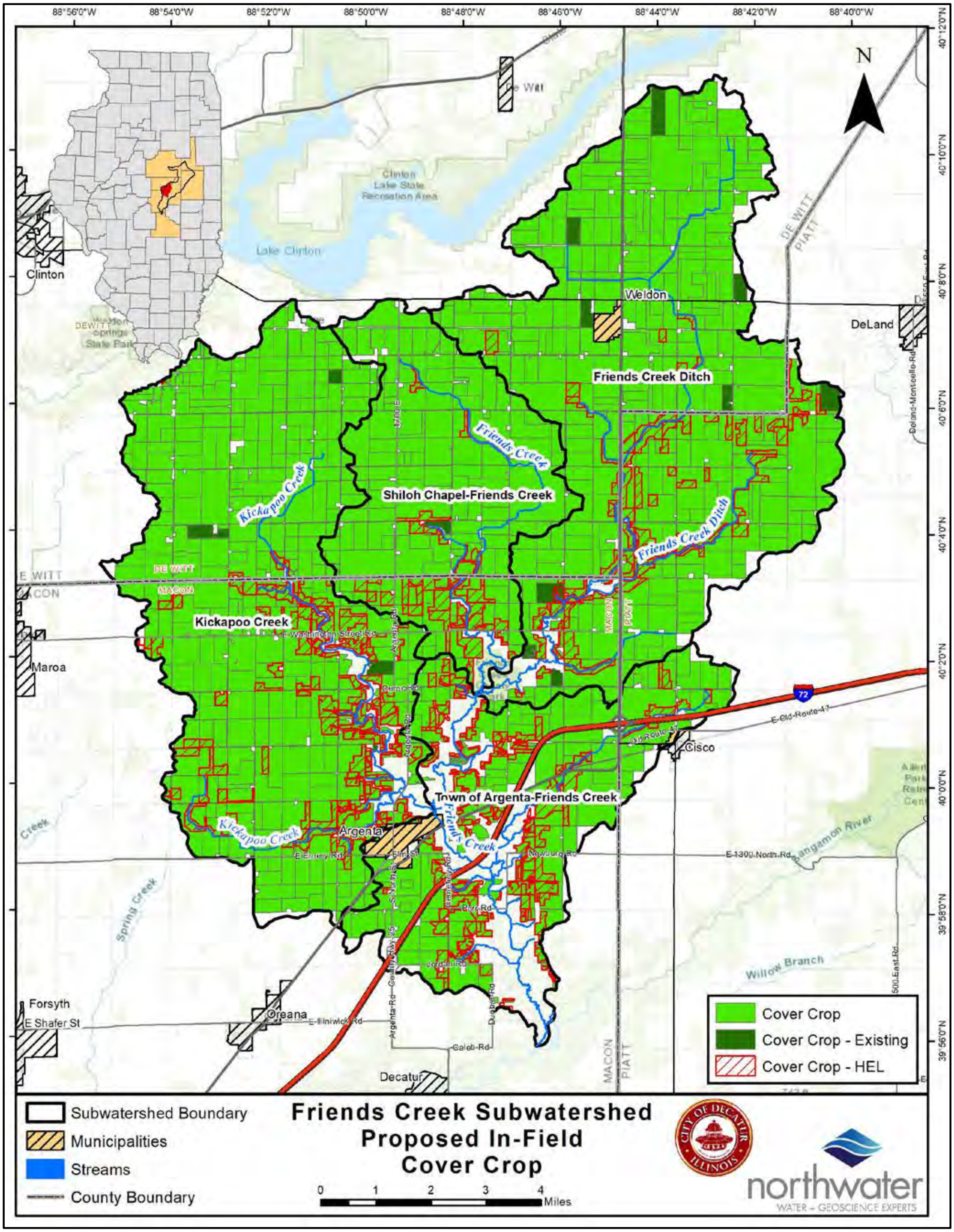


Figure 9 – Proposed BMPs – In-Field Cover Crop

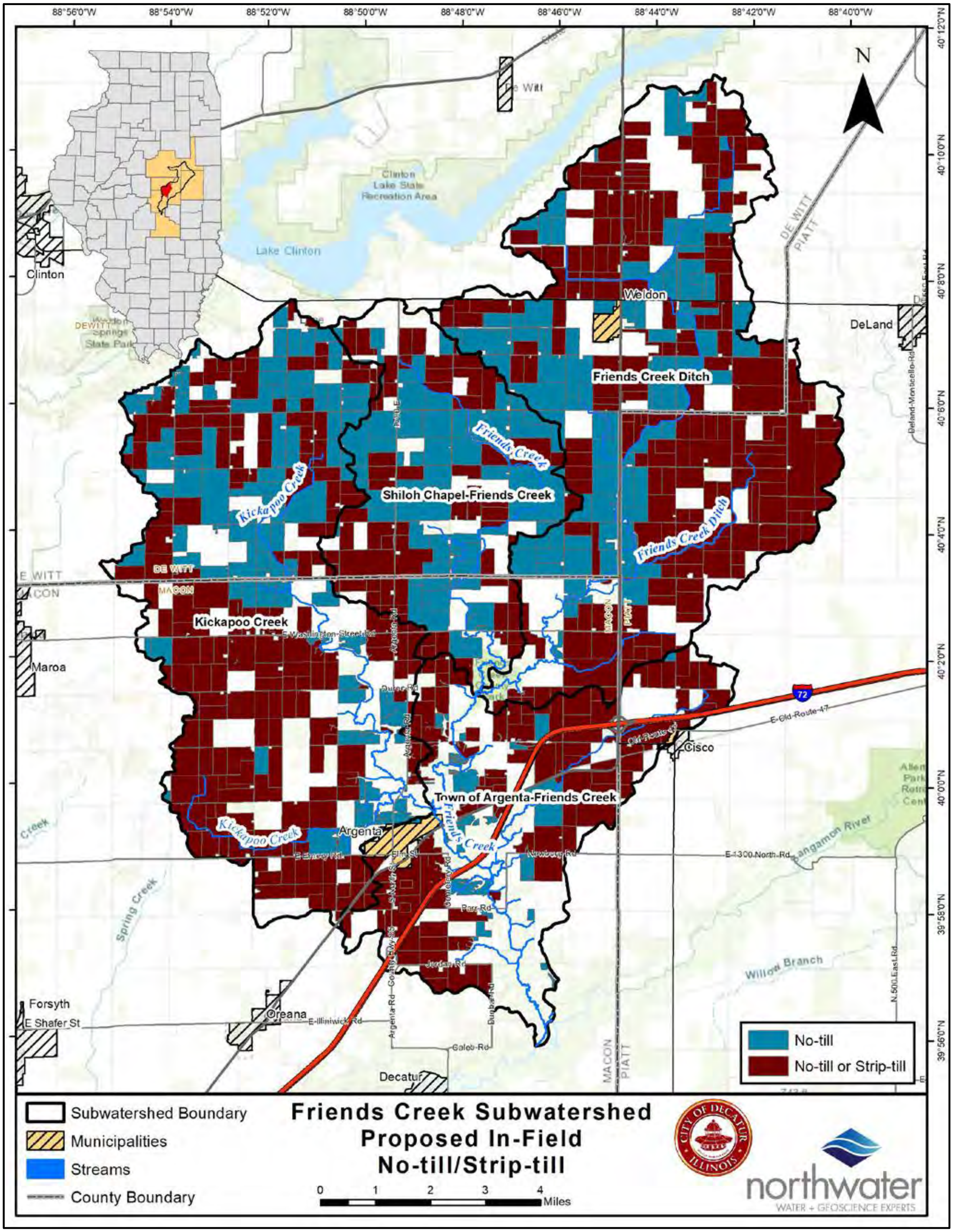


Figure 10 – Proposed BMPs – In-Field Tillage

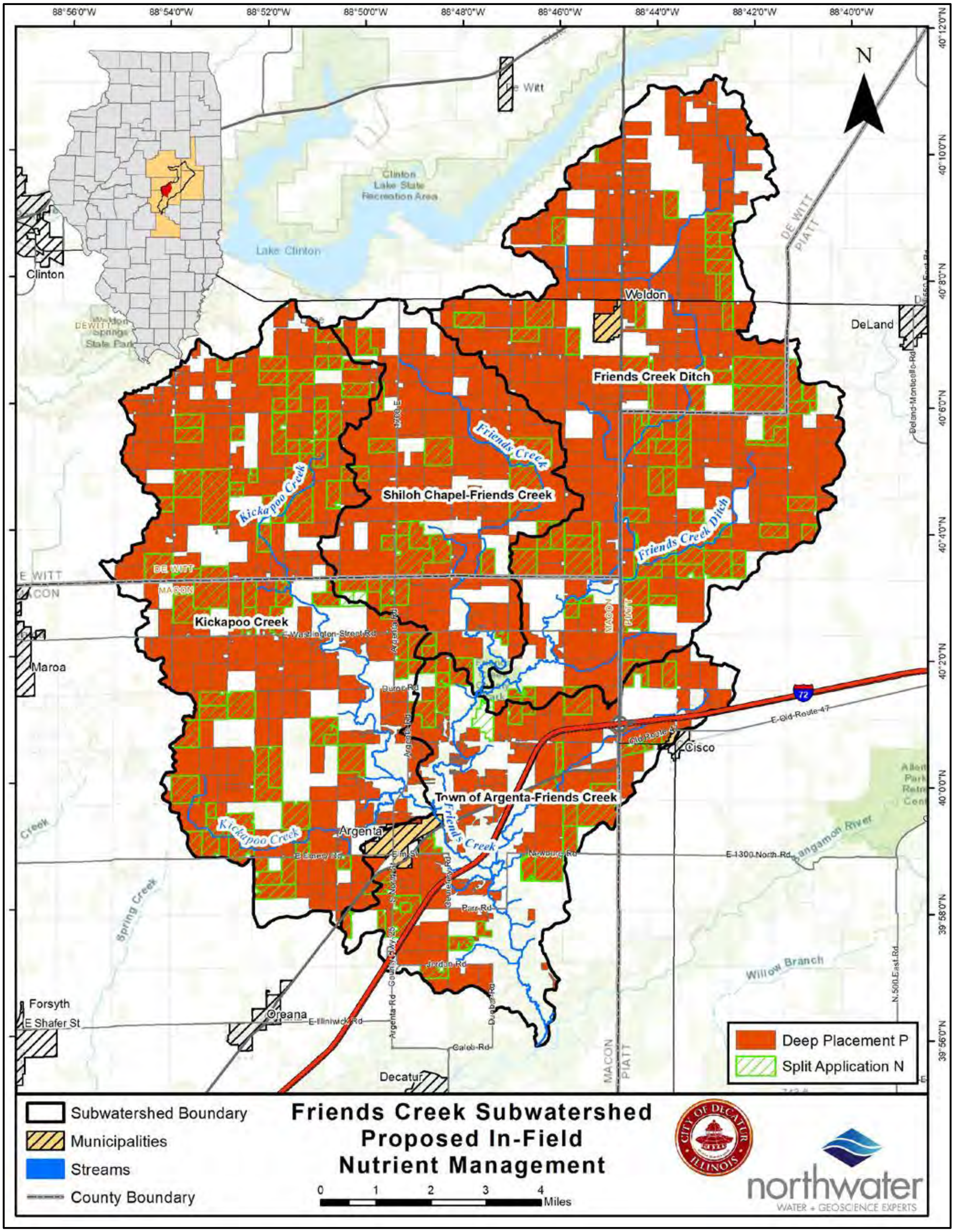


Figure 11 – Proposed BMPs - In-Field Nutrient Management

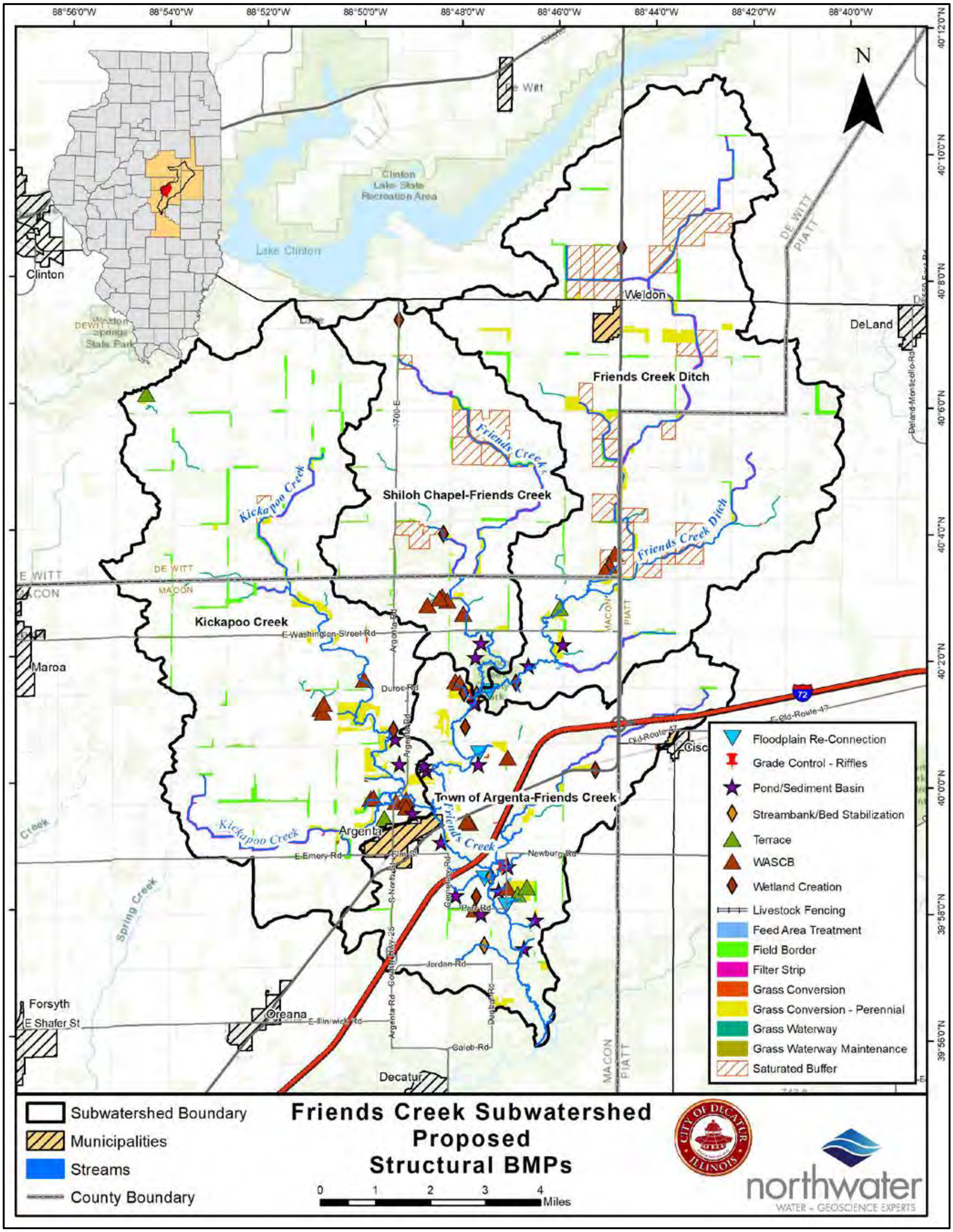


Figure 12 – Proposed Structural BMPs – Agricultural/Non-Urban

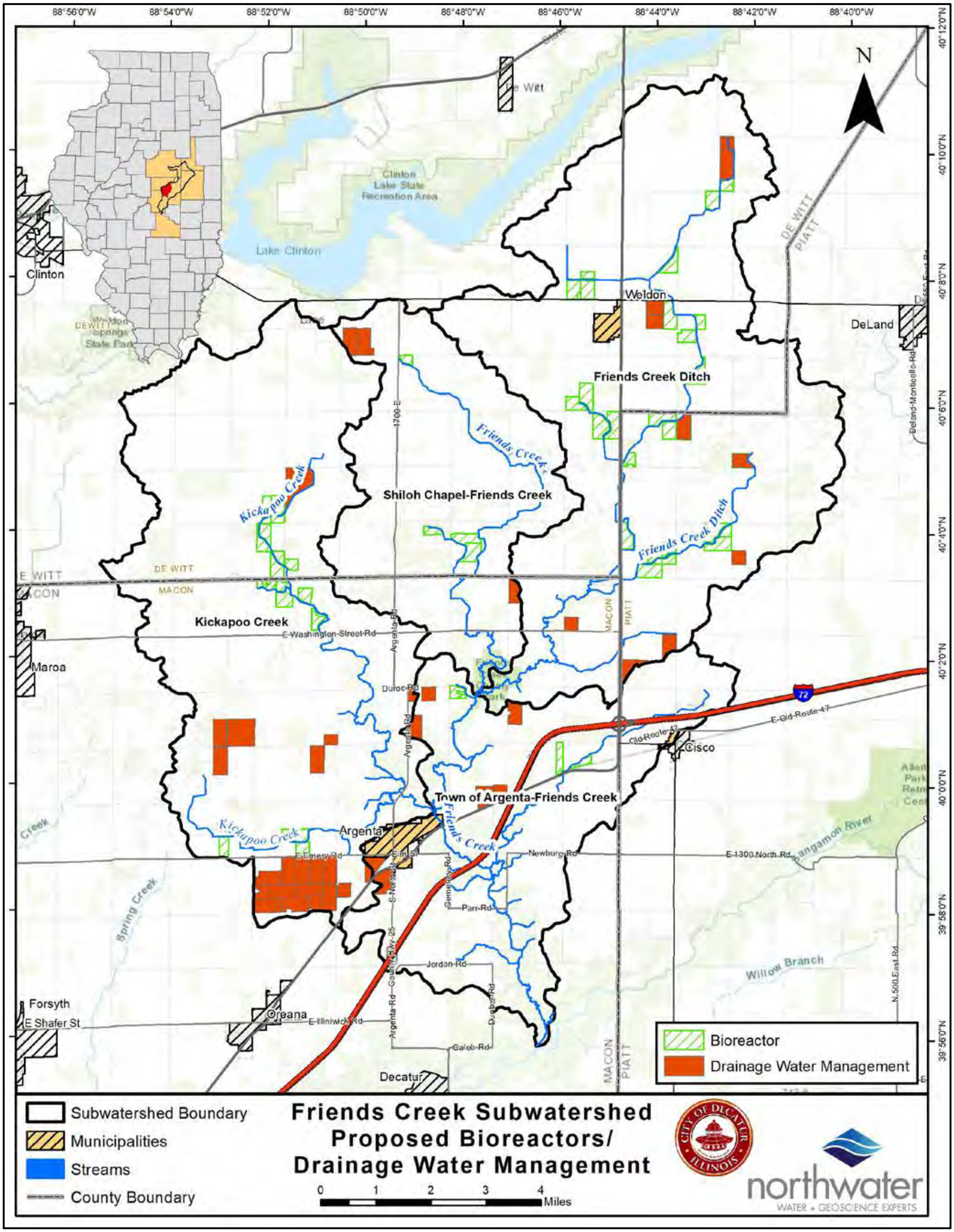


Figure 13 – Proposed Structural BMPs – Agricultural DWM & Bioreactors

5.1.1 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.

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 1,085 fields or 71,046 acres. If all acres are planted to cereal rye, the following annual load reductions are expected:

- 880,176 lbs nitrogen
- 12,243 lbs phosphorus
- 9,089 tons sediment

Cover Crop - Existing - fields currently in cover crop are recommended to be maintained so they can continue to provide water quality benefits. A total of 20 fields, or 990 acres, were selected. If all acres are maintained, the following annual load reductions are expected:

- 6,792 lbs nitrogen
- 131 lbs phosphorus
- 49 tons sediment

Cover Crop - HEL Only – 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 340 fields or 8,108 acres are recommended. If all acres are planted, the following annual load reductions are expected:

- 150,411 lbs nitrogen (17% of the reductions for all cover crops and 11% of the total acreage)
- 2,084 lbs phosphorus (17% of the reductions for all cover crops and 11% of the total acreage)
- 1,696 tons sediment (19% of the reductions for all cover crops and 11% of the total 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 342 fields are recommended covering 20,285 acres. If all acres are treated, the following annual reductions are expected:

- 47,864 lbs nitrogen
- 6,050 lbs phosphorus
- 5,888 tons sediment

Strip-till and/or No-till – is proposed on fields with less than 5% slopes. A total of 610 fields are recommended covering 39,219 acres. If all acres are treated, the following annual reductions are expected:

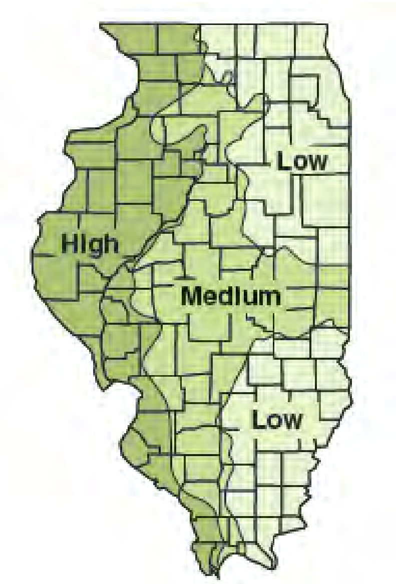
- 79,892 lbs nitrogen
- 9,583 lbs phosphorus
- 8,523 tons sediment

No-Till

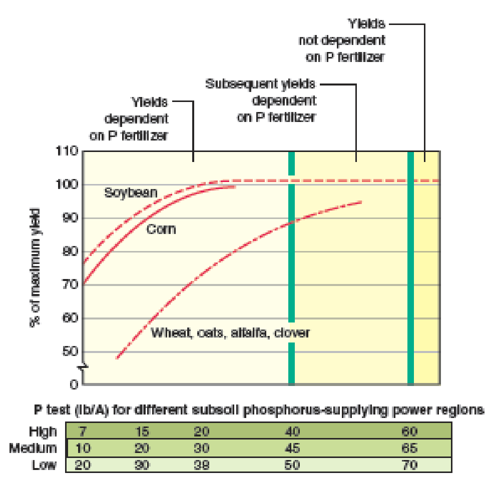
Nutrient Management

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, 2018). 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 and without a known nutrient management plan were selected for the deep placement of phosphorus fertilizer. If applied to all 952 fields, or 59,505 acres, expected annual load reductions are:

- 6,253 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 234 fields, or 16,078 acres, expected annual load reductions are:

- 62,808 lbs nitrogen

5.1.2 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 forested areas. For example, several wetlands and floodplain re-connections are recommended in small tributaries, in forested draws, and along the Sangamon River.

Water and Sediment Control Basins (WASCB) / Terrace

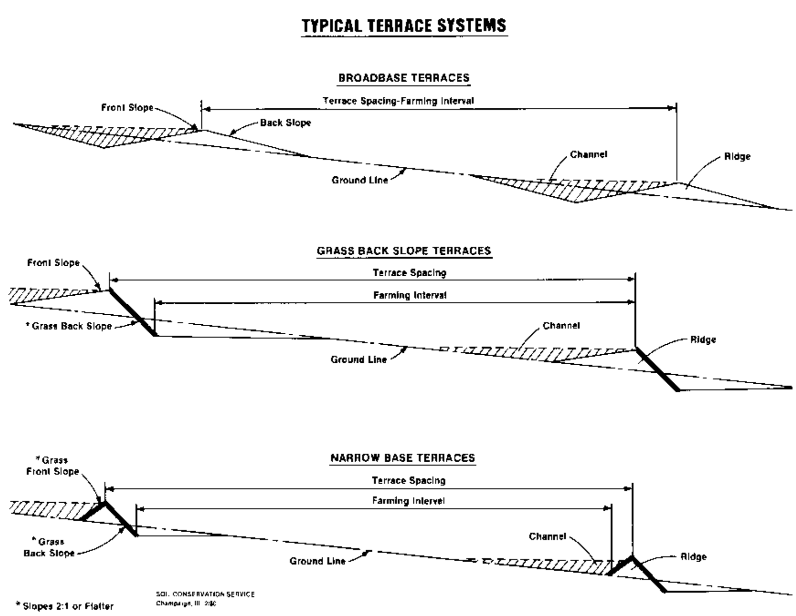
These practices are earth embankments constructed across a drainage channel or along contours of a slope to intercept runoff water and trap soil. WASCBs are often constructed to mitigate gully erosion where concentrated flow is occurring and where drainage areas are relatively small. Multiple basins 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 in the subwatershed.

WASCBs are recommended at 24 locations, for a total of 74 individual basins and 41,095 feet of tile. If all practices are installed, a total of 419 acres will be treated. Expected annual load reductions (including gully stabilization) will total:

- 2,337 lbs nitrogen
- 203 lbs phosphorus
- 191 tons sediment

Terraces can be applied at 5 locations totaling 7,080 feet of terrace. If all are installed, a total of 51 acres will be treated. Expected annual load reductions (including gully stabilization) will total:

- 283 lbs nitrogen
- 26 lbs phosphorus
- 25 tons sediment



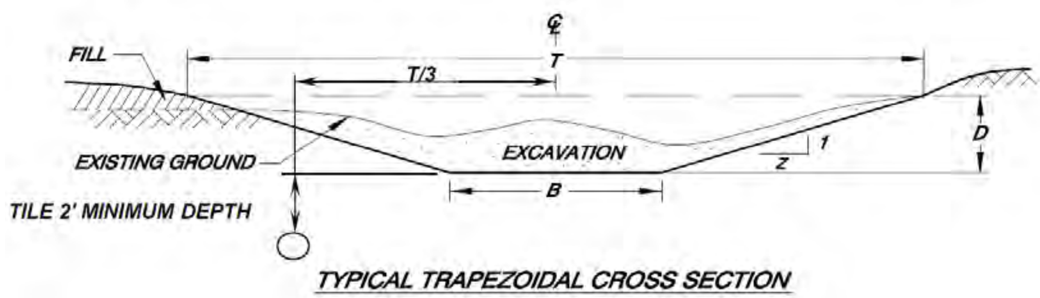
NRCS Detail – Terrace/WASCB

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. These practices are well suited to the subwatershed.

Grassed waterways are recommended at 30 locations, for a total of 75 acres and 63,020 ft of tile. Maintenance of existing grassed waterways is recommended at 3 locations for a total of 1 acre. If all are installed, a total of 20,679 acres will be treated. Expected annual load reductions (including gully stabilization) are:

- 29,429 lbs nitrogen
- 663 lbs phosphorus
- 831 tons sediment



NRCS Grassed Waterway Detail

Constructed Wetlands

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.

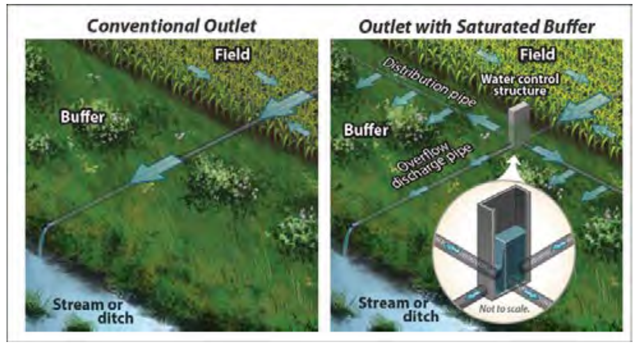
Constructed Wetland

Wetland creation is recommended at 9 locations, for a total of 19 acres. If all are implemented, they will treat 3,478 acres and the annual expected load reductions (including gully and streambank stabilization) are:

- 26,637 lbs nitrogen
- 678 lbs phosphorus
- 344 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*

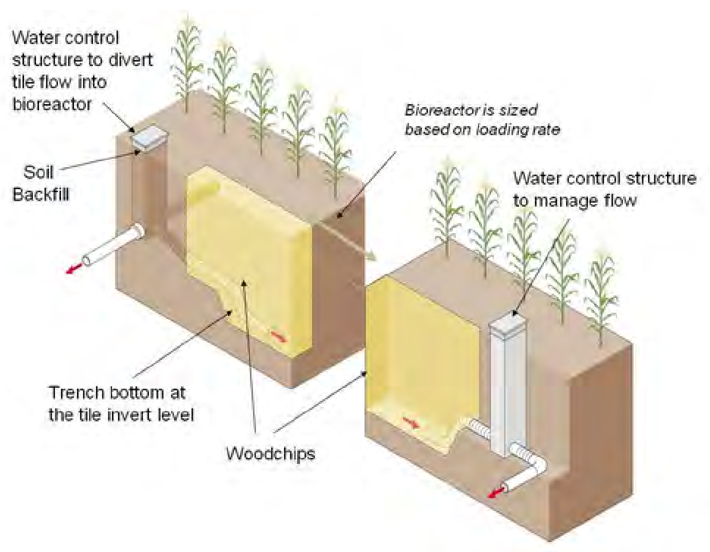
A total of 41 systems or sites are recommended, representing a treatment area of 3,594 acres and 29,000 ft of tile. Annual expected load reductions if all sites are implemented total:

- 30,928 lbs nitrogen
- 192 lbs phosphorus

Denitrifying Bioreactor

A denitrifying bioreactor is a structure containing a carbon source, 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-seven bioreactors at 52 locations can likely be applied effectively and will treat 2,244 acres. Annual load reductions expected if all are implemented total:



Bioreactor

- 14,761 lbs nitrogen
- 24 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. A total of 43 locations are recommended to treat a total of 2,650 acres. Annual expected load reductions if all sites are treated total:

Water Control Structure

- 15,917 lbs nitrogen
- 78 lbs phosphorus

Filter Strips, Field Borders, & Grass Conversion (Perennial)

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 use in bioenergy and feedstock are also recommended as an option.

Field Borders - are recommended at 148 locations for a total of 802 acres. Forty-seven of the 148 locations are also recommended as harvestable perennial grasses. If all borders are planted, they will treat 47,745 acres. Expected annual load reductions (including gully stabilization) are:

- 659,305 lbs nitrogen
- 14,133 lbs phosphorus
- 9,305 tons sediment

Filter Strip

Filter Strips - are recommended at 121 locations for a total of 357 acres. Nine of the 121 locations are also recommended as harvestable perennial grasses. If all strips are planted, they will treat 1,351 acres. Expected annual load reductions (including gully stabilization) are:

- 219,791 lbs nitrogen
- 5,103 lbs phosphorus
- 3,860 tons sediment

Grass Conversion - or conservation cover consisting of native grasses is recommended at 12 locations totaling 10 acres. If all are planted, expected annual load reductions (including gully stabilization) are:

- 210 lbs nitrogen
- 5.2 lbs phosphorus
- 4.1 tons sediment

Conversion to Harvestable Perennial Grasses - planting to perennial grass is recommended at 170 locations totaling 1,724 acres of planting. If all are planted, expected annual load reductions (including gully stabilization) are:

- 88,725 lbs nitrogen
- 2,649 lbs phosphorus
- 2,006 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 riffles, a practice used to stabilize streambed erosion. Rock riffles are also described in the streambank stabilization section.

Grade control structures (riffles) are recommended at 2 locations for a total of 6 individual structures. If all are installed, they will treat a total of 828 acres. Expected annual load reductions are:

- 409 lbs nitrogen
- 118 lbs phosphorus
- 112 tons sediment

Grade Control Structure – Block Chute

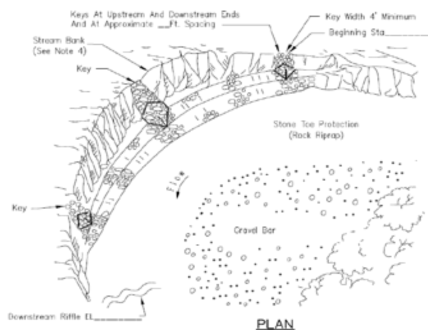
Streambank/Bed Stabilization: Stone-Toe Protection & Riffle

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. Thirteen stream riffles and 4,200 ft of STP are recommended at 3 locations. Locations were selected based on recommendations in the 2019 Friends Creek plan, sediment load, accessibility and cost effectiveness.

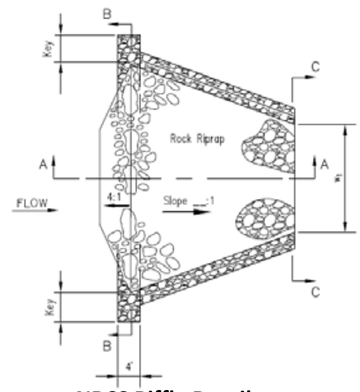
Riffle

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

- 485 lbs nitrogen
- 498 lbs phosphorus
- 551 tons sediment



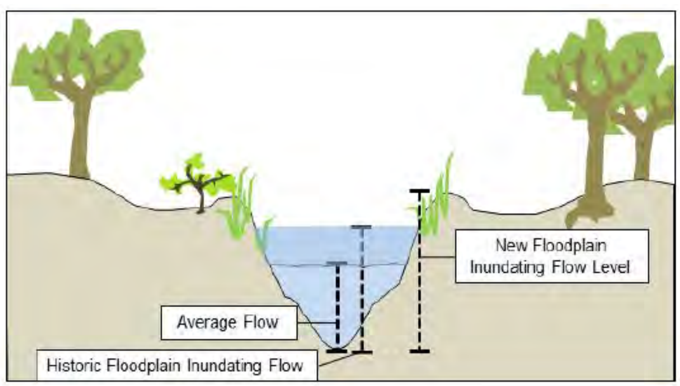
NRCS STP Detail



NRCS Riffle Detail

Floodplain Re-Connection

Reconnecting rivers with their historical floodplains focus 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, increasing water quality (UNEP-DHI Partnership, 2017). The recommended locations include 15 acres of wetland restoration in the floodplain.



Vertically Disconnected Floodplain

Source: American Rivers

Re-connecting to the floodplain is recommended at 4 locations utilizing 21 large grade control structures (riffles) and wetland restoration. If all are installed, 32,341 acres will be treated, resulting in expected load reductions of:

- 31,685 lbs/yr nitrogen
- 1,435 lbs/yr phosphorus
- 1,033 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 11 ponds and 8 sediment basins are recommended to treat 1,352 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:

- 16,118 lbs nitrogen
- 697 lbs phosphorus
- 552 tons sediment

Pasture Management & 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

Stream fencing is recommended at 1 pasture location. No stream crossings are needed. A total of 1,020 ft of fence is recommended.

If installed, 10 acres would be treated. Expected annual load reductions are:

- 23 lbs nitrogen
- 3.6 lbs phosphorus
- 1.7 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.

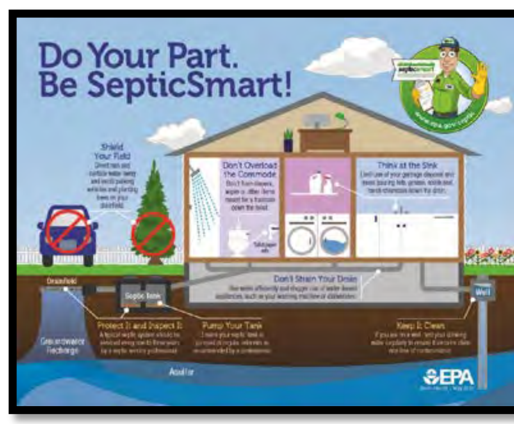
Waste Containment Area

Eight systems are recommended to treat 7 acres. If these systems are implemented, the following annual load reductions are expected:

- 187 lbs nitrogen
- 33 lbs phosphorus
- 0.7 tons sediment

Septic Systems

Failing septic systems are likely a source of nutrients to the lake. 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.



Septic Smart Brochure: *Credit: EPA*

6.0 Cost Estimates

Costs are determined based on professional judgment and expertise, 2023 United States Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS) scenario rates, and unit costs used in other watershed plans. Many of the estimates are based on field visits and known quantities for a given practice. Costs should be considered as estimates only and revisited during implementation, 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.

6.1 Unit Costs

Unit estimates and assumptions are presented in the following table:

Table 21 - Unit Costs & Assumptions

BMP	Unit Cost	Unit	Notes/Assumptions
Bioreactor	$20,401.78	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.
Cover Crop	$103.08	acre	Based on USDA-NRCS rates. Assumes 1 year of multiple species including spring termination.
Filter Strip	$822.20	acre	Based on USDA-NRCS rates for native species. Costs include land preparation, materials and seeding. Estimates do not include any reoccurring annual rental payments or land acquisition.
Field Border	$822.20	acre	Based on USDA-NRCS rates for native species. Costs include land preparation, materials and seeding. Estimates do not include any reoccurring annual rental payments or land acquisition.
Grass Conversion	$835.46	acre	Based on USDA-NRCS rates for Critical Area Planting with moderate grading. Includes land prep and seeding. Estimates do not include any annual rental payments or land acquisition costs.
Perennial Grass Conversion	$1,112.46	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.
Grade control structure – Riffles, Small Stream/Gully	$4,860.05	each	Based on professional judgement and USDA-NRCS rates for "small" riffles.
Grass Waterway	$6,278.27	acre	Based on USDA-NRCS rates for shaping and seeding, checks and crop season construction.
Streambank Stabilization (STP)	$90	foot	Based on professional judgement and includes some engineering and permitting.
Grass Waterway	$6.46	foot	Based on USDA-NRCS rates for waterway tile. Maintenance of existing waterways does not include tile.
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	acre	Based on USDA-NRCS rates up to a maximum of $5,407.
Pond	$69,000	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.

BMP	Unit Cost	Unit	Notes/Assumptions
Saturated Buffer	$17.68	foot	Based on USDA-NRCS rates for saturated buffer with automated control structure.
Drainage Water Management	$222.95	acre	Per acre for installation to retrofit an existing tile system, using estimates obtained from the Agricultural Watershed Institute in Macon County.
Floodplain Reconnection	$28,720	each	Based on professional judgement and 1.75 times the USDA rates for “large” riffles, plus 20% for engineering and permitting.
Terrace	$6.73	foot	Based on USDA rates for farmable terrace, crop season construction.
Terrace	$6.46	foot	Terrace tile. Based on NRCS rates for 8-in tile.
Water and Sediment Control Basin	$2,840.24	each	Per basin and an average of 700 yd^3 soil. Based on professional judgement and USDA-NRCS rates for crop season construction.
Water and Sediment Control Basin	$6.46	foot	Water and sediment control basin tile. Based on NRCS rates for 8-in tile.
Sediment Basin	$17,130	each	Based on NRCS rates of $6.85 per yd^3 and 2,500 yd^3.
Wetland Creation	$24,000	acre	Includes earthwork, tree removal (if needed) and seeding. Based on professional judgement and USDA-NRCS rates.
Wetland Creation	$3,600	each	For water control structure and tile. Based on professional judgement and USDA-NRCS rates.

6.2 Total Cost

Table 22 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 is estimated to be $22,424,010 or **$21,841,749** excluding feed area treatment practices that have a very high cost per unit of sediment and nutrients reduced. Excluding this one practice, average per pound of nitrogen removed is $101, phosphorus $5,087, and the average cost for a ton of sediment is $1,366 (Table 22).

Annual per pound of nitrogen reduction, field borders, filter strips, cover crops, cover crop on HEL soils only, and split application of nitrogen are the most effective, followed by no-till/strip-till and continuing the application of existing cover crops. Conversion to no-till or strip-till, filter strips, and field borders are the most cost effective for phosphorus reduction, followed by deep placement of phosphorus, and select structural practices. Conversion to no-till or strip-till, filter strips, and field borders are the most effective for reducing sediment delivery and can be used on a big percentage of the subwatershed. Those structural practices that treat larger drainage areas, such as grass waterways and ponds, will generate higher volume reductions.

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 23 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 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.

Table 22 – BMP Cost Summary by BMP Type

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
In-Field Practices	Cover Crop	71,046 (ac)	$7,323,404.84	$8.32	$598.15	$805.71
	Cover Crop – Existing to be Maintained	990 (ac)	$102,090.79	$15.03	$777.63	$2,081.11
	Cover Crop – Cropped HEL Soils Only[1]	8,108 (ac)	$835,731.54	$5.56	$400.97	$492.84
	Nutrient Management - Deep Placement Phosphorus	59,505 (ac)	$1,130,588.02	n/a	$180.80	n/a
	Nutrient Management –Split Application Nitrogen	16,078 (ac)	$305,480.16	$4.86	n/a	n/a
	No-till	20,285 (ac)	$461,289.32	$9.64	$76.25	$78.34
	No-till or Strip-till	39,219 (ac)	$891,846.03	$11.16	$93.07	$104.64
In-field Practices Subtotal/ Av. BMP Reduction Cost			***$10,214,699.15***	***$9.10***	***$354.48***	***$329.57***
Structural Practices	Bioreactor	52 (locations), 106 (structures)	$2,162,588.63	$146.50	$90,914.64	n/a
	Drainage Water Management	43 (locations), 2,650 (ac)	$590,835.10	$37.12	$7,600.65	n/a
	Feed Area Treatment	8 (locations), 7 (ac)	$582,261.17	$3,108.72	$17,517.99	$879,561.88
	Field Border	148 (locations), 802 (ac)	$808,994.95	$1.23	$57.24	$86.94
	Filter Strip	121 (locations), 357 (ac)	$293,564.32	$1.34	$57.53	$76.06
	Floodplain Re-Connection (with wetlands)	4 (locations), 15 (riffles), 21 (structures)	$977,625.00	$30.85	$681.30	$945.96
	Grade Control - Riffles	2 (locations), 6 (riffles)	$29,160.30	$71.30	$246.32	$259.83
	Grass Conversion	12 (locations), 10 (ac)	$8,212.65	$39.09	$1,577.08	$1,987.69
	Grass Conversion - Perennial	170 (locations), 1,724 (ac)	$1,903,033.62	$21.45	$718.39	$948.70
	Grass Waterway	30 (locations), 63,020 (ft tile), 75 (ac)	$875,005.48	$30.10	$1,363.44	$1,118.30
	Grass Waterway Maintenance	3 (locations), 1 (ac)	$9,287.35	$25.56	$439.79	$188.78
	Livestock Fencing	1 (location), 1,020 (ft fencing)	$3,070.20	$134.07	$864.18	$1,812.96
	Pond	11 (locations)	$1,566,300.00	$108.86	$2,608.05	$3,186.61

BMP Class	BMP	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorous Reduction	Cost/ton Sediment Reduction
	Saturated Buffer	41 (locations), 29,000 (ft tile)	$512,720.00	$16.58	$2,670.07	n/a
	Sediment Basin	8 (locations)	$325,470.00	$188.09	$3,395.09	$5,426.90
	Streambank/Bed Stabilization	3 (locations), 4,200 (ft STP), 13 (riffles)	$509,749.70	$1,051.03	$1,024.62	$925.14
	Terrace	5 (locations), 7,080 (ft terrace), 3,550 (ft tile)	$70,581.40	$249.50	$2,671.98	$2,842.15
	WASCB	24 (locations), 41,095 (ft tile), 74 (basins)	$475,651.46	$203.53	$2,342.34	$2,486.30
	Wetland Creation	9 (locations), 19 (ac)	$505,200.00	$18.97	$745.42	$1,469.82
Structural Practices Subtotal/ Av. BMP Reduction Cost			**$12,209,311.32**	**$288.63**	**$7,236.64**	**$56,457.75**
Grand Total/ Av. BMP Reduction Cost			**$22,424,010.47**	**$221.54**	**$5,584.92**	**$1,366.24**
Structural Practices Subtotal/ Av. BMP Reduction Cost[2]			**$11,627,050.15**	**$140.20**	**$6,695.51**	**$5,013.74**
Grand Total/ Av. BMP Reduction Cost[2]			**$21,841,749.31**	**$101.24**	**$5,087.71**	**$1,366.24**

[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] – Excludes Feed Area Treatment due to high cost and low reductions

Table 23 – 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
In-Field Practices	Cover Crop	$73,234,048.39	$7,323,404.84	$8.32	$598.15	$805.71
	Cover Crop – Existing to be Maintained	$1,020,907.85	$102,090.79	$15.03	$777.63	$2,081.11
	Cropped HEL Soils Only	$8,357,315.38	$835,731.54	$5.56	$400.97	$492.84
	Nutrient Management - Deep Placement Phosphorus	$11,305,880.22	$1,130,588.02	n/a	$180.80	n/a
	Nutrient Management - Split Application Nitrogen	$3,054,801.57	$305,480.16	$4.86	n/a	n/a
	No-Till	$4,612,893.22	$461,289.32	$9.64	$76.25	$78.34
	No-till or Strip-till	$8,918,460.28	$891,846.03	$11.16	$93.07	$104.64
Structural Practices	Bioreactor	$2,162,588.63	$216,258.86	$14.65	$9,091.46	n/a
	Drainage Water Management	$590,835.10	$59,083.51	$3.71	$760.06	n/a
	Feed Area Treatment	$582,261.17	$58,226.12	$310.87	$1,751.80	$87,956.19
	Field Border	$808,994.95	$80,899.49	$0.12	$5.72	$8.69
	Filter Strip	$293,564.32	$29,356.43	$0.13	$5.75	$7.61

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
	Floodplain Reconnection (with wetlands)	$977,625.00	$97,762.50	$3.09	$68.13	$94.60
	Grade Control - Riffles	$29,160.30	$2,916.03	$7.13	$24.63	$25.98
	Grass Conversion	$8,212.65	$821.26	$3.91	$157.71	$198.77
	Grass Conversion - Perennial	$1,903,033.62	$190,303.36	$2.14	$71.84	$94.87
	Grass Waterway	$875,005.48	$87,500.55	$3.01	$136.34	$111.83
	Grass Waterway Maintenance	$9,287.35	$928.74	$2.56	$43.98	$18.88
	Livestock Fencing	$3,070.20	$307.02	$13.41	$86.42	$181.30
	Pond	$1,566,300.00	$156,630.00	$10.89	$260.81	$318.66
	Saturated Buffer	$512,720.00	$51,272.00	$1.66	$267.01	$3,049.73
	Sediment Basin	$325,470.00	$32,547.00	$18.81	$339.51	$542.69
	Streambank/Bed Stabilization	$509,749.70	$50,974.97	$105.10	$102.46	$92.51
	Terrace	$70,581.40	$7,058.14	$24.95	$267.20	$284.22
	WASCB	$475,651.46	$47,565.15	$20.35	$234.23	$248.63
	Wetland Creation	$505,200.00	$50,520.00	$1.90	$74.54	$146.98

7.0 Water Quality Targets

This section describes water quality targets and those implementation actions required to meet them. The primary constituents of concern in Lake Decatur are sediment and nitrogen. Targets of a 75% reduction in sediment and phosphorus and a 28% reduction in nitrogen are consistent with existing TMDL plans and the INLRS and have been applied to the Friends Creek subwatershed. The 75% sediment target is set to match the Lake Decatur phosphorus TMDL and reflects the City's desire to achieve substantial reductions.

Table 24 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, perennial grass conversion, filter strips and field borders will likely provide the greatest potential for reductions. Combined, in-field practices will achieve moderately greater reductions in sediment and phosphorus compared to structural practices (Table 24). 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 years.

The importance of lake and watershed management is even greater today as the City looks to protect the recent investment in dredging and considers upgrades to water treatment and supply infrastructure. The LTS and this watershed plan detail 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, prolong recent investments and increase reservoir resiliency. 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 24 – Lake Decatur Water Quality Targets & Load Reductions

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (% Total Load)	Phosphorus Reduction (% Total Load)	Sediment Reduction (% Total Load)
In-Field Practices	Cover Crop	71,046 (ac)	71,046	38%	22%	31%
	Cover Crop – Existing to be Maintained	990 (ac)	990	0.3%	0.2%	0.2%
	Cropped HEL Soils Only[4]	8,108 (ac)	8,108	6.5%	3.8%	6%
	Nutrient Management - Deep Placement Phosphorus	59,505 (ac)	59,505	0%	11%	0%
	Nutrient Management - Split Application Nitrogen	16,078 (ac)	16,078	2.7%	0%	0%
	No-Till	20,285 (ac)	20,285	2.1%	11%	20%
	No-till or Strip-till	39,219 (ac)	39,219	3.5%	17%	29%
In-Field Practices Subtotal			**207,123**	***47%***	***62%***	***81%***
Structural Practices	Bioreactor	52 (locations), 106 (structures)	2,244	0.6%	0.04%	0%
	Drainage Water Management	43 (locations), 2,650 (ac)	2,650	0.7%	0.1%	0%
	Feed Area Treatment	8 (locations), 7 (ac)	7	0.01%	0.1%	0.002%
	Field Border	148 (locations), 802 (ac)	47,745	29%	26%	32%
	Filter Strip	121 (locations), 357 (ac)	7,346	9.5%	9.3%	13%

BMP Class	BMP	Quantity	Area Treated (ac)	Nitrogen Reduction (% Total Load)	Phosphorus Reduction (% Total Load)	Sediment Reduction (% Total Load)
	Floodplain Reconnection (with wetlands)	4 (locations), 15 (riffles), 21 (structures)	32,341	1.4%	2.6%	3.6%
	Grade Control - Riffles	2 (locations), 6 (riffles)	828	0.02%	0.2%	0.4%
	Grass Conversion	12 (locations), 10 (ac)	10	0.01%	0.01%	0.01%
	Grass Conversion - Perennial	170 (locations), 1,724 (ac)	n/a	3.8%	4.8%	6.9%
	Grass Waterway	30 (locations), 63,020 (ft tile), 75 (ac)	20,581	1.3%	1.2%	2.7%
	Grass Waterway Maintenance	3 (locations), 1 (ac)	98	0.0%	0.0%	0.2%
	Livestock Fencing	1 (location), 1,020 (ft fencing)	10	0.001%	0.01%	0.01%
	Pond	11 (locations)	1,112	0.6%	1.1%	1.7%
	Saturated Buffer	41 (locations), 29,000 (ft tile)	3,594	1.3%	0.4%	0.1%
	Sediment Basin	8 (locations)	240	0.1%	0.2%	0.2%
	Streambank/Bed Stabilization	3 (locations), 4,200 (ft STP), 13 (riffles)	n/a	0.02%	0.9%	1.9%
	Terrace	5 (locations), 7,080 (ft terrace), 3,550 (ft tile)	51	0.01%	0.05%	0.1%
	WASCB	24 (locations), 41,095 (ft tile), 74 (basins)	419	0.1%	0.4%	0.7%
	Wetland Creation	9 (locations), 19 (ac)	3,478	1.15%	1.2%	1.2%
Structural Practices Subtotal			***122,757***	***49%***	***48%***	***65%***
Grand total			**329,880**	**66% - 96% (target exceeded)[1]**	**81 - 100%[3] (target exceeded)[1]**	**100%[2] (target exceeded)[1]**

[1] – A range is provided to account for the cumulative effects of BMPs implemented as a "system" [2] - Summed total sediment reductions are 146% of the total load when considered individually [3] - Summed total phosphorus reductions are 111% [4] - Cover Crop – HEL not included in totals

8.0 Critical Areas

Critical areas are those BMP locations and individual fields throughout the subwatershed 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 nitrogen. Those that address phosphorus also maximize sediment reductions.

Eighteen fields were selected as critical due to multiple overlapping BMPs where measurable reductions can be achieved. If all recommended BMPs on all 18 fields are implemented, annual reductions of 123,811 lbs of nitrogen, 3,185 lbs of phosphorus, and 2,420 tons of sediment are expected. At a combined cost of $1,239,469, 11% of total nitrogen, 12% of total phosphorus, and 13% of total sediment reductions can likely be achieved at 6% of the total cost.

8.1 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.

8.1.1 Nutrient Management

Critical areas for nutrient management were selected based on the practices with lowest cost per pound reduced. As listed in Table 25 and depicted in Figure 14, critical areas are expected to achieve 41% of the total nitrogen and 11% of the total phosphorus reductions associated with these practices, while only encompassing 9% of the recommended acres.

Deep placement of phosphorus fertilizer – fields that cost less than $90 per lb phosphorus reduced. This represents a total of 3,123 acres, or 96 fields.

Split application of nitrogen fertilizer - fields that cost less than $4 per pound nitrogen reduced. This represents a total of 3,902 acres, or 45 fields.

Table 25 - Critical Areas - Nutrient Management

Critical Practice	Quantity	Total Nitrogen Reduction (lbs/yr)	Total Phosphorus Reduction (lbs/yr)	Percent of Total Practice Load Reduction - Nitrogen	Percent of Total Practice Load Reduction - Phosphorus
Nutrient Management Plan – Deep Placement P	3,123 (ac)	0	714	n/a	11%
Nutrient Management Plan – Split Application N	3,902 (ac)	25,648	0	41%	n/a

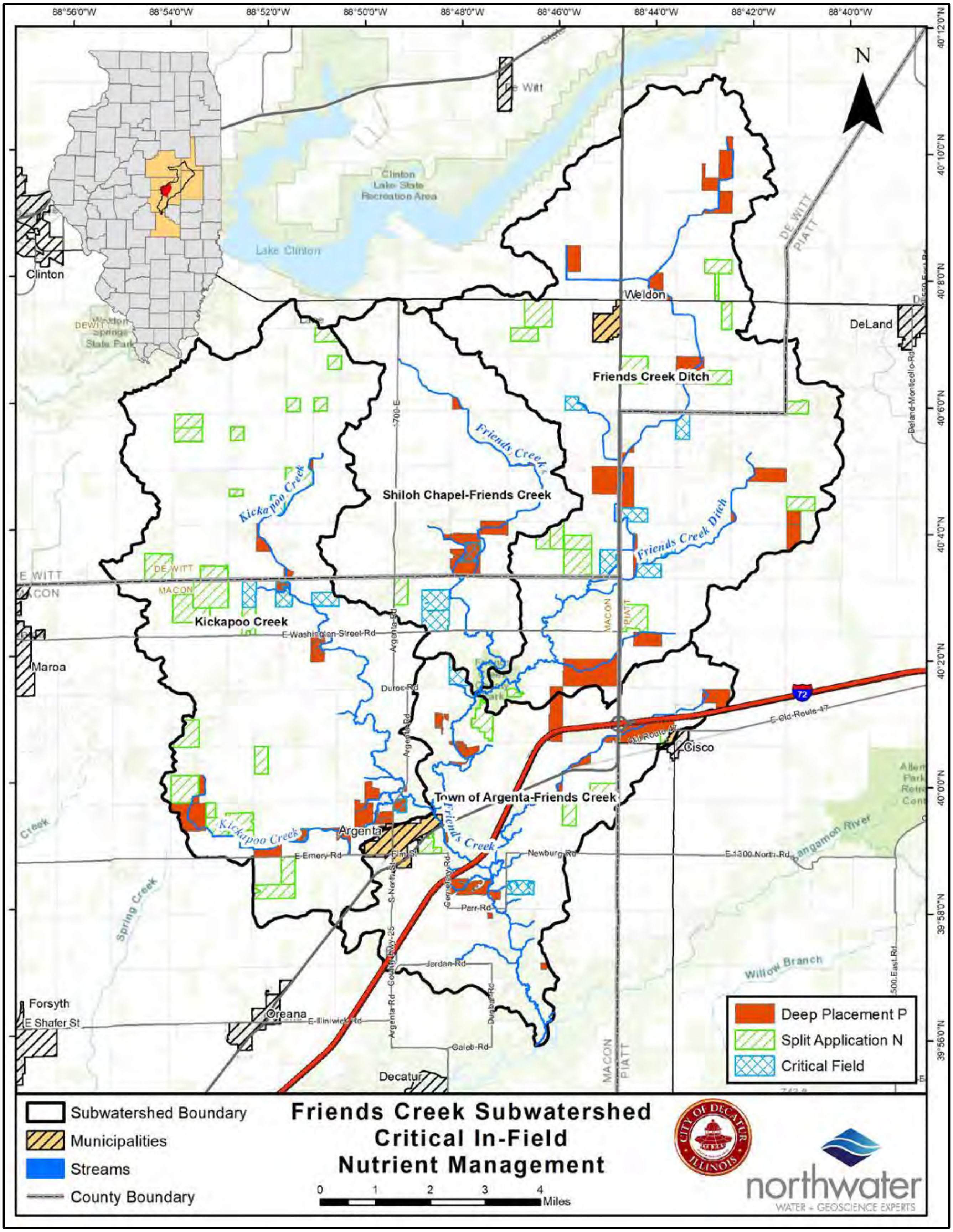


Figure 14 - Critical Areas - In-Field Nutrient Management

8.1.2 No-till & Strip-Till

No-till critical areas were selected as those fields costing less than $35 per ton sediment reduced. A total of 44, or 997 acres, were selected. If implemented, annual reductions of 4,389 lbs of nitrogen, 646 lbs of phosphorus, and 764 tons of sediment are expected. No-till or strip-till critical areas were also selected as those fields costing less than $60 per ton sediment reduced. A total of 88, or 4,668 acres, were selected. If implemented, annual reductions of 16,299 lbs of nitrogen, 2,223 lbs of phosphorus, and 2,285 tons of sediment are expected. As listed in Table 26 and depicted in Figure 15, critical areas for no-till or strip-till are expected to achieve 20% of the total nitrogen, 23% of the total phosphorus, and 27% of the total sediment reductions associated with these practices, while only encompassing 12% of the total recommended acres.

8.1.3 Cover Crops

Cover crop - critical areas were selected as those fields costing less than $400 per ton sediment reduced. A total of 127 fields, or 5,587 ac, were selected. If implemented, annual reductions of 92,648 lbs of nitrogen, 1,856 lbs of phosphorus, and 1,812 tons of sediment are expected. As listed in Table 26 and depicted in Figure 16, critical areas for cover crops are expected to achieve 11% of the total nitrogen, 15% of the total phosphorus and 20% of the total sediment reductions associated with these practices, while only encompassing 8% of the total recommended acres.

Maintaining of existing cover crop - critical areas were selected as those fields costing less than $750 per ton sediment reduced. A total of 3 fields, or 48 ac, were selected. If implemented, annual reductions of 566 lbs of nitrogen, 12 lbs of phosphorus, and 8.4 tons of sediment are expected.

Cover crop on HEL only soils - critical areas were selected as those fields costing less than $250 per ton sediment reduced. A total of 43 fields, or 737 ac, were selected. If implemented, annual reductions of 19,120 lbs of nitrogen, 351 lbs of phosphorus, and 391 tons of sediment are expected.

Table 26 – Critical Area – Tillage & Cover Crop

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
Cover Crop	5,587 (ac)	92,648	1,856	1,812	11%	15%	20%
Cover Crop – Existing to be Maintained	48 (ac)	566	12	8.4	8%	9%	17%
Cover Crop – HEL Soils Only[1]	737 (ac)	19,120	351	391	13%	17%	23%
No-Till	997 (ac)	4,389	646	764	9%	11%	13%
No-Till or Strip-Till	4,668 (ac)	16,299	2,223	2,285	20%	23%	27%
Grand Total		**113,902**	**4,737**	**4,869**	**11%**	**17%**	**21%**

[1] - Cover Crop - HEL not included in totals

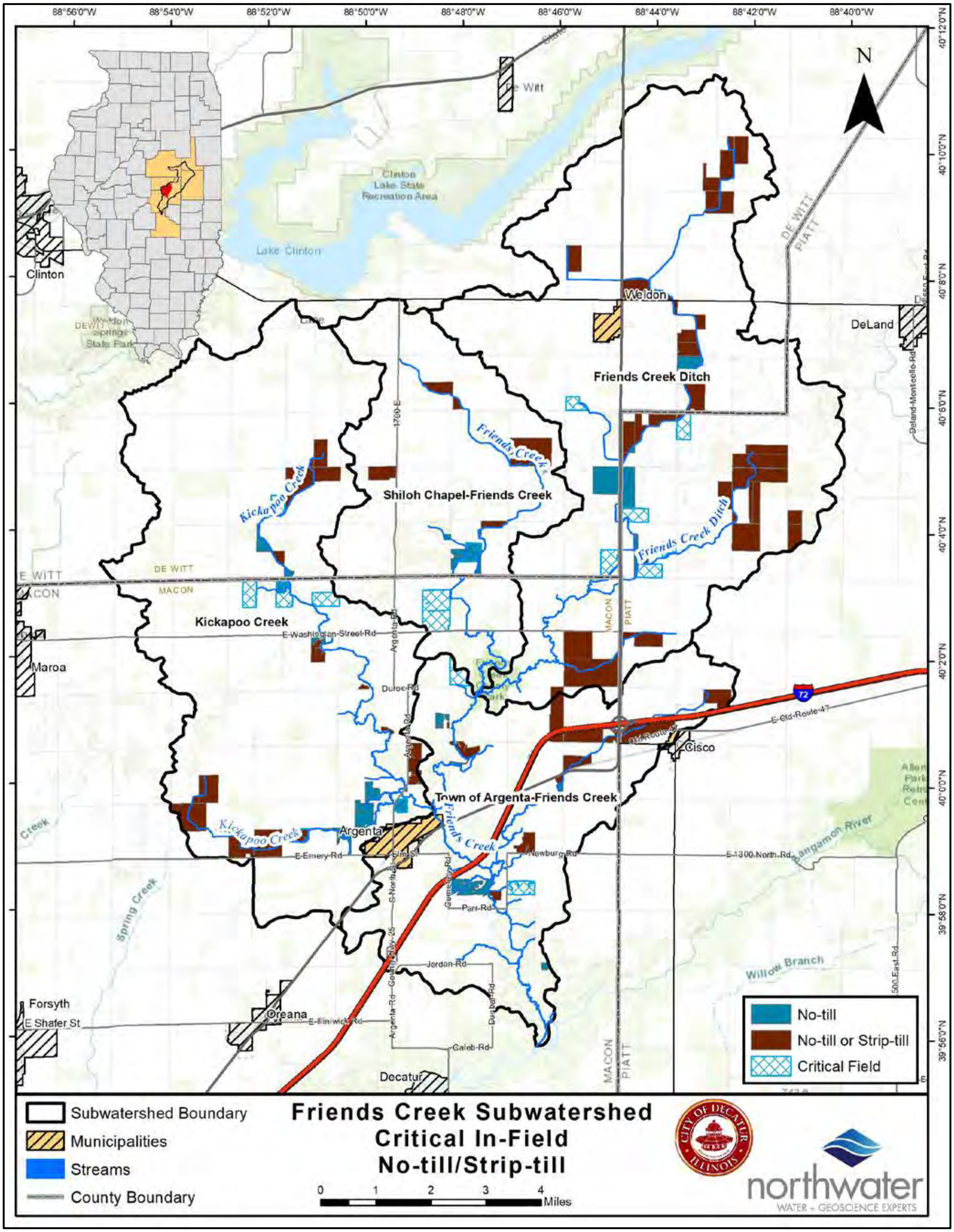


Figure 15 - Critical Areas - In-Field No-Till/Strip-Till

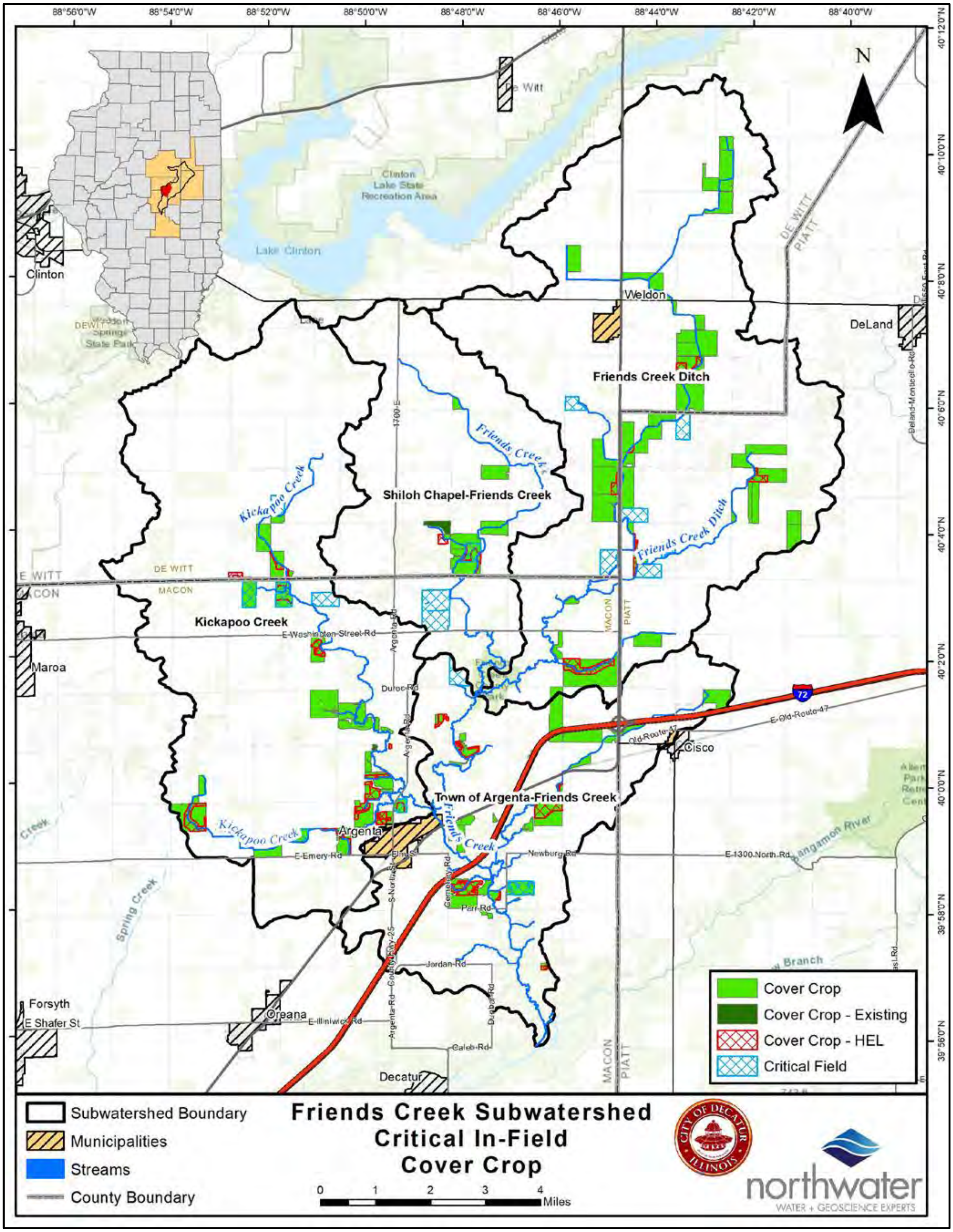


Figure 16 - Critical Areas - In-Field Cover Crop

8.2 Structural BMPs

A selection of structural practices are prioritized for implementation throughout the watershed and classified as critical (Table 27, Figure 17, and Figure 18 that shows DWM and bioreactor 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, 33% of the total nitrogen, 36% of the phosphorus, and 38% of the sediment reductions associated with all recommended structural practices will be achieved.

Critical bioreactors – those that cost less than $95 per pound nitrogen reduced. Seven sites were selected for a total of 14 structures to treat approximately 382 acres.

Critical DWM - priority DWM were selected from those fields that cost less than $32 per pound nitrogen reduced. A total of 5 sites were chosen to treat 457 acres.

Critical field borders and filter strips – for field borders, those fields that cost less than $50 per ton sediment reduced. Twenty-two sites were selected for a total of 92 acres to treat 18,427 acres. For filter strips, those that cost $42 or less per ton of sediment reduced. A total of 16 sites were selected, or 26 acres to treat 1,093 acres.

Critical floodplain re-connection – the site with the highest potential for sediment reductions was selected as critical. This practice includes over 4 acres of wetland creation. If implemented, it will treat 24,497 acres.

Critical grade control – the practice with the greatest sediment reduction was chosen as critical. If constructed, this site is expected to treat 407 acres.

Critical grass conversion – the sites with the greatest nitrogen reductions were chosen as critical. Two fields for a total of 3.3 acres were selected.

Critical perennial grass conversion – those fields that cost less than $500 per ton sediment reduced were selected and, if implemented, will cover 349 acres and treat an additional 7,366 acres.

Critical grass waterway – those locations that cost less than $657 per ton sediment reduced were selected. Four sites were chosen, covering 8.8 acres and treating 2,935 acres.

Critical grass waterway maintenance – one location was selected representing the highest total sediment tonnage reduced. This waterway is 1.3 acres in size and will treat 98 acres.

Critical livestock fencing – the only practice proposed is critical. If implemented, this practice will treat 10 acres.

Critical feed area treatment – the two sites generating the greatest nutrient reductions were selected to treat 2 acres.

Critical pond – the site with the greatest total sediment and nutrient reductions was chosen as critical. If constructed, this site is expected to treat 118 acres.

Critical saturated buffers – critical saturated buffers were chosen as those costing less than $10 per pound of nitrogen removed. Six locations were chosen and, if implemented, will treat 733 acres.

Critical sediment basin – one basin was selected representing the highest total sediment reduction. This site will treat 41 acres.

Critical streambank/bed stabilization – the location that will generate the greatest sediment reduction was selected as critical.

Critical terraces – one critical site was chosen representing the highest total sediment reduction. If implemented, it will treat 9.2 acres.

Critical WASCB – three locations with the greatest total sediment reductions were selected. If implemented, these critical practices will treat 28 acres.

Critical wetland creation – the wetland with the highest estimated sediment reduction was selected as critical. If implemented, it will treat 2,791 acres.

Table 27 - Critical Area - 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
Bioreactor	7 (locations), 14 (structures)	3,783	6.1	0	26%	26%	n/a
Drainage Water Management	5 (locations), 457 (ac)	4,998	31	0	31%	40%	n/a
Feed Area Treatment	1 (locations), 2 (ac)	70	12	0.3	37%	35%	39%
Field Border	22 (locations), 92 (ac)	240,855	5,228	3,478	37%	1%	37%
Filter Strip	16 (locations), 26 (ac)	30,933	733	599	14%	14%	16%
Floodplain Reconnection (with wetlands)	1 (locations), 6 (riffles), 4 (ac)	20,478	902	566	65%	63%	55%
Grade Control - Riffles	1 (locations), 3 (riffles)	225	90	88	55%	76%	79%
Grass Conversion	2 (locations), 3 (ac)	69	1.6	1.2	33%	31%	28%
Grass Conversion - Perennial	24 (locations), 349 (ac)	32,267	1,205	989	36%	45%	49%
Grass Waterway	4 (locations), 7,500 (ac), 9 (ac)	3,511	124	179	12%	19%	23%
Grassed Waterway Maintenance	1 (locations), 1 (ac)	360	21	48	99%	97%	97%

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
Livestock Fencing	1 (locations), 1,020 (ft fencing)	23	4	2	100%	100%	100%
Pond	1 (location)	1,696	175	180	12%	29%	37%
Saturated Buffer	6 (locations), 3,400 (ft tile)	8,689	54	0	28%	28%	n/a
Sediment Basin	1 (location)	376	20	16	22%	21%	26%
Streambank/Bed Stabilization	1 (location), 3,300 (ft STP)	277	284	315	57%	57%	57%
Terrace	1 (location), 600 (ft terrace), 1,600 (ft tile)	600	9.2	70	25%	32%	41%
WASCB	3 (locations), 1,975 (ft tile), 7 (basins)	1,975	28	288	12%	16%	20%
Wetland Creation	1 (locations), 3 (ac)	18,883	505	262	71%	74%	76%
Grand Total		**370,047**	**9,439**	**7,101**	**33%**	**36%**	**38%**

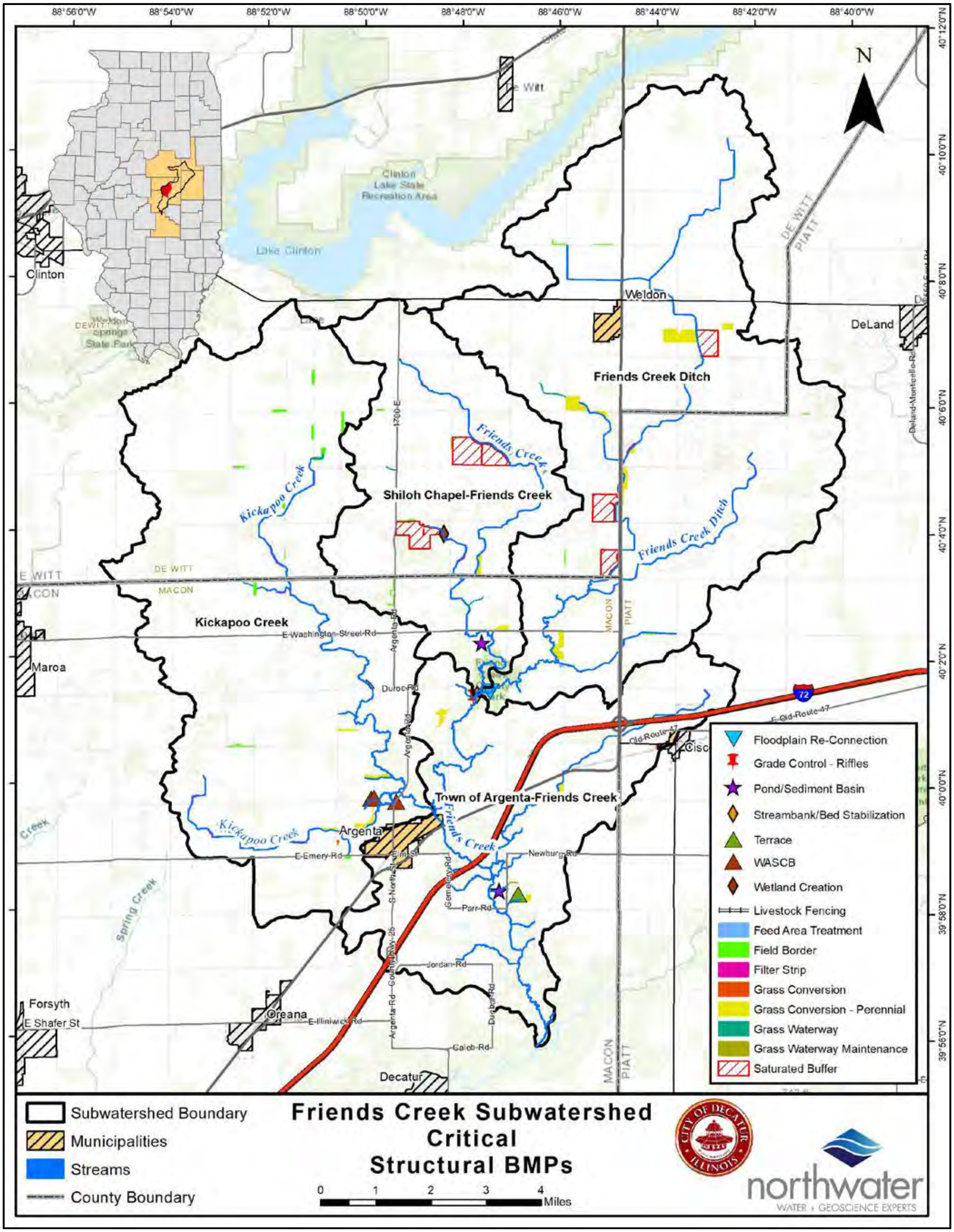


Figure 17 – Critical Areas – Structural Practices

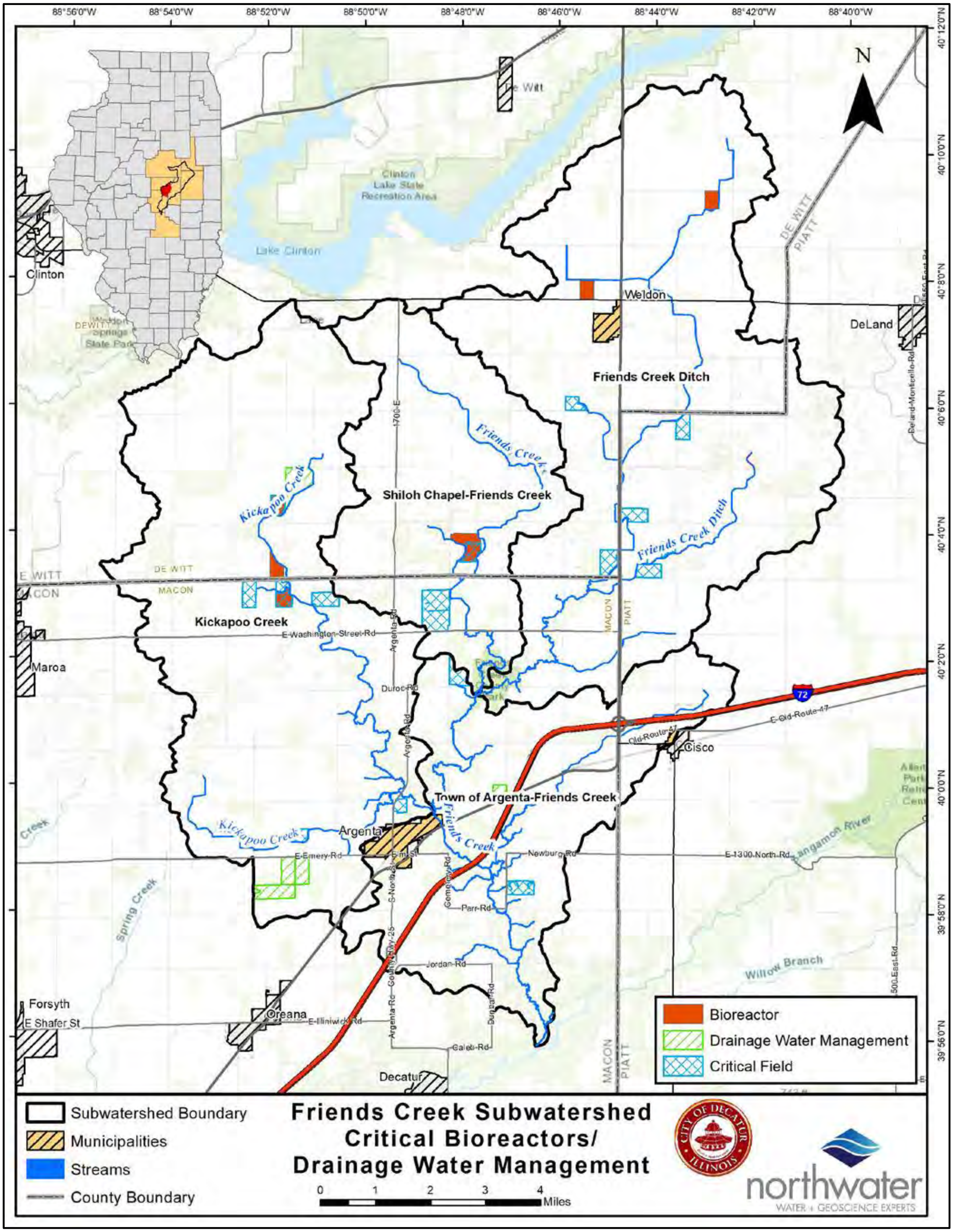


Figure 18 - Critical Bioreactors & DWM

9.0 Monitoring & Tracking Strategy

9.1 Programmatic Monitoring

Tracking subwatershed investments is one of the simplest and most effective means to monitor progress towards achieving watershed plan goals. Keeping track of hundreds of projects across diverse partners and stakeholders requires significant effort and organization. It also requires regular technical support to properly estimate load reductions that can be counted towards each project.

An investment in watershed management software will simplify programmatic monitoring and enable tracking of investments such as BMPs. The City of Decatur recently invested in a custom online system to track BMP implementation. Their system houses important GIS layers of the subwatershed plan and the pollution load model. It also maintains a database of all proposed/recommended and constructed BMPs and associated pollutant load reductions and water quality benefits. Details and status of BMPs are entered by the users and load reduction calculations are made using the model results presented in Section 3.0. A real-time dashboard enables status and tracking of load reductions towards specified goals.

Regardless of the specific methodologies or programs applied, it is pertinent to establish a system of working with watershed partners and stakeholders to track BMP projects that are implemented in the subwatershed and their water quality benefits.

9.2 Water Quality Monitoring

Water quality monitoring is an effective means to evaluate the health of Lake Decatur and Friends Creek, and to directly measure plan effectiveness and progress towards water quality goals. This data also supports science and research, enabling practitioners to better understand the subwatershed(s) and lake dynamics to guide future investments and interventions.

The strategy is to utilize and build upon current and historical monitoring efforts. Monitoring relevant to the plan area is from Friends Creek indicating the subwatershed is an important driver of Lake Decatur water quality.

The monitoring strategy and recommendations include three sections (i) Lake Decatur, (ii) Best Management Practices, and (iii) Lake Decatur tributaries.

Monitoring Station on Friends Creek

9.2.1 Lake Monitoring

Lake Decatur 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 water quality impairments, and rates and sources of sediment accumulation in the basins.

Lake Water Quality - Table 28 outlines the current lake monitoring and recommended improvements. The City of Decatur re-initiated Volunteer Lake Monitoring Program (VLMP) monitoring at three stations in the lake starting in 2021 with the support of the Illinois EPA. The National Great Rivers Research and Education Center (NGRREC) also maintains a station on the lake.

Table 28 - Lake Decatur Monitoring Summary & Recommendations

Monitoring Program	Entity	Current Configuration	Recommendations
VLMP	City of Decatur	• Bi-weekly monitoring from May – October at REA-1, REA-2 and REA-3 o Secchi depth and Dissolved Oxygen profile • Monthly monitoring from May-October at REA-1, REA-2 and REA-3 o Water chemistry of shallow and deep lake water	• Add station to Basin 2. Recent dredging increased depth in this area • Pursue Tier 3 VLMP status • Work with Illinois EPA to utilize its laboratory to analyze chemistry samples
Intake	City of Decatur	• RAW water monitoring of Calcium, Magnesium, Hardness, Turbidity, pH	• Consider including Nitrate-N analysis of RAW water
Lake Stage	City of Decatur	• Daily readings of lake stage and reported on City website	• Manage lake stage data so that it can be easily plotted and analyzed
Upper Lake Decatur (GREON)	NGRREC	• Continuous monitoring (2 hr) for Nitrate-N, Specific Conductance, Temperature, Turbidity, Dissolved Oxygen, Blue-green algae and Dissolved Organic Matter	• Continue to support NGRREC as necessary to continue monitoring • Begin collecting monthly samples from this location for total phosphorus, dissolved phosphorus and TSS

Lake Sediment Monitoring - Lake bathymetry and sediment accumulation monitoring is important to track the loss of lake storage capacity, both spatially and temporally. It also serves to estimate sediment yields and track progress towards reducing loading.

With the recent $92M investment in dredging, a post-dredging bathymetric contour map for Lake Decatur was completed in 2022 and from which all future measurements will be based. It will provide a baseline for management purposes since lake bathymetry has changed significantly post-dredging. Bathymetric mapping and sediment accumulation analysis will be considered every 2-5 years as advancements in technology make it easier and more cost-efficient than in the past.

9.2.2 Best Management Practice Monitoring

Installation of Bank Pins

Monitoring of BMP effectiveness is an important consideration as the major lake tributaries do not represent runoff from Friends Creek. Water quality data representative of BMPs will require site or project-specific monitoring. Custom monitoring should be considered as BMPs are further developed and implemented. Smaller ephemeral drainages with large or multiple BMPs in the upstream basin would be good candidate sites for storm-event monitoring. Other larger BMP projects may warrant special monitoring. For example, the City is currently evaluating a highly eroding ravine in the Bluffs subwatershed where stabilization is underway to reduce sediment loading to the lake. Sixty-eight bank pins were installed in October 2020 to estimate sediment loads and are monitored to quantify load reductions post-construction.

9.2.3 Lake Tributary Monitoring

Friends Creek falls under the current Lake Decatur tributary monitoring program. The strategy for tributary monitoring integrates several historical and current research, projects and initiatives of many organizations, some of which include the United States Geological Survey (USGS), the Illinois State Water Survey (ISWS), University of Illinois and NGRREC. The City of Decatur, ISWS and NGRREC re-established long-term flow and water quality monitoring of the Upper Sangamon River, Friends Creek, and Long Creek (Table 59). The stations represent approximately 80% of the watershed area of Lake Decatur and enables the monitoring of nutrient and sediment yields over time to evaluate trends and track progress towards reduction goals. It is recommended that the City continue long-term monitoring of Friends Creek.

Table 29 – Existing Lake Decatur Watershed Tributary Monitoring Stations

Station ID	Name	Drainage Area	Data Monitored				
			Stage	Flow	Nutrients	Sediment	Other
101	Long Creek at South Twin Bridge Rd.	66.4 mi^2	X	X	X	X	X
102	Friends Creek at IL Route 48	26.0 mi^2	X	X	X	X	X
113[1]	Upper Sangamon River at Route 32 (Cisco Bridge)	627.2 mi^2	X	X	X	X	X
05572000[2]	Sangamon River at Monticello	550 mi^2	X	X	X	X	X

[1] – Continuous monitoring station installed in 2022 by the City of Decatur and NGRREC. [2] – Monitoring performed by USGS, ISWS and UIUC with City of Decatur support for sediment monitoring

9.2.4 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 considering the volume of information being collected and such a system 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 database expertise and capacity is limited, it may be necessary for external support in its management and utilization. Figure 19 shows a screenshot of an environmental database system that is being applied for monitoring programs elsewhere in Illinois.

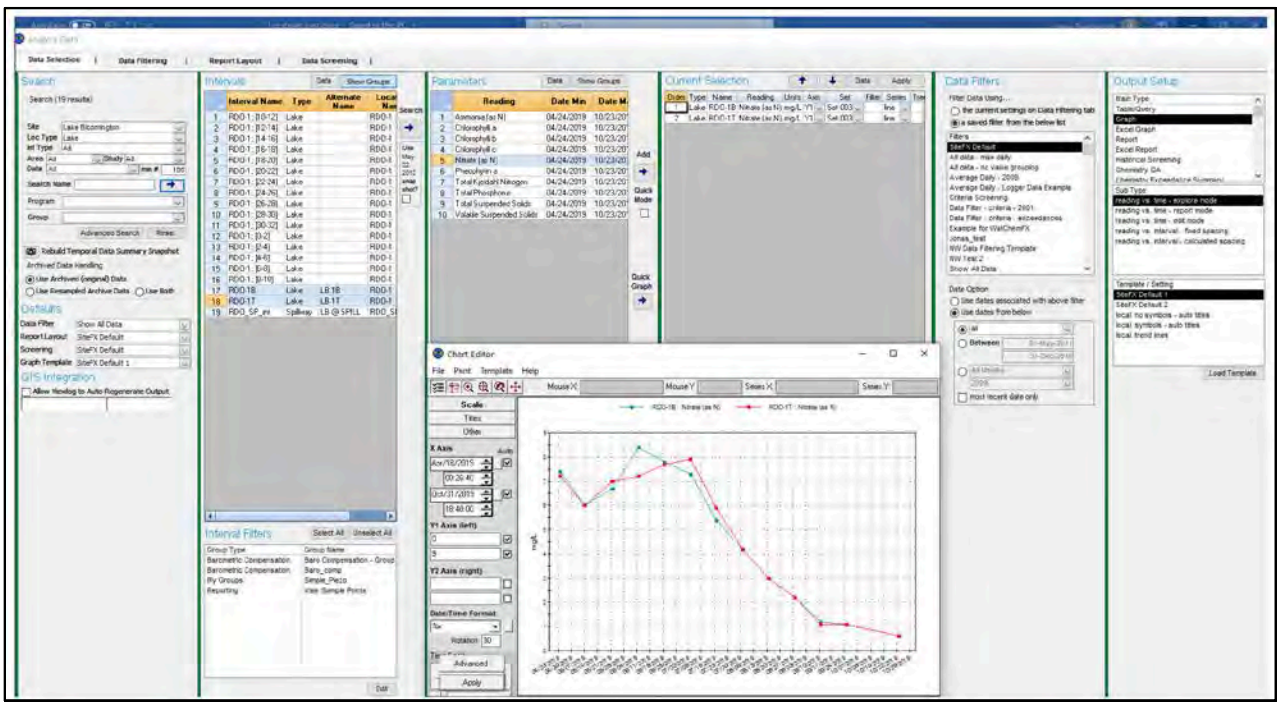


Figure 19 – Screenshot of Database System for Monitoring Data

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Appendix A: 2019 Friends Creek Watershed-Based Plan & Inventory

Available for download at:
https://www.olsonecosolutions.com/uploads/3/4/0/5/34057362/friends_creek_watershed_resource_inventory___plan_-_final_05.01.19.pdf