Waverly Lake Watershed Implementation Plan & Total Maximum Daily Load

Funded by Illinois Environmental Protection Agency (IEPA) Agreement # 3191502

Approved Final Report
3/28/2017

Prepared & Submitted By Northwater Consulting

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAR 2 8 2017

REPLY TO THE ATTENTION OF

WW-16J

Sanjay Sofat, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Sofat:

The U.S. Environmental Protection Agency has conducted a complete review of a final Total Maximum Daily Load (TMDL) for phosphorus for Waverly Lake, including supporting documentation and follow up information. The waterbody is located in south-central Illinois. The TMDL for phosphorus submitted by the Illinois Environmental Protection Agency addresses the impaired designated General Use for the waterbody.

The TMDL meets the requirements of Section 303(d) of the Clean Water Act and EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, EPA hereby approves Illinois's one TMDL for phosphorus as noted in Table 1 of the enclosed decision document. The statutory and regulatory requirements, and EPA' s review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois's effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Peter Swenson, Chief of the Watersheds and Wetlands Branch, at 312-886-0236.

Sincerely,

Christopher Korleski
Director, Water Division

Enclosure

cc: Abel Haile, IEPA

TMDL: Waverly Lake, Alexander County, Illinois
Date: MAR 2 8 2017

DECISION DOCUMENT FOR THE APPROVAL OF THE WAVERLY LAKE, IL TMDL

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 C.F.R. Part 130 describe the statutory and regulatory requirements for approvable TMDLs. Additional information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable. These TMDL review guidelines are not themselves regulations. They are an attempt to summarize and provide guidance regarding currently effective statutory and regulatory requirements relating to TMDLs. Any differences between these guidelines and EPA's TMDL regulations should be resolved in favor of the regulations themselves.

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal should identify the waterbody as it appears on the State's/Tribe's 303(d) list. The waterbody should be identified/georeferenced using the National Hydrography Dataset (NHD), and the TMDL should clearly identify the pollutant for which the TMDL is being established. In addition, the TMDL should identify the priority ranking of the waterbody and specify the link between the pollutant of concern and the water quality standard (see section 2 below).

The TMDL submittal should include an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading, e.g., lbs/per day. The TMDL should provide the identification numbers of the NPDES permits within the waterbody. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of the natural background. This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

(1) the spatial extent of the watershed in which the impaired waterbody is located;
(2) the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;
(4) present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and
(5) an explanation and analytical basis for expressing the TMDL through *surrogate*

measures, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

Comment:
Location Description: The Illinois Environmental Protection Agency (IEPA) developed a TMDL for total phosphorus for Waverly Lake (Lake ID: SDC) in south-central Illinois. Waverly Lake is located in Morgan County. The lake is a reservoir formed from Woods Creek, which was dammed in 1938 to form a drinking water supply for the City of Waverly. The lake is owned by the City of Waverly.

The watershed for Waverly Lake is relatively small, approximately 6,700 acres and inflow to the lake is from Woods Creek and several smaller tributaries. The lake is 107 acres in size, and averages seven feet in depth, with a maximum of 14 feet in depth. The lake discharges through a spillway at the southern end of the lake (Figure 1 of the TMDL).

Distribution of land use: The land use for Waverly Lake is mainly agricultural and forest in nature, with most of the agricultural land use in row crop (corn/soybean). Grassland/pasture and open developed land make up most of the remaining land use (Section 4.6 of the TMDL). Table 1 of this Decision Document contains the land use for Waverly Lake.

Table 1 Land use in acres in the Waverly Lake Watershed

Land Use	Acres	Watershed %
Row Crops	4260	74
Forest	725	12
Grassland	343	5
Urban open space	182	3
Pasture	68	1
Roads	50	1
Other	119	4
Total	14,697	100

Problem Identification:
Waverly Lake was added to the 2006 303(d) list for being impaired due to high levels of phosphorus and suspended solids. IEPA reviewed data back to 1999 and determined that the lake had elevated total phosphorus (TP) average concentrations for 86% of the samples. Water quality sampling performed documented exceedences of the water quality criteria at all three lake sample locations (Table 5 of the TMDL). The median whole lake TP concentration in 2015 was 0.153 (WQS = 0.05), and almost all lake samples exceeded the WQS for TP.

Pollutants of Concern:
The pollutant of concern is total phosphorus (TP). However, IEPA determined that reductions in nitrogen and sediment will be needed to fully restore Waverly Lake (Section 2 of the TMDL). Although TP reductions are the focus of the TMDL, Sections 8 (Reasonable Assurance) and Section 10 (Implementation Plan) of this Decision Document contain additional discussion of nitrogen and sediment reduction efforts.

Pollutant:
While TP is an essential nutrient for aquatic life, elevated concentrations of TP can lead to nuisance algal blooms that negatively impact aquatic life and recreation (swimming, boating, fishing, etc.). Algal decomposition depletes oxygen levels which stresses benthic macroinvertebrates and fish. Excess algae can shade the water column which limits the distribution of aquatic vegetation. Aquatic vegetation stabilizes bottom sediments, and also is an important habitat for macroinvertebrates and fish. Furthermore, depletion of oxygen can cause phosphorus release from bottom sediments (i.e. internal loading).

Degradations in aquatic habitats or water quality (ex. low dissolved oxygen) can negatively impact aquatic life use. Increased turbidity, brought on by elevated levels of nutrients within the water column, can reduce dissolved oxygen in the water column, and cause large shifts in dissolved oxygen and pH throughout the day. Shifting chemical conditions within the water column may stress aquatic biota (fish and macroinvertebrate species). In some instances, degradations in aquatic habitats or water quality have reduced fish populations or altered fish communities, from those communities supporting sport fish species, to communities which support more tolerant rough fish species.

Priority Ranking:
The watershed was given priority for TMDL development due to the impairment impacts on public health, the public value of the impaired water resource, the likelihood of completing the TMDL in an expedient manner, the inclusion of a strong base of existing data and the restorability of the water body, the technical capability and the willingness of local partners to assist with the TMDL, and the appropriate sequencing of TMDLs within a watershed or basin.

Source Identification (point and nonpoint sources):
Point Source Identification: No point sources in the watershed were identified by IEPA. There is one wastewater treatment facility (WWTF) in the watershed, the Franklin WWTF. It is a spray-irrigation system, where wastewater is applied to fields. No discharge to open waters is permitted, and the system is operated to prevent runoff or overapplication (Section 4.12.1 of the TMDL).

Nonpoint Source Identification: The potential nonpoint sources for the Waverly Lake phosphorus TMDL are:

Non-regulated stormwater runoff: Non-regulated stormwater runoff can add phosphorus to the lake. The sources of phosphorus in stormwater include organic material such as leaves, animal/pet wastes, fertilizers, etc. IEPA surveyed the watershed for gullies, where surface water runoff is significant enough to begin downcutting of the surface. IEPA noted the presence of gullies in the watershed, and determined the gullies are a source of sediment and phosphorus to the lake (Section 4.13 of the TMDL).

Lake shoreline erosion: IEPA mapped the lake shoreline, and noted areas where active or potential erosion was occurring (Section 4.11 of the TMDL). IEPA noted locations where erosion is occurring, and the severity (Table 26 of the TMDL). Phosphorus is often attached to soil particles, and shoreline erosion contributes local large amounts of phosphorus-rich soil to the lake. This effort identified critical areas for restoration.

Streambank erosion: IEPA performed surveys of significant portions of tributaries in the Waverly Lake watershed. As noted above, streambank erosion can contribute locally significant amounts of phosphorus-rich sediment to Waverly Lake (Section 4.11 of the TMDL).

Failing septic systems: IEPA noted that failing septic systems, where waste material can pond at the surface and eventually flow into surface waters or be washed in during precipitation events, are potential sources of phosphorus. IEPA reviewed available septic system data and using GIS information, was able to estimate the number of homes on septic systems in the watershed.

Internal loading: The release of phosphorus from lake sediments via physical disturbance from wind mixing the water column, and anoxic release of TP from deeper sediments, may contribute internal phosphorus loading to Waverly Lake. Phosphorus may build up in the bottom waters of the lake and may be resuspended or mixed into the water column.

Population and future growth trends: The population for the watershed is fairly small, less than 1,000 people. The City of Waverly (population 1,307) is located approximately three miles east of the lake, outside of the watershed. A portion of the Village of Franklin (population 610) is located within the Waverly Lake watershed. IEPA does not expect any future growth in the watershed (Section 7.3.2 of the TMDL).

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this first element.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. (40 C.F.R. §130.7(c)(1)). EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

The TMDL submittal must identify a numeric water quality target(s) - a quantitative value used to measure whether or not the applicable water quality standard is attained. Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. The TMDL expresses the relationship between any necessary reduction of the pollutant of concern and the attainment of the numeric water quality target. Occasionally, the pollutant of concern is different from the pollutant that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as Dissolved Oxygen (DO) criteria). In such cases, the TMDL submittal should explain the linkage between the pollutant of concern and the chosen numeric water quality target.

Comment:

Designated Use/Standards: Section 3.1 of the TMDL states that Waverly Lake is not meeting the General Use designation. The applicable water quality standards (WQS) for these waterbodies are established in Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards, Subpart B for General Use Water Quality Standards. The portions of the General Use standard that applies to Waverly Lake is the aesthetic quality and public water supply uses. The lake is meeting the public water supply use, but is impaired for the aesthetic quality use (Section 3.1 of the TMDL).

Criteria: IEPA has a lake criterion for phosphorus of 0.05 mg/L (Title 35, Section 302.205).

Target: The water quality target for this TMDL is the water quality criterion of 0.05 mg/L TP.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this second element.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). If the TMDL is expressed in terms other than a daily load, e.g., an annual load, the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen. The TMDL submittal should describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

The TMDL submittal should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling. EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

TMDLs must take into account *critical conditions* for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable *critical conditions* and describe their approach to estimating both point and nonpoint source loadings under such *critical conditions*. In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

Comment:
The approach utilized by the IEPA to calculate the loading capacity for Waverly Lake for phosphorus is described in Sections 5 and 7 of the final TMDL.

To determine the watershed loadings into Waverly Lake, IEPA used SWAMM (Spatial Watershed Assessment and Management Model). SWAMM is a nonpoint source GIS-based model that utilizes the Universal Soil Loss Equation (USLE) model to determine runoff loads based upon soil types, land use, precipitation data, and Event Mean Concentration (EMC) data.

SWAMM can be used to determine loads at the field level. Appendix A of the TMDL provides more information on SWAMM.

In addition to using SWAMM to determine runoff loads, gullies were analyzed to determine loadings of TP. In Section 4.13 of the TMDL, IEPA noted that gullies were surveyed from both field inspection and GIS estimates. Loads from gullies were calculated based upon sediment erosion estimates and the TP concentration in the soils. Similar to gullies, streambank erosion and lake bank erosion were calculated based upon both field surveys of streambank and lake banks, multiplied by the TP concentration in the soil (Section 4.1.1 of the TMDL). Septic systems were also assessed as possible sources of TP. Every home in the watershed was mapped, and those outside the Franklin WWTF system were plotted. A spreadsheet was used to estimate septic systems loads, based upon average use and a 15% failure rate (Section 4.12.2). Internal loading of TP was calculated based upon the initial results of the BATHTUB model.

After the lake inputs were calculated, IEPA used BATHTUB to determine the water quality based upon the TP loading. The BATHTUB model applies a series of empirical equations derived from assessments of lake data and performs steady state water and nutrient calculations based on lake morphometry and tributary inputs. The BATHTUB model requires fairly simple inputs to predict phosphorus loading. The model accounts for pollutant transport, sedimentation, and nutrient cycling. The model was used to determine the load needed to meet or maintain water quality standards for the lake (Section 7.1 of the TMDL).

The model parameters were adjusted until the model predictions fit the sample data. Once the data were calibrated, the source loads were reduced until the in-lake concentration met the appropriate water quality standard (WQS) (Section 7.1 of the TMDL). To account for internal loading of TP, IEPA added additional internal loading into the model based upon the direct lake shore erosion and a calculation of the deeper portions of the lake where anoxic conditions could release TP (Section 7.2.2 of the TMDL). The internal loading was determined to be 243 lbs/yr (0.7 lbs/d), 3% of the current load (Table 2 of the TMDL).

Table 2: Current TP load to Waverly Lake

Source	TP lbs/yr	TP (lbs/d)	% of total load
Direct Runoff	6262	17	71
Streambank Erosion	867	2.4	10
Lake Bank Erosion	566	1.6	6
Gully Erosion	687	1.9	8
Septic Systems	170	0.5	2
Internal Load	243	0.7	3
Total	8795	24.1	100

IEPA subdivided the loading capacity among the WLA, LA and MOS components of the TMDL (Table 3 of this Decision Document). These calculations were based on the critical condition, the spring/early summer time, which is typically when loading is the highest. Modeling results showed that the current load of TP is well-above the WQS. Table 3 of this Decision Document shows the TMDL summary for Waverly Lake. The allocations result in an approximate 82% reduction in watershed loading.

Table 3 TMDL summary for Waverly Lake

Category	TP lbs/yr	TP (lbs/d)
Existing load	8795	24.1
Reduction	82%	82%
Wasteload Allocation	0	0
Load Allocation	1367	3.7
Margin of Safety	72	0.2
Loading capacity (TMDL)	**1439**	**3.9**

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this third element.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity attributed to existing and future nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, load allocations should be described separately for natural background and nonpoint sources.

Comment:

The LA for the waterbodies are found in Table 3 of this Decision Document. Since IEPA determined there are no point sources of TP in the watershed, all the loading capacity was allocated to the load allocation. The sources of TP in the watershed are nonpoint source runoff from row crop agricultural fields, gullies, failing septics, streambank erosion, and lake bank erosion. IEPA did not assign LA to the source categories, however, as discussed in Sections 8 and 10 of this Decision Document, IEPA did provide further analysis of how reductions from the various sources could be attained.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fourth element.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. These individual WLAs may be adjusted during the NPDES permitting process. If the WLAs are adjusted, the individual effluent limits for each permit issued to a discharger on the impaired water must be consistent with the assumptions and requirements of the adjusted WLAs in the TMDL. If the WLAs are not adjusted, effluent limits contained in the permit must be consistent with the individual WLAs specified in the TMDL. If a draft permit provides for a higher load for a discharger than the corresponding individual WLA in the TMDL, the State/Tribe must demonstrate that the total WLA in the TMDL will be achieved through reductions in the remaining individual WLAs and that localized impairments will not result. All permittees should be notified of any deviations from the initial individual WLAs contained in the TMDL. EPA does not require the establishment of a new TMDL to reflect these revised allocations as long as the total WLA, as expressed in the TMDL, remains the same or decreases, and there is no reallocation between the total WLA and the total LA.

Comment:
IEPA stated there are no known point sources of phosphorus in the watersheds. The WLA is 0 for the Waverly Lake phosphorus TMDL.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fifth element.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

Comment:
The Waverly Lake TMDL incorporated an explicit MOS of 5% of the TMDL (Table 3 of this Decision Document). IEPA noted that the 5% is reasonable due to the results of the generally good agreement between the BATHTUB water quality model and observed sampling results. (Section 7.3.4 and Appendix A of the TMDL). The results indicate the model adequately characterizes the lake and surrounding watershed, and therefore additional explicit MOS is not needed. Implicit MOS was provided by conservative assumptions used in the BATHTUB model. IEPA calibrated the model based upon the lake-wide mean TP values, rather than median values as discussed in the IEPA lake assessment methodology. This results in a slightly higher reduction of TP.

EPA finds that the TMDL document submitted by IEPA has an appropriate implicit MOS satisfying all requirements concerning this sixth element.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variations. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Comment:
IEPA accounted for seasonal variation via the modeling process. As noted in Section 7.3 of the TMDL, the model inputs focused on the April-October period, corresponding to when the lake water quality data was collected, as well as representing the impact of where the TP loadings were the greatest. The BATHTUB model was run to determine annual loads as well as daily loads, to allow Best Management Practices (BMPs) to be utilized year-round.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this seventh element.

8. Reasonable Assurances

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL.

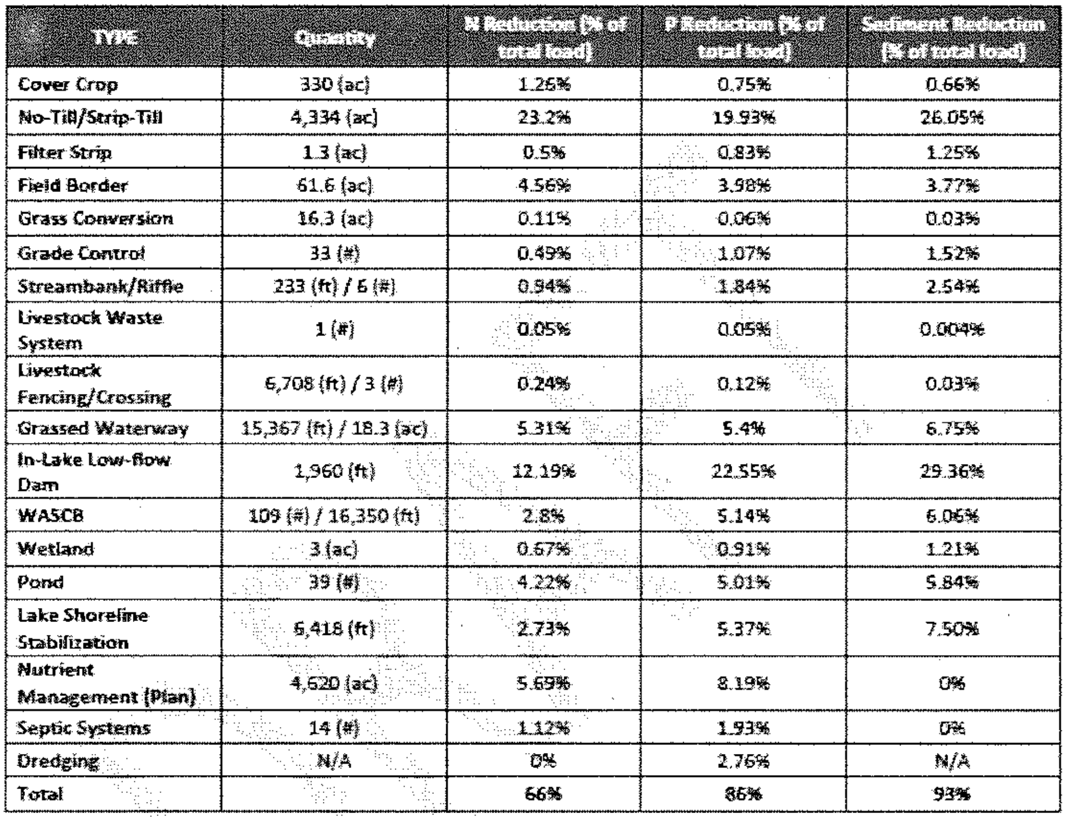
When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

EPA's August 1997 TMDL Guidance also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

Comment:
Sections 9, 10, 11 and 13 of the TMDL discusses reasonable assurance for Waverly Lake. Reasonable assurance does not strictly apply to the Waverly Lake TMDL, as there are no point sources contributing to the impairment. However, IEPA provided detailed information on controls of TP that will be targeted to the watershed.

Section 10 of the TMDL identifies various BMPs that, when implemented, will reduce phosphorus sufficiently to attain WQS (Table 46 of the TMDL). IEPA noted that reductions in nitrogen and sediment are also needed to attain standards, and therefore included reductions in nitrogen and sediment resulting from the implementation of the BMPs (Table 4 of this Decision Document). For example, the BMP analysis demonstrates that changing from conventional/reduced tillage to no-till/strip till will reduce TP by 20%, nitrogen by 23% and sediment by 26%. The other major BMP reduction is from the installation of in-lake low-flow dams, which are expected to reduce TP by 23%, nitrogen by 12%, and sediment by 30%. Details on the BMPs are found in Section 10 of this Decision Document.

Table 4 Waverly Lake Percent Reduction for BMPs (from Table 46 of the TMDL)



TYPE	Quantity	N Reduction (% of total load)	P Reduction (% of total load)	Sediment Reduction (% of total load)
Cover Crop	330 (ac)	1.26%	0.75%	0.66%
No-Till/Strip-Till	4,334 (ac)	23.2%	19.93%	26.05%
Filter Strip	1.3 (ac)	0.5%	0.83%	1.25%
Field Border	61.6 (ac)	4.56%	3.98%	3.77%
Grass Conversion	16.3 (ac)	0.11%	0.06%	0.03%
Grade Control	33 (#)	0.49%	1.07%	1.52%
Streambank/Riffle	233 (ft) / 6 (#)	0.94%	1.84%	2.54%
Livestock Waste System	1 (#)	0.05%	0.05%	0.004%
Livestock Fencing/Crossing	6,708 (ft) / 3 (#)	0.24%	0.12%	0.03%
Grassed Waterway	15,367 (ft) / 18.3 (ac)	5.31%	5.4%	6.75%
In-Lake Low-flow Dam	1,960 (ft)	12.19%	22.55%	29.36%
WASCB	109 (#) / 16,350 (ft)	2.8%	5.14%	6.06%
Wetland	3 (ac)	0.67%	0.91%	1.21%
Pond	39 (#)	4.22%	5.01%	5.84%
Lake Shoreline Stabilization	6,418 (ft)	2.73%	5.37%	7.50%
Nutrient Management (Plan)	4,620 (ac)	5.69%	8.19%	0%
Septic Systems	14 (#)	1.12%	1.93%	0%
Dredging	N/A	0%	2.76%	N/A
Total		66%	86%	93%

Section 11 of the TMDL discusses the priority areas for BMP implementation in the watershed. IEPA determined these areas based upon the willingness of the landowners and the greatest "bang for the buck" benefit to the watershed. IEPA divided the priority areas into two parts, no-till/strip-till and watershed BMPs. The no-till/strip-till priority areas were defined based upon the upper quartile of lowest cost per pound of phosphorus removed. IEPA identified 590 acres that should be converted from conventional/reduced tillage to no-till/strip till (Section 11.1 and Figure 47 of the TMDL). Conversion of these acres could reduce TP loads from these acres by 36%. IEPA noted that the largest source of TP in the watershed is runoff from fields in the watershed.

Section 11.2 of the TMDL discusses the reduction of TP, nitrogen, and sediment from watershed BMPs. Figures 48 and 49 of the TMDL identify the critical locations for BMP development, and Appendix C of the TMDL provides greater detail on BMP locations, amount of reduction expected, and costs. Section 11.2 also identifies which portions of the watershed are privately owned, and which are owned by the City of Waverly or the Village of Franklin. Waverly Lake is owned by Waverly, and the city has shoreline regulations regarding building and maintaining structures along the shoreline (Official Waverly Lake Rules and Regulations, accessed 3/09/17). Table 5 of this Decision Document (Table 48 of the TMDL) summarizes the reductions in TP, nitrogen, and sediment expected from the BMPs, based upon the responsible entity.

Table 5 Load Reduction Summary; Watershed BMPs (from Table 48 of the TMDL)

Responsible Entity	Total Cost	N Reduction (lbs/yr)	% Total Load Reduction	P Reduction (lbs/yr)	% Total Load Reduction	Sediment Reduction (tons/yr)	% Total Load Reduction
City of Waverly	$7,259,361.30	6,028	39%	2,544	46%	2,690	57%
Franklin Outing Club/Village of Franklin	$56,435.74	153	1%	43	1%	51	1%
Private Landowner	$718,642.00	5,657	37%	1,623	29%	1,589	34%
Total	$8,034,439	11,838	76%	4,210	76%	4,331	92%

IEPA also provided an Implementation Milestone table (Table 49 of the TMDL). The timeline is based on 2-3 year increments over a 10-year time period. The milestones are based upon various nonpoint source programs such as Section 319 of the Clean Water Act, National Resource Conservation Service (NRCS) programs, etc. Milestone efforts that extend past the 10 year plan are considered long-term and will likely require significant capital expenditures. IEPA noted that several of the milestones in years 1-2 have already begun or have written commitments from landowners (including Waverly and Franklin), although some are contingent on funding. Table 50 of the TMDL summarizes the BMPs, responsible parties, and the Primary Technical Assistance/Funding Mechanism.

Cost estimates for the BMPs were provided in Section 9 of the TMDL. The assumption used to determine the cost estimates (i.e., cost to seed per acre, installation of grass waterways per acre, etc.) were provided in Section 9.1 of the TMDL. Table 45 of the TMDL provides a detailed breakdown of BMP costs, both overall costs and the cost per pound of pollutant reduced for TP nitrogen, and sediment. The total cost of implementing all BMPs was estimated to be $8,892,622. IEPA noted that no-till/strip-till are both cost-effective and will likely result in large overall load reductions.

IEPA, and their contractor Northwater Consulting, have already begun information and outreach efforts to landowners in the watershed (Section 14 of the TMDL). Several public meetings have occurred, and several one-on-one meetings with landowners have occurred as well. Over 15 site visits have been performed to discuss new and existing BMPs. IEPA also noted that several shoreline restoration projects have been completed by the City of Waverly to address erosion problems for Waverly Lake.

The Waverly TMDL and Implementation Plan was also reviewed for meeting the nine elements of a Section 319 Watershed Base Plan. The EPA Nonpoint Source Program determined that the Section 319 requirements were met. Having an approved Section 319 plan allows IEPA to apply for and utilize funding to address nonpoint source BMPs.

EPA finds that this criterion has been adequately addressed.

9. Monitoring Plan to Track TMDL Effectiveness

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan to track the effectiveness of a TMDL, particularly when a TMDL involves both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur. Such a TMDL should provide assurances that nonpoint source controls will achieve expected load reductions and, such TMDL should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.

Comment:
The TMDL contains discussion on future monitoring (Section 15 of the TMDL). There are currently three lake monitoring sites. The TMDL recommends monitoring continue at these sites, and suggests three additional sites be monitored, at the mouth of the three main tributaries to Waverly Lake. The TMDL suggests these sites would be useful in determining BMP effectiveness as well as providing additional data on water quality. Suggested water quality parameters and bioassessment metrics are explained in Tables 53 and 54 of the TMDL.

EPA finds that this criterion has been adequately addressed.

10. Implementation

EPA policy encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. In addition, EPA policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

Comment:
Numerous implementation options are discussed in Section 8 of the TMDL. These options are directed sediment and nitrogen reductions, as well as TP reductions. Table 42 of the TMDL lists the suggested BMPs for the watershed, and the range of reductions for each option. The SWAMM model was used to determine the locations of various BMPs, and to determine the pollutant reduction that could potentially occur. Table 43 of the TMDL summarizes the type, number, and effectiveness of the BMP options. Assuming all BMPs are implemented, a total of 7, 992 lbs/yr could be reduced in the watershed. Locations of where the BMPs should be implemented are identified in Figures 34 and 35 of the TMDL. The numbered locations are identified in Appendix C of the TMDL.

The potential BMPs are:

- Cover crops
- No-till/strip till
- Water and Sediment Control Basins (WASCB)
- Grassed waterways
- Constructed wetlands
- Filter strip, grass conversion, and field borders
- Grade control structures
- Streambank stabilization
- Shoreline stabilization

- Detention basin/pond
- In-lake/low flow dam
- Livestock Feed Area Waste System
- Pasture management and fencing
- Lake Dredging
- Septic Systems
- Nutrient management

Each of these BMPs are discussed in detail on Section 8 of the TMDL. Based upon the proposed BMPs and the locations, no-till/strip-till (1753 lbs/yr) and in-lake/low-flow dams (1984 lbs/yr provide the greatest reduction in TP Table 6 of this Decision Document). As noted in Section 8 of this Decision document, in-lake/low-flow dams are expensive ($6,000,000) to install, but will remove the greatest amount of TP (as well as nitrogen and sediment). IEPA discussed in great detail the options for installing the dams, and the various cost/benefit issues (Section 8.2.2 of the TMDL).

Table 6 BMP Load Reduction Summary (from Table 43 of the TMDL)

TYPE	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
Cover Crop	330 (ac)	330	485	66	47
No-Till/Strip-Till	4,334 (ac)	4,334	8,956	1,753	1,843
Filter Strip	1.3 (ac)	21	194	73	89
Field Border	61.6 (ac)	888	1,759	350	267
Grass Conversion	16.3 (ac)	16	42	5.0	2.2
Grade Control	33 (#)	253	191	94	107
Streambank Stabilization / Riffle	233 (ft) / 6 (#)	0	361	162	180
Livestock Waste System	1 (#)	3	19	4.1	0.3
Livestock Fencing	6,708 (ft) / 3 (#)	25	94	11	1.9
Grassed Waterway	15,367 (ft) / 18.3 (ac)	1,197	2,050	475	478
In-Lake / Low-flow Dam	1,960 (ft)	6,236	4,707	1,984	2,077
WASCB	109 (#) / 16,350 (ft)	666	1,082	452	429
Wetland	3 (ac)	214	257	80	85
Pond	39 (#)	696	1,628	441	413
Lake Shoreline Stabilization	6,418 (ft)	N/A	1,055	472	531
Nutrient Management (Plans)	4,620 (ac)	4,620	2,196	720	0
Septic Systems	14 (#)	N/A	1,553	608	0
Dredging	N/A	N/A	N/A	243	N/A
Total		14,879	26,629	7,992	6,550

EPA reviews, but does not approve, implementation plans. EPA finds that this criterion has been adequately addressed.

11. Public Participation

EPA policy is that there should be full and meaningful public participation in the TMDL development process. The TMDL regulations require that each State/Tribe must subject calculations to establish TMDLs to public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval should describe the State's/Tribe's public participation process, including a summary of significant comments and the State's/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. §130.7(d)(2)).

Provision of inadequate public participation may be a basis for disapproving a TMDL. If EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

Comment:
An initial public meeting was held on December 9th, 2015, to describe the watershed plan and TMDL process. On March 1, 2016, a public meeting held by the Morgan County Soil and Water Conservation District, where a presentation on soil health and cost-share options was made. IEPA representatives were in attendance. The public comment period for the draft TMDL opened on November 10th, 2016 and closed on January 14, 2017. A public meeting was held on December 14, 2016, in Waverly, Illinois.

The public notices were published in the local newspaper and interested individuals and organizations received copies of the public notice. A hard copy of the TMDL was made available at the Waverly City Hall. The draft TMDL was also made available at the website http://www.epa.state.il.us/water/tmdl/. No comments were received.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this eleventh element.

12. Submittal Letter

A submittal letter should be included with the TMDL submittal, and should specify whether the TMDL is being submitted for a *technical review* or *final review and approval.* Each final TMDL submitted to EPA should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final review and approval, should contain such identifying information as the name and location of the waterbody, and the pollutant(s) of concern.

Comment:
On January 31, 2017, EPA received the Waverly Lake, Illinois TMDL, and a submittal letter from Sanjay Sofat, IEPA to Chris Korleski, EPA. In the submittal letter, IEPA stated it was

submitting the TMDL report for EPA's final approval. The submittal letter included the name and location of the waterbody and the pollutant of concern.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this twelfth element.

Conclusion

After a full and complete review, EPA finds that the TMDL for Waverly Lake satisfies all of the elements of an approvable TMDL. This approval is for one TMDL for phosphorus for one waterbody.

EPA's approval of this TMDL does not extend to those waters that are within Indian Country, as defined in 18 U.S.C. Section 1151. EPA is taking no action to approve or disapprove TMDLs for those waters at this time. EPA, or eligible Indian Tribes, as appropriate, will retain responsibilities under the CWA Section 303(d) for those waters.

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Acronyms

AFT - American Farmland Trust
AQI - Aesthetic Quality Index
ACEP - Agricultural Conservation Easement Program
BMP – Best Management Practice
CRP – Conservation Reserve Program
CREP – Conservation Reserve and Enhancement Program
CSP – Conservation Stewardship Program
CWS - Community Water Supply
NCWS - Non-Community Water Supply
CCA - Certified Crop Advisors
C-BMP – Illinois Council on Best Management Practices
HUC - Hydrologic Unit Code
IDNR – Illinois Department of Natural Resources
IDPH - Illinois Department of Public Health
INPC – Illinois Nature Preserves Commission
IEPA – Illinois Environmental Protection Agency
IGIG - Illinois Green Infrastructure Grant Program
ISGS - Illinois State Geologic Survey
ISWS – Illinois State Water Survey
ISA – Illinois Stewardship Alliance
NGVD - National Geodetic Vertical Datum
NPDES - National Pollutant Discharge Elimination System
NVSS - Non-Volatile Suspended Solids
NWI – National Wetlands Inventory
RCPP - Regional Conservation Partnership Program
TDH - Total Dynamic Head
TDS – Total Dissolved Solids
TP – Total Phosphorus
TN – Total Nitrogen
TSS – Total Suspended Solids
TSI - Trophic State Index (TSI)
TSP - Technical Service Providers
TMDL – Total Maximum Daily Load
TSS – Total Suspended Solids
VSS - Volatile Suspended Solids
USFWS – U.S. Fish and Wildlife Service
USACE - U.S. Army Corps of Engineers
USEPA – United States Environmental Protection Agency
USDA – United States Department of Agriculture
USGS - U.S. Geological Survey
WIP - Watershed Implementation Plan

Executive Summary

The Waverly Lake Watershed

The Watershed Implementation Plan (WIP) and Total Maximum Daily Load (TMDL) includes Waverly Lake and its 6,270-acre watershed. The TMDL serves to define the maximum quantity of a pollutant that a water body can receive whilst still achieving water quality standards. The Watershed Implementation Plan provides a road map to achieve the TMDL objectives for phosphorus whilst also characterizing and addressing other non-regulatory watershed problems identified through analysis and stakeholder input.

Characteristics of Waverly Lake and its watershed are summarized below:

- Waverly Lake is a 107-acre public water supply reservoir located in Morgan County and serves the City of Waverly. It is also an emergency water supply for the Village of Franklin.
- There are 163 homes within the watershed; the highest density is around Franklin Lake.
- Waverly Lake is currently impaired for total phosphorus and total suspended solids.
- Average withdrawals from the lake are 180,000 – 230,000 gallons per day, fluctuating seasonally.
- The reservoir was constructed in 1938 and capacity is diminishing due to sedimentation.
- Woods Creek is the lake's primary tributary and is 3.7 miles in length.
- Three established water quality stations are located within the lake; water quality data is available from 1999-2015.
    - The lake regularly exceeds Illinois' 0.05 mg/L phosphorus standard (86% of the time).
    - The average phosphorus concentration is 0.267 mg/L. Since 1999, the concentrations are increasing.
    - Nitrogen is low overall, but average concentrations have increased since 1996.
    - Total suspended solids regularly exceed 15 mg/L (74 % of the time).
- The watershed has an average slope of 2.15% and ranges in elevation from 611 to 708 feet above sea level.
- Average annual precipitation (1930-2014) is 37.4 inches.
- Twenty landuse categories cover the watershed:
    - 74% or 4,620 acres crop land.
    - 12% or 725 acres of forest.
    - 5% or 343 acres grassland.
- Twenty-three unique soil types blanket the watershed:
    - Ipava silt loam is the dominant soil type (28%).
    - 19% or 1,215 acres highly erodible ground; 6% of all cropped soils are highly erodible.
    - 22% or 1,356 acres of wetland or hydric soils.
    - Majority of soils (54%) have moderate runoff potential.
    - 68% of all soils classified as limited for septic system suitability.
- Conventional and reduced tillage systems represent 90% of all crop fields in the watershed.

- Substantial work has been implemented in the watershed to reduce sediment and nutrients entering the lake.
- 94% of all crop ground in the watershed is believed to be tile drained.
- A stream and lake survey concluded that the majority of the Waverly Lake shoreline and watershed streams are well buffered with expansive riparian areas.
- Streambank erosion is responsible for 10% of the lakes' phosphorus load (867 lbs/yr) and 14% of the lakes' sediment load (959 tons/yr).
    - Most of the sediment and phosphorus is from tributary drainages and not Woods Creek. The majority of streambank erosion is considered low to moderate.
- Lake shoreline erosion is responsible for 7% of the lakes' phosphorus load (566 lbs/yr) and 9% of its sediment load (637 tons/yr).
    - 19% of banks are responsible for 84% of the shoreline phosphorus load and 81% of the sediment load.
- There are an estimated 93 septic systems in the watershed and it is possible that up to 14 are failing.
    - Phosphorus loading from potentially failing septic systems may contribute 2% of the lakes' total phosphorus load.
- Gully erosion is most severe in steep forested draws; there are 13 miles of eroding gullies in the watershed.
    - Gully erosion is responsible for 8% of the lakes' phosphorus load (687 lbs/yr) and 11% of its sediment load (763 tons/yr).
    - 58% of all eroding gullies are responsible for 96% of the entire sediment load from gully erosion.
- Sheet and rill erosion from crop ground is responsible the majority of soil loss from crop ground.
    - 58% of the entire sediment load from crop ground is originating from only 17% of the fields in the watershed.
- Total nutrient and sediment loading to Lake Waverly is: 38,599 lbs/yr nitrogen, 8,795 lbs/yr phosphorus, and 7,074 tons/yr sediment.
    - 243 lbs/yr of phosphorus is thought to release from lake sediment on an annual basis.
    - Row crops are responsible for the highest percentage of the total watershed sediment and nutrient load: 78% of nitrogen, 67% of phosphorus, and 66% of sediment.
- Conventional and reduced tillage systems (94% of all fields) on crop ground in the watershed are responsible for 96% of the entire nitrogen load from crop ground, 97% of the phosphorus load, and 98% of the sediment load.
    - Conventional or reduced tillage on highly erodible soils contribute the highest per-acre sediment and nutrient loads.
- TMDL Modeling indicates that Waverly Lake needs to see an annual phosphorus reduction of 82-85% to meet the state's 0.05 mg/L standard.
- The most effective practices for addressing phosphorus and sediment are: widespread conversion away from conventional and reduced tillage systems, grass field borders, grassed waterways, a series of in-lake-low flow dams, small farm ponds, lake shoreline stabilization, and nutrient management.

  - Shifting away from conventional or reduced tillage to no-till or strip-till will reduce 20% of the entire watershed phosphorus load, 26% of the sediment load and 23% of the nitrogen load.
- Installing one or two in-lake/low flow dam structures may achieve substantial total reductions; cost is a major consideration.
- An estimated expenditure of $8,892,622.00 is likely needed to meet the phosphorus standard.

Results of the Watershed Study

Table 1 - Waverly Lake & Watershed Problem Ranking

	Assessment Item	Summary	Ranking
Watershed	Landuse & Watershed Characteristics	Currently, cropland has the greatest water quality influence in the watershed. The watershed contains a relatively high percentage of forest and grassland.	**Medium**
	Nutrient & Sediment Loading	Nutrient and sediment loading from upland runoff is high. Crop ground in the watershed is responsible for the greatest percentage of the watershed's phosphorus and nitrogen load. Sediment loading from upland runoff is also highest from crop ground. Agricultural practices will be most effective in reducing sediment and nutrient loads to Waverly Lake.	**High**
	Landuse Change	The watershed is sparsely populated and there is little evidence that development will increase and lead to major changes in landuse.	**Low**
	Streambank Erosion	Streambank erosion is responsible for a moderate portion of the watershed sediment and phosphorus load. Although it is a natural process, bank erosion is severe at certain locations within the watershed's forested stream corridors. Due to access constraints and costs associated with stabilization, addressing other sources of sediment and nutrients should be prioritized	**Low**
	Gully Erosion	Gully erosion occurring in steep forest areas is significant and contributes a high sediment and nutrient load to the lake. Structures that stabilize these gullies should be a priority.	**Medium**
	Tillage & HEL Soils	Conventional and reduced tillage systems on crop ground in the watershed are common on 94% of all fields. Nutrient and sediment loading from these fields is responsible for the vast majority of the crop land loading. A shift away from conventional or reduced tillage may have the single greatest impact on improving water quality.	**High**
	Septic Systems	There are an estimated 93 homes with septic systems in the watershed. It is possible that up to 14 of these may be failing and contributing to phosphorus loading in the lake. A septic system inspection and maintenance program is recommended to verify if septic systems are an issue.	**Low**
	Landuse & Lake Characteristics	The majority of the land directly adjacent to the lake is well buffered and in forest or grass. The small amount of residential area near the lake does not appear to be significantly impacting water quality.	**Low**

	Assessment Item	Summary	Ranking
In Lake	Lake Sediment & Lake Sediment Nutrient Release	It is estimated that 243 lbs/yr of phosphorus is mobilized from lake sediment annually, whilst total sediment loading to the lake is over 7,000 tons/yr. A long-term objective should be to remove this accumulated sediment through dredging to also improve lake storage, however, contributions from the watershed are a priority.	**Low**
	Lake Shoreline	Lake shoreline erosion is responsible for 7% of the total phosphorus load and 9% of the total sediment load. Given the high delivery rates associated with shoreline erosion, stabilization of critical areas should be a priority.	**High**
	Chemical Water Quality	The state water quality data collected and analyzed since 1999 indicates a trend toward higher phosphorus and sediment concentrations. Nitrogen concentrations are low overall with a slight increasing trend since 2006.	**Medium**

Recommendations

Primary lake and watershed recommendations include:

1. Implement agricultural Best Management Practices (BMPs) that include: no-till/strip-till, field borders, grassed waterways, ponds in steep forested draws, and nutrient management. Other agricultural BMPs could include wetland restoration, grade control structures, cover crops, and pasture/livestock management systems. Locations adjacent to stream corridors or the lake and on steeper sloping ground should receive first priority.
2. Stabilize the most severely eroding shoreline segments.
3. Following treatment in the watershed to reduce inputs to the lake, install up to two in-lake/low-flow dams.
4. Determine if septic systems are failing or require maintenance.

Acknowledgements

- AquAeTer Inc. supported the TMDL calculations and relevant sections in the report.
- Benton & Associates, provided information and a narrative on lake and watershed history, a description of the Franklin wastewater plant and evaluated options for a series of low-flow/ in-lake dams.
- The City of Waverly provided support throughout. City staff met with watershed landowners and assisted with components of the watershed assessment.
- The Morgan County Natural Resource Conservation Service conducted landowner outreach and provided technical assistance concurrently with planning efforts.
- The Illinois Environmental Protection Agency provided support and direction throughout.
- Woody Woodruff of the Illinois Stewardship Alliance organized and hosted a cover crop workshop for local producers.
- The Franklin Outing Club.
- The Village of Franklin.
- All the watershed landowners and land managers that participated in and supported site visits.

1.0 Introduction

The Waverly Lake Watershed Implementation Plan (WIP) and Total Maximum Daily Load (TMDL) serves to characterize Waverly Lake and its watershed and define an achievable implementation strategy to address sediment and nutrient load reduction problems related to the lake.

Located in southeastern Morgan County between Franklin and Waverly, the Waverly Lake watershed area is 6,270 acres in size and includes the 107-acre public water supply reservoir. The Apple Creek Water Cooperative serves as the primary water and sewerage utility that is supplied by the City of Waverly. The reservoir is also an emergency water supply for the Village of Franklin, Illinois.

With 1,023 connections, average daily withdrawals from the lake are 180,000 – 230,000 gallons, fluctuating seasonally. Water quality samples dating back to 1999 have shown an increasing trend in phosphorus concentrations and consistent exceedences in the state's 0.05 mg/L total phosphorus standard.

This report includes the required TMDL and Watershed Based Plan components and is organized into the following sections:

- Section 2 – Lake and Watershed History
- Section 3 – Total Maximum Daily Load Overview
- Section 4 – Watershed Resource Inventory
- Section 5 – Pollutant Loading
- Section 6 – Sources of Watershed Impairments
- Section 7 – TMDL & TMDL Model Development
- Section 8 - Nonpoint Source Management Measures & Load Reductions
- Section 9 – Cost Estimates
- Section 10 – Water Quality Targets
- Section 11 – Critical Areas & Priority Projects
- Section 12 – Technical Assistance & Responsible Parties
- Section 13 –Implementation Milestones, Objectives, & Schedule
- Section 14 – Information & Education
- Section 15 – Water Quality Monitoring Strategy

1.1 Watershed Implementation Plan & TMDL

The Watershed Implementation Plan and TMDL components of this report are intended to be cohesive to achieve regulatory requirements whilst also addressing watershed and lake concerns that do not have regulatory drivers. The intent of this report is to deliver a road map to guide strategic implementation activities that will address reservoir capacity issues and water quality impairments resulting from sediment and nutrients, respectively. Phosphorus is the regulatory impairment for Waverly Lake for which a TMDL has been developed.

TMDL Background

The TMDL serves to define the maximum quantity of a pollutant that a water body can receive whilst still achieving water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (IEPA) must identify water bodies not achieving water quality standards and establish TMDLs for restoration of water quality. The IEPA publishes a list known as the "303(d) list" of water bodies not achieving water quality standards every two years. Water bodies on the 303(d) list are targeted for TMDL development.

A TMDL is a quantitative assessment of water quality impairments, contributing sources, and pollutant reductions needed to attain water quality standards. The TMDL specifies the amount of pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollutant control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body (CDM Smith, 2014).

Watershed Implementation Plan

The WIP provides a road map to achieve the TMDL objectives for phosphorus whilst also characterizing and addressing other watershed problems identified through analysis and stakeholder input. The WIP outlines regulatory and non-regulatory impairments, causes and sources, identifies critical areas, and recommends specific Best Management Practices (BMPs) and other management measures. It adheres to the United States Environmental Protection Agency's (USEPA) nine-minimum elements of a watershed plan

Inlet of Waverly Lake Looking Downstream

The primary components of the WIP are summarized below:

- Inventory and characterize the lake and associated watershed
- Identify and prioritize lake and watershed issues and concerns
- Quantify lake and watershed impairments (regulatory and non-regulatory)
- Establish nutrient and sediment reduction targets
- Identify critical areas and priority projects
- Directive for outreach, education and implementation to achieve targets
- Strategy for monitoring and measuring success

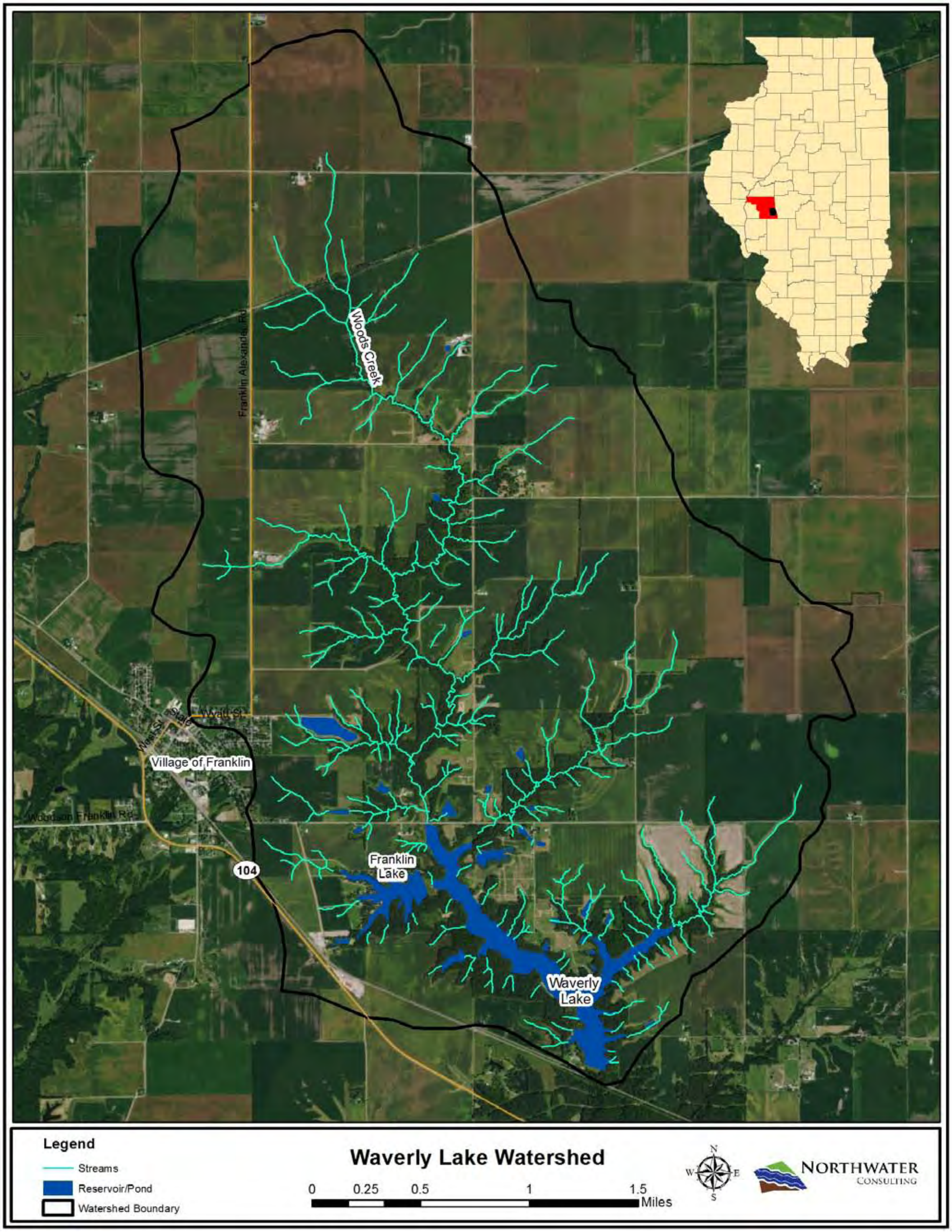

Figure 1 – Waverly Lake Watershed

2.0 Lake & Watershed History

Waverly Lake is the public water supply reservoir for the City of Waverly (2010 population, 1,307) and the Apple Creek Water Cooperative with Waverly as their parent supply. Waverly Lake also serves as an emergency supply for the Village of Franklin (2010 population, 610). The total number of water service connections is 1,023 (705 for Waverly and 318 for Apple Creek) and the average daily withdrawals from the lake are 180,000 – 230,000 gallons, fluctuating seasonally.


Waverly Lake Spillway

The reservoir was constructed in 1938 with an original estimated capacity of 100.5 million gallons (308 acre-feet). The spillway elevation when constructed in 1938 was 619 feet National Geodetic Vertical Datum (NGVD). Since the original date of construction, the spillway elevation has been raised twice. In 1960, it was raised three feet to 622 feet NGVD, giving the lake a capacity of 117.2 million gallons (359.6 acre-feet) and, more recently, in 1984, was raised an additional seven feet to its current elevation of 629 feet NGVD, giving the lake a capacity of 269.1 million gallons (825.4 acre-feet). Raising the elevation of the spillway increased the storage capacity of the reservoir, which was determined necessary due to the decreasing capacity resulting from sedimentation, and an increase in usage from the lake as a public water supply (ISWS, 2009).

Sedimentation surveys conducted on the lake confirmed that the capacity had diminished at a steady rate. The first survey was conducted by the Illinois State Water Survey (ISWS) in 1952 and determined that the capacity decreased from the original 100.5 million gallons in 1938 to 77.8 million gallons, a loss of 22.6% of the lake capacity and an annual average of 1.62 million gallons of capacity loss. A second sedimentation survey was conducted by Casler & Associates in 1971, eleven years after raising the spillway elevation the first time, and determined that the capacity of the lake had decreased from 117.2 million gallons in 1960 to 100.1 million gallons in 1971 for an annual average of 1.55 million gallons of capacity loss. A third sedimentation survey was conducted by Benton & Associates, Inc. in 1976 and determined that the capacity of the lake was 85.9 million gallons, an annual average of 2.84 million gallons of capacity loss since the 1971 study. The fourth and most recent sedimentation study was conducted by the ISWS in 2009, 25 years after the spillway was raised in 1984, and determined that the capacity had decreased by 38.6 million gallons over those 25-years, an annual average of 1.54 million gallons of capacity loss (ISWS, 2009). Figure 2 illustrates the bathymetry of Waverly Lake based on the 2009 ISWS assessment.

Due to the constant sedimentation documented since the first study in 1952, the City of Waverly has taken measures to help reduce the amount of sedimentation in and around the lake. In April 2001, the City installed riprap in locations where large amounts of erosion and sedimentation were occurring on the banks due to wave action. The City also installed aggregate ditch checks near the lake, and currently maintains a vegetated strip surrounding the lake on property owned by the City. A boat speed ordinance is enforced for the lake which limits speed to 5 mph.

Conservation practices were also implemented within the watershed of the lake. A 1984 study conducted by the United States Department of Agriculture (USDA) Soil Conservation Service recommended conservation measures to be implemented in the watershed to reduce the amount of sedimentation. Recommended practices included conservation tillage, terracing, grassed waterways and filter strips, and grade stabilization structures. These measures have been implemented to varying degrees in cooperation with landowners in portions of the watershed since the 1980s.

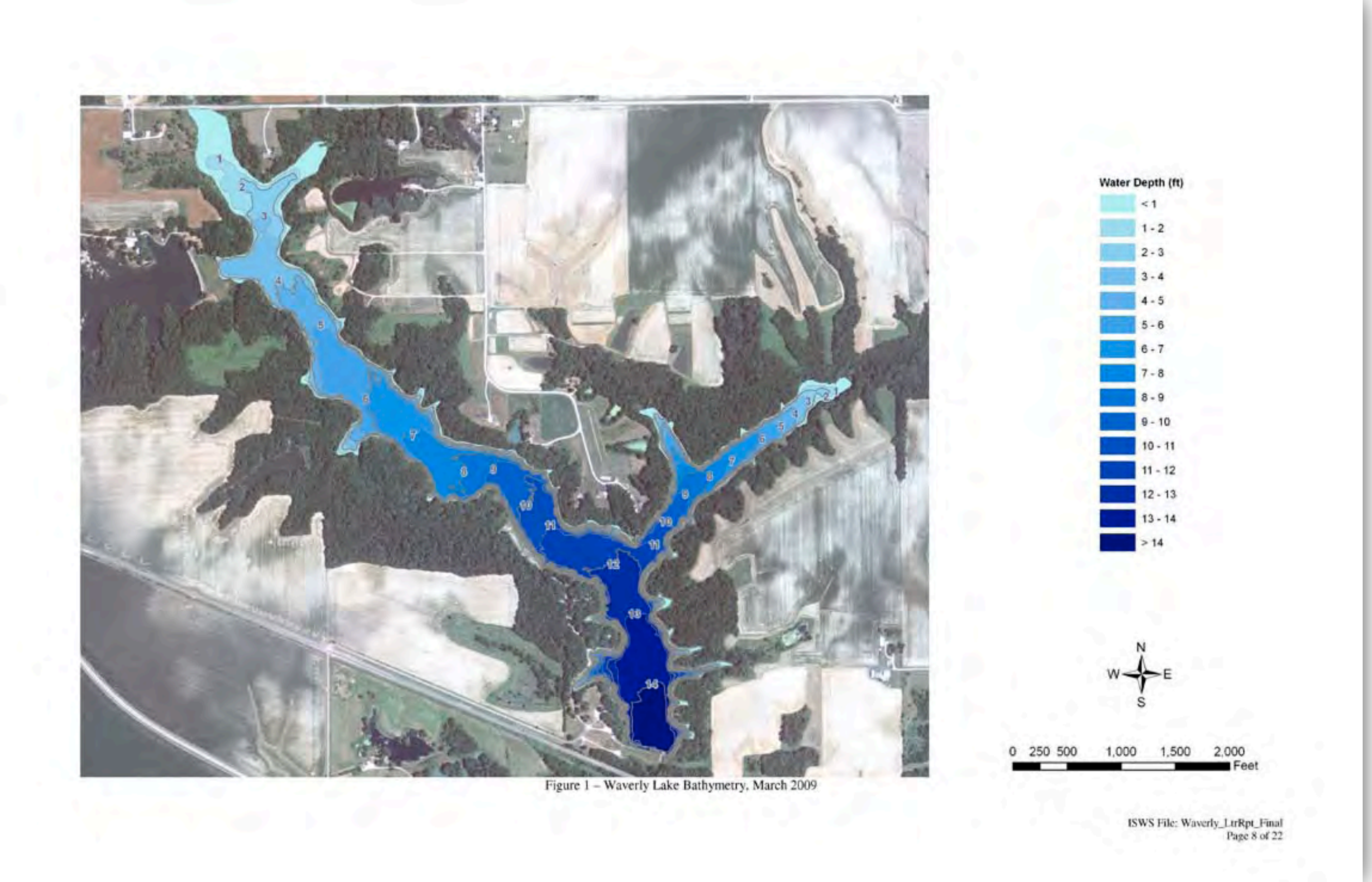

Figure 1 – Waverly Lake Bathymetry, March 2009

ISWS File: Waverly_LtrRpt_Final
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Figure 2 - Waverly Lake 2009 Bathymetry (ISWS, 2009)

Also relevant to the history of Waverly Lake is Franklin Lake, the second largest body of water in the watershed at 24 acres. Franklin Lake is located in the southwest section of the watershed and drains land to the south and east of Franklin. Around the turn of the century, Franklin was a thriving farming community, supported by the railroad. In 1905-1906, the reservoir was constructed to serve as a fill-up point for steam engines to support the railroad. In 1908, the Franklin Outing Club was formed to manage and oversee recreational activities on and around the lake. Around 1952, the lake became a popular seasonal destination; in 1961, the first owners to live year round purchased cabin No. 41 (Spradlin, 1979). Today, Franklin Lake remains an important recreational resource and the most densely populated area in the watershed.

3.0 Total Maximum Daily Load Overview

A TMDL is a calculation of the maximum quantity of a pollutant that a water body can receive whilst still achieving water quality standards. For the purposes of this report, the IEPA has included all lands upstream of the Waverly Lake spillway or outlet contained in the 12-digit U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) basin 071300110601. The 303(d) impaired water body segments in the Waverly Lake watershed are:

- Waverly Lake (IL_SDC) - Phosphorus

The Waverly Lake TMDL is developed for parameters that have numeric water quality standards. The only parameter in Waverly Lake with an associated numeric standard is total phosphorus. The TMDL for the segment listed above will specify the following elements:

- **Loading Capacity (LC)** the maximum amount of pollutant loading a water body can receive without violating water quality standards
- ***Waste Load Allocation (WLA)*** the portion of the TMDL allocated to existing or future point sources. Although WLAs are typical of most TMDLs, no point source discharges exist with the watershed and, therefore, a WLA will not be included in the TMDL calculations.
- **Load Allocation (LA)** the portion of the TMDL allocated to existing or future nonpoint sources and natural background.
- **Margin of Safety (MOS)** an accounting of uncertainty about the relationship between pollutant loads and receiving water quality.
- **Reserve Capacity (RC)** a portion of the load explicitly set aside to account for growth in the watershed.

These elements are combined into the following equation specific to Waverly Lake:

$$\mathbf{TMDL = LC = \Sigma LA + MOS + RC}$$

The TMDL development takes into account the seasonal variability of pollutant loads, so that water quality standards are met during all seasons of the year. Reasonable assurance that the TMDL will be achieved is detailed in this report.

3.1 Water Quality Standards, Guidelines, & Lake Impairments

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards consist of: a designated beneficial use or uses of a water body, the water quality criteria necessary to protect uses and an antidegradation policy. Examples of designated uses are primary contact (swimming), protection of aquatic life, and public and food processing water supply. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected (CDM Smith, 2014). The water quality general use standard that applies to Waverly Lake is **0.05 mg/L** for phosphorus (Title 35, Subchapter C, Part 302.205); designated use is aesthetic quality and public water supplies. Eighty-four samples collected by the IEPA within Waverly Lake since 1999 have exceeded this standard. According to the 2016 Illinois Integrated Water Quality Report and List of Impaired Waters, Waverly Lake is in full support the public water supply use and not supporting aesthetic quality.

The public water supply designated use is applied where there is the presence of an active public water supply intake and the assessment of this use is based on conditions in both treated and untreated water (IEPA, 2016). For freshwater lakes, the Aesthetic Quality Index (AQI) represents a point system used to assess the aesthetic quality designated use. The AQI represents the extent to which pleasure boating, canoeing, and aesthetic enjoyment are attained and is based primarily on physical and chemical water quality data. Three evaluation factors are used in establishing the number of AQI points; the higher AQI scores indicate increased impairment (IEPA, 2016):

1. Median Trophic State Index (TSI); data collected May-October and calculated from total phosphorus (at 1-ft depth), chlorophyll a, and Secchi disk transparency.
2. Macrophyte Coverage; average percentage of lake surface area covered by macrophytes during peak growing season
3. Nonvolatile Suspended Solids (NVSS) concentration; median lake surface NVSS concentration for samples collect at 1-ft depth (reported in mg/L)

Sediment, chemicals and nutrients have negatively affected the lake, and it is listed on the 2016 Illinois 303(d) impaired waters list for phosphorus and total suspended solids (TSS).

Table 2 - 2016 Waverly Lake Impairments

Priority	10 digit HUC	Water Body Name	Assessment ID	Water Size (acres)	Designated Use	Cause
Low	0713001106	Waverly Lake	IL_SDC	135	Aesthetic Quality	Phosphorus (Total),
Medium	0713001106	Waverly Lake	IL_SDC	135	Aesthetic Quality	Total Suspended Solids (TSS)

Although phosphorus is the primary lake impairment from a regulatory water quality standpoint, lake sedimentation and TSS is of particular concern. Phosphorus loading in agricultural watersheds is often significantly associated with erosion, as soils can have elevated phosphorus concentrations. Many phosphate compounds are not very soluble in water, therefore, most of the phosphate in natural systems exists in solid form (Bushman, Lamb, Randall, Rehm and Schmitt, 2002).

Significant quantities of phosphorus can also exist in accumulated lake sediment. The release of phosphorus from sediment plays an important role in the overall nutrient dynamics of shallow lakes and, even where external phosphorus loading has been reduced, internal phosphorus may prevent improvements in lake water quality. Numerous studies have shown that high phosphorus loading leads to high phytoplankton biomass, turbid water and often undesired biological changes (Sondergaard, Jensen and Jeppesen, 2003). Furthermore, lake sedimentation and reductions in water capacity can be problematic during extreme drought conditions. A water budget analysis suggests that Waverly Lake would be in a state of decline for roughly 30 months if 1952-1955 drought conditions were to reoccur (ISWS, 2009).

The IEPA has established non-regulatory water quality guidelines for a number of parameters. Water quality guidelines are target values used by IEPA during assessments for parameters that do not have numerical water quality criteria. The previous guideline for listing total suspended solids (TSS) for aquatic life in lakes is a non-volatile fraction of suspended solids or NVSS [TSS-volatile suspended solids (VSS)] greater than 12 mg/L. Although NVSS is only one of three evaluation criteria for determining the AQI, the maximum number points (15) is achieved when NVSS concentrations are greater than or equal to 15 mg/L.

Inlet of Waverly Lake Looking Upstream

4.0 Watershed Resource Inventory

The resource inventory summarizes watershed characteristics specific to Waverly Lake. It includes information on hydrology, landuse, soils, habitat and water quality, demographics and other relevant information specific to the watershed.

4.1 Location & Watershed Boundary

Waverly Lake and its 6,270-acre watershed are located in Morgan County within in the Woods Creek watershed, which encompasses 14,447 acres. For the purposes of this report, the IEPA has included all lands upstream of the Waverly Lake spillway or outlet contained in the 12-digit U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) basin 071300110601 (Figure 1). This 12-digit basin is contained within the Lower Illinois River HUC 8 watershed (07130011); the HUC 10 watershed code is 0713001106. Supplemental watershed delineation was not performed due to the relatively small size of the basin.

The headwaters of Woods Creek is approximately two miles northeast of the Village of Franklin. The creek meanders for 3.7 miles southward through heavily forested riparian areas before entering Waverly Lake just east of Franklin. Smaller, ephemeral and perennial streams and forested drainages also drain to Woods Creek and directly to Waverly Lake.

4.2 Lake Water Quality

As noted in Section 3.1, Waverly Lake is impaired for total phosphorus and has exceeded the standard of 0.05 mg/L on eighty-four occasions since 1999 (86% of samples). Although total phosphorus is the only impairment with a numeric water quality standard, other potential water quality issues exist in Waverly Lake. This section also summarizes water quality concerns related to nitrogen and TSS. Dissolved oxygen (DO), temperature, chlorophyll-a, Secchi depth and pH are also addressed as they are common lake water quality parameters.

Nutrient loading (phosphorus and nitrogen) to Waverly Lake is of particular importance as an increase in nutrient concentrations can lead to eutrophication and subsequent algae blooms. Lake and watershed pollutant loads and implementation recommendations described in this report will specifically address total phosphorus, total nitrogen and TSS.

The IEPA maintains three monitoring sites within Waverly Lake (Figure 3). All data presented in this section was obtained from the IEPA for a period from 1999-2015 and includes 1999, 2003, 2006, 2010 and 2015. Average annual results indicate a very slight trend of increasing total phosphorus, ammonia, TSS, total nitrogen, and a slight decrease in Secchi depth since 2006. Figures 4 through 9 display average concentrations of nitrogen, phosphorus, TSS, ammonia, Secchi depth, and chlorophyll-a between 1999 and 2015. Results represent averages from all three sampling locations at all depths within the lake.

Figure 3 - Waverly Lake IEPA Water Quality Monitoring Stations

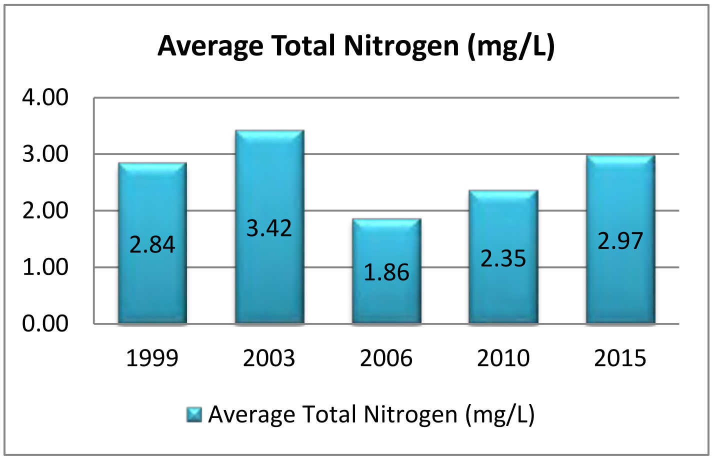


Figure 4 - Average Total Nitrogen 1999-2015

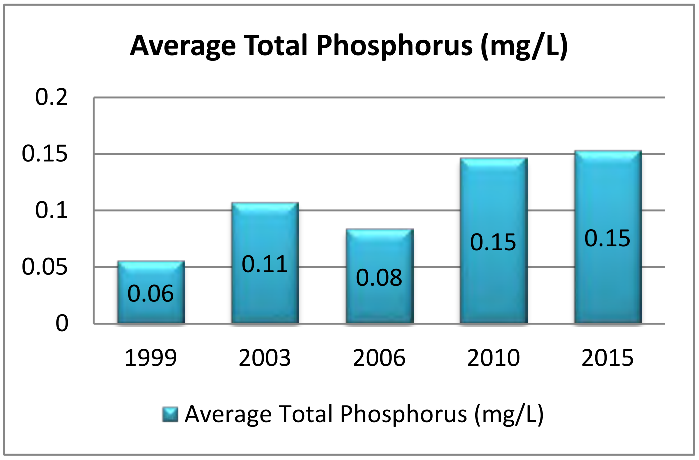


Figure 5 - Average Total Phosphorus 1999-2015

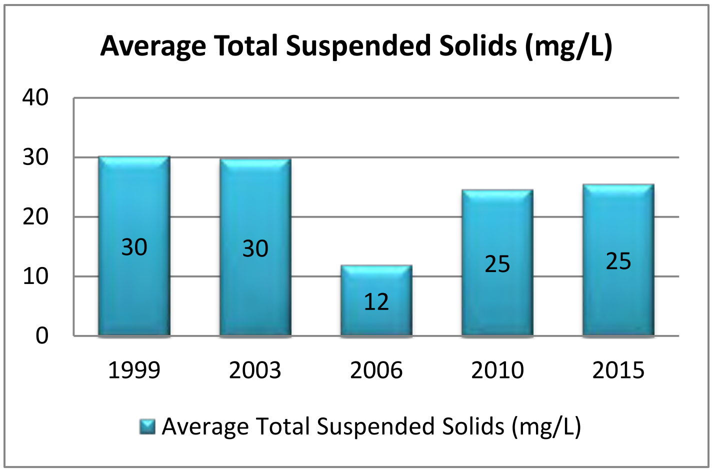


Figure 6 - Average Total Suspended Solids 1999-2015

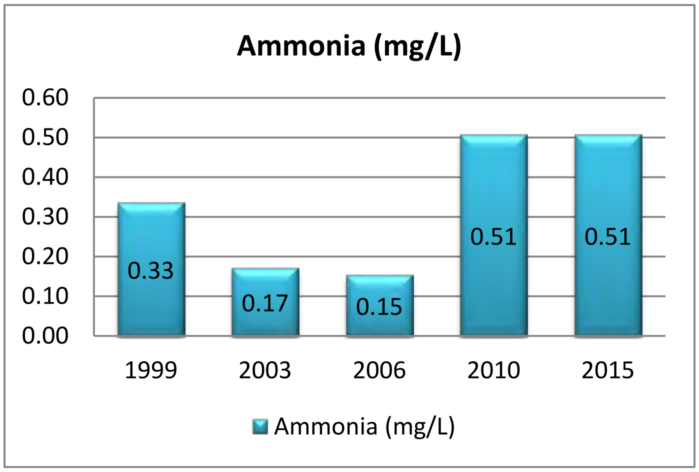


Figure 7 - Average Ammonia 1999-2015

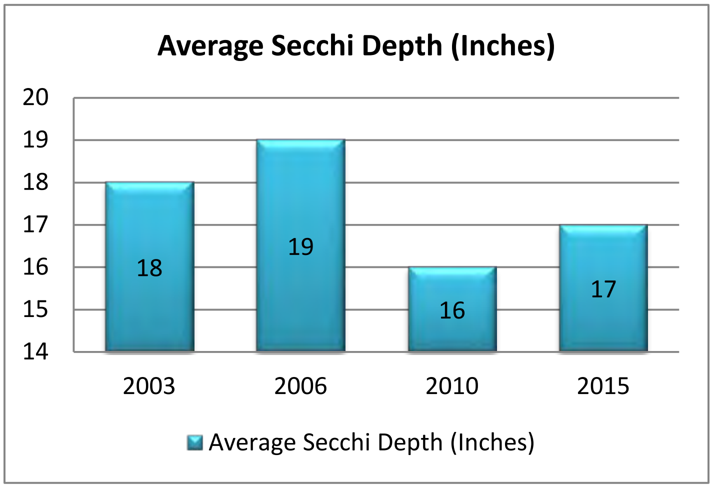


Figure 8 - Average Secchi Depth 2003-2015

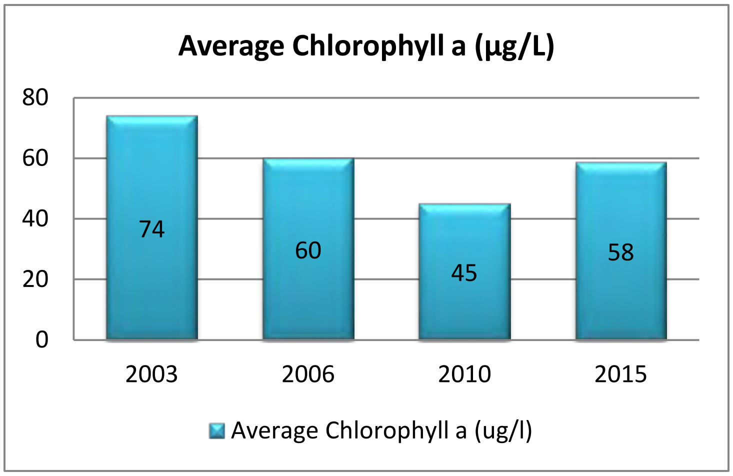


Figure 9 - Average Chlorophyll a 2003-2015

4.2.1 Phosphorus

Phosphorus is a major cellular component of organisms. Phosphorus can be found in dissolved and sediment-bound forms. However, phosphorus is often locked up in living biota, primarily algae. In the watershed, phosphorus is found in fertilizers and in human and animal wastes. The availability of phosphorus determines the growth and production of algae and makes it the limiting nutrient in the system. The more nutrients such as phosphorus present in a body of water, the more algae that will grow and form a bloom which can be harmful to water quality and aquatic health. Dissolved phosphorus is important because it is readily usable by algae and other plants. The two common forms of phosphorus are:

- **Soluble reactive phosphorus (SRP)** – is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae and cycled very rapidly. Sources of dissolved phosphorus include fertilizers, animal wastes, and septic systems.
- **Total phosphorus (TP)** – includes dissolved and particulate forms of phosphorus. According to Illinois water quality standards, total phosphorus must not be greater than 0.05 mg/L in lakes greater than 20 acres in size.

Total annual phosphorus concentrations in Waverly Lake routinely exceed the state water quality standard. Since 1999, the maximum, minimum and average concentration values have increased and the standard has been exceeded 86% of the time; all water quality samples exceeded the standard in 2003, 2010, and 2015. The highest TP values recorded each year have occurred in July. Table 3 lists the results of TP data collected between 1999 and 2015 organized as annual averages from all sites and depths.

Table 3 - Total Phosphorus Results - 1999-2015

Year	Max Value (mg/L)	Min Value (mg/L)	Average Concentration (mg/L)	# of Exceedences in Water Quality Std.	% Exceeded
1999	0.154	0.014	0.055	8	36%
2003	0.209	0.053	0.107	20	100%
2006	0.127	0.049	0.083	19	95%
2010	0.505	0.067	0.146	18	100%
2015	0.342	0.096	0.153	19	100%
Average	**0.267**	**0.056**	**0.109**	**17**	**86%**

Monthly average TP results between 1999 and 2015 are presented in Table 4; results represent averages from all sample sites and depths. Results indicate that the TP standard is exceeded for all samples in September. Excluding an incomplete dataset for September, results clearly show that the month of June experienced the largest number of TP exceedences followed by July, August, and October; April experienced the fewest number of exceedences. Maximum values and average concentrations are also highest in July. Average TP concentrations appear to be the lowest in October.

Table 4 - Total Phosphorus Results by Month - 1999-2015

Month	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)	Number of Exceedences in Std.	% Exceeded
April	0.127	0.04	0.074	12	71%
June	0.295	0.042	0.127	16	89%
July	0.505	0.036	0.137	23	88%
August	0.158	0.014	0.097	12	86%
September[1]	0.147	0.116	0.127	3	100%
October	0.121	0.041	0.081	18	86%

1 – Only 3 samples taken in September and these 3 samples occurred in 2010.

Table 5 summarizes TP results by monitoring station; results represent average values by year and depth. The highest average values are found at Station 1 near the dam (5-year average of 0.112 mg/L). The lowest average results are found at Station 3. It should be noted that no data exists at Station 3 for 2010 or 2015.

Table 5 - Total Phosphorus Results by Monitoring Station - 1999-2015

	Station 1		Station 2		Station 3	
Year	**Average Concentration (mg/L)**	**Number of Exceedences in Std./%**	**Average Concentration (mg/L)**	**Number of Exceedences in Std./%**	**Average Concentration (mg/L)**	**Number of Exceedences in Std./%**
1999	0.057	6/50%	0.06	1/20%	0.046	1/20%
2003	0.104	12/100%	0.103	4/100%	0.12	4/100%
2006	0.078	9/90%	0.087	10/100%	0.09	5/100%
2010	0.152	13/100%	0.131	5/100%	N/A	N/A
2015	0.171	14/100%	0.102	5/100%	N/A	N/A

Average dissolved phosphorus levels in Waverly Lake have increased since 2003. Between 2006 and 2015, the maximum recorded concentrations have increased, whereas minimum concentrations have decreased. Table 6 lists the results of dissolved phosphorus data collected between 1999 and 2015.

Table 6 - Dissolved Phosphorus - 1999-2015

Year	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)
1999	0.049	0.015	0.021
2003	0.057	0.003	0.011
2006	0.057	0.014	0.024
2010	0.104	0.009	0.031
2015	0.123	0.006	0.041
Average	**0.078**	**0.009**	**0.026**

4.2.2 Total Nitrogen & Ammonia Nitrogen

The various forms of nitrogen are of particular importance with respect to lake health. Inorganic forms of nitrogen are readily available by algae for growth and other forms of nitrogen, in high concentrations, can be toxic to fish and other aquatic organisms. The four common forms of nitrogen are:

- **Nitrite (NO2)** – is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to nitrate and in the reduction of nitrate.
- **Nitrate (NO3)** – generally occurs in trace quantities in surface water but may attain high levels in some groundwater. Nitrate travels easily through soil carried by water into surface waterbodies and groundwater. The current standard of 10 mg/L for nitrate nitrogen in drinking water is specifically designated to protect human health.
- **Ammonia (NH4)** – is present naturally in surface waters. Bacteria produce ammonia as they decompose dead plant and animal matter. In Illinois, the total ammonia general use standard is 15 mg/L.
- **Organic nitrogen (TKN)** – is defined functionally as organically bound nitrogen in the tri-negative oxidation state. Organic nitrogen includes nitrogen found in plants and animal materials, which includes such natural materials as proteins and peptides, nucleic acids and urea. In the analytical procedures, Total Kjeldahl Nitrogen (TKN) determines both organic nitrogen and ammonia. Raw sewage will typically contain more than 20 mg/L.

Total nitrogen is the sum of TKN (ammonia, organic and reduced nitrogen) and nitrate-nitrite and for the purposes of this report; the nitrate nitrogen standard of 10 mg/L is applied for total nitrogen. The highest recorded concentration occurred in April of 1999. No samples have exceeded the 10 mg/L standard since 1999, however, average concentrations have been increasing since 2006 following higher than average levels experienced in 1999 and 2003. Table 7 lists the results of total nitrogen data collected between 1999 and 2015.

Table 7 - Total Nitrogen - 1999-2015

Year	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)
1999	7.2	0.37	2.8
2003	5.4	1.0	3.4
2006	3.4	0.85	1.9
2010	4.2	0.72	2.4
2015	5.1	1.9	3.0
Average	**5.0**	**0.98**	**2.7**

As with total nitrogen, ammonia has remained consistently below the general use standard of 15 mg/L. The highest recorded value of 2.7 mg/L occurred in July of 2010. Average concentrations have increased since 2006 but remain relatively steady. Table 8 lists the results of ammonia data collected between 1999 and 2015.

Table 8 - Ammonia - 1999-2015

Year	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)
1999	1.3	0.03	0.33
2003	1.7	0.01	0.17
2006	0.38	0.03	0.15
2010	2.7	0.13	0.51
2015	1.3	0.23	0.51
Average	**1.5**	**0.09**	**0.33**

4.2.3 Total Suspended Solids

Total Suspended Solids is a water quality measurement which refers to the portion of total solids retained by a filter; whereas total dissolved solids (TDS) refers to the portion that passes through the filter. TSS includes both organic forms and inorganic forms and can be divided into volatile suspended solids (VSS), which include organic materials such as algae and decomposing organic matter and nonvolatile suspended solids (NVSS), which includes non-organic "mineral" substances (IEPA, 2016). TSS measurements and modeling are frequently used to represent sediment loading; TSS data presented includes both VSS and NVSS for data between 1999 and 2003; for 2006, 2010 and 2015 data, TSS values are provided.

With the exception of 2006, average annual TSS results exceed the 15 mg/L AQI maximum point score for suspended solids. In 1999 and 2003, all samples exceeded 15 mg/L; the majority of 2010 and 2015 results showed exceedences. The highest levels are typically observed in the spring and are associated with storm events and runoff. The average annual TSS concentration for Waverly Lake is 24 mg/L. Table 9 lists the results of TSS data collected between 1999 and 2015.

Table 9 -TSS - 1999-2015

Year	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)	# of Exceedences of 15 mg/L	% Exceeded
1999	44	18	30	23	100%
2003	52	15	30	25	100%
2006	18	4	12	2	10%
2010	98	8	25	13	72%
2015	59	12	25	17	89%
Average	**54**	**11**	**24**	**16**	**74%**

4.2.4 Dissolved Oxygen & Temperature

Dissolved oxygen (DO) is the gaseous form of oxygen available in the water and is essential for respiration of aquatic organisms (e.g., fish and plants). Although it is discussed in this section, DO is not listed as a cause of impairment in Waverly Lake. Dissolved oxygen enters water by diffusion from the atmosphere. It also enters as a byproduct of photosynthesis by algae and other plants. During the day, DO levels increase as a byproduct of photosynthesis, but as plant respiration continues throughout the night, DO levels drop. DO is also consumed during bacterial decomposition of plant and animal matter. Low levels of DO in the water do not provide adequate oxygen for aquatic organisms. Excessively high levels of DO in the water could be an indicator of excessive algae growth. Illinois's DO standard is no less than 5.0 mg/L; a standard intended to support natural ecological functions and resident aquatic communities.

Temperature affects overall water quality in a lake in several ways and is used to characterize the presence or absence of thermal stratification. Colder water holds more DO than warmer water. Higher temperatures can lead to increased photosynthesis and plant growth. Decomposition of greater quantities of organic matter causes increased biological oxygen demand.

Temperature and DO measurements were made by the IEPA at various depths (between 0 and 15 feet) from 1999 through 2015. Results presented in this section represent average results by depth range; 0-3 ft, 3-6 ft, 6-9 feet and greater than 9 feet. Generally, the lowest DO values are recorded during the summer months at depths greater than 9 feet when temperatures are higher.

Average DO in Waverly Lake remained consistently above the standard up to 6 ft in depth with the exception of 2015; it is important to note that half of the recorded values in 2015 are above the standard. An analysis of average DO and temperature for all years indicates that temperature has remained relatively consistent, whereas DO appears to show a slight decreasing trend at depths greater than 6 feet. Low average DO values are most prevalent in the 2015 data; this is likely a result of missing data for the month of October. Table 10 presents average temperature and DO values by depth in the lake.

Table 10 - Waverly Lake Average Temperature & DO by Depth

	Depth (0-3 ft)		Depth (3-6 ft)		Depth (6-9 ft)		Depth (< 9 ft)	
Year	**Average Temp (°C)**	**Average DO (mg/L)**	**Average Temp (°C)**	**Average DO (mg/L)**	**Average Temp (°C)**	**Average DO (mg/L)**	**Average Temp (°C)**	**Average DO (mg/L)**
1999	21.5	8.37	20.8	7.56	21.4	5.23	19.6	2.88
2003	20.3	9.16	19.7	7.13	19.3	4.05	17.7	2.40
2006	21.2	8.06	20.9	6.07	20.6	4.10	21.4	2.26
2010	24.3	10.07	23.1	7.49	21.8	4.19	18.5	1.50
2015	21.8	8.77	21.3	4.79	20.2	1.74	18.1	1.90
Average	**21.8**	**8.9**	**21.2**	**6.6**	**20.7**	**3.9**	**19.1**	**2.2**

4.2.5 pH

The acidity or alkalinity of water is measured using the pH scale. Water contains both hydrogen ions (H+) and hydroxide ions (OH-) and the relative concentrations of these ions determine whether it is acidic, neutral, or alkaline. pH is defined as –log [H+]. A low pH signifies an acidic medium, acids are defined as proton donors (lethal effects of most acids begin to appear at a pH of 4.5). A high pH signifies an alkaline medium, alkalis are defined as proton acceptors (lethal effects of most alkalis begin to appear at a pH of 9.5). Neutral pH is 7. The actual pH of a water sample indicates the buffering capacity of that waterbody. Illinois designates a water quality standard which supports aquatic life for pH as values between 6.5 and 9.0.

Values averaged among all three lake monitoring sites between 1999 and 2015 indicate a slight trend toward more neutral pH values. With the exception of 2010, at no point since 1999 has Waverly Lake experienced pH values outside of the 6.5-9.0 range. Higher or more alkaline pH values tend to be observed in the spring and early summer whereas lower or more acidic values are observed late summer and into the fall. Historical pH results are presented in Table 11.

Table 11 - Waverly Lake Historical pH

Year	Maximum pH	Minimum pH	Average pH
1999	8.53	6.78	8.0
2003	8.99	6.72	8.1
2006	8.7	7.5	8.15
2010	8.74	6.34	7.54
2015	8.59	7.29	7.96
Average	**8.71**	**6.93**	**7.95**

4.2.6 Secchi Disk Transparency

Secchi disk transparency refers to the depth to which the black and white disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments already on the bottom of the lake. Measurements reveal how deep sunlight can reach into the water and low Secchi transparencies can indicate a lack of available sunlight for the growth of algae and rooted aquatic plants in the eutrophic zone. In Illinois, there are no standards for Secchi Transparency, although the Illinois Department of Public Health suggests at least 48 inches of clarity for swimming safety.

Average results from all three sampling stations from 2003 through 2015 (1999 data unavailable) indicate a slight decreasing trend with respect to Secchi disk transparency. The average value over the 4 years of sampling is 18 inches or 1.5 feet. In Waverly Lake, low average Secchi disk transparency may be a limiting factor in the growth of algae and rooted aquatic plants. Data from 2010 represents a year when the Lake experienced the lowest values ranging from only 9 inches of transparency in June to 22 inches in July. The greatest overall depth of 26 inches was recorded on July 1, 2003. Table 12 lists average, minimum and maximum depth measurements.

Table 12 - Waverly Lake Historical Secchi Disk Transparency

Year	Max Depth (inches)	Minimum Depth (inches)	Average Depth (inches)
2003	26	12	18
2006	24	14	19
2010	22	9	16
2015	24	10	17
Average	**24**	**11**	**18**

4.2.7 Chlorophyll-*a*

Chlorophyll is the pigment in plants that allows them to create energy from light in a process called photosynthesis. Different forms of chlorophyll absorb a different wavelength of light and chlorophyll-*a* is found in all photosynthesizing plants. For this reason, the amount of suspended algae in a lake is commonly estimated using the chlorophyll *a* concentration (IEPA, 2016). Algae produce oxygen during daylight hours but use up oxygen during the night and again when they die and decay. Decomposition of algae also causes the release of nutrients to the lake, which may allow more algae to grow. Their processes of photosynthesis and respiration cause changes in lake pH, and the presence of algae in the water column is the main factor affecting Secchi disk readings (State of Washington, 2016).

Illinois' general lake assessment criteria suggests that chlorophyll-*a* levels greater than 55 µg/L (micrograms per liter) could "highly impair recreational lake use," while concentrations of 7-20 µg/L could cause slight impairment (IEPA, 2016).

Average results from all three sampling stations from 2003 through 2015 (1999 corrected chlorophyll data unavailable) indicate a slight decreasing trend in chlorophyll-*a* concentrations (Table 13).

Table 13 - Chlorophyll a - 2003-2015

Year	Maximum Chlorophyll-a (µg/L)	Minimum Chlorophyll a (µg/L)	Average (µg/L)	# of Exceedences in Criteria	% Exceeded
2003	159	38	74	8	57%
2006	104	24	60	9	64%
2010	81	20	45	4	40%
2015	97	33	58	4	40%
Average	**110**	**29**	**59**	**6.25**	**50%**

4.3 Watershed Jurisdictions & Demographics

The Waverly Lake watershed is entirely within Morgan County and, although it is the City of Waverly's water supply, only the City of Franklin lies within the watershed. No other incorporated or unincorporated areas exist within the watershed, with the exception of the small community surrounding Franklin Lake. An analysis of municipal boundaries indicates that the Village of Franklin encompasses 65 acres of the watershed (1%) and is located in the central-west section.

4.3.1 Watershed Jurisdictions & Jurisdictional Responsibilities

The City of Waverly is the primary entity responsible for watershed protection and the management and improvement of Waverly Lake. Excluding the lake, the city owns 177 acres of forested area adjacent to the lake (Figure 10). The Village of Franklin is responsible for those areas of the watershed that fall within its municipal boundaries. The small development surrounding Franklin Lake is managed by the Franklin Outing Club and is responsible for the area surrounding Franklin Lake, as well as the lake itself.

State or federally owned lands are not known within the watershed and, therefore, the U.S. Fish and Wildlife Service (USFWS), Illinois Department of Natural Resources (IDNR), or Illinois Nature Preserves Commission (INPC) does not hold any jurisdictional responsibilities within the basin.

The IEPA Bureau of Water regulates wastewater and stormwater discharges to streams, rivers, and lakes through the National Pollutant Discharge Elimination System (NPDES). No NPDES permits exist within the watershed.

The Morgan County Soil and Water Conservation District (SWCD), and the Natural Resources Conservation Service (NRCS), are both active in watershed protection activities through various conservation incentive programs as well as technical assistance and education and outreach to the agricultural community.

4.3.2 Demographics

According to 2010 Illinois Census data, the Village of Franklin has a population of 610, up from 586 in 2000; an increase of 4.1%. In contrast, the City of Waverly has a population of 1,307, down from 1,346 in 2000; a decrease of 2.9%. Franklin represents just 1.7% of Morgan County's population of 35,547, and Waverly represents only 3.7%. According to United States Census Tract data, median household income for the watershed is $51,632 and 15.3% of the population is over the age of 65. Population density is approximately 1,304 people per square mile. An analysis of 2015 aerial imagery for the watershed indicates that there are approximately 163 individual homes within the watershed, 67 of which are located within Franklin. Homes are scattered throughout the watershed with the greatest density within the Village of Franklin and on Franklin Lake (See Figure 10).

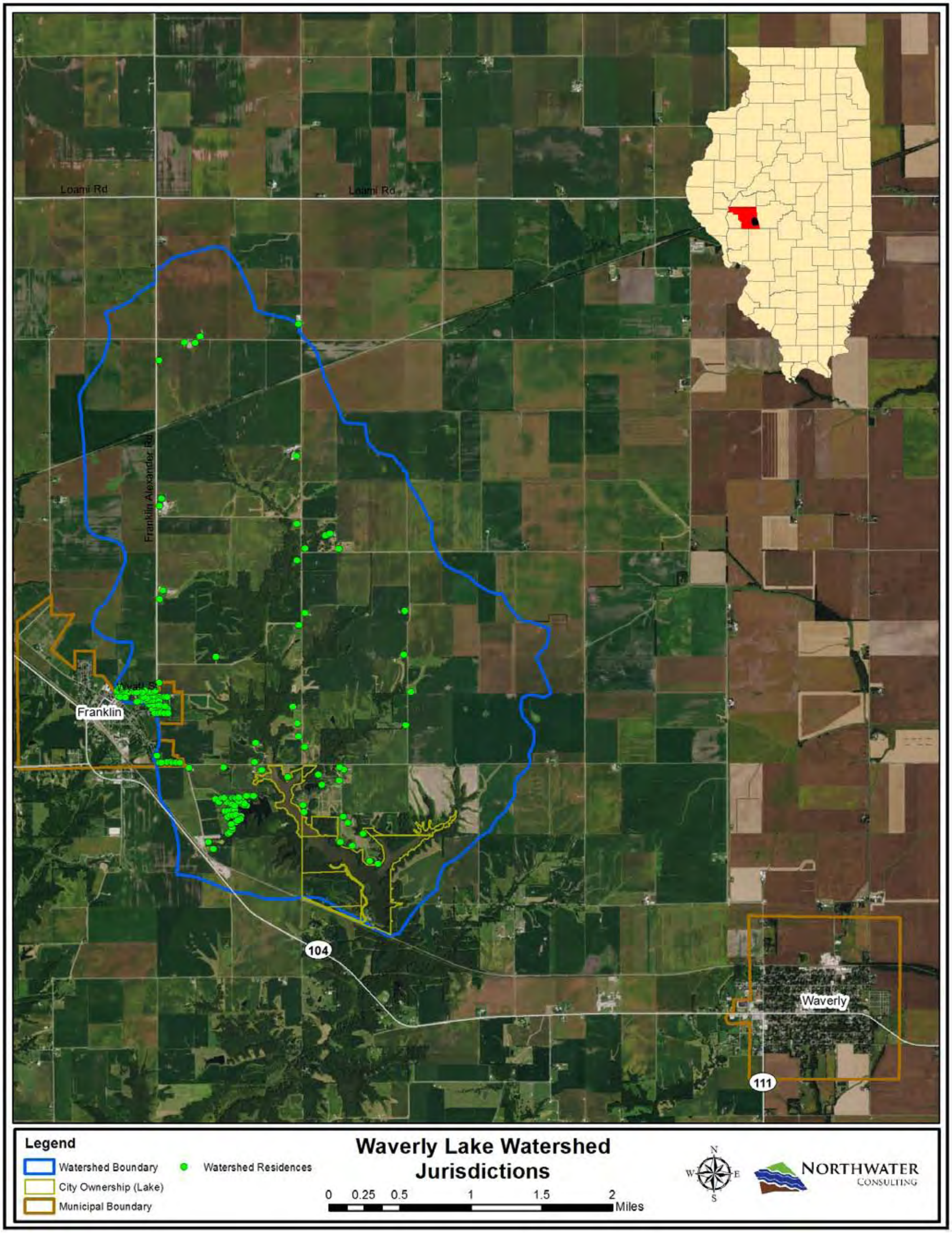


Figure 10 - Waverly Lake Jurisdictions

4.4 Geology, Hydrogeology & Topography

4.4.1 Geology

The Waverly Lake watershed is located in the northwest portion of the Springfield Till Plain region of Illinois in Morgan County. The surficial materials and hydrology of the watershed have been fundamentally shaped by glacial processes of deposition and erosion. The watershed is primarily covered with loess, a fine-grained windblown glacial deposit which is highly erodible on steeper slopes. Beneath this veneer of loess is typically a sandy or loamy glacial till with variable thickness and composition. The spatial extents and statistics of each surficial deposit type are illustrated in Figure 11 and Table 14.

Surficial geology was adapted from Illinois State Geologic Survey (ISGS) 1995 Stack-Unit mapping of the top 15 meters of earth materials. Drift thickness varies from less than 20 feet to over 49 feet and is generally thickest in the southern and western portion of the watershed. Underlying the unconsolidated deposits are the Pennsylvanian-aged Patoka, and Shelburn formations, which are locally primarily shale and sandstone bedrock. Bedrock is mapped within 20 feet of the ground surface in the eastern and northern portion of the watershed.

The widespread veneer of highly erodible and fine-grained glacial loess is a major potential source of sediment in the watershed.

Table 14 – Waverly Lake Watershed Surficial Geology

Surficial Geology	Bedrock Geology	Description[1]	Area (acres)	Percent of Watershed
Loess	**Shale**	Shallow loess with thick sandy and loamy Glasford till underneath. Pennsylvanian shale present within 15 m of surface.	750	11.8%
		Shallow loess with thin sandy and loamy Glasford till underneath. Pennsylvanian shale present within 6 m of surface.	1147	18.1%
	Sandstone	Shallow loess with thick sandy and loamy Glasford till underneath. Pennsylvanian sandstone present within 15 m of surface.	1471	23.2%
		Shallow loess with thin sandy and loamy Glasford till underneath. Pennsylvanian sandstone present within 6 m of surface.	2973	46.9%

[1] Adapted from Illinois State Geological Survey *Stack-Unit Mapping of Geologic Materials in Illinois to a Depth of 15 Meters*

4.4.2 Hydrogeology

There are estimated to be at least 15 private water wells within the watershed based on ISGS Wells and Borings database. There are no Community Water Supply (CWS) or Non-Community Water Supply (NCWS) wells found in the state database. Based on the limited dataset for private wells (Count=15), the average depth is 46 feet with a minimum of 28 feet and a maximum of 91 feet. An inferred average depth to water bearing units of 29 feet was calculated based on the ten wells, which denoted depth to top of screened interval.

The recorded wells are primarily located where the depth to bedrock is less than 20 feet and thus a majority of wells are believed to be completed in the bedrock units. Seven of the wells are zones mapped as sandstone bedrock, while eight are mapped in areas of shale bedrock. ISGS mapping for major sand and gravel aquifers and major bedrock aquifers show no regional sand and gravel or bedrock aquifers present in the watershed and, thus, it is assumed that most private wells are low-yielding and may also receive recharge from the overlying unconsolidated units.

Forested Draw Adjacent to Waverly Lake

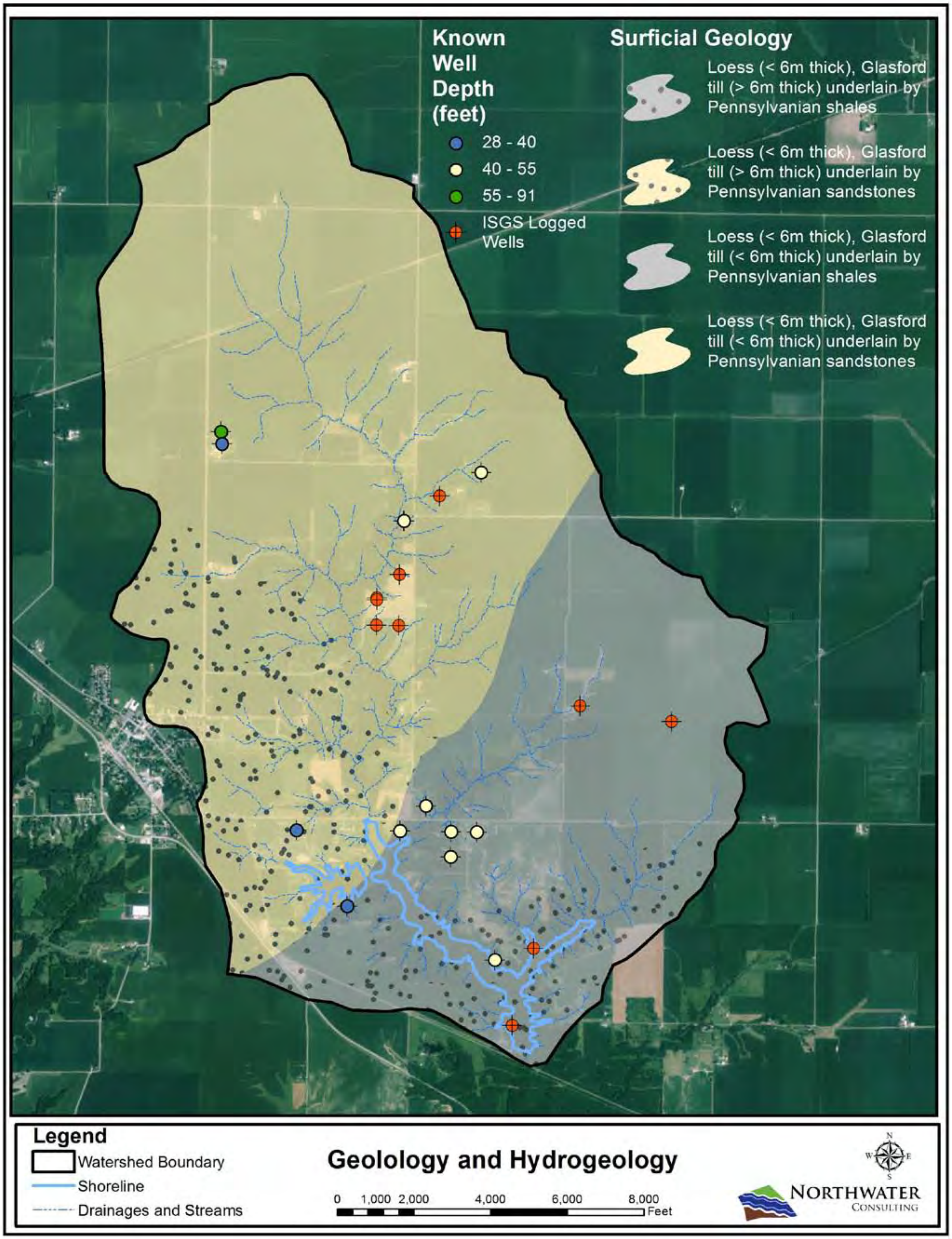


Figure 11 - Waverly Lake Watershed Geology & Wells

4.4.3 Watershed Topography & Relief

The Waverly Lake watershed is generally flat with steeper slopes throughout; the elevation ranges from 611 to 708 feet above sea level (Figure 12). The watershed is flatter in the headwaters or upland areas transitioning to steeper slopes adjacent to stream corridors and major waterbodies. The watershed has an average slope of 2.15% (1.23°) and a maximum percent slope of 24% (13.5°), as shown in Figure 13.

4.5 Climate

The Illinois State Water Survey (ISWS) maintains a weather station at Jacksonville (Station #114442). Long-term average annual precipitation (1930-2014) recorded at Jacksonville is 37.4 inches. From 2000-2014, average annual precipitation was 39.5 inches. The maximum annual precipitation was 60.05 inches (1993) and the minimum annual precipitation was 25.38 inches (1930). On average, there are 106.5 days with precipitation of at least 0.01 inch and 9.8 days with precipitation greater than 1 inch. Average snowfall is approximately 23.3 inches per year. Average maximum and minimum temperatures recorded at Jacksonville are 34.5° F and 16.0° F, in January and 86.6° F and 63.5° F in July (1970-2014 data). The average temperature recorded in January is 25.5° F and the average temperature recorded in July is 75.1° F.

Woods Creek

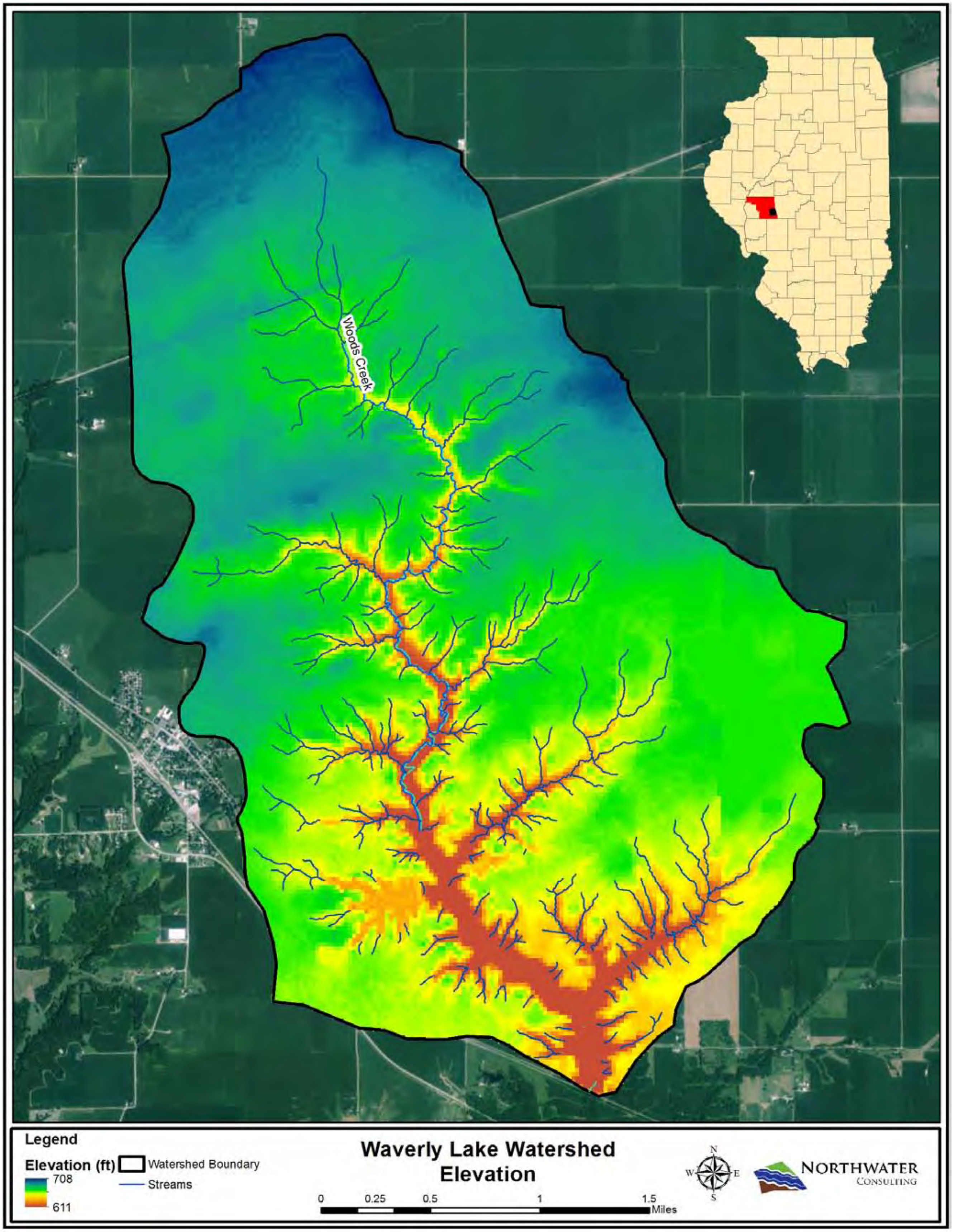


Figure 12 - Waverly Lake Watershed Elevation above Sea Level

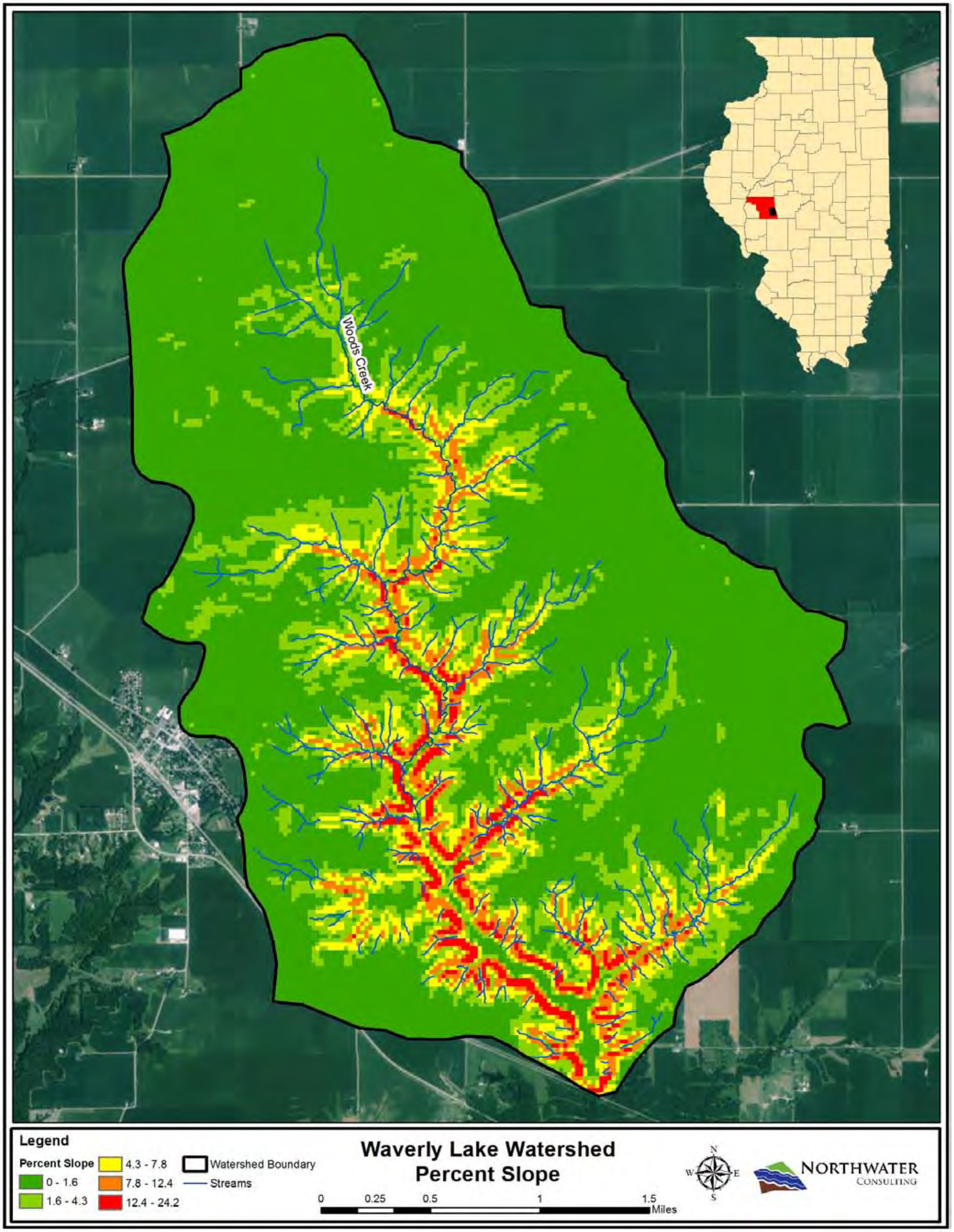


Figure 13 - Waverly lake Watershed Slope

4.6 Landuse

In order to better characterize watershed landuse and nonpoint source pollutants contributing to the lake impairments, a custom GIS landuse layer was created for the watershed (Figure 14). This layer was developed from 2015 aerial imagery and verified through field surveys. Table 15 summarizes landuse categories and coverage, and Figure 14 illustrates the distribution throughout the watershed. The predominant land use in the watershed is row crop agriculture. Cropland makes up 74% (4,620 acres) of the watershed area. Crops are primarily a corn-soy bean rotation with a very small number of fields in wheat. Forest and grassland cover approximately 17% of the watershed.

Table 15 – Waverly Lake Landuse

Landuse	Area (acres)	Percentage of Watershed
Row Crops	4,620	74%
Forest	725	12%
Grassland	343	5%
Urban Open Space	182	3%
Open Water Pond or Reservoir	163	3%
Pasture[1]	68	1%
Roads	50	1%
Residential Farm	31	0.5%
Urban Residential	18	0.3%
Open Water Stream	16	0.3%
Farm Building	16	0.2%
Wetland	14	0.2%
Railroad	11	0.2%
Industrial	6	0.1%
Warehousing	3	0.1%
Cemetery	2	0.03%
Feed Area	2	0.02%
Institutional	1	0.02%
Other Agriculture	1	0.02%
Confinement	1	0.01%
Total	**6,270**	**100%**

[1] – Exact livestock numbers are unknown; total number estimated to be 90-100

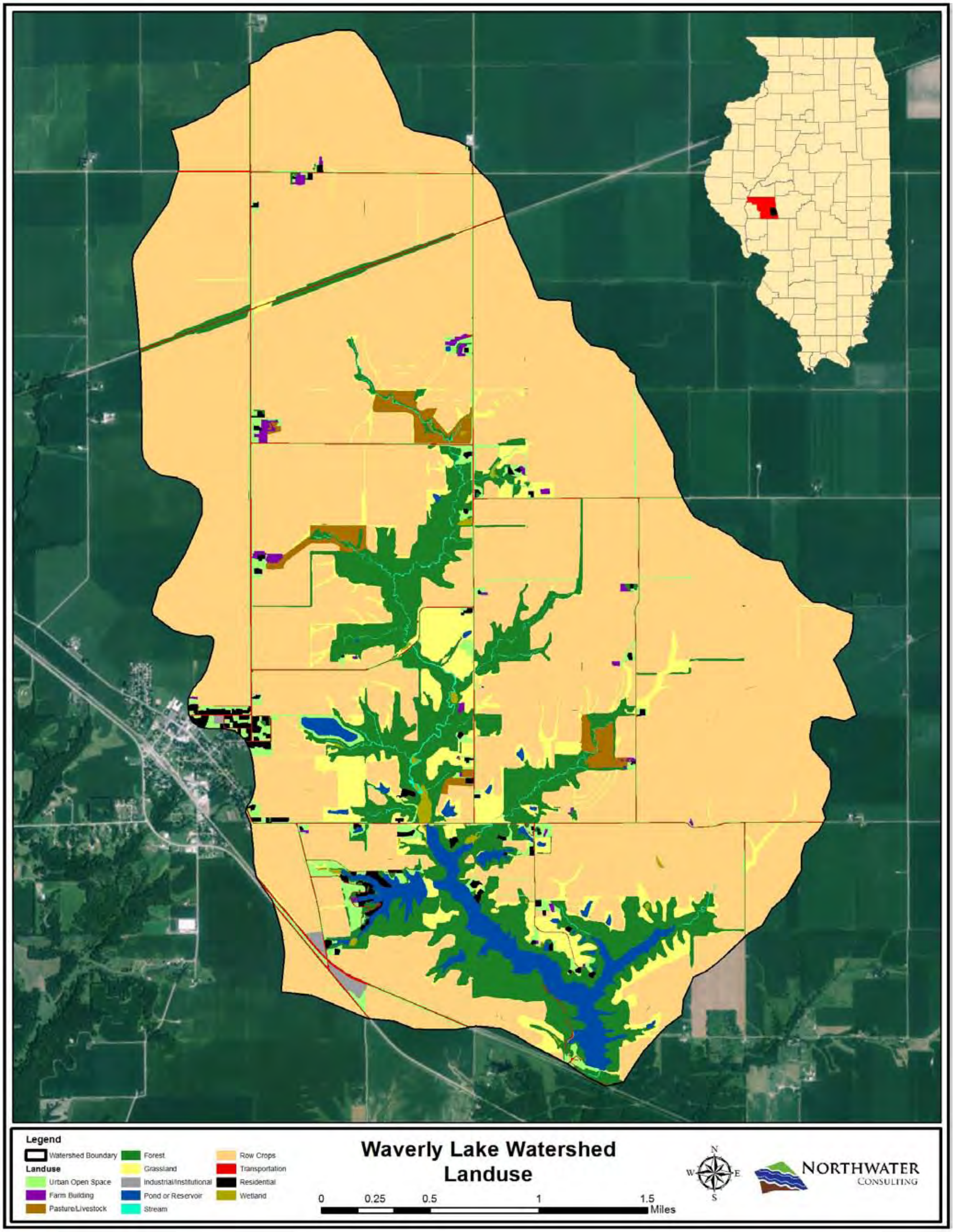


Figure 14 - Waverly Lake Landuse

4.7 Soils

Based on spatial and tabular soils data available online from the USDA National Cooperative Soil Survey, twenty-three unique soil types exist within the watershed (Table 16); the remaining two categories found within the soils database are water and earthen dam. Ipava silt loam is the most dominant soil type, accounting for 28% of the entire watershed, or 1,779 acres. Sable silty clay loam and Rozetta silt loam are also prevalent in the watershed and account for 19% (1,213 acres) and 15% (914 acres), respectively.

Ipava soils consist of somewhat poorly drained, slowly permeable soils on broad upland ridges and on side slopes along shallow drainageways. These soils are formed in loess or windblown sediment; slopes range from 0 to 5 percent. The Sable series consist of poorly drained, moderately soils on upland flats; Sables soils are also formed in loess and have slopes ranging from 0 to 2 percent. Rozetta soils are well drained, moderately permeable and are generally located on low terraces (NRCS, 1998). Ipava and Sable soils are located in the upper reaches of the watershed on flatter slopes where as Rozetta soils are generally found on steeper slopes near stream channels and within forested areas.

Table 16 - Waverly Lake Watershed Soils

Soil Type	Total Acres	Percent of Watershed
Ipava silt loam, 0 to 2 percent slopes	1,779	28%
Sable silty clay loam, 0 to 2 percent slopes	1,213	19%
Rozetta silt loam, 2 to 5 percent slopes	914	15%
Osco silt loam, 2 to 5 percent slopes	381	6.1%
Hickory loam, 18 to 25 percent slopes, eroded	347	5.5%
Rozetta silt loam, 5 to 10 percent slopes, eroded	337	5.4%
Keomah silt loam, 0 to 2 percent slopes	223	3.6%
Muscatune silt loam, 2 to 5 percent slopes	168	2.7%
Rozetta silty clay loam, 5 to 10 percent slopes, severely eroded	151	2.4%
Water	135	2.2%
Clarksdale silt loam, 0 to 2 percent slopes	128	2.1%
Elco silt loam, 18 to 25 percent slopes, eroded	98	1.6%
Osco silt loam, 5 to 10 percent slopes, eroded	89	1.4%
Elco silt loam, 10 to 18 percent slopes, eroded	75	1.2%
Elco silty clay loam, 10 to 18 percent slopes, severely eroded	53	0.85%
Virden silty clay loam, 0 to 2 percent slopes	50	0.79%
Lawson silt loam, 0 to 2 percent slopes, frequently flooded	31	0.50%
Hickory silt loam, 18 to 35 percent slopes	30	0.48%
Assumption silt loam, 5 to 10 percent slopes, eroded	25	0.40%
Hartsburg silty clay loam, 0 to 2 percent slopes	11	0.18%
Fayette silty clay loam, 10 to 18 percent slopes, severely eroded	9.7	0.16%
Wakeland silt loam, 0 to 2 percent slopes, frequently flooded	7.7	0.12%
Earthen dam	6.4	0.10%
Denny silt loam, 0 to 2 percent slopes	3.9	0.06%
Buckhart silt loam, 2 to 5 percent slopes	3.1	0.05%

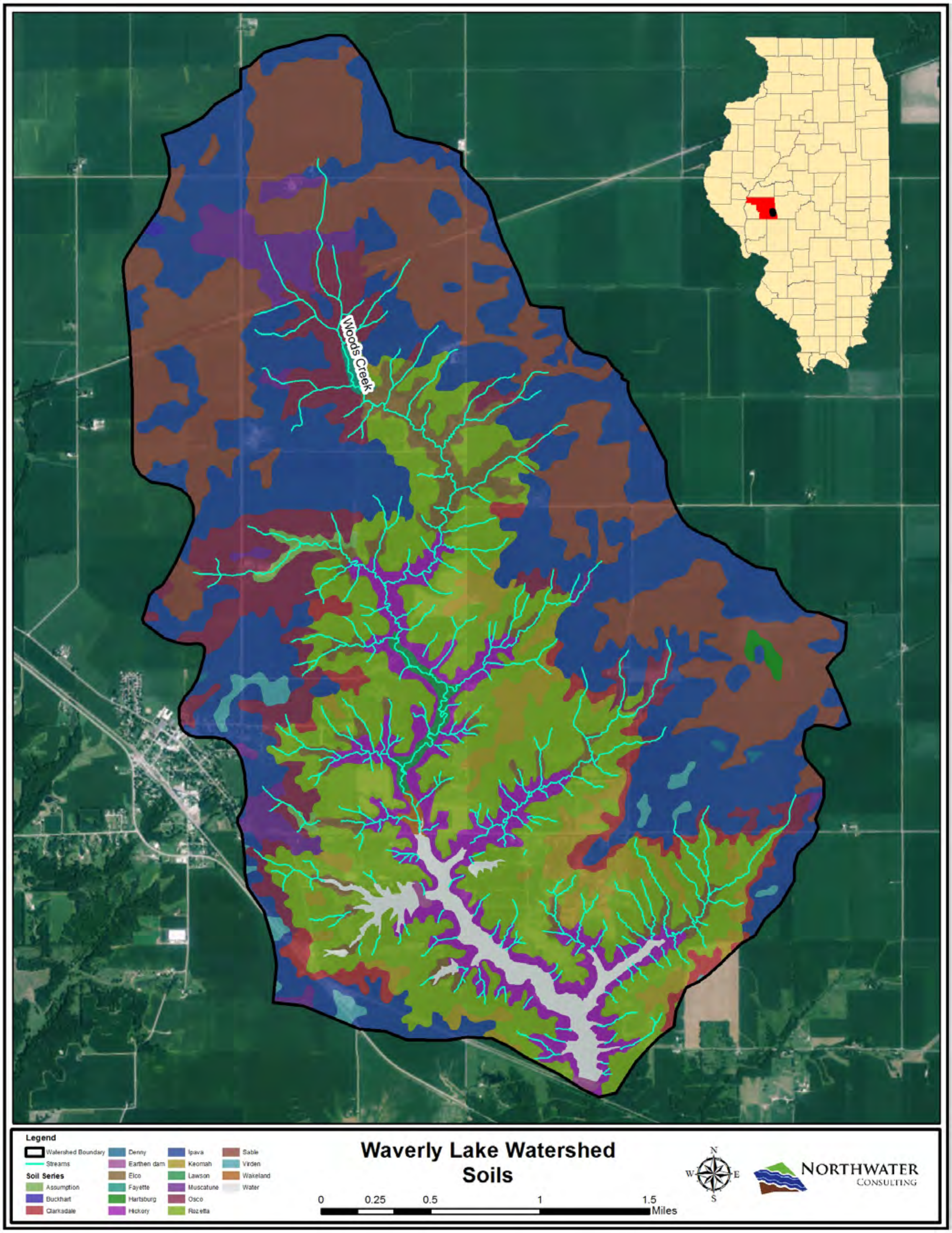


Figure 15 - Waverly Lake Watershed Soils

4.7.1 Highly Erodible Soils

As defined by the NRCS, a highly erodible soil, or soil map unit, has a maximum potential for erosion that equals, or exceeds, eight times the tolerable erosion rate. The maximum erosion potential is calculated without consideration to crop management or conservation practices, which can markedly lower the actual erosion rate on a given field.

The Waverly Lake watershed contains 1,215 acres of highly erodible soils representing 19% of the total watershed area (Table 17 and Figure 15). The location and extent of highly erodible soils were identified using the USDA-NRCS SSURGO database and the Morgan County frozen soils list. These soils are generally located immediately adjacent to streams and in steep forested or grassed areas. A small percentage of these soils are being cropped as described in Section 7.

4.7.2 Cropped Highly Erodible Soils

According to the NRCS, Highly Erodible Land (HEL) is cropland, hayland or pasture that can erode at excessive rates, containing soils that have an erodibility index of eight or higher. If a producer has a field identified as highly erodible land and wishes to participate in a voluntary NRCS cost-share program, that producer is required to maintain a conservation system of practices that maintains erosion rates at a substantial reduction of soil loss. Fields that are determined not to be highly erodible land are not required to maintain a conservation system to reduce erosion.

Table 17 - HEL & Cropped HEL Soils

Watershed Area (Acres)	Acres HEL Soils	Acres Cropland	Acres Cropped HEL	% of Watershed as HEL	% of Watershed as Cropped HEL	% Cropped Soils HEL
6,270	1,215	4,620	294	19%	5%	6%

Of the 4,620 acres of crop ground in the watershed, 6%, or 294 acres (5% of the entire watershed), are considered HEL and could be targeted for erosion control measures, if necessary. Cropped HEL soils and tillage practices are further discussed in Section 6.

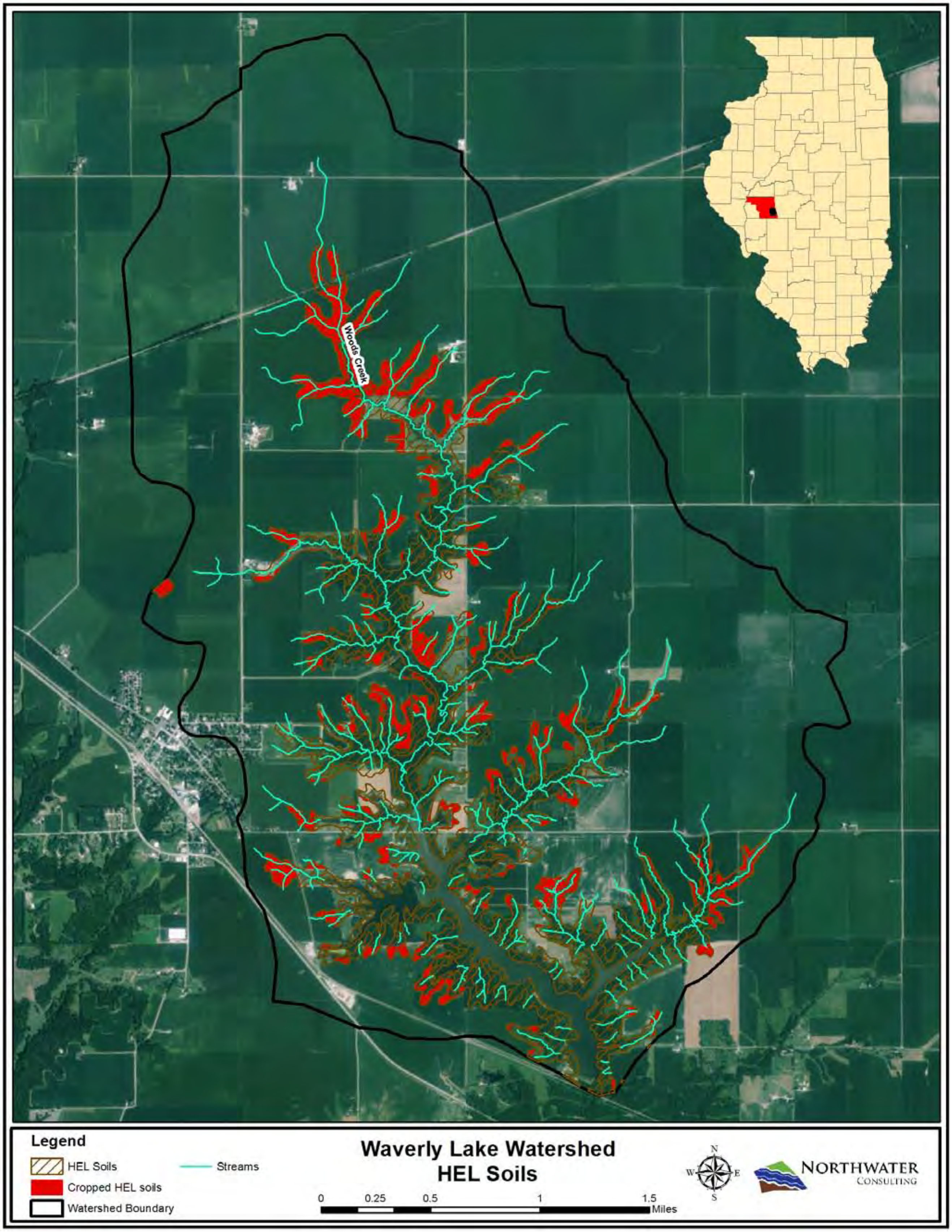


Figure 16 - Waverly Lake Watershed HEL & Cropped HEL Soils

4.7.3 Hydric Soils

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation (NRCS, 2014).

Hydric soils are scattered throughout the watershed and are an indicator of former wetlands and potential areas for wetland development. These soils are typically wet and will flood if proper drainage, overland or through field tiles, is not available. There are six different hydric soils within the watershed totaling 1,356 acres and are located primarily in the flat, upper reaches of the watershed and low lying areas directly upstream of the lake. Table 18 provides a breakdown of area of hydric soils and Figure 17 indicates the location of hydric soils within the watershed. As an indicator of the potential for wetland development, understanding where hydric soils are located can inform wetland restoration and creation activities.

Table 18 - Waverly Lake Hydric Soils

Hydric Rating	Acres	% of Watershed
Yes	1,356	22%
No	4,779	76%
Unclassified (water)	135	2%

4.7.4 Hydrologic Soil Groupings

The NRCS has classified soils into four hydrologic soil groups based on the infiltration capacity and runoff potential of the soil. The soil groups are identified as A, B, C, and D. Group A has the greatest infiltration capacity and least runoff potential, while group D has the least infiltration capacity and greatest runoff potential. In its simplest form, hydrologic soil group is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable or depth to a water table, if present (USDA, 2007). For those soils with two groups, certain wet soils are tabulated as D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition (USDA, 2007).

Hydrologic soils grouping information presented in this section represents the most up-to-date spatial and tabular data available (10/9/15) for download through the USDA National Cooperative Soil Survey and may differ from what is available or being used by local NRCS staff and watershed partners.

Table 19 provides a breakdown of hydrologic groupings and Figure 18 illustrates the distribution of hydrologic soil groups within the watershed.

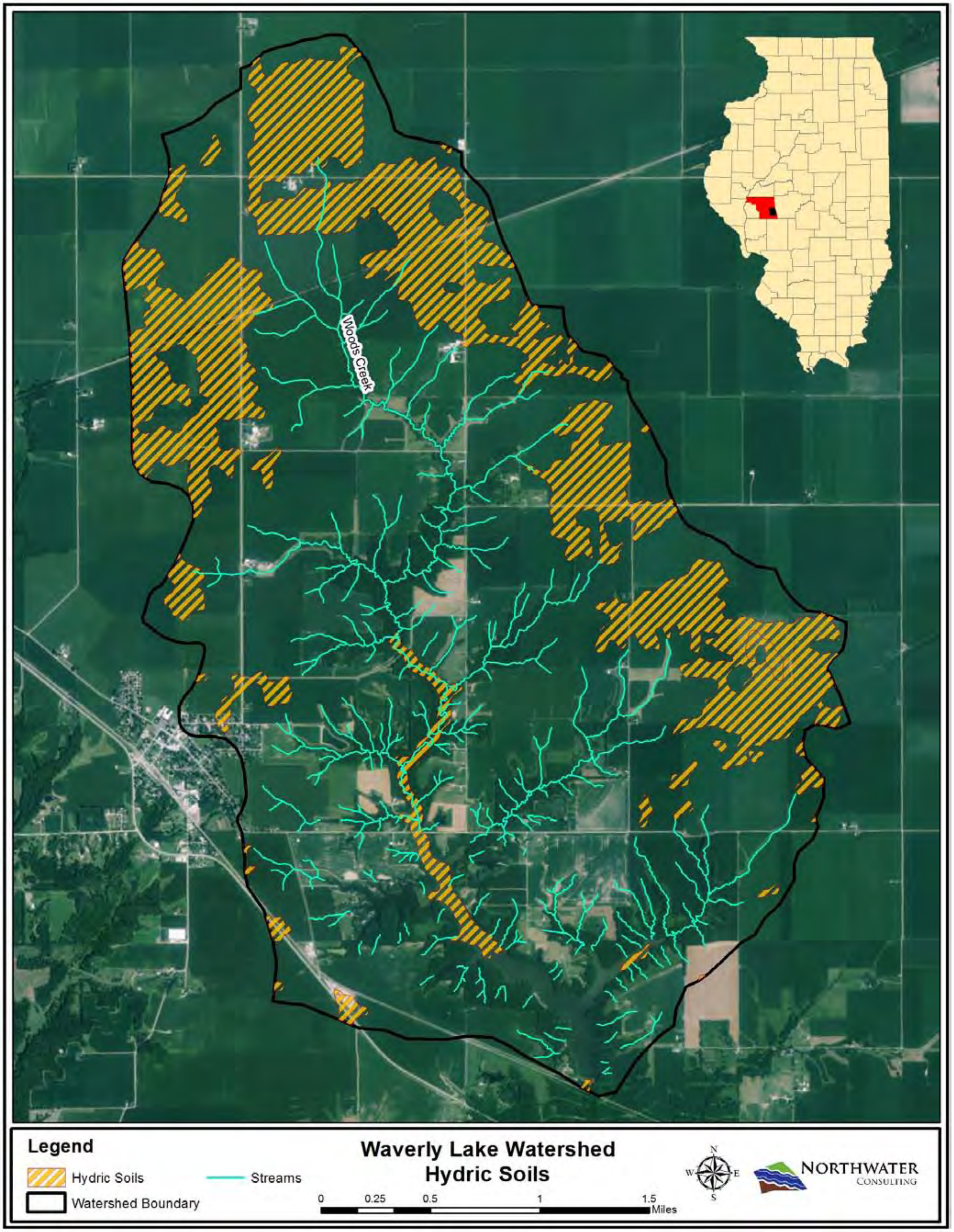


Figure 17 - Waverly Lake Watershed Hydric Soils

Table 19 - Waverly Lake Hydrologic Soils Groupings

Hydrologic Group	Acres	% of Watershed
B	2,264	36%
B/D	1,432	23%
C	255	4%
C/D	2,185	35%
Unclassified (water)	135	2%

The Waverly Lake watershed is dominated by B group soils which make up 59% of all watershed soils. Group C soils encompass 39% of the watershed indicating that a relatively high percentage of soils with moderately high rates of runoff. A further analysis of soil hydrologic groups indicates that 54% (2,492 acres) of all cropped soils are B or B/D group soils and 45% (2,080 acres) are C or C/D soils and likely drained. Tile drainage is discussed in Section 4.10.

4.7.5 Septic System Suitability

Not all soil types support septic systems and improperly constructed systems can lead to failure and allow leaching of wastewater into groundwater and surrounding waterways. An analysis of the USDA national soils dataset indicates that 68%, or 4,248 acres (Table 20) of the watershed, has soils classified as “very limited” with respect to septic suitability. This does not necessarily indicate that all of the soils are unsuitable for septic systems but special consideration is required when establishing systems within most of the watershed. Figure 19 illustrates the extent of limiting soils for septic fields along with the location of homes within the watershed. Including those homes within the Village of Franklin, a total of 83 residences (51%) are located on soils classified as very limited for septic systems.

Table 20 - Waverly Lake Septic Soil Suitability

Septic Suitability	Acres	% of Watershed
Very limited	4,248	68%
Somewhat limited	1,881	30%
Not rated	141	2%

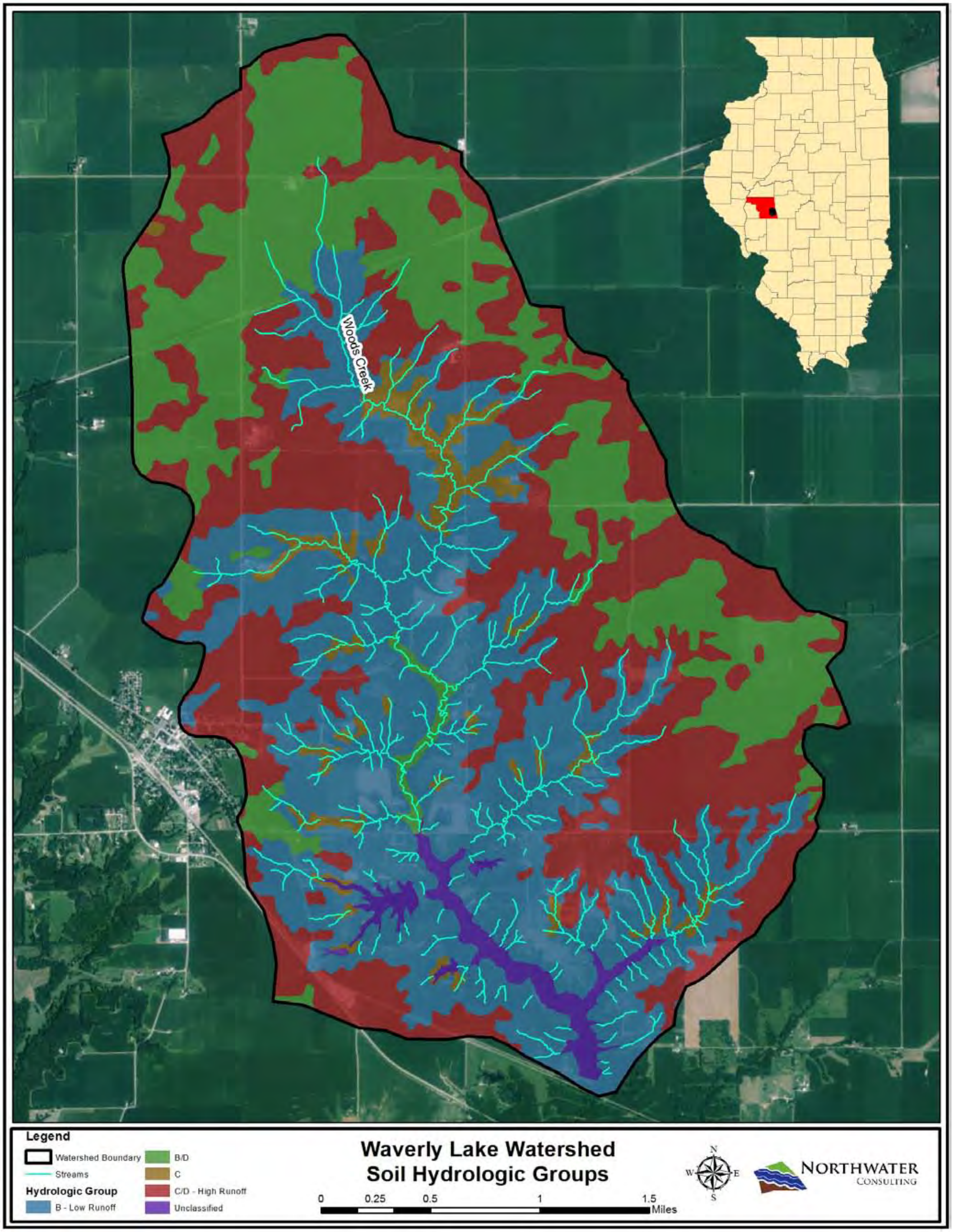


Figure 18 - Waverly Lake Watershed Hydrologic Soil Groupings

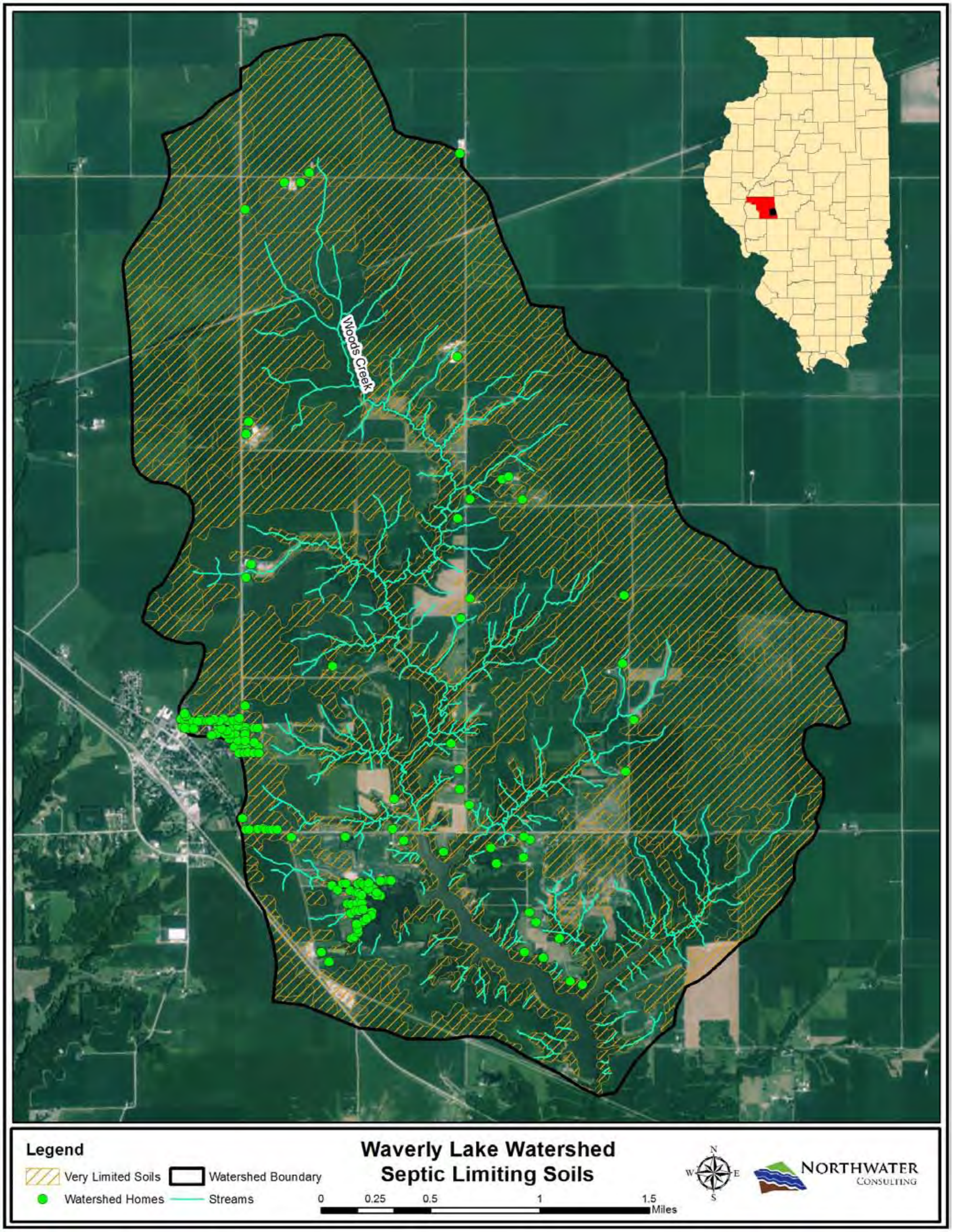


Figure 19 - Waverly Lake Watershed Septic Limiting Soils

4.8 Tillage

According to the 2015 Morgan County tillage transect survey, approximately 59.2% of the corn and 3.5% of the soybean croplands are tilled using conventional tillage methods that leave little or no residue on the surface. An additional 13.5% of the corn cropland and 15.1% of the soybean cropland are tilled by reduced tillage methods, which can reduce soil loss in comparison to conventional methods by 30%.

The remaining 27.3% of corn cropland and 81.4% of soybean cropland are planted using mulch-tillage methods, or without any tillage. Mulch-till methods leave 30% residue of the previous year's crop on the land and can reduce soil loss by 75%. These two conservation tillage systems can significantly reduce soil loss in the watershed.

Northwater performed a detailed field-based assessment of watershed tillage practices in the spring of 2016 in order to better characterize the current conditions. Tillage specific to the Waverly Lake watershed falls into four categories: Conventional, Reduced, Spring-Till, and No-Till (Table 21 and Figure 20).

Table 21 - Waverly Lake Watershed Tillage

Conventional Tillage		Reduced Tillage		Spring Tillage		No Tillage	
Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils
1,323	29%	2,826	61%	184	4%	287	6%

Conventional Tillage

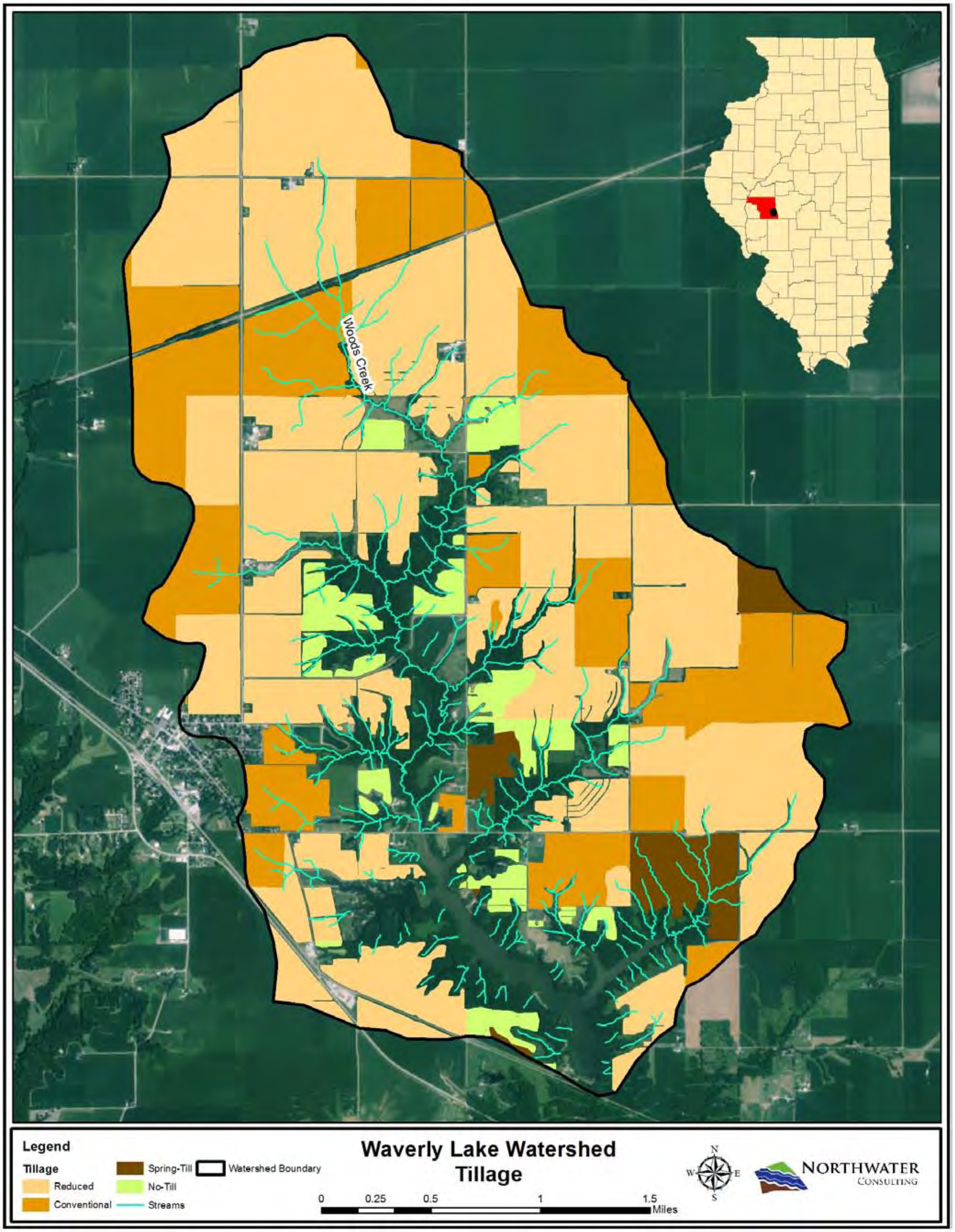


Figure 20 - Waverly Lake Watershed Tillage

4.9 Existing Conservation Practices

Existing management practices within the watershed are extensive and vary by individual property. Although the complete extent was not documented, numerous producers have taken advantage of federal or state cost-share programs or have implemented conservation practices on their own, independent of any state or federal program. Based on a series of site visits and an evaluation of 2015 aerial imagery, there are approximately 21 acres of land in the watershed enrolled in the Conservation Reserve Program (CRP); no land within the watershed is enrolled in the Conservation Reserve and Enhancement Program (CREP). Some structural BMPs, such as grassed waterways, filter strips, water and sediment control basins (WASCB), terraces or ponds, have been applied to treat approximately 4,685 acres within the watershed, or 74% of the entire watershed (Table 22 and Figure 21).

It is important to note that each practice varies in its ability to effectively remove pollutants, however, these practices appear to be providing benefits to lake water quality. With relatively large reductions required to meet the phosphorus standard in Waverly Lake, areas of high loading still exist and should be addressed. This is especially true where sediment and nutrient loading is the greatest or where pollutants may bypass existing BMPs such as nitrogen in tile water bypassing a filter strip.

Table 22 - Existing Watershed Best Management Practices

Best Management Practice	Number	Acres	Estimated Area (acres) Treated
Pond	28	56	537
WASCB/Basin/Grade Control	159	N/A	997
Grassed Waterway[1]	40	48	1,770
Field Border/Filter Strip	29	29	1,381
Total	**253**	**133**	**4,685**

1 - A grassed waterway is designed to reduce erosion in a concentrated flow area, such as in a gully or in ephemeral gullies, and reduce sediment and nutrients delivered to receiving waters. Vegetation also reduces runoff and filters some of the sediment and nutrients delivered to the waterway; however, filtration is a secondary function of a grassed waterway.

Cover Crops

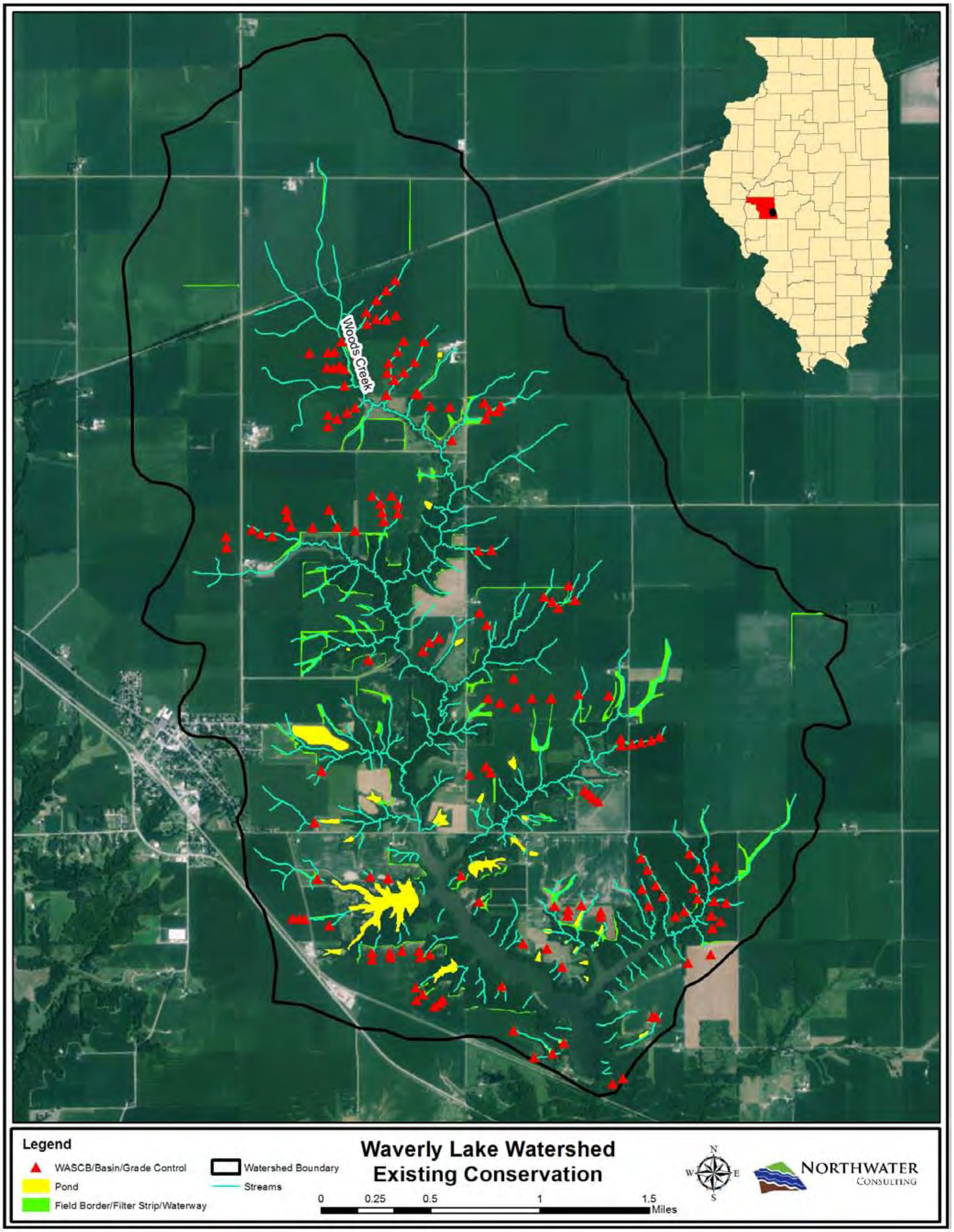


Figure 21 – Existing Conservation Practices

4.10 Hydrology & Drainage System

There are no USGS stream-flow gages in the watershed and, therefore, no historical data on stream flow is available. Woods Creek is the primary named stream draining to Waverly Lake and all other tributary drainages are unnamed. Due to limitations with the accuracy of the National Hydrography Dataset (NHD), a custom-generated GIS layer was generated to better represent the actual wetted extent of Woods Creek. Based on this layer, the wetted extent of Woods Creek is 19,304 feet, or 3.7 miles in length, and can be classified as a perennial stream. All remaining tributaries, forested gullies or subsurface drainageways in the watershed can be considered intermittent or ephemeral and account for an additional 205,992 feet, or 39 miles, according to the NHD.

An analysis of Woods Creek at its confluence with Waverly Lake using the USGS StreamStats system indicates that estimated peak flows range from 624 cubic feet per second (ft^3/s) for a 2-year recurrence interval to 4,040 ft^3/s for a 500-year recurrence interval. Five-year peak flows are estimated to be 1,150 ft^3/s and 10-year peak flows are 1,550 ft^3/s. These estimates are based on a 7.71 square-mile drainage area and a stream slope of 13.72 feet per mile.

Open water ponds and reservoirs are scattered throughout the watershed totaling 163 acres, or 2.6% of the watershed. These open water areas range in size from 107 to 0.05 acres with the majority concentrated around Waverly Lake. Waverly Lake is the largest body of water at 107 acres; Franklin Lake is the second largest at 24 acres. The watershed drainage system is depicted in Figure 22.

Woods Creek

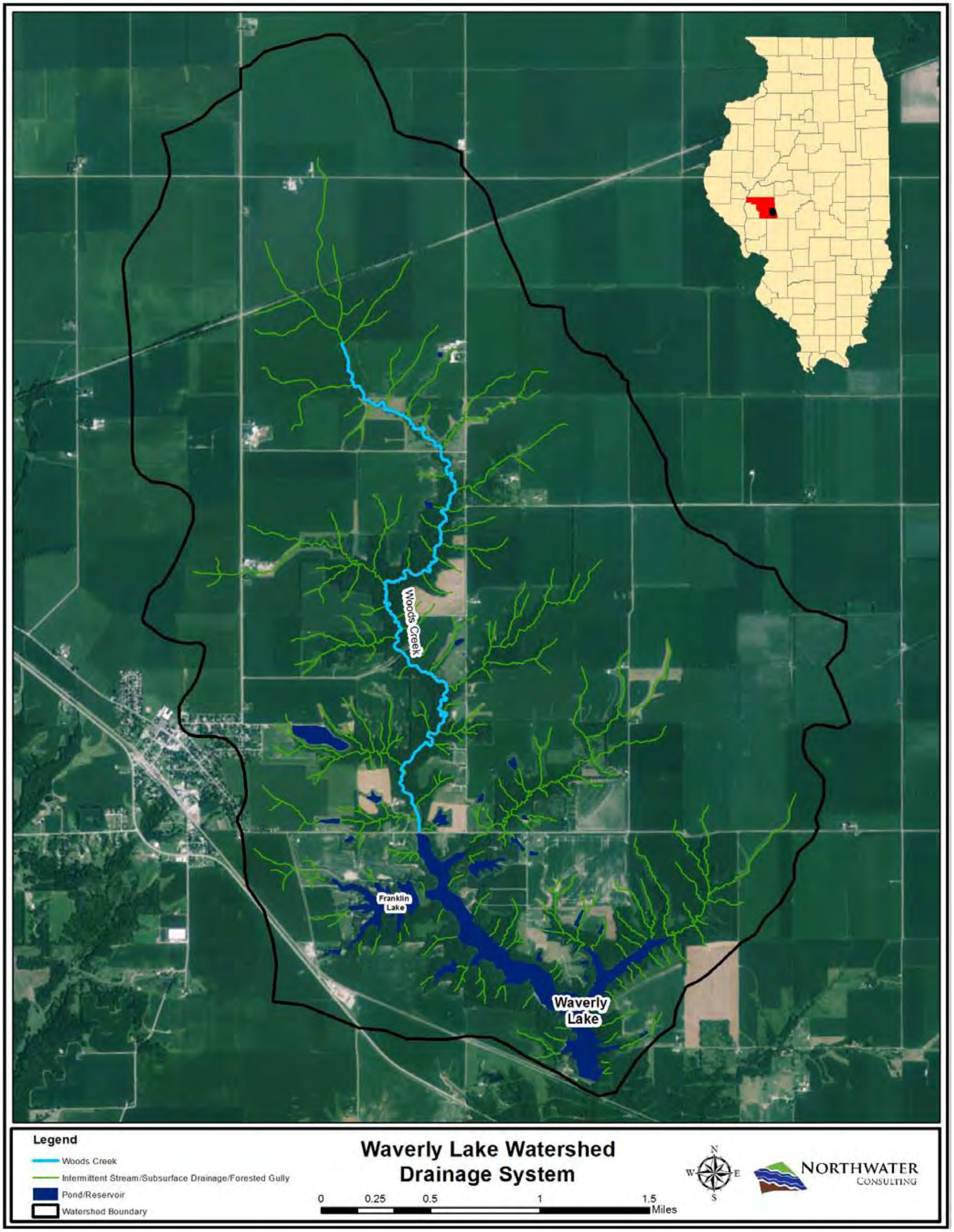


Figure 22 - Waverly Lake Watershed Drainage System

4.10.1 Tile Drainage

The true extent of tile drainage in the watershed is largely unknown. Extensive tile systems in adjoining watersheds, combined with observations made during a watershed field assessment and a stream survey, indicate that tile drainage is extensive. An evaluation of tile drainage in the adjacent Lake Springfield watershed indicated that 94% of all cropped soils are tile drained. Using the same method developed for Lake Springfield where all A & B slopes (0-5%), consisting of silty clay loams or silt loams were assumed to be tiled, 4,308 acres, or 93% of all cropped soils in the Waverly Lake watershed, are likely tile drained. Four tile outlets were observed along the main stem of Woods Creek; small tributary drainages accommodate the majority of tile flow in the watershed.

4.10.2 Riparian Areas & Stream Buffers

Substantial riparian and buffer areas exist adjacent to streams within the watershed. There is no evidence of stream channelization, however, subsurface drainage is prevalent in the headwaters. A stream survey, combined with a GIS analysis of watershed landuse, was performed to evaluate the extent and general quality of riparian zones adjacent to major open water streams within the watershed. Excluding subsurface and intermittent forested drainage ways, a total of 52,111 feet, or 9.9 miles, of perennial and intermittent streams were evaluated for riparian buffer extent and quality (Figure 23). Table 23 lists results of the buffer analysis.

A buffer quality ranking system was developed by Northwater Consulting and applied to individual stream reaches. Three categories of buffer quality include:

1. High quality – greater than 50 feet of un-impacted riparian or buffer area, either forest or grass.
2. Moderate quality – 30 to 50 feet of un-impacted riparian or buffer area, either forest or grass.
3. Low quality (inadequate) – less than 30 feet riparian or buffer area, impacted or degraded.

Table 23 - Riparian Area Buffer Quality

Reach Code	Buffer Condition	Notes	Length (ft)	Stream
1	High		235	Woods Creek
2	Moderate		435	Woods Creek
3	High-Low	Left Bank High Quality, Right Bank Low Quality	90	Woods Creek
4	High-Low	Left Bank Low, Right Bank High	190	Woods Creek
5	High		210	Woods Creek
6	High-Low	Left Bank High Quality, Right Bank Low Quality	93	Woods Creek
7	High		508	Woods Creek
8	High		2,818	Woods Creek
9	High		551	Unnamed Tributary
10	High		1,182	Unnamed Tributary
11	High		8,267	Woods Creek
12	High		2,106	Unnamed Tributary
13	High		1,080	Unnamed Tributary
14	High		661	Unnamed Tributary

Reach Code	Buffer Condition	Notes	Length (ft)	Stream
15	High		287	Unnamed Tributary
16	High		2,769	Unnamed Tributary
17	High		1,971	Unnamed Tributary
18	Moderate-High	Left Bank Moderate, Right Bank High	289	Woods Creek
19	High		6,170	Woods Creek
20	High		2,303	Unnamed Tributary
21	High-Low	Left Bank Low, Right Bank High	146	Unnamed Tributary
22	High		113	Unnamed Tributary
23	High		2,561	Unnamed Tributary
24	Moderate		339	Unnamed Tributary
25	High		2,688	Unnamed Tributary
26	High		997	Unnamed Tributary
27	High		782	Unnamed Tributary
28	High		841	Unnamed Tributary
29	High		891	Unnamed Tributary
30	High		1,879	Unnamed Tributary
31	High		4,542	Unnamed Tributary
32	Moderate		794	Unnamed Tributary
33	High		2,094	Unnamed Tributary
34	High		1,228	Unnamed Tributary

Ninety-five percent of all streams evaluated are adequately buffered and of high quality; only 3% of sampled reaches are moderate quality and 2% where one bank is of high quality. Overall, streams in the Waverly Lake watershed are well buffered and of high quality, though a few areas exist that could use improvement.

Woods Creek

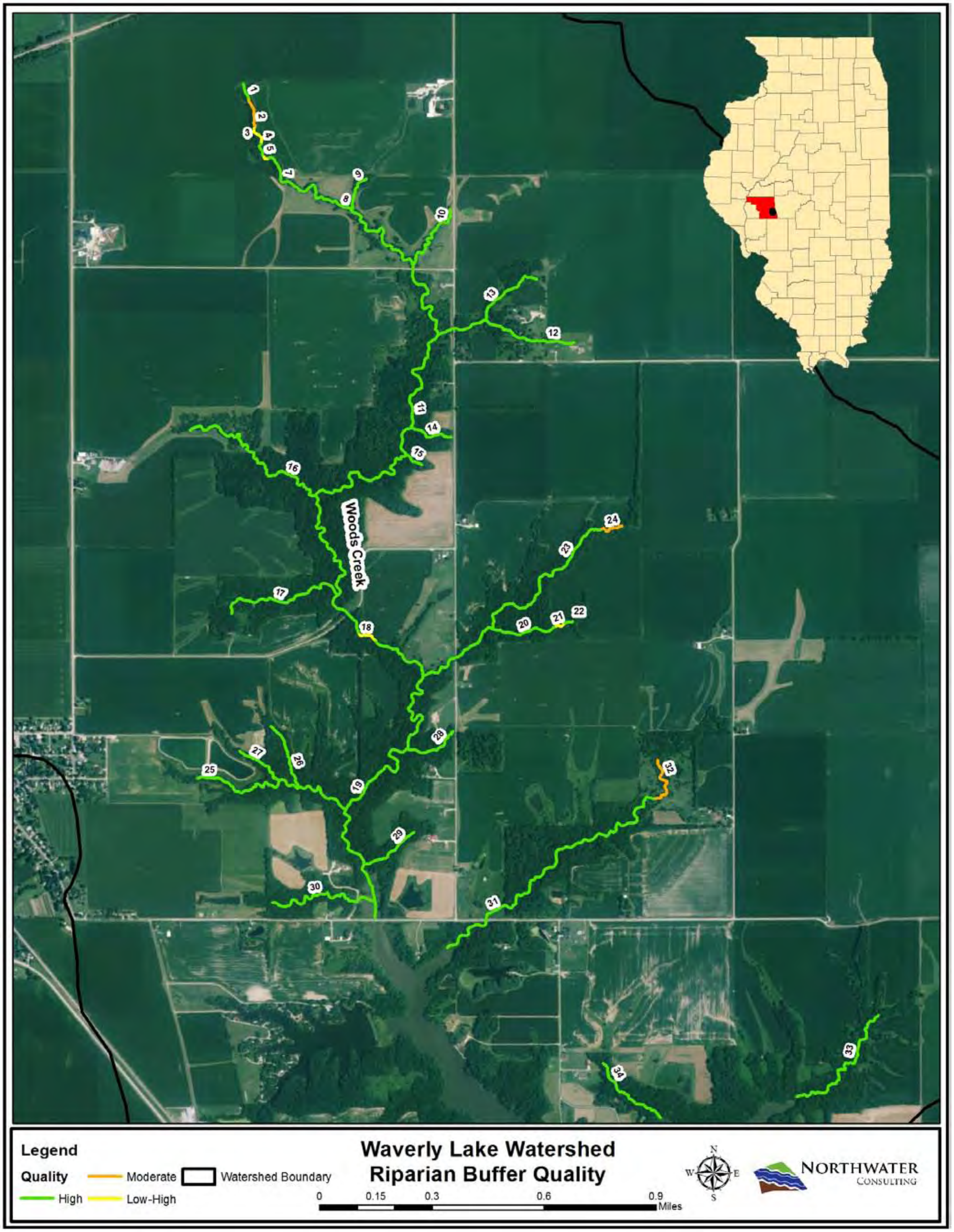


Figure 23 - Waverly Lake Riparian Buffer Quality

4.10.3 Lake Shoreline Buffers

Waverly Lake is well buffered, containing large, contiguous riparian areas. A field assessment of lake shoreline buffers performed by Northwater Consulting in the spring of 2016 indicates that 97%, or 5.8 out of 6 miles of shoreline, is well buffered. Only 2,000 feet (0.38 miles) contain an inadequate buffer zone. Table 24 lists buffer quality and extent by reach and Figure 24 depicts the spatial extent of shoreline buffers

Table 24 - Lake Shoreline Buffers

Reach Code	Adequate Buffer (Y,N)	Buffer Condition	Length (ft)	Length (miles)	% of Shoreline
1	Y	Good - Forested	16,861	3.19	52%
2	N	Poor - Turf Grass/Residential	220	0.04	1%
3	Y	Good - Forested	203	0.04	1%
4	N	Poor - Turf grass	63	0.01	0.2%
5	Y	Good - Forested	10,714	2.03	33%
6	N	Poor - Road/Dock	607	0.11	2%
7	Y	Good - Forested	1,680	0.32	5%
8	N	Poor - Road	571	0.11	2%
9	Y	Good - Forested	930	0.18	3%
10	N	Poor - Dam	539	0.10	2%
		Total	**32,389**	**6**	**100%**

Waverly Lake Shoreline Buffer

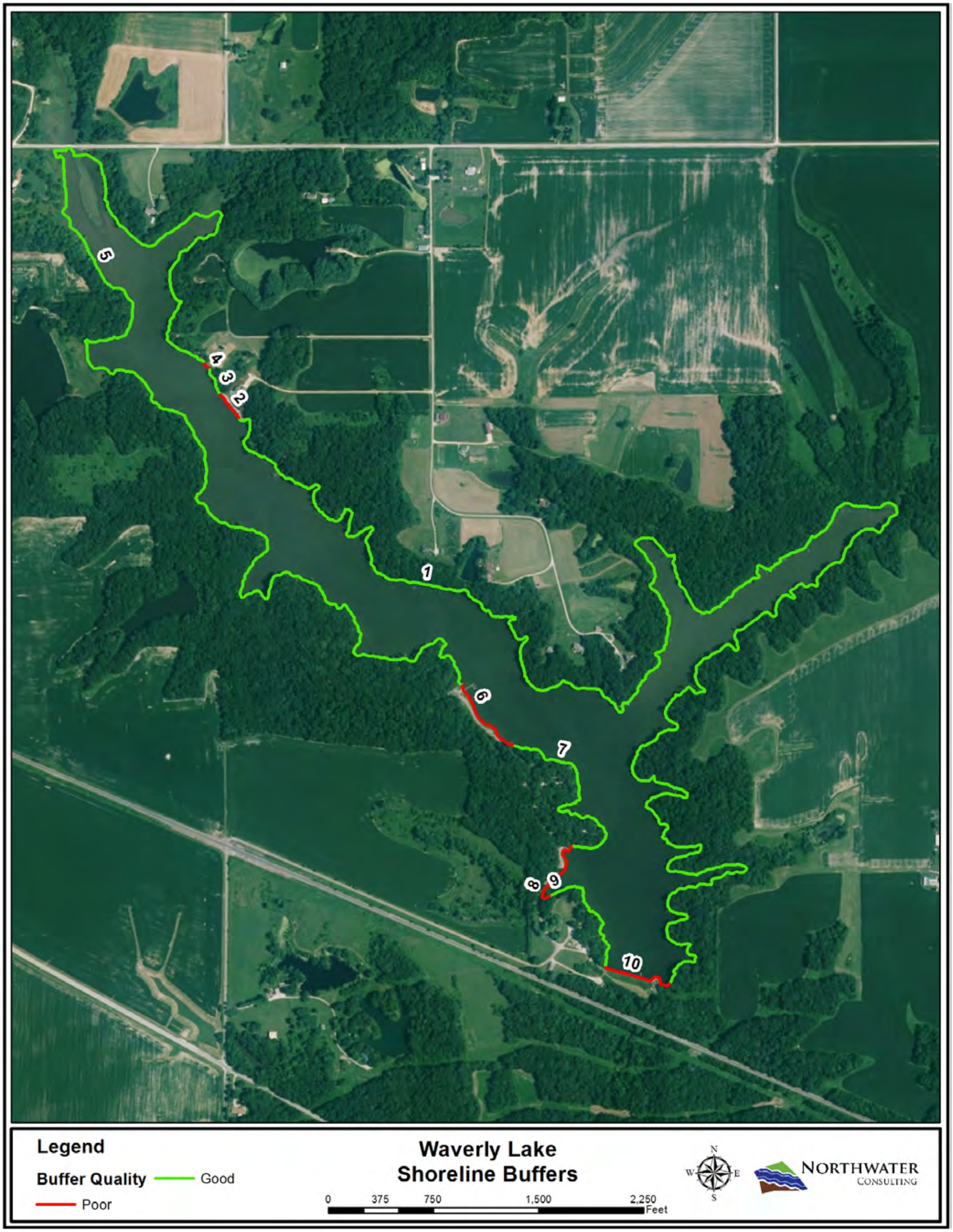


Figure 24 - Waverly Lake Shoreline Buffer Quality

4.10.4 Wetlands

The United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) indicates there is a total of 117 acres (1.9%) of wetlands within the watershed. These wetlands can be classified into twelve unique types (U.S. Fish and Wildlife Service, 2016):

1. Freshwater Emergent Wetland: Palustrine Emergent, Temporarily Flooded (PEMA)
2. Freshwater Emergent Wetland: Palustrine Emergent, Temporarily Flooded, Diked/Impounded (PEMAH)
3. Freshwater Emergent Wetland: Palustrine Emergent, Seasonally Flooded (PEMC)
4. Freshwater Emergent Wetland: Palustrine Emergent Seasonally Flooded, Diked/Impounded (PEMCH)
5. Freshwater Forested/Shrub Wetland: Palustrine Forested, Broad-Leaved Deciduous, Temporarily Flooded (PFO1A)
6. Freshwater Forested/Shrub Wetland: Palustrine Forested, Broad-Leaved Deciduous, Temporarily Flooded, Diked/Impounded (PFO1AH)
7. Freshwater Forested/Shrub Wetland: Palustrine Scrub-Shrub. Broad-Leaved Deciduous, Temporarily Flooded, Diked/Impounded (PSS1AH)
8. Freshwater Pond: Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Diked/Impounded (PUBFH)
9. Freshwater Pond: Palustrine, Unconsolidated Bottom, Intermittently Exposed, Diked/Impounded (PUBGh)
10. Freshwater Pond: Palustrine, Unconsolidated Bottom, Intermittently Exposed, Excavated (PUBGx)
11. Freshwater Pond: Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded (PUBHH)
12. Lake: (L1UBHH)

Table 25 provides a breakdown of wetland types in the watershed. Lakes are the dominant category and encompass 77 acres (66%) of the watersheds NWI classified wetlands. Freshwater pond (PUBGh) and freshwater emergent wetland (PEMCH) combined account for 23 acres or 20%.

Table 25 - NWI Wetlands

Type	Acres	% Wetland Area
L1UBHH	77.4	66%
PUBGh	13.2	11%
PEMCH	10.2	9%
PUBHH	7.8	7%
PFO1A	2.3	2%
PEMA	1.6	1%
PFO1AH	1.6	1%
PEMAH	1.3	1%
PUBGx	0.42	0.4%
PSS1AH	0.39	0.3%

Type	Acres	% Wetland Area
PEMC	0.35	0.3%
PUBFH	0.10	0.1%
Total	117	100%

Wetlands provide numerous valuable functions that are necessary for the health of the watershed (Figure 25). They play a critical role in protecting and moderating water quality through a combination of filtering and stabilizing processes. Additionally, wetland vegetation removes pollutants through the natural filtration that occurs from absorption and assimilation. This effective treatment of nutrients and physical stabilization leads to an increase in overall water quality to downstream reaches.

In addition, wetlands have the ability to increase stormwater detention capacity, increase stormwater attenuation, and moderate high flows. These benefits help to reduce flooding and erosion. Wetlands also facilitate groundwater recharge by allowing water to seep slowly into the ground, thus replenishing underlying aquifers. This groundwater recharge is also valuable to wildlife during the summer months when precipitation is low and the base flow of the river draws on the surrounding groundwater table.

Restored Wetland

Considering the outdated nature of the NWI dataset, an analysis was performed on existing landuse data for the watershed to better understand the current extent of watershed wetlands. Excluding open water ponds and lakes, only 14.3 acres of wetlands are believed to exist within the watershed and would fall into the categories of: freshwater forested/shrub wetland and freshwater emergent wetland. A further analysis of NWI wetlands data, combined with an interpretation of aerial imagery, indicates that approximately 1.4 acres of previously delineated wetlands have either been drained or modified; opportunities exist to restore these historical wetlands.

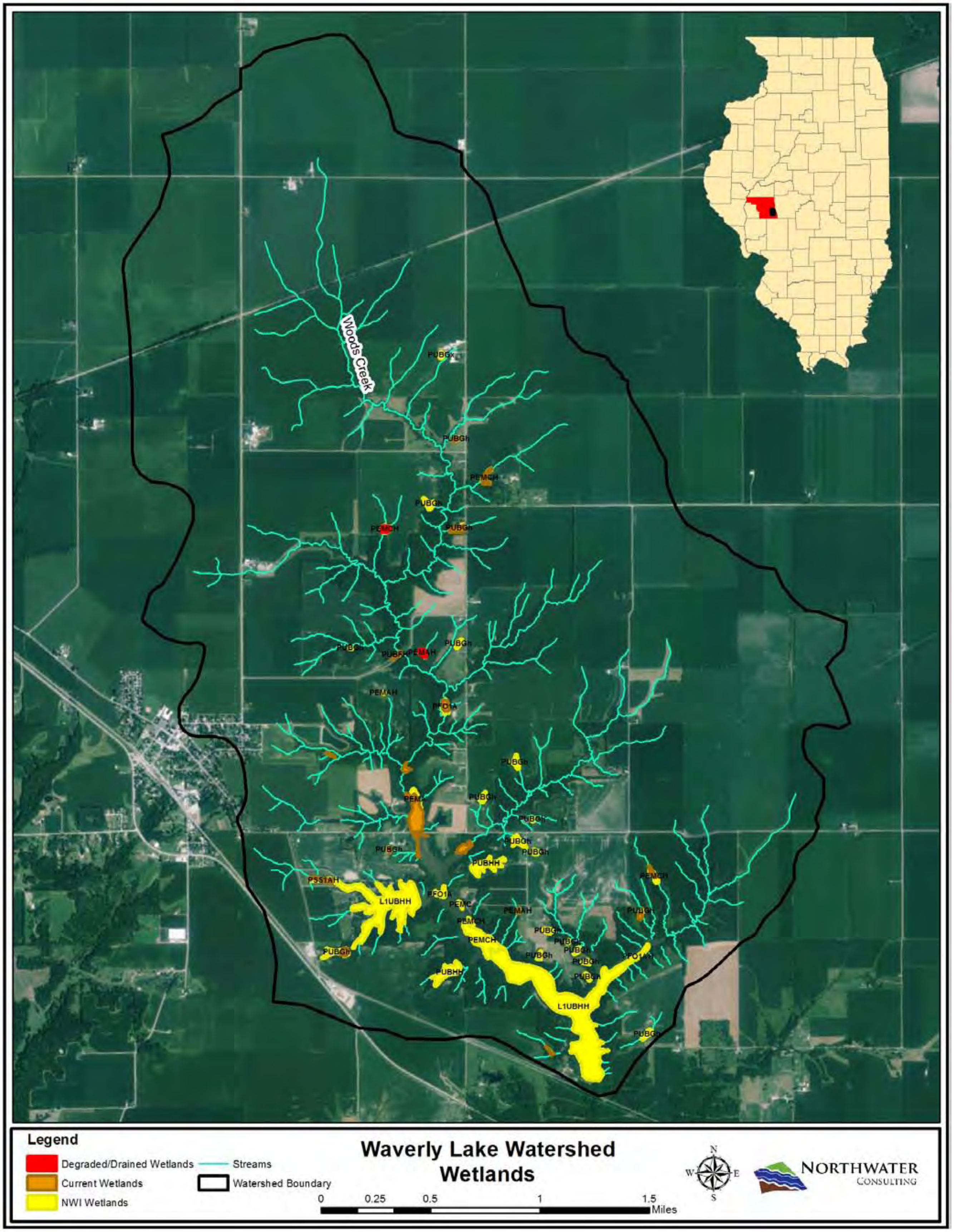


Figure 25 - Waverly Lake Watershed Wetlands

4.10.5 Floodplain

A review and analysis of the most recent Federal Emergency Management Agency's (FEMA) Digital Flood Insurance Rate Maps (DFIRM) indicates there are 470 acres of floodplain within the Waverly Lake watershed, or 7.5% of the total watershed area.

Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood, or 100-year flood (FEEMA, 2015). All floodplain area within the Waverly Lake watershed is classified as zone A, or the 100-year floodplain (Figure 26).

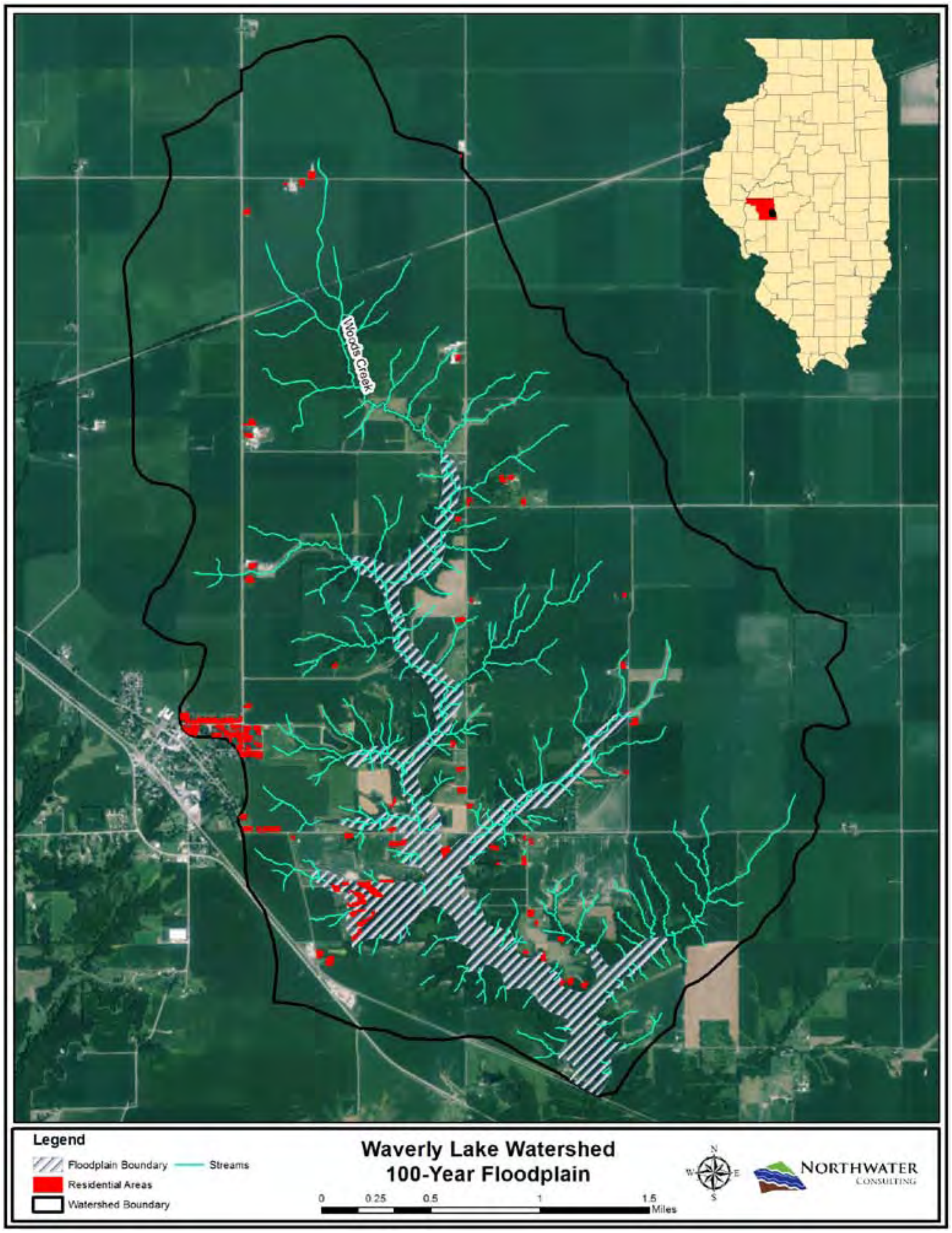


Figure 26 - Waverly Lake Watershed Floodplain

4.11 Lake Shoreline & Streambank Erosion

Lake shoreline and streambank erosion is a source of sediment and nutrients within the watershed. An evaluation of the extent and severity of lake bank and streambank erosion was performed to identify critical areas requiring attention and to quantify sediment and nutrient loading. The main stem of Woods Creek and thirteen tributaries was assessed for streambank erosion; both Waverly Lake and Franklin Lake were assessed for shoreline erosion.

Stream stability was evaluated through direct observations during a stream inventory performed by Northwater Consulting in January of 2016. All 3.6 miles (19,022 feet) of Woods Creek and 6 miles (31,586 feet) of tributary channels were assessed and data captured with a GPS receiver. Due to property access concerns, some tributary channels were evaluated by extrapolating observations at road crossing and results from similar assessed segments. Data captured in the field included:

1. Eroding bank height and an estimate of lateral recession rates using the NRCS Rapid Assessment, Point Method (RAP-M)
2. Locations of significant channel bed instability or “headcutting” or “knickpoints”
3. Critical project locations based on need and feasibility
4. Other information, such as tile locations, recommended BMPs and gully locations

Data collected in the field was transferred into GIS to create a map database representing location-specific estimates of annual soil loss from bank erosion and recommended project locations.

Franklin Lake Shoreline Erosion

Lake banks were assessed in the summer of 2015 using a boat and a Trimble GPS receiver. Data points collected in the field were transferred into ArcMap (Geographic Information Software - GIS) and processed into a line file representing erosion severity. A GIS model was used to quantify soil loss and nutrient loading from eroding banks. Total net erosion in tons/year and estimates of nitrogen and phosphorus loading in pounds were calculated using GIS and equations derived from IEPA’s load reduction spreadsheet. A description of erosion severity rankings are presented in Tables 26 and 27 below; color coded rankings are depicted in Figures 29 and 30.

Table 26 - Waverly Lake Shoreline Erosion Severity Rankings

Bank Rank	Description		Lateral Recession Rate (ft/yr)
1	⬛	Mechanical stabilization completed	0.001
2	🟩	Hand laid stabilization completed with no maintenance required	0.005
3	🟧	Hand laid stabilization completed with maintenance required; not adequately preventing bank erosion	0.4
4	🟦	Natural and stable banks	0.001
5	🟦	Low overhanging/undercut bank; relatively stable	0.03
6	🟨	Intact bank vegetation but slight-moderate bank undercut – trees at a slight angle	0.1
7	🟫	Severe undercut bank; vegetation at an extreme angle or falling in	0.5
8	🟪	Active erosion and severe; exposed banks	0.8
9	🟥	Active erosion and very severe; large exposed banks with recent evidence of erosion	1.0

Table 27 – Franklin Lake Shoreline Erosion Severity Rankings

Bank Rank	Description		Lateral Recession Rate (ft/yr)
1	⬛	Mechanical stabilization completed/ adequate rock or seawall	0.001/ 0.005 if maintenance required
2	🟩	Hand laid stabilization completed with no maintenance required	0.005
3	🟨	Hand laid stabilization completed with maintenance required; not adequately preventing bank erosion	0.03 – 0.05
4	🟦	Natural and stable banks	0.001
5	🟦	Low overhanging/undercut bank; relatively stable	0.03 – 0.05
6	🟧	Intact bank vegetation but slight-moderate bank undercut – trees at a slight angle	0.06 - 0.1
7	🟥	Severe undercut bank; vegetation at an extreme angle or falling in	0.5

Quantities of sediment and nutrient loading from stream (left and right banks) and lake banks were estimated using GIS tools. Annual sediment, nitrogen and phosphorus loads were calculated using the methods outlined in the EPA Region 5 Load Reduction Model. Eroding bank height, bank length and lateral recession rates were measured and estimated in the field and transferred to GIS. The following equations were used to estimate total annual loads for sediment, nitrogen and phosphorus:

Total Tons (sediment) = Bank length (ft) * Eroding bank height (ft) * Lateral recession rate (ft/yr) * Dry soil density (tons/ft^3)
Nitrogen Load (lbs) = Soil mass (tons) * 2000 lbs/ton * N concentration in soil (0.001 lbs/lbs)
Phosphorus Load (lbs) = Soil mass (tons) * 2000 lbs/ton * P concentration in soil (0.00045 lbs/lbs)

4.11.1 Streambank Erosion

Streambank erosion is a natural process but the rate at which it occurs is often increased by anthropogenic or human activities such as urbanization and agriculture. Bank erosion is typically a result of streambed incision and channel widening. Field observations indicate that the majority of Woods Creek and its tributaries are relatively stable and well connected to the floodplain. Bank erosion and channel incision appeared more prevalent in tributary channels which appear to be attempting to accommodate higher flows; this could be the result of the high density of drainage tiles.

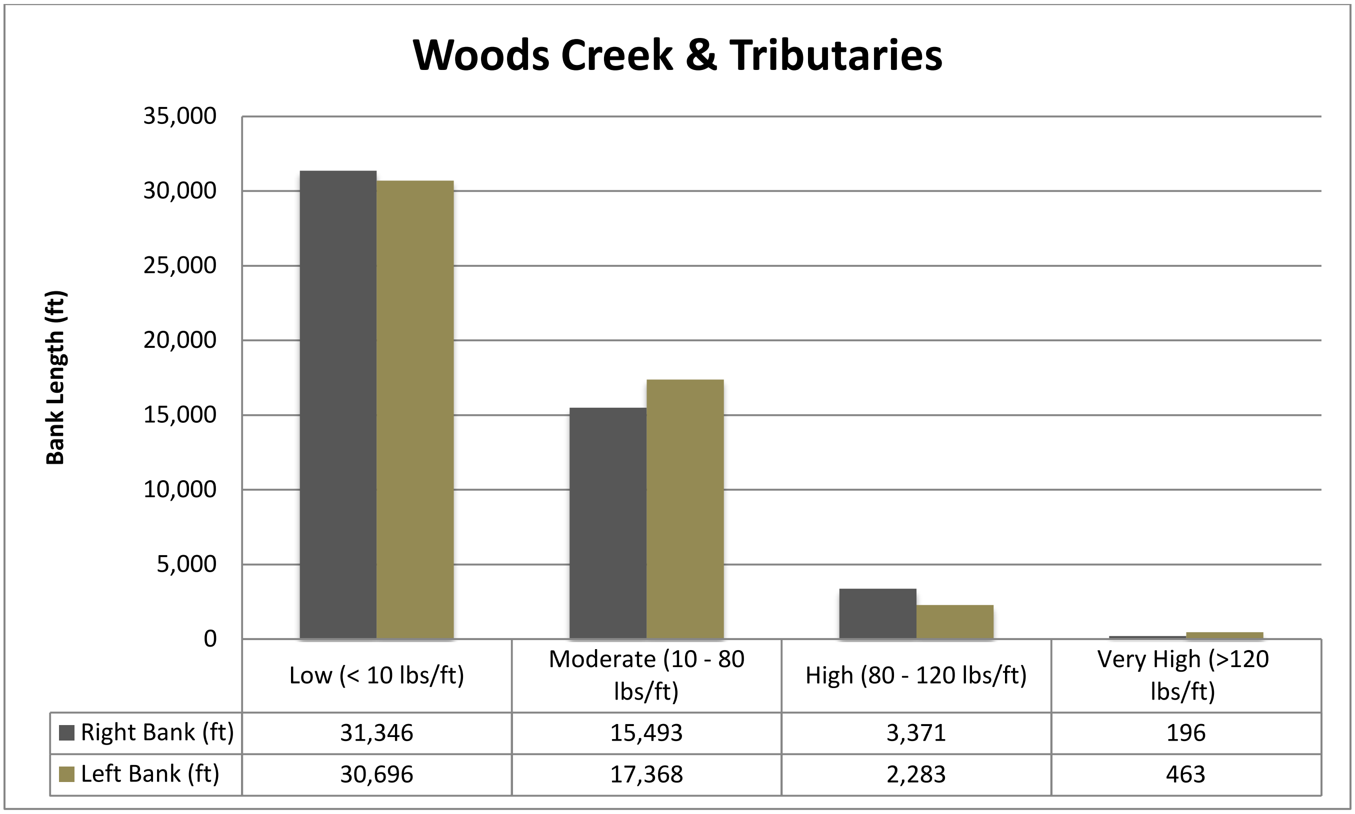
Woods Creek; High Bank Erosion

Results of the stream survey indicate that bank erosion within the watershed is responsible for contributing 959 tons of sediment annually to Waverly Lake. Streambank erosion also contributes approximately 1,833 pounds of nitrogen and 867 pounds of phosphorus each year. Fifty-three percent of all streambank erosion originates from tributary streams and ditches. Table 28 is a summary of results for Woods Creek and all unnamed tributary drainages.

Table 28 - Streambank Erosion Summary

Stream	Bank Length (miles)	Average Eroding Bank Height (ft)	Average Lateral Recession Rate (ft/yr)	Sediment Load (tons)	Nitrogen Load (lbs)	Phosphorus Load (lbs)
Woods Creek	7.2	1.2	0.16	453	907	411
Unnamed Tributary	12	0.76	0.13	506	926	456
Total (avg)	**19.2**	**(0.98)**	**(0.15)**	**959**	**1,833**	**867**

Greater than one-half, or 61%, of all bank erosion in the watershed can be classified as low erosion, 33% as moderate and 6% as high or very high as depicted in Figures 27 and 28.



	Low (< 10 lbs/ft)	Moderate (10 - 80 lbs/ft)	High (80 - 120 lbs/ft)	Very High (>120 lbs/ft)
■ Right Bank (ft)	31,346	15,493	3,371	196
■ Left Bank (ft)	30,696	17,368	2,283	463

Figure 27 - Streambank Erosion Severity; Woods Creek & Tributaries

Woods Creek; High Bank Erosion

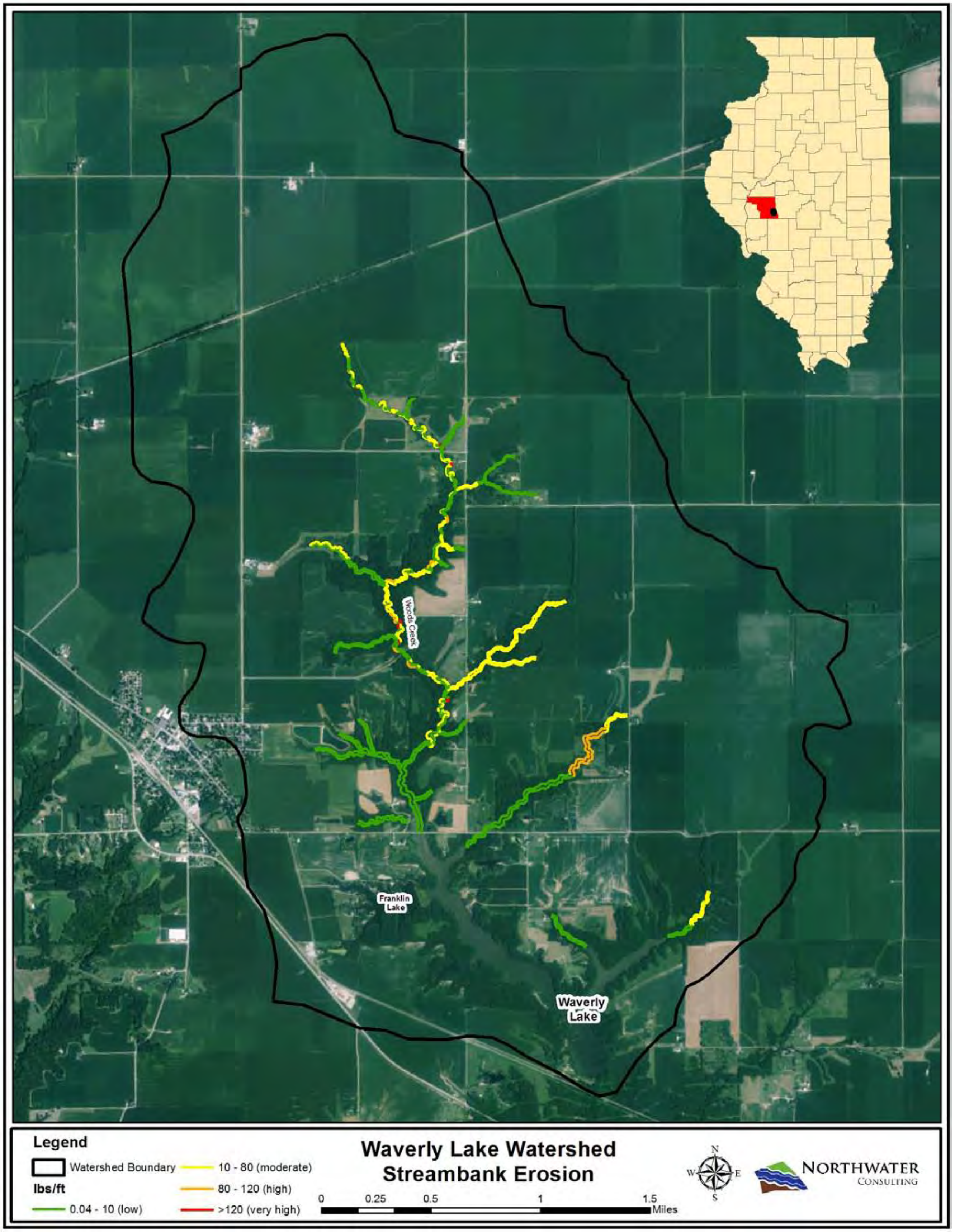


Figure 28 - Waverly Lake Watershed Streambank Erosion

4.11.2 Waverly Lake Shoreline Erosion

Waverly Lake; Severe Shoreline Erosion

A total of 32,389 feet, or 6 miles of shoreline, were evaluated. Within Waverly Lake, shorelines are generally stable or moderately eroding with 91% of bank length low to moderately eroding. Average eroding bank height is 4.6 feet and average annual lateral recession rates are 0.29 feet/year. Total sediment from lake bank erosion is 619 tons/year; total annual nitrogen load is 1,238 pounds and the annual phosphorus load is 557 pounds. The 9% of high or severely eroding shoreline account for 78% of the entire sediment and nutrient load generated from lake bank erosion and should be addressed first. A total of seven bank segments (1,079 feet) contributing greater than 20 tons per year of sediment are responsible for 26% of the entire sediment load from shoreline erosion; these banks represent only 3% of the total length of shoreline in Waverly Lake. Table 29 provides a breakdown of lake shoreline assessment results; bank rankings are depicted in Figure 29.

Table 29 - Waverly Lake Shoreline Assessment Results

Bank Rank	Bank Length (ft)	Average Height (ft)	Average Lateral Recession Rate (ft/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)
1	821	5.0	0.001	0.21	0.09	0.11
2	1,327	2.0	0.005	1.1	0.50	0.6
3	1,461	4.4	0.3	153	69	77
4	6,200	0.94	0.001	0.43	0.19	0.21
5	16,342	1.3	0.03	48	21	24
6	3,238	2.8	0.1	66	30	33
7	1,765	5.1	0.4	287	129	144
8	1,124	7.7	0.8	574	258	287
9	112	12	1	108	49	54
Total	**32,389**	**4.6**	**0.29**	**1,238**	**557**	**619**

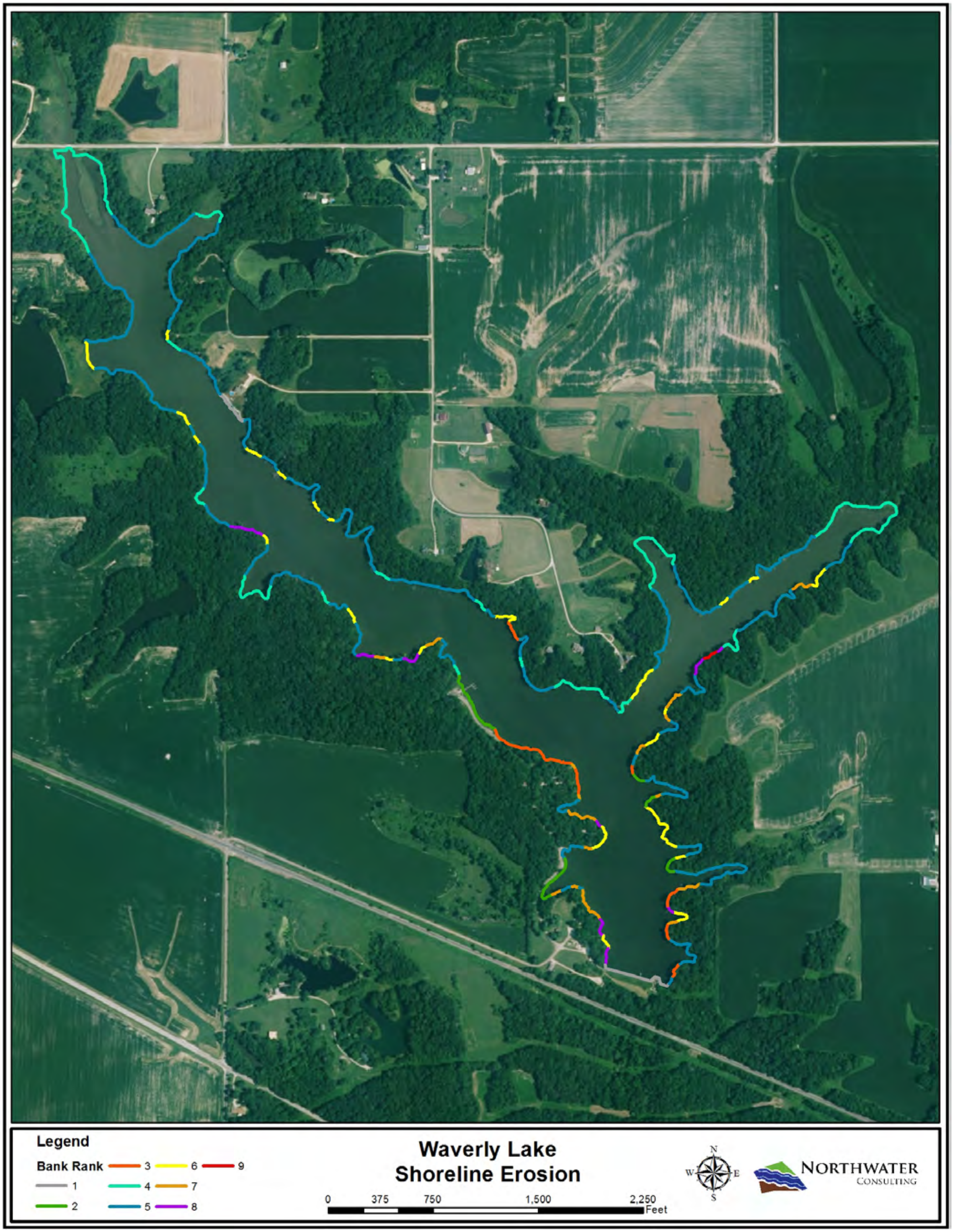


Figure 29 - Waverly Lake Shoreline Erosion

4.11.3 Franklin Lake Shoreline

Waverly Lake; Previously Armored Shoreline

Based on an evaluation of 12,238 feet or 2.3 miles of shoreline, results indicate that bank erosion in Franklin Lake is negligible with the exception of one, 153-foot section. The remaining banks are either armored with rock or seawalls; several sections of existing rock and seawall require maintenance.

Annual sediment load from shoreline erosion is 18 tons; one severely eroding section is contributing 12 tons/yr. Annual nitrogen load from shoreline erosion is 29 pounds; annual phosphorus load is 9 pounds. Average eroding bank height is 1.2 feet and the average annual recession rate is 0.09. Table 30 provides a breakdown of lake shoreline assessment results; bank rankings are depicted in Figure 30.

Table 30 - Franklin Lake Shoreline Assessment Results

Bank Rank	Bank Length (ft)	Average Height (ft)	Average Lateral Recession Rate (ft/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)
1	5,419	0.2	0.002	0.2	0.05	0.10
2	251	0.6	0.01	0.05	0.01	0.03
3	504	0.7	0.04	0.8	0.3	0.53
4	2,855	0.6	0.001	0.1	0.04	0.07
5	2,529	0.8	0.03	4.3	1.4	2.7
6	528	1.4	0.09	4.1	1.3	2.6
7	153	4.0	0.50	20	6.1	12
Total	**12,238**	**1.2 (avg)**	**0.09 (avg)**	**29**	**9**	**18**

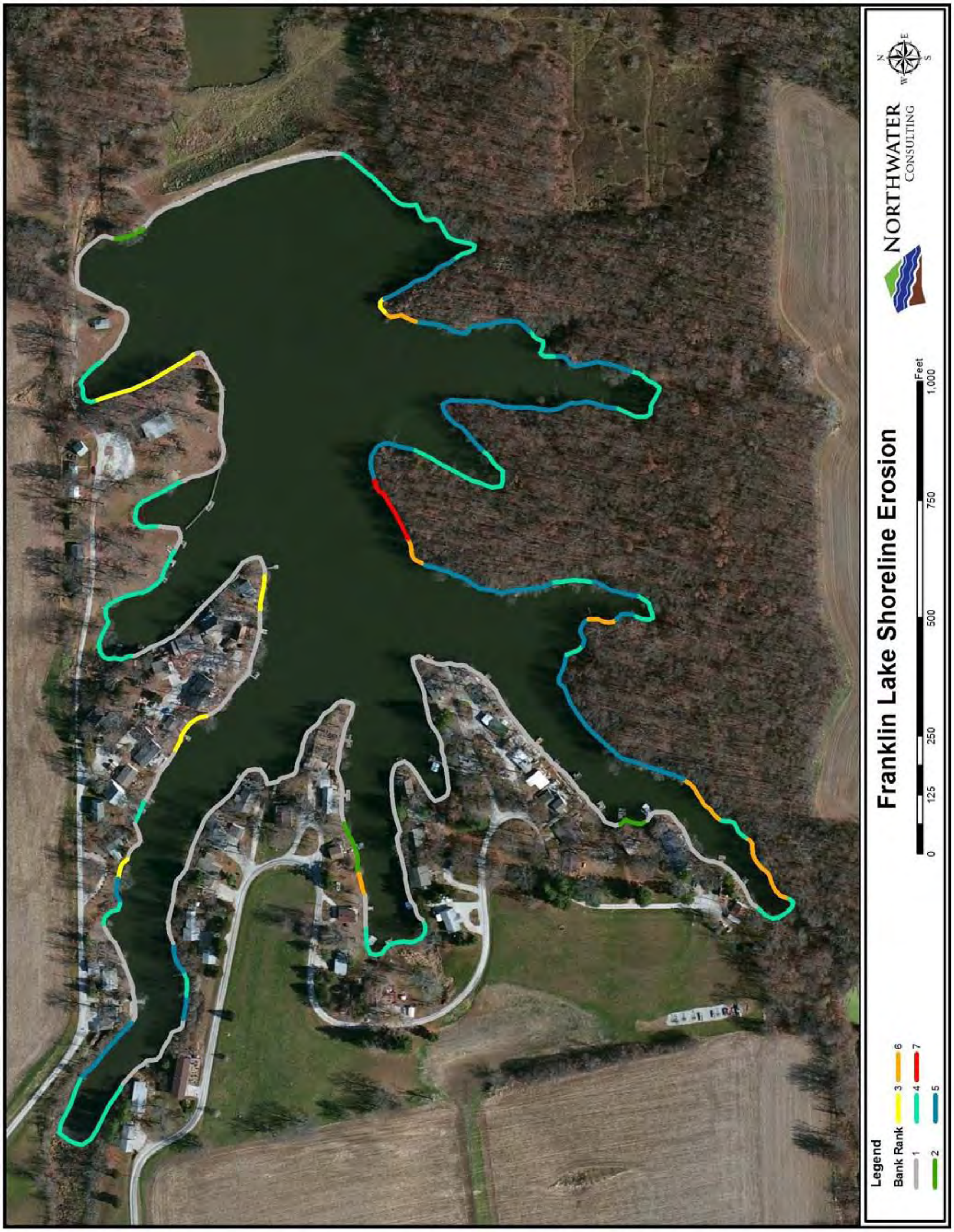


Figure 30 - Franklin Lake Shoreline Erosion

4.12 Urbanization, Septic Systems & Wastewater Treatment

Urbanization of the Waverly Lake watershed is considered minimal, containing only two very small developed residential areas. The majority of the watershed is sparsely populated with the exception of residential areas with the Village of Franklin and surrounding Franklin Lake. The village of Franklin occupies 65 acres or 1% of the watershed. Of the 163 watershed residences, 67 homes fall within the municipal limits of Franklin. The small, dense residential area surrounding Franklin Lake includes 50 individual homes. The remaining 46 residences or farm homes are scattered throughout the watershed. There is no current indication that the watershed will experience any significant development pressure in the future, as the population is likely to remain flat or experience minor declines.

Out of 163 residences, a total of 96 homes that are located outside of Franklin city limits are thought to be on septic systems. Of these 96 homes, 24 (25%) are located on soils classified as very limited for septic systems. Sixty-seven residences are within the Village of Franklin are connected to the Franklin Waste Water Treatment Plant.

4.12.1 Wastewater Treatment

By Jamie Headen – Benton & Associates

The Village of Franklin operates a wastewater collection and treatment system serving the residents of the village. The treatment system is located within the watershed, directly east of Franklin, and just over one-half of a mile north of Franklin Lake. Construction of the wastewater treatment facility and irrigation system for the Village of Franklin was completed in 2009 with authorization to begin operation from IEPA in November 2009. Operating permit 2002-AO-0040 was issued in February 2012, along with a supplemental operating permit issued on March 2, 2012.

Following treatment in a two-cell facultative lagoon, wastewater is spray irrigated. The first cell of the lagoon has a surface area of 231,195 square feet at the normal operating depth. The second cell has a surface area of 126,400 square feet at the normal operating depth. The storage volume available above the normal operating depth is 12,170,000 gallons. The design population equivalent is 800 with a design average flow to of 80,000 gallons per day, a design organic loading of 136 lbs per day, and a design suspended solids loading of 160 lbs per day.

Village of Franklin Lagoons

Wastewater is pumped from the lagoon effluent structure to an adjacent field where valves are used to control the location of the application by a stationary irrigation system. Pumping is achieved through the spray irrigation pump station having two pumps rated at 350 gallons per minute at 170 feet Total Dynamic Head (TDH). The operator may choose to spray irrigate any one of four runs at any time. Each run covers approximately 4.5 acres. There are 18 total spray guns installed for application on approximately 20 acres of agricultural land.

Village of Franklin Lagoons; Aerial View

Wastewater is land applied when conditions allow and in such a manner as to avoid runoff. Wastewater is not land applied when the water table in the irrigation area is within 4 feet of the soil surface; when groundwater or saturated soil conditions do not permit irrigation; during precipitation; when the ground is frozen or covered in ice or snow; or when winds exceed 20 mph. Three monitoring wells are used to determine the depth to the water table in the irrigation area. The operator is responsible for observing weather conditions prior to operating the spray irrigation equipment.

Village of Franklin Irrigation Area

Upgradient and downgradient groundwater is tested via the three monitoring wells. Groundwater is monitored for nitrate, nitrite, ammonia, chloride, sulfates, pH and Total Dissolved Solids (TDS). The operator also maintains a log of the influent flow via pump run times in the terminal lift station, the water level in the lagoon cells, and the amount of wastewater applied to the land daily.

In accordance with the operating permit, the spray irrigation system is operated at an average weekly application rate of 1.00 inch per week with the following maximum rates depending upon climatic conditions:

Maximum hour	≤ 0.25 inches
Maximum day	≤ 0.75 inches
Maximum week	≤ 2.00 inches

Any precipitation received during the 24-hour period prior to irrigation is subtracted from the maximum day rate to determine the maximum day application rate that can be applied.

4.12.2 Septic Systems

Outside of the Village of Franklin, septic systems provide treatment of wastewater from individual properties. Failing septic systems are typically an active source of pollutants. Faulty or leaking septic systems are sources of bacteria, nitrogen, and phosphorus. Typical national septic system failure rates are 10-20% and no failure rates are reported specifically for Illinois (U.S. EPA 2002). However, reported failure rates vary widely depending on the local definition of failure (U.S. EPA 2002). A 15% failure rate was used to analyze the Waverly Lake watershed.

Every home in the watershed was located and mapped using GIS, which was applied to estimate the number of individual residential homes using septic systems. A corresponding nitrogen and phosphorus load was then estimated using the Spreadsheet Tool for Estimating Pollution Loading (STEPL). Assuming a septic system failure rate of 15%, it is possible that 14 homes within the watershed have failing septic systems; due to the planning nature of this analysis, the exact locations of these systems are not determined. Phosphorus and nitrogen loading from potentially failing septic systems is presented in Table 31. Potentially failing systems contribute annual phosphorus loads of 170 lbs/yr and 434 lbs/yr of nitrogen. For the purposes of this report, it is assumed that these loadings do make it to the lake. However, loading is likely a function of location to a waterway and it is possible that septic water from a portion of failing systems may be absorbed or filtered prior to entering the lake.

Table 31 - Nutrient Loading; Potentially Failing Septic Systems

Number of Septic Systems	Population per Septic System	Septic System Failure Rate (%)	Number of Homes on Failing Septic	Phosphorus Load (lbs/yr)	Nitrogen Load (lbs/yr)
93	2.43	15	14	170	434

4.13 Gully Erosion

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

Gully erosion in the Waverly Lake watershed was evaluated during a watershed windshield survey, a forested gully assessment, individual property evaluations, and estimated using GIS. Gully erosion presented in this section represents 170 eroding gullies, both ephemeral (those that form each year) and permanent (those that receive intermittent streamflow and expand over time such as a forested ditch or channel).

For those ephemeral gullies not visible from a road or observed during site assessment, GIS was used to estimate their location and extent. Gullies were delineated in GIS using aerial imagery, and conservative width (1 ft), depth (0.5 ft), and years eroding (1 yr) were applied to each gully. For gullies observed in the field, dimensions were directly measured in the field and transferred to GIS for analysis.

Total net erosion in tons/year and estimates of nitrogen and phosphorus loading were calculated using GIS and equations derived from IEPA's load reduction spreadsheet. A distance-based delivery ratio was applied to account for distance to a receiving waterbody. Sediment trapping efficiency was accounted for, if the gully drained to a retention or detention structure.

The following equations were applied to estimate gully erosion:

Eroding Forested Gully

Sediment (tons/yr) = Length (ft) * Width (ft) * Depth (ft) / Years Eroding * Soil Weight Dry Density (tons/ft3)
Nitrogen (lbs/yr) = Sediment (tons/yr) * N concentration in soil (0.001 lbs/lb) * 2,000 (lbs/ton) * Corr. Factor
Phosphorus (lbs/yr) = Sediment (tons/yr) * P concentration in soil (0.00045 lbs/lb) X 2,000 (lbs/ton) * Corr. Factor

Delivery Ratio = Gully distance from lake or receiving perennial stream (ft) ^-0.2069

Gully erosion in the watershed is prevalent, especially in steep forested draws or ephemeral water courses adjacent to major perennial drainage ways. Gully erosion is also evident on crop ground; conservation practices observed in the watershed, such as WASCBs or grassed waterways and other grade control structures, have been widely implemented to address this type of erosion.

Results indicate that there are 13 miles of eroding gullies in the watershed, 4.3 miles (33%) which drain to an existing pond or detention structure. It is estimated that gully erosion is responsible for the annual delivery of 763 tons of sediment, 687 pounds of phosphorus and 1,527 pounds of nitrogen to Waverly Lake. Table 32 provides results of the gully assessment and Figure 31 depicts the locations within the watershed.

Table 32 - Waverly Lake Watershed Gully Erosion

Gully Length (ft/mi)	Average Gully Width (ft)	Average Gully Depth (ft)	Nitrogen (lb/yr)	Phosphorus (lbs/yr)	Sediment (tons/yr)
68,631/13	2.9	1.9	1,527	687	763

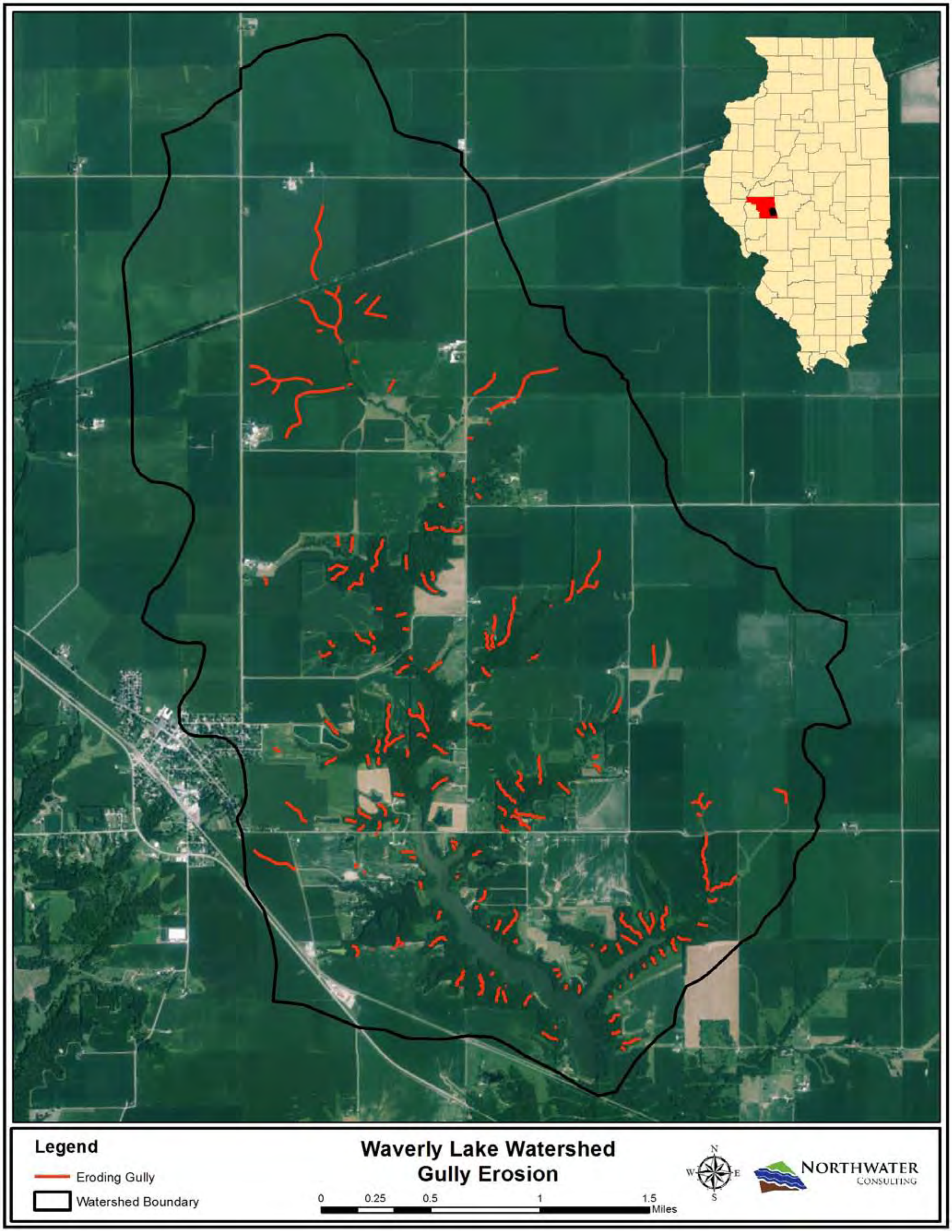


Figure 31 - Waverly Lake Watershed Eroding Gullies

4.14 Sheet & Rill Erosion

Through rain and shallow water flows, sheet erosion removes the thin layer of topsoil. When sheet flows begin to concentrate on the surface through increased water flow and velocity, rill erosion occurs. Rill erosion scours the land even more, carrying off rich nutrients and adding to the turbidity and sedimentation of waterways. The extent of sheet and rill erosion in the Waverly Lake watershed was calculated using the Universal Soil Loss Equation (USLE) which widely used to estimate rates of soil erosion caused by rainfall and associated overland flow. This method relies on soil properties, precipitation, slope, cover types and conservation practices (if applicable). A map-based USLE model was developed for all cropped soils within the watershed and used to quantify sediment loading from agricultural ground and identify locations with the potential for excessive erosion.

Gully Erosion

In the Waverly Lake watershed, sheet and rill erosion from crop ground is responsible for 4,680 tons of sediment delivered to the lake on an annual basis. This translates into 1 tons/ac/yr delivered from crop ground alone. Modeled results indicate that the majority of sheet and rill erosion delivered to the lake is originating from conventionally or reduced tillage fields; tilled HEL soils and those fields closest to a stream or the lake.

Cropped soils that have the greatest per acre loads or are eroding at greater than 1 ton/ac/yr are responsible for the annual delivery of 2,705 tons, or 58%, of the entire sediment load from crop ground; these areas represent only 17% of all crop ground in the watershed. Nutrient loading from sheet and rill erosion, as well as a more detailed discussion on pollutant loading, is presented in Section 5.

5.0 Pollutant Loading

5.1 Introduction & Methodology

A watershed survey was completed to gain an understanding of watershed conditions and features, collect field specific data, and discuss management measures with willing landowners. Data collected in the field included:

- Tillage practices
- Cover types
- Project (BMP) locations and site suitability
- Sources of sediment and gully erosion

Landowners were contacted and a series of site visits were conducted. These site visits, combined with an interpretation of aerial imagery, resulted in the identification of site-specific BMP locations. Drainage areas were then delineated for each site.

A spatially explicit and field-specific GIS-based pollution loading model (SWAMM) was then developed to estimate loading from direct runoff. A model methodology is provided in Appendix A. This supporting model simulates surface runoff using the curve number approach, local precipitation, the Universal Soil Loss Equation (USLE), and Event Mean Concentrations (EMCs) specific to land use and soil types in the watershed. A custom and accurate land use layer was developed for the watershed to ensure model inputs represented actual watershed characteristics. In addition, information collected in the field was incorporated into the model, such as tillage practices, gully erosion and existing conservation practices. Model results were then reviewed against estimated TMDL loads for phosphorus and incorporated into the TMDL calculations.

5.2 Pollutant Loading

Pollutant load estimates are presented in this section. Estimates are provided for loading resulting from direct runoff, observed gully erosion, septic systems, and streambank and lake shoreline erosion. Gully erosion was observed in the field to the extent it was visible. Streambank and lake shoreline erosion was directly assessed. Loading from septic systems was estimated based on those homes not connected to a WWTP. Results from the GIS-based direct runoff pollution load model are illustrated in Figures 32 through 34. Loading from direct runoff or surface runoff accounts for what is contributed to the lake just from overland flow.

As presented in Table 33, total annual nitrogen loading to Waverly Lake from all sources is 38,599 lbs/yr; 8,552 lbs/y of phosphorus and 7,074 tons/yr of sediment is delivered to the lake annually. Direct runoff is responsible for 87% of the total nitrogen load, 73% of the phosphorus load and 67% of the sediment load. Stream and lake bank erosion also contribute relatively high percentages of the total watershed load and combined account for 8% of the nitrogen load, 17% of the phosphorus load and 23% of the sediment load.

Table 33 - Pollution Loading Summary

Source	Total Nitrogen (lbs/yr)	% of Total Load	Total Phosphorus (lbs/yr)	% of Total Load	Total Sediment (tons/yr)	% of Total Load
Direct Runoff	33,538	87%	6,262	73%	4,715	67%
Streambank Erosion	1,833	5%	867	10%	959	14%
Lake Bank Erosion[1]	1,267	3%	566	7%	637	9%
Gully Erosion	1,527	4%	687	8%	763	11%
Septic Systems	434	1%	170	2%	0	0%
Total	**38,599**		**8,552**[2]		**7,074**	

1 – Includes Franklin Lake shoreline erosion

2 – Does not include 243 lbs/yr of internal phosphorus loading from lake sediment; See section 7, TMDL

Modeled pollution loading from direct or surface runoff is further quantified in Table 34; per-acre results are calculated by dividing the total annual load of a given landuse category by the total number of acres present in the watershed. Results clearly show that row crops contribute the greatest total load of nitrogen and the greatest and total and per-acre loading of phosphorus and sediment generated from surface runoff. Crop ground delivers annual nitrogen loads of 31,152 lbs, or 6.74 lbs/ac/yr; annual phosphorus loads of 6,004 lbs, or 1.3 lbs/ac/yr; and 4,680 tons, or 1.01 tons/ac/yr. 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 or not a BMP is in place.

Modeled per-acre sediment delivery rates from crop ground in the watershed range from 0.06 tons/ac/yr to 39 tons/ac/yr. Phosphorus delivery rates range from 0.1 lbs/ac/yr to 36 lbs/ac/yr and nitrogen delivery rates range from 0.9 lbs/ac/yr to as high as 96 lbs/ac/yr. As noted in a previous section, up to 47% of a watersheds' nitrogen load can be expected from tile flow.

Other landuse categories, such as forest and pasture, are responsible for the second and third highest total nutrient and sediment loads from direct or surface runoff. Although per-acre loading from forested areas is low compared to other landuse categories, the watershed contains a high percentage of forested area and, therefore, cumulative loading is higher.

Livestock feed areas, confinements, and streams contribute the highest per-acre nitrogen and phosphorus loads, however, total loadings from these three landuse categories only account for a very small percentage of the overall load. Per-acre nitrogen loading to Waverly Lake from streams within the watershed is largely a result of direct delivery to the lake. Roads can deliver relatively high per-acre sediment loads; this is primarily a function of higher runoff rates and less infiltration.

Table 34 - Loading from Direct Runoff by Landuse Category

Landuse Category	Acres	Nitrogen Load (lbs/yr)	Per Acre	Phosphorus Load (lbs/yr)	Per Acre	Sediment Load (tons/yr)	Per Acre
Row Crops	4,620	**31,152**	6.74	**6,004**	**1.3**	**4,680**	**1.01**
Forest	725	**706**	0.97	**88**	0.12	**16**	0.02
Pasture	68	**430**	6.34	**43**	0.63	**5**	0.07
Roads	50	222	4.48	33	0.66	6	**0.12**
Open Water Pond or Reservoir	163	371	2.27	25	0.15	1	0.004
Grassland	343	92	0.27	17	0.05	2	0.005
Urban Open Space	182	199	1.10	14	0.08	2	0.01
Open Water Stream	16	141	**8.85**	12	0.78	0.2	0.01
Residential Farm	31	49	1.58	7	0.22	1	0.03
Urban Residential	18	32	1.80	5	0.28	1	0.04
Farm Building	16	68	4.37	4	0.27	1	0.06
Feed Area	2	17	**11.42**	3	**1.95**	0.2	**0.12**
Railroad	11	13	1.19	2	0.20	1	0.06
Confinement	1	8	**8.24**	2	**2.09**	0.1	0.11
Industrial	6	11	1.83	1	0.24	0.4	0.07
Warehousing	3	2	0.59	0.5	0.15	0.1	0.03
Institutional	1	4	3.36	0.5	0.42	0.1	0.09
Cemetery	2	2	1.44	0.3	0.21	0.02	0.02
Other Agriculture	1	2	1.88	0.3	0.26	0.1	**0.14**
Wetland	14	19	1.33	0.3	0.02	0.01	0.001
Total	**6,270**	**33,538**	**5.35**	**6,262**	1.00	**4,715**	**0.75**

Table 35 compares the loadings originating from direct runoff with the summed watershed load from all sources, including streambank and lake bank erosion, gully erosion, and failing septic systems. Compared to all sources, row crops are responsible for 81% of the total nitrogen load, 70% of the total phosphorus and 66% of the total sediment load delivered to the lake. Forest and pasture contribute the second and third highest percentage of the total nutrient and sediment load at 2% and 1% for nitrogen, 1% and 0.5% for phosphorus and 0.2% and 0.1% for sediment.

Table 35 – Loading from Direct Runoff by Landuse as a Percentage of Total Watershed Load

Landuse Category	Nitrogen Load (lbs/yr)	% Total Watershed Load	Phosphorus Load (lbs/yr)	% Total Watershed Load	Sediment Load (tons/yr)	% Total Watershed Load
Row Crops	31,152	**81%**	6,004	**70%**	4,680	**66%**
Forest	706	**2%**	88	**1%**	16	**0.2%**
Pasture	430	1%	43	0.5%	5	0.1%
Roads	222	1%	33	0.4%	6	0.1%
Open Water Pond or Reservoir	371	1%	25	0.3%	1	0.01%
Grassland	92	0.2%	17	0.2%	2	0.02%
Urban Open Space	199	1%	14	0.2%	2	0.03%
Open Water Stream	141	0.4%	12	0.1%	0.2	0.002%
Residential Farm	49	0.1%	7	0.1%	1	0.01%
Urban Residential	32	0.1%	5	0.1%	1	0.01%
Farm Building	68	0.2%	4	0.05%	1	0.01%
Feed Area	17	0.04%	3	0.03%	0.2	0.003%
Railroad	13	0.03%	2	0.02%	1	0.01%
Confinement	8	0.02%	2	0.02%	0.1	0.001%
Industrial	11	0.03%	1	0.02%	0.4	0.01%
Warehousing	2	0.005%	0.5	0.01%	0.1	0.001%
Institutional	4	0.01%	0.5	0.01%	0.1	0.001%
Cemetery	2	0.01%	0.3	0.004%	0.02	0.000%
Other Agriculture	2	0.01%	0.3	0.003%	0.1	0.002%
Wetland	19	0.05%	0.3	0.003%	0.01	0.0001%
Total	**33,538**	**87%**	**6,262**	**73%**	**4,715**	**67%**

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

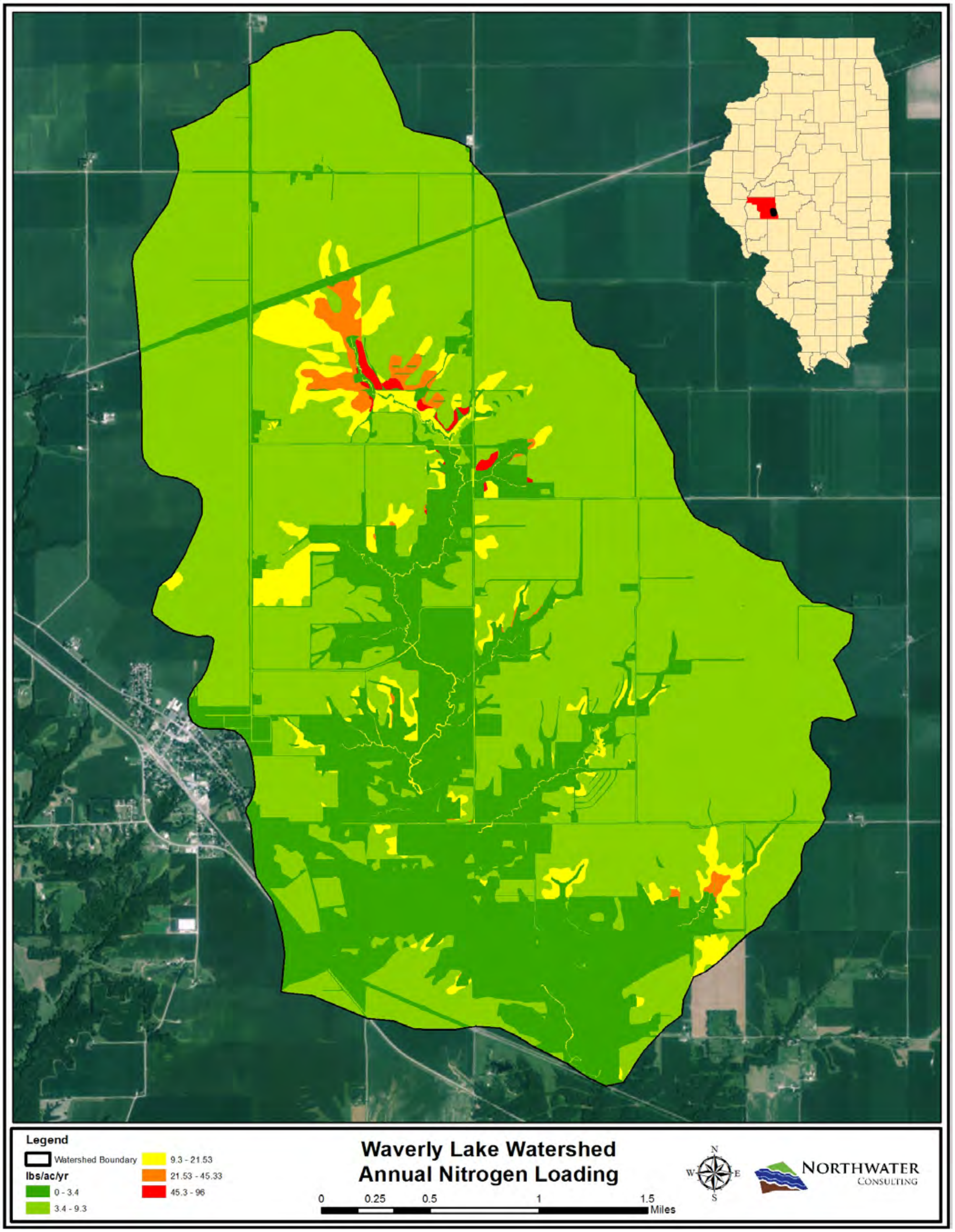


Figure 32 - Waverly Lake Annual Nitrogen Loading from Direct Runoff (lbs/ac/yr)

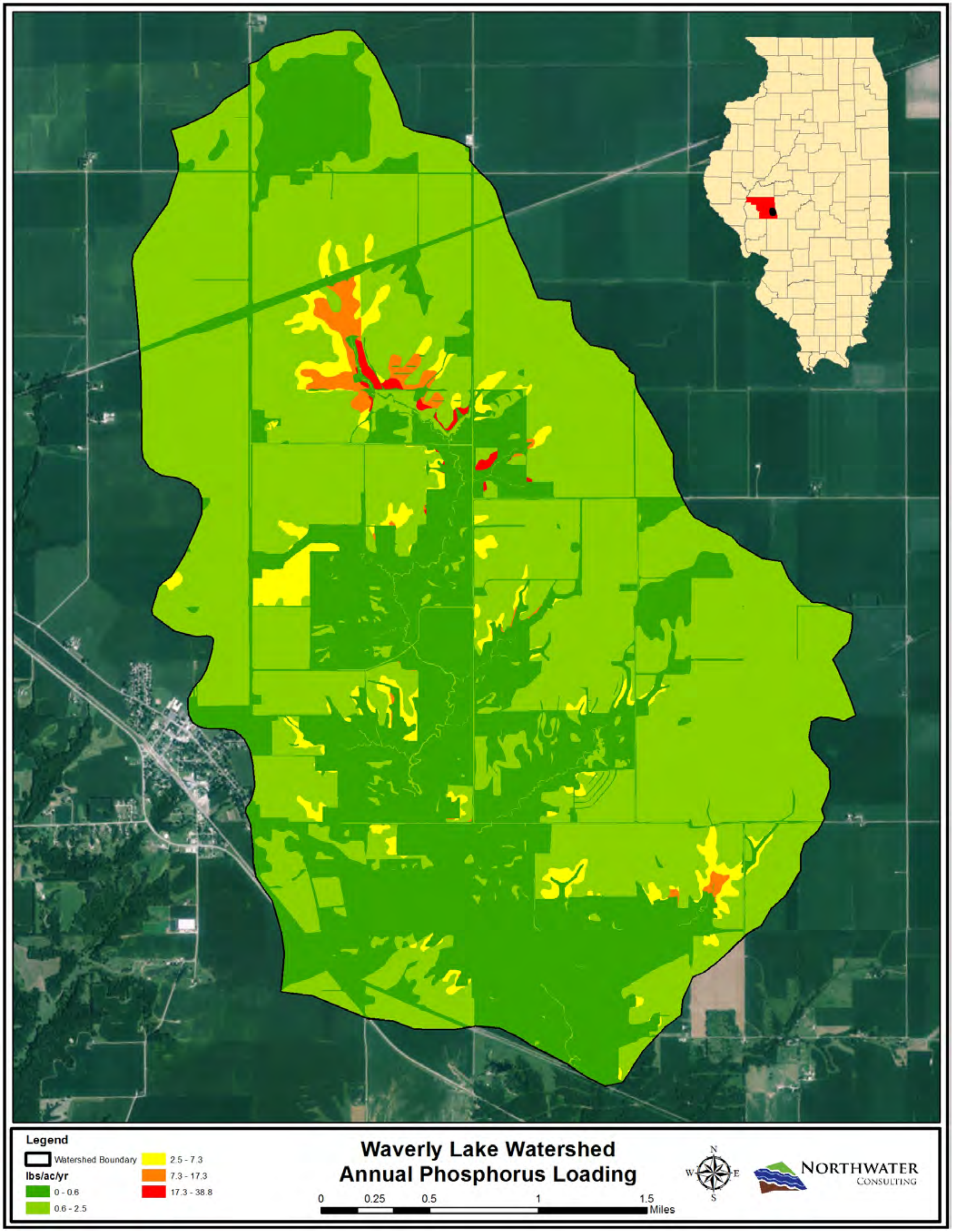


Figure 33 - Waverly Lake Annual Phosphorus Loading from Direct Runoff (lbs/ac/yr)

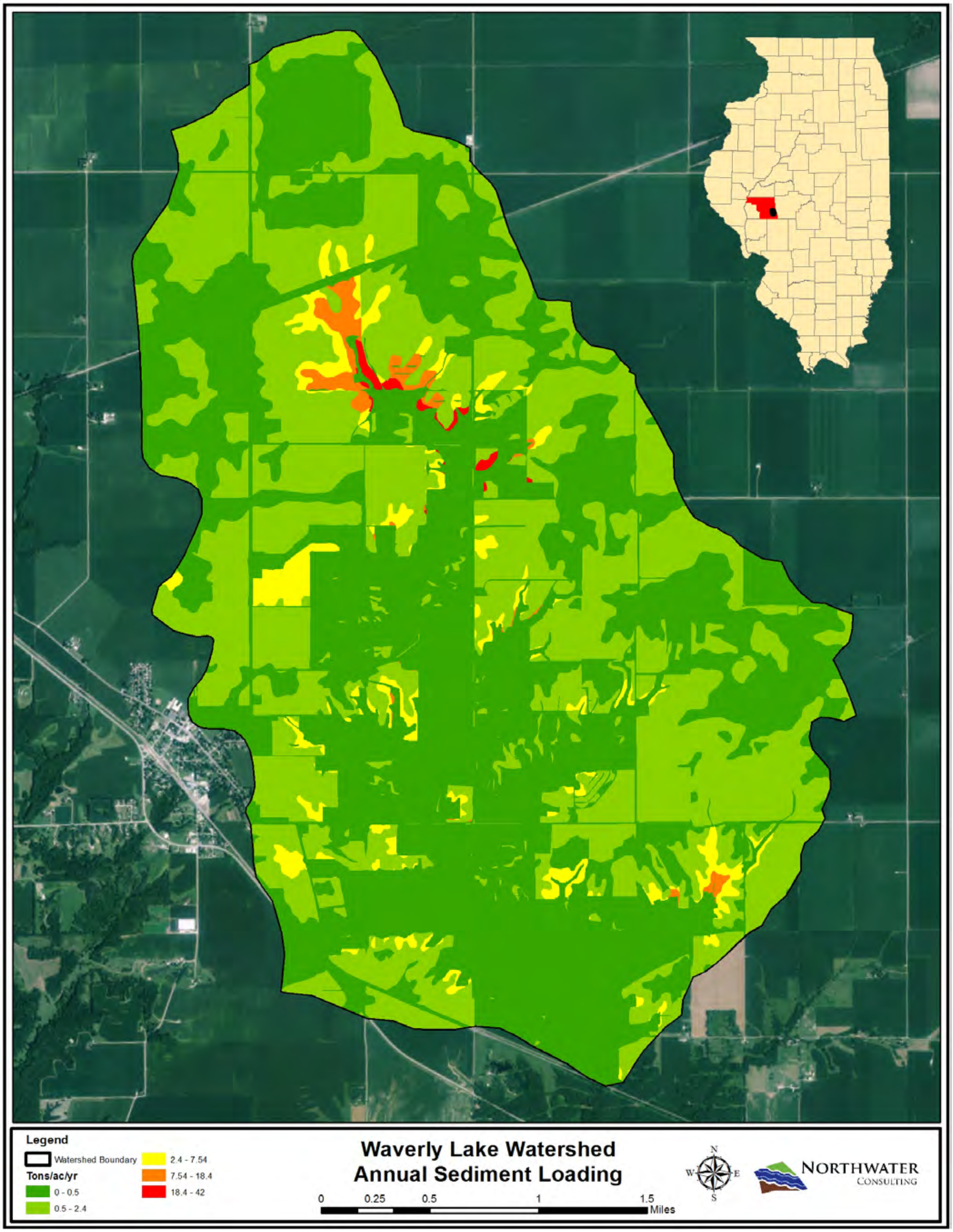


Figure 34 - Waverly Lake Annual Sediment Loading from Direct Runoff (tons/ac/yr)

6.0 Sources of Watershed Impairments

Watershed impairments originate from either nonpoint source (NPS) pollution or point source pollution. The term "point source" is defined as any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture (US EPA, 2016).


Forested Gully

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 industrial and sewage treatment plants, nonpoint source (NPS) pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (US EPA, 2016). No point sources exist within the watershed and, therefore, any lake impairments are believed to be originating entirely from NPS pollution.

In the Waverly Lake watershed, sources of sediment and nutrients are thought to be originating from crop ground, gullies in steep forested areas within the watershed, streambank erosion, lake shoreline erosion and lake sediment (internal phosphorus). Leaking or improperly maintained septic systems may also be a source of nutrients in the watershed.

6.1 Analysis of Pollution Sources

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

6.1.1 Phosphorus & Nitrogen

The primary source of both nitrogen and phosphorus in the watershed is from crop ground which is responsible for 81% of the total watershed nitrogen and 70% of the phosphorus load delivered to the lake. Secondary sources include eroding gullies, stream and lake bank erosion, septic systems and lake sediment.

Crop Ground

The amount of nutrients originating from crop ground depends on tillage practices, proximity to a receiving waterbody, and the presence or absence of conservation practices; although tiling was not specifically assessed in this study, tile flow can have large impacts on nitrogen loading. A modeling effort performed for the Lake Springfield watershed indicated that loading from tile systems accounted for 47% of the entire watershed nitrogen load.

An analysis was performed to better understand the extent of nutrient loading based on tillage practices and HEL designation and results are presented in Table 36. Results indicate that the majority of crop ground nitrogen and phosphorus is from non-HEL reduced/conventionally tilled fields (79% and 68%). It should be noted that a relatively high percentage of the total load is originating from a small percentage of cropped HEL ground. See Figure 35.

Table 36 - Nutrient Load Allocation by Tillage & HEL

Tillage/HEL	Acres	% of Total Crop Area	Nitrogen Load (lbs/yr)	% Total Crop Ground Load	Phosphorus Load (lbs/yr)	% Total Crop Ground Load
Conventional/Reduced HEL	261	6%	5,182	17%	1,761	29%
Conventional/Reduced Non-HEL	4,068	88%	24,669	79%	4,082	68%
No-Till HEL	48	1%	262	1%	50	1%
No-Till Non-HEL	244	5%	1,039	3%	110	2%
Total	**4,620**	**100%**	**31,152**	**100%**	**6,004**	**100%**

Gullies, Lake Shoreline, Streambanks, Septic Systems, & Lake Sediment

The 171 known eroding gullies in the watershed are responsible for 4% of the total watershed nitrogen load and 8% of the total phosphorus load. Streambank erosion delivers 5% of the total watershed nitrogen load and 10% of the total phosphorus load. Lake shoreline erosion accounts for 3% of the total watershed nitrogen load and 7% of the total watershed phosphorus load. It is possible that if the estimated 14 failing septic systems exist in the watershed, they would contribute 1% of the total nitrogen load and 2% of the total phosphorus load.

The 67 gullies (58%) that contribute more than 1 pound of phosphorus per year to the lake contribute 656 lbs/yr of phosphorus or 95% of the entire gully phosphorus load; these same gullies are also responsible for 95% of the entire gully nitrogen load.

Streambanks with high or very severe rates of erosion (greater than 80 lbs/ft/yr) are responsible for 33% of the entire phosphorus and nitrogen load originating from streambank erosion; these banks only make up 6.2% of the entire stream length in the watershed. Nutrient loading from lake shoreline erosion is concentrated at locations where erosion rates are high. Only 19% of the shoreline that is considered to be high in terms of erosion contributes 84% of the entire shoreline nitrogen and phosphorus load (Figure 35).

Internal phosphorus loading from lake sediment was estimated when developing the TMDL (Section 7). The loading from existing sediments within the Lake was estimated using 2015 water quality data – those samples collected from depths greater than 10 feet. The total loading from the sediments for the lake was estimated to be 0.7 pounds per day, or 243 pounds per year (3% of the total phosphorus load).

6.1.2 Total Suspended Solids

The primary sources of TSS in the watershed is cropped agricultural soils; crop ground is responsible for 66% of the entire sediment load. Secondary sources include actively eroding gullies on crop ground and in steep forested areas and eroding streambanks and lake banks.

Crop Ground

The amount of sediment originating from crop ground depends on tillage practices, proximity to a receiving waterbody, the presence or absence of conservation practices, and land slope. As noted in Section 5.14, crop ground that delivers greater than 1 ton/ac/yr of sediment to the lake is responsible for a significant portion of the overall sediment load; 38% of the entire watershed sediment load and 58% of the sediment load from crop ground. An analysis was performed to better understand the extent of loading based on tillage practices and HEL designation and results are presented in Table 37. Non-HEL reduced/conventionally tilled fields are responsible for the majority of the total crop ground sediment load (59%), however, reduced/conventionally tilled HEL fields contribute 39% of the total crop ground sediment load at only 6% of the total crop ground acreage. Addressing soil loss from reduced/conventionally tilled fields is likely an efficient means of reducing overall sediment loads to the lake.

Table 37 - Sediment Load Allocation by Tillage & HEL

Tillage/HEL	Acres	% of Total Crop Area	Sediment Load (tons/yr)	% Total Crop Ground Load
Conventional/Reduced HEL	261	6%	1,836	39%
Conventional/Reduced Non-HEL	4,068	88%	2,773	59%
No-Till HEL	48	1%	39	1%
No-Till Non-HEL	244	5%	32	1%
Total	**4,620**	**100%**	**4,680**	**100%**

Gullies, Lake Shoreline, Streambanks

Gully, lake shoreline and streambank erosion combined is responsible for 34% of the watershed sediment load. As with nutrients, the majority of the sediment for these sources can be traced back to a relatively small number of locations. The 58% of known eroding gullies that contribute greater than 1 ton of sediment per year are responsible for 96% of the entire sediment load from gully erosion. Streambanks exhibiting high or severe rates of erosion are responsible for 33% of the entire streambank load, or 319 tons/yr (Figure 35). As with nutrient loading, a very large percentage of the entire sediment load from shoreline erosion can be allocated to only 19% of the total length. This 19%, or 6,328 feet, contributes 519 tons/yr, or 81% of the entire shoreline sediment load. Targeting these areas first is an efficient means of reducing sediment loads from lake banks.

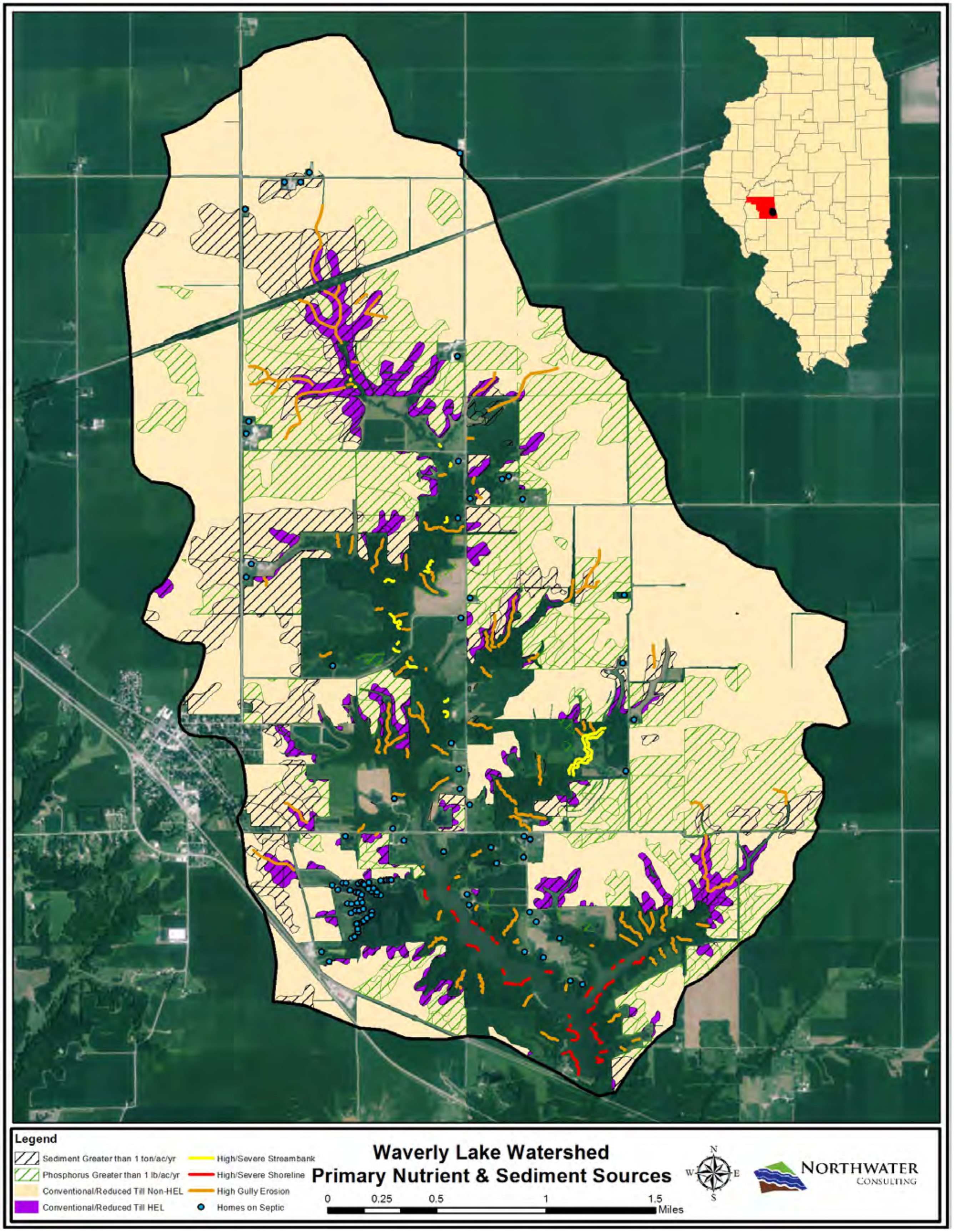


Figure 35 - Waverly Lake Watershed Primary Nutrient & Sediment Sources

7.0 TMDL & TMDL Model Development

7.1 Model Development

The BATHTUB model, version 6.20, was used to link nutrient loads with observed water quality for Waverly Lake. BATHTUB was developed for the United States Army Corps of Engineers (Walker, 1982). The model is an empirical model that was derived and refined based on assessments of a large number of lakes and reservoirs. The empirical equations are used to perform steady-state water and nutrient calculations based on the lake morphology and tributary inputs. This model was selected because it requires fairly simple inputs to predict the target constituent. BATHTUB can account for transport, sedimentation and nutrient cycling. BATHTUB has been accepted for lake TMDLs in Illinois, as well as other states.

BATHTUB has three primary input interfaces relative to Waverly Lake. These are: 1) global; 2) segment; and 3) tributary inputs. BATHTUB provides several selection options on the mathematical formulation to predict total phosphorus. Watershed loadings were derived independently and input into the model as direct inputs. These loadings were developed based on the direct runoff model described in Section 5.0 and in Appendix A, as well as other estimated contributions from streambank erosion, gully erosion, and potentially failing septic systems.

The Total Phosphorus (TP) standard for lakes set by Illinois is 0.05 milligrams per liter (mg/L). The BATHTUB model was used to predict the TP concentration for existing conditions in Waverly Lake based on monitoring data for April to October 2015. In looking at the entire dataset, there was a general trend of increasing phosphorus concentrations in the Lake. Therefore, the 2015 dataset was selected so that the overall lake average was not artificially decreased from the most current dataset. The 2015 dataset also provided the most comprehensive monthly sample results, which provides a better comparison to the assessment methodology used by the State. The calibrated model was then used to predict the reduction in inputs of TP needed to achieve the 0.05 mg/L standard.

7.2 Model Setup

Total phosphorus was predicted using the 2nd Order, Available P selection. This formulation utilizes a second-order sedimentation coefficient to predict removal of phosphorus from the Lake (Walker, (1987). Given that monitoring data for TP are available only for the lower part of the lake, Waverly Lake was simulated with a single segment. The approach chosen for the longitudinal dispersion was the Fischer-Numeric model.

7.2.1 Global Variables

For this model deck, the user specifies the "Averaging Period" in years for which other global variables are averaged. An averaging period of 1-year was used in this application consistent with the watershed loadings and runoff volume provided to AquAeTer by Northwater Consulting. Global variables include precipitation, evaporation, storage gain in water for the averaging period, and atmospheric loadings of total nitrogen (TN), TP, and the inorganic fractions of nitrogen and phosphorus.

The precipitation used was 39.49 inches per year (in/yr) based on the Jacksonville gage consistent with the watershed modeling (2000-2015 data record).

The evaporation rate was set at 32.3 in/yr (0.82 m/yr). The pan evaporation rate was set based on the average pan evaporation for three stations: Hennepin; Perry; and Springfield. The pan evaporation data were multiplied by 0.75 to represent the evaporation expected from Waverly Lake relative to the published pan evaporation data (ISWS, 2007).

The atmospheric loading for total phosphorus was set at 0.03 milligrams per square meter per year (mg/m2·yr), which is the default value recommended in absence of site-specific data in the model guidance (USACE, 1999).

7.2.2 Lake Inputs

For this model deck, the user can input the lake morphometry, internal water quality, segment-specific rate adjustments, and internal loadings. For this application, one segment was chosen to represent Waverly Lake. This was partially due to the small size of the lake, but it is mainly due to limited available data within the Lake. Data for the morphometry were taken from the Sedimentation Survey of Waverly City Reservoir Final Report, dated October 13, 2009. Water quality data from Waverly Lake were provided by Northwater Consulting.

The surface area of Waverly Lake was given as 104.8 acres and was input as 0.4241 square kilometers (km2). The mean depth of the reservoir was determined to be 7.0 feet and was input as 2.13 meters. This was derived by averaging the volume of each one-foot interval and determining the corresponding depth. Alternatively, the volume to surface area of the lake is also 7.0 feet. The length was measured based upon the longest pathway from the dam to the upper reaches of the reservoir (1.44 miles). This was input as 2.31 kilometers.

The segment was not separated into separate layers. There is a potential for the deepest section of the Lake to separate during the summer months. However, this volume represents a small fraction, approximately 6%, of the overall lake volume. More data would be required for the lake in order to justify separating the lake into separate segments with layers.

Pond in Watershed

The TP data collected on the Lake was evaluated. Total phosphorus data were collected from two to three stations at multiple depths (Figure 9). These data were used to compute lake-wide average TP concentrations incorporating the lake volume represented by samples collected at different water depths. An average value for all samples collected from depths between 1 to 10 feet was calculated for the upper portions of the lake, and all samples collected for depths greater than 10 feet was calculated for the deep layer in the deepest portion of the lake. By averaging data for these two depth layers, the seasonal increase in TP concentration in bottom waters from sediment release of phosphorus can be integrated into the TP mass balance for the lake while weighting the data to account for the small volume of bottom waters. From these two depth averages, a lake average TP concentration was calculated based on the volumes represented by each depth average.

The data range showed a generally increasing trend, with 2015 representing the largest average concentrations (Figure 36). For this reason, the 2015 dataset was used for the calibration dataset. The lake arithmetic average was calculated as 0.138 mg/L, with a standard deviation of 0.038 mg/L. The median lake-wide average TP concentration for the five sampling dates in 2015 was 0.122 mg/L. Both the median and the mean were used in separate calibration runs.

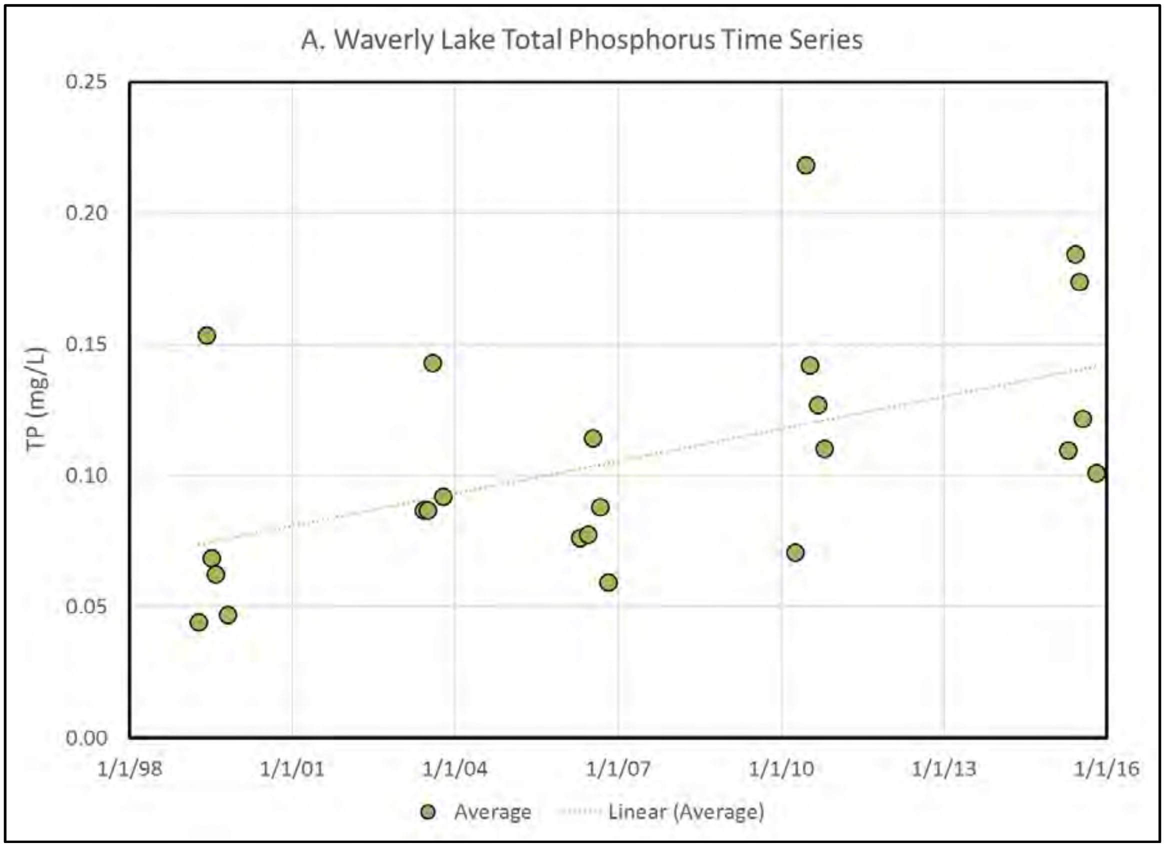


Figure 36 - Waverly Lake TP Time Series Plot

The internal TP loading used in the model calibration was derived to account for two direct sources to lake waters. Loading from the lake shore was provided by Northwater Consulting. This value was 557 lbs/yr. The loading from existing sediments within the Lake was estimated using the 2015 water quality dataset for the samples collected from depths greater than 10 feet, where the average TP concentration increased between April and July samplings. A regression for the 2015 dataset was determined to be

0.055 mg/L per month (30 days). The volume of the lake that was greater than 11 feet deep was 14 million gallons.

Based on this volume and the regression, the release rate from the deeper portion of Waverly Lake was determined in mass per unit area per time. To account for total phosphorus release from sediments in areas of the lake with maximum depth of less than 10 feet, it was assumed that the shallower sections of the lake would have an average release rate over the year that was 50% of the deeper sections. The assumed lower sediment phosphorus release rate from shallower regions is due to the typical pattern of sedimentation in a lake with fine sediments accumulating at a higher rate in the deeper portions of the lake. The deeper sections of the Waverly Lake account for 19% of the lake surface area. The total loading of TP from the sediments for the lake was estimated as 243.3 lbs/yr. The lake shore loading and the sediment loading were added together and divided by the lake area to determine the internal loading rate. The corresponding rate entered in the model was 2.3 $mg/m^2 \cdot day$.

7.2.3 Tributary Inputs

For this model deck, the user can input the total watershed area, the annual flow rate, and the inlet concentrations. Land uses can also be specified. However, loadings were provided by Northwater Consulting, so this feature of the BATHTUB model was not used. The watershed area was determined to be 9.31 mi^2, which was input into the model as 25.46 km^2.

The annual runoff flow rate from the watershed draining to Waverly Lake was provided with estimated TP, TN, and sediment loads by Northwater Consulting. The annual runoff was 5,431 acre-feet per year. The TP loadings provided by Northwater Consulting totaled 7,995 lbs/yr for the direct runoff, streambank, and gully erosion loadings, as well as TP input through tributaries from failing septic tanks. This loading was combined with the annual runoff to calculate the incoming TP concentration. This was determined to be 0.541 mg/L.

7.2.4 Model Calibration

Two separate calibration models were developed with the data described in the above paragraphs. One model used the lake-wide mean for TP concentration from 2015 as the Lake target concentration while the second model used the median concentration. The use of the median TP concentration to assess lake condition is consistent with the Illinois assessment methodology for waters of Illinois (IEPA, 2016). Each model was calibrated by adjusting the rate adjustment factor for TP sedimentation from the default value of 1.

Case 1 was calibrated to the mean lake average concentration of 0.138 mg/L. The second model, Case 2, was calibrated to the median lake average concentration of 0.122 mg/L. For the mean lake average of 0.138 mg/L, the rate adjustment factor was set to 1.94, resulting in a predicted area-weighted mean of 0.137 mg/L. For the median lake average of 0.122 mg/L, the rate adjustment factor was set to 2.52, resulting in a predicted area-weighted mean of 0.121 mg/L.

7.2.5 Model Sensitivity

Parameters were adjusted to determine the model's sensitivity to variation in key inputs. The following table presents the input for the calibrated models, the change, and the resulting predicted concentration. All sensitivity runs were performed with the Case 1 calibrated model with the adjustment of a single input factor. Units listed are those required by the BATHTUB model. The predicted lake TP concentration for the Case 1 model is 0.137 mg/L.

Table 38 - TMDL Model Sensitivity Analysis Summary

Parameter	Base	Adjustment	Model	Change
Averaging Period	1 yr	1.25	0.137	0%
		0.75	0.137	0%
Precipitation	1.0 m/yr	1.2	0.137	0%
		0.8	0.138	0.7%
Evaporation	0.82 m/yr	1	0.138	0.7%
		0.6	0.137	0%
Atmospheric Loading	0.03 mg/m^2/yr	30	0.137	0%
Surface area	0.4241 km^2	0.53	0.132	-4%
		0.32	0.146	7%
Mean Depth	2.13 m	2.7	0.124	-9%
		1.6	0.156	14%
Length	2.31 km	2.89	0.137	0%
		1.73	0.137	0%
Internal Load	2.3 mg/m^2/day	2.9	0.139	1%
		1.7	0.136	-0.7%
Watershed Area	25.46 km^2	31.8	0.137	0%
		19.0	0.137	0%
Annual Flow Rate	6.699 hm^3/yr	8.37	0.144	5%
		5.02	0.131	-4%
Inlet Concentration	0.570 mg/L	0.670	0.149	9%
		0.470	0.124	-9%

The model is most sensitive to the inlet tributary concentration and mean depth but also sensitive to the surface area and annual flow rate. The mean depth and surface area are both set by the physical setting of the lake, although the mean depth is expected to change with time based on the past sedimentation surveys. The percentage change listed for each sensitivity run is relative to the base Case 1 run, which predicted a lake TP concentration of 0.137 mg/L.

7.2.6 Load Reduction

For each case, a series of model runs were done in which the internal and tributary loadings were reduced until the target TP concentration of 0.05 mg/L was met. For each reduction case, the tributary and lake shore loadings were multiplied by a scale factor, while the internal sediment loading were multiplied by one-half the scale factor. The load reduction scenarios are provided in Table 39. The change in predicted lake TP concentration for the calibrated models is illustrated in Figure 37. Bold values indicate reduction scenarios that achieve the TP standard of 0.05 mg/L for either Case 1 (calibrated to mean TP value) or Case 2 (calibrated to the median TP value).

Table 39 - TMDL Loading & Reduction Summary

Tributary TP (lbs/yr)	Tributary TP (lbs/day)	Internal TP (lbs/yr)	Internal TP (lbs/day)	Reduction (%)	Case 1 (mg/L)	Case 2 (mg/L)
7,995	23	800.3	2	0	0.137	0.122
3,998	12	600.2	1.6	50	0.094	0.085
3,198	9	560.2	1.5	60	0.083	0.075
2,399	7	520.2	1.4	70	0.072	0.065
1,999	6	500.2	1.3	75	0.065	0.059
1,599	5	480.2	1.3	80	0.058	0.052
1,439	4	472.2	1.3	82	0.055	**0.05**
1,199	3	460.2	1.3	85	**0.05**	0.046
800	2	440.2	1.2	90	0.041	0.038

The model predicts that a load reduction of 82 to 85 percent of the existing load to Waverly Lake through watershed loading is needed to achieve the TP standard for the lake of 0.05 mg/L based on median or mean values. Further, the reduction scenario incorporates reductions in shoreline erosion of 41% and 42.5% incorporated into the model as an internal load.

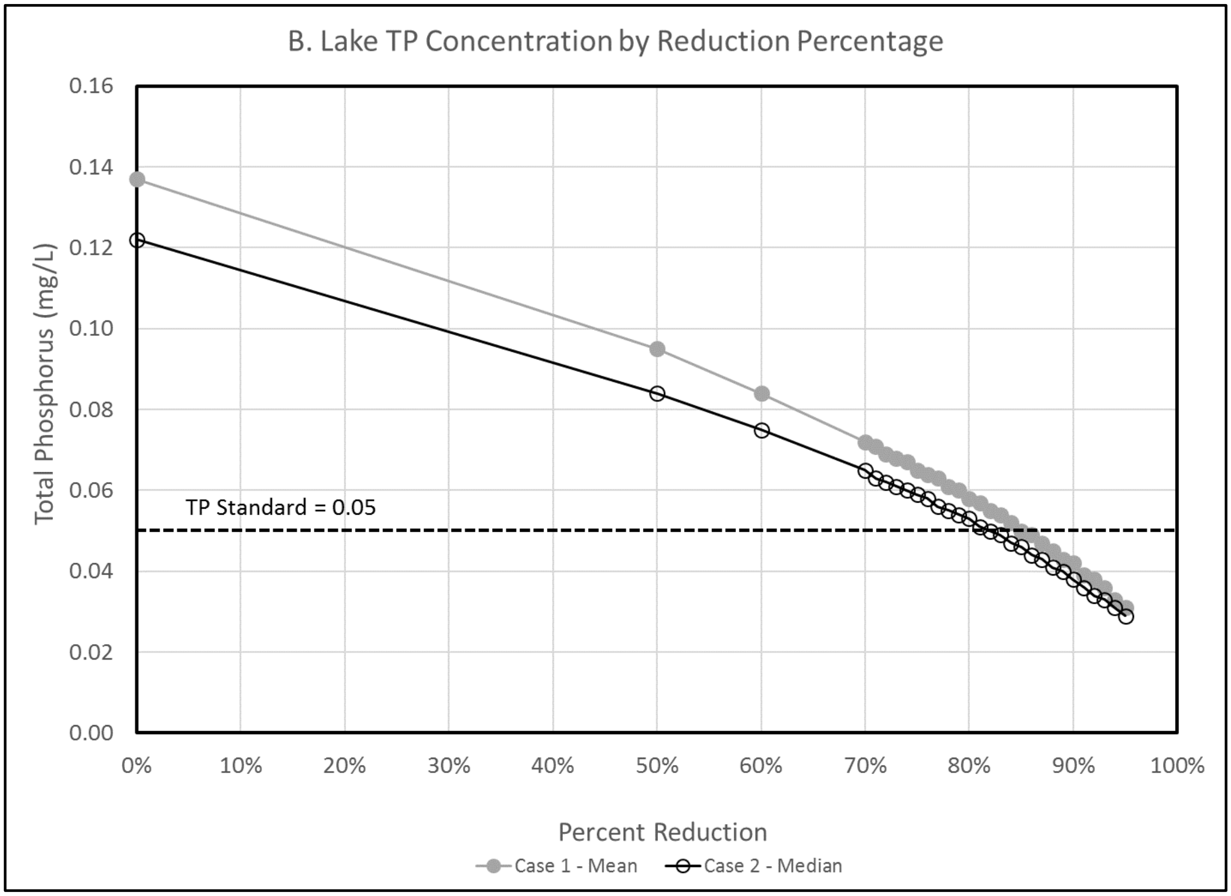


Figure 37 - Waverly Lake TP Concentrations by Reduction Percentage

7.2.7 Conclusions

The calibrated BATHTUB Model developed for Waverly Lake provided an adequate prediction of the whole-lake average TP concentration from five monitoring dates in 2015. The mean (0.138 mg/L) and median (0.122 mg/L) concentrations for monitoring in 2015 between April and October were well above the water quality standard TP of 0.05 mg/L for lake waters in Illinois. Calibrated Models for 2015 based on either the mean TP concentration or the median value indicated loading of TP to Waverly Lake would need to be reduced by 82-85% to attain the water quality standard of 0.05 mg/L.

7.3 TMDL

This section represents the various components of the TMDL, as required by the Clean Water Act. Description of the model development and use to support the reduction percentage is provided in the previous section.

7.3.1 Loading Capacity

The loading capacity of Waverly Lake is the maximum amount of total phosphorus (TP), in pounds per year, which allows attainment of the water quality standard for TP of 0.05 mg/L; loading of TP at a higher amount would result in TP concentrations above the water quality standard. The BATHTUB model was used to identify the load capacity of Waverly Lake for TP inputs. For this assessment, the loading capacity was determined for attainment of the TP water quality standard as the median of TP concentrations for monitoring during months of April to October and as the mean. The loading capacity was determined to be 1,439 lbs/yr for TP loading. Loadings from tributaries, shoreline erosion, and bottom sediments were included in the analysis based on analyses reported in this report and lake data from 2015. The reduction from the current loading of TP to the lake would be 82% of total inputs.

7.3.2 Allocations

Development of allocations for this TMDL were done based on the current and anticipated future use of the watershed for agricultural crop production. The TMDL allocation is expressed as:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS} + \text{RC}$$

Where TMDL is the overall load capacity, WLA is the waste load allocation assigned to point sources, LA is the load allocation assigned to nonpoint sources, MOS is the margin of safety, and RC is the reserve capacity. In this TMDL, inputs to the lake are from nonpoint sources, and so, allowable TP load to the lake is not assigned for WLA. Also, RC is not allocated because future growth in the watershed is not projected to occur in the near future. New future inputs in the watershed would need to be offset with reduction of existing sources.

The allocations of TP loads for the Waverly Lake TMDL are summarized in Table 40. The existing TP load to the lake is based on the watershed analysis presented in section 6, including shoreline erosion, and estimated phosphorus release from bottom sediments calculated from 2015 TP concentration data for bottom waters of the lake for April to July 2015. The loading capacity is based on attainment of a median TP concentration of 0.05 mg/L in Waverly Lake for the April to October period consistent with the implementation of the TP standard in the assessment of compliance for the 305(b) and 303(d) reporting requirements of the Clean Water Act. The loading capacity was determined through the use of the BATHTUB model. The loadings into Waverly Lake were adjusted until the target TP concentration was met, as previously shown in Table 39. This resulted in the loading capacity presented in Table 40. For comparison purposes, a breakdown of all total phosphorus sources are presented in Table 41. A margin of safety of 10% is used based on conservatism integrated into the modeling (implicit) and an explicit allocation of 5% (see Section 7.3.4)

Table 40 - Waverly Lake TMDL Summary for TP

Category	TP (lbs/yr)	TP (lbs/day)
Existing Load	8,795	24.1
Reduction	82%	82%
Loading Capacity	1,439	3.9
Waste Load Allocation	0	0
Margin of Safety (5%)	72	0.2
Load Allocation	1,367	3.7

Table 41 - Waverly Lake TP Source Summary

Source	TP (lbs/yr)	TP (lbs/day)	% of Total Load
Direct Runoff	6,262	17	71%
Streambank Erosion	867	2.4	10%
Lake Bank Erosion	566	1.6	6%
Gully Erosion	687	1.9	8%
Septic Systems	170	0.5	2%
Internal P Release (Lake Sediment)	243	0.7	3%
Total	**8,795**		**100%**

7.3.3 Seasonal Variation

Section 303(d)(1)(C) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7(c)(1) require that a TMDL be established that addresses seasonal variations normally found in natural systems. Seasonal changes to lake systems involve variation in tributary inflows and TP loading from sources in the watershed. For this TMDL, seasonal variation for inputs to Waverly Lake is incorporated both from total inputs to the lake on an annual basis and from use of lake TP concentration data for April to October 2015 in calibrating the BATHTUB model. Modeling on an annual basis takes into account the seasonal effects the lake will undergo during a given year. Since pollutant sources can be expected to contribute loadings in different quantities during different times of the year, the loadings for this TMDL will focus on average annual loadings rather than specifying different loading by a particular season. This will incorporate both variation in agricultural activities throughout the year and in rainfall intensity. Because an average annual period was used for TMDL development, it is assumed that any critical condition is accounted for within the analysis.

The TMDL scenario simulated by the BATHTUB model is predicted to meet the compliance targets based on an overall loading capacity of TP to the lake. The key to achieving the TP standard for the lake is implementation of a set of management practices that will achieve the proposed load reduction. The expression of the cumulative set of management practices to attain the TP standard is best expressed in terms of annual loading rates due to the internal component of the phosphorus cycle in lakes where phosphorus accumulated in sediments from inputs throughout the year is released back to the water column. However, the TMDL must include daily load allocations as required by USEPA. To specify a daily maximum load that achieves the loading capacity, the annual loads were simply divided by 365 days. The daily load expression, while required by law, is thus a supplementary expression to the longer term loading capacity and allocations that form the essential part of achieving use support in the lake.

7.3.4 Margin of Safety

Section 303(d) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7 require that TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variation and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitation and water quality. The margin of safety (MOS) in a TMDL is an additional factor included to account for scientific uncertainties in the analysis.

Forested Gully

The MOS can be expressed implicitly in the analysis through use of conservative assumptions in the model development and application effort or explicitly as a portion of the loading capacity. Use of conservative modeling assumptions and a high level of certainty in modeling due to a comprehensive data set on which to develop the TMDL would provide reasonable justification for a low explicit MOS. For this model, the lake-wide average data were used as the target concentration for meeting the water quality standard. Based on the dataset, the lake-wide average data are 5% greater than the surface TP concentrations. This is an implicit conservatism that is built into the model.

For this TMDL, the calibration target for model development was based on the whole-lake average TP concentration rather than on data limited to the upper photic layer of the lake. This would include the accumulation of TP in bottom waters from sediment release. Because of the limited data available for model development, an explicit MOS of 5% of the loading capacity was also included. This results in an effective MOS of 10% including both the implicit and explicit contributions.

8.0 Nonpoint Source Management Measures & Load Reductions

This section details the recommended BMPs for the watershed, their applicable quantities and expected annual pollution load reductions. Although reductions presented below include nitrogen, phosphorus and sediment, special attention is given to phosphorus. Phosphorus is the only parameter for which a TMDL was developed and described in the previous section. An 82% reduction in annual phosphorus loading is needed for Waverly Lake to meet the water quality standard of 0.05 mg/L. Practices that reduce phosphorus and sediment loading should receive priority.

BMPs can be described as a practice or procedure to prevent or reduce water pollution and address stakeholder concerns. BMPs typically include treatment requirements, operating procedures, and practices to control runoff and abate the discharge of pollutants. This section of the plan describes all site-specific BMPs needed to achieve measurable load reductions in phosphorus, nitrogen and sediment.

Estimates of the expected pollution load reductions associated with recommended practices are included in this section. Load reductions are calculated using average pollutant reduction percentages based on existing literature and local expertise. Average pollutant reduction percentages can be found in Table 42.

Table 42 - Average Pollutant Reduction Percentages

BMP	Reduction % Nitrogen	Reduction % Phosphorus	Reduction % Sediment
WASCB/Terrace[1,3]	15-30%	30-65%	35-70%
Grade Control/Riffle[1]	2-5%	10-40%	15-40%
Detention Basin/Pond	20-40%	25-50%	40-70%
Pasture Management System	60%	70%	85%
Feed Area Waste System	80%	90%	90%
Grassed Waterway[3]	15-35%	10-45%	10-50%
Filter Strip	30-50%	35-55%	40-65%
In-Lake/Low Flow Dam	10-20%	15-30%	20-35%
Grass Conversion	75%	75%	75%
Livestock Stream Fencing	40%	45%	50%
Wetland[2]	10-60%	15-75%	20-80%
No-Till/Strip Till	30%	30%	40%
Cover Crop	30%	30%	40%
Nutrient Management (Plan)[4]	15%	12%	0%

[1] – Controls 100% of gully erosion
[2] – Reduction percentage used for two-stage ditch; two-stage ditch reduction includes 100% reduction in streambank erosion
[3] – Reduction percentage includes BMP maintenance of existing structures
[4] – Reduction percentage for nitrogen only applies to tile nitrogen

8.1 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 location and, therefore, expected load reductions are spatially explicit; all estimated reductions represent delivered pollutants.

Table 43 lists all proposed BMPs, quantities, area treated, and expected annual load reductions. Project or BMP locations are shown in Figures 38 and 39; Figure 40 is specific to just shoreline stabilization. The largest total expected reductions are realized from tillage practices and a series of in-lake/low-flow dams, however, these practices may be costly or difficult to implement due to landowner willingness. Section 9, cost estimates, evaluates cost per unit of pollutant reduction; Section 10, Water Quality Targets, compares each BMP against TMDL and water quality targets; Section 11, Priority BMPs & Critical Areas, details priority implementation actions. Individual BMP load reductions and details by BMP number are in Appendix C.

Table 43 – Recommended BMP & Load Reduction Summary

TYPE	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
Cover Crop	330 (ac)	330	485	66	47
No-Till/Strip-Till	4,334 (ac)	4,334	8,956	1,753	1,843
Filter Strip	1.3 (ac)	21	194	73	89
Field Border	61.6 (ac)	888	1,759	350	267
Grass Conversion	16.3 (ac)	16	42	5.0	2.2
Grade Control	33 (#)	253	191	94	107
Streambank Stabilization / Riffle	233 (ft) / 6 (#)	0	361	162	180
Livestock Waste System	1 (#)	3	19	4.1	0.3
Livestock Fencing	6,708 (ft) / 3 (#)	25	94	11	1.9
Grassed Waterway	15,367 (ft) / 18.3 (ac)	1,197	2,050	475	478
In-Lake / Low-flow Dam	1,960 (ft)	6,236	4,707	1,984	2,077
WASCB	109 (#) / 16,350 (ft)	666	1,082	452	429
Wetland	3 (ac)	214	257	80	85
Pond	39 (#)	696	1,628	441	413
Lake Shoreline Stabilization	6,418 (ft)	N/A	1,055	472	531
Nutrient Management (Plans)	4,620 (ac)	4,620	2,196	720	0
Septic Systems	14 (#)	N/A	1,553	608	0
Dredging	N/A	N/A	N/A	243	N/A
Total		**14,879**	**26,629**	**7,992**	**6,550**

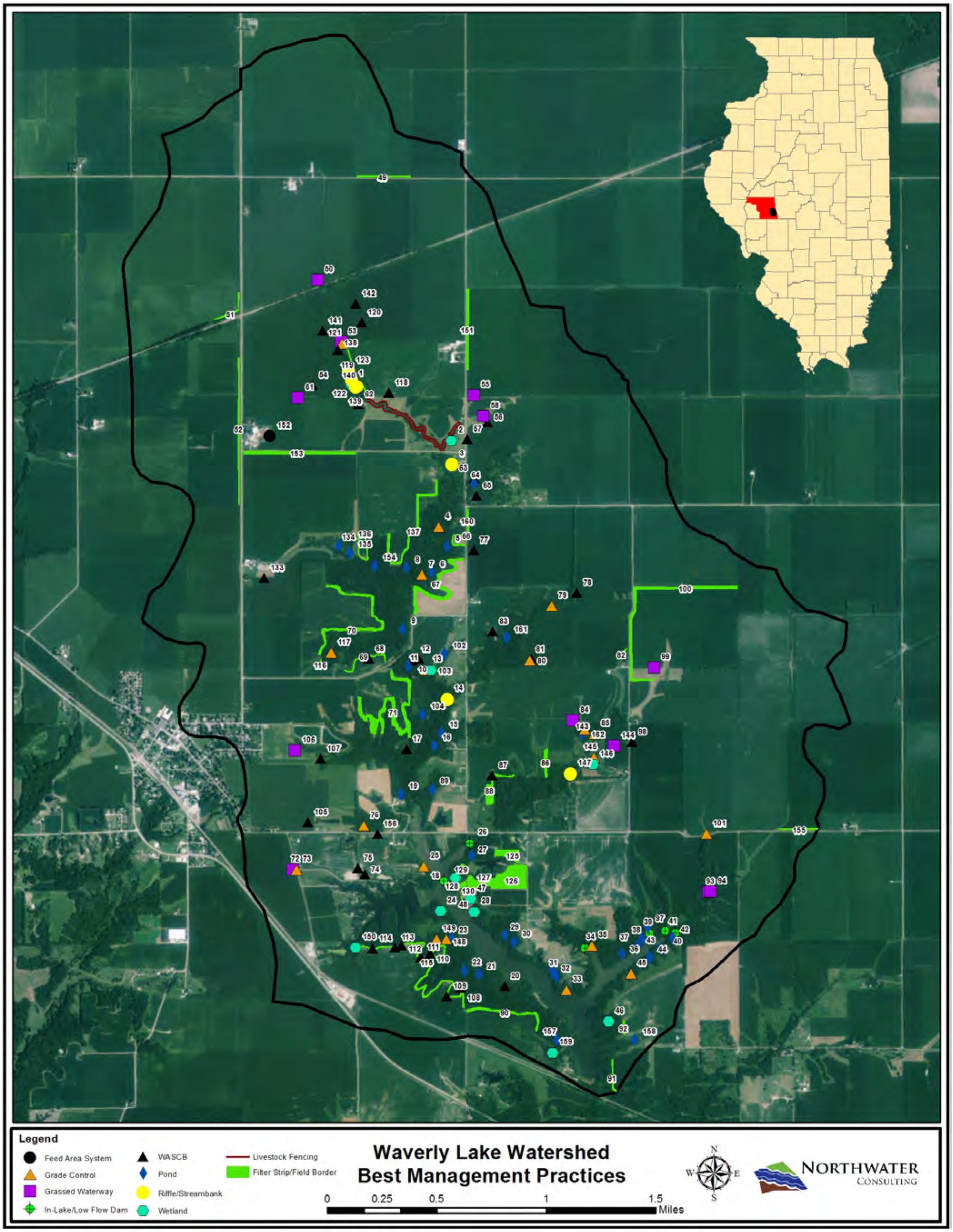


Figure 38 - Waverly Lake Watershed BMPs (1)

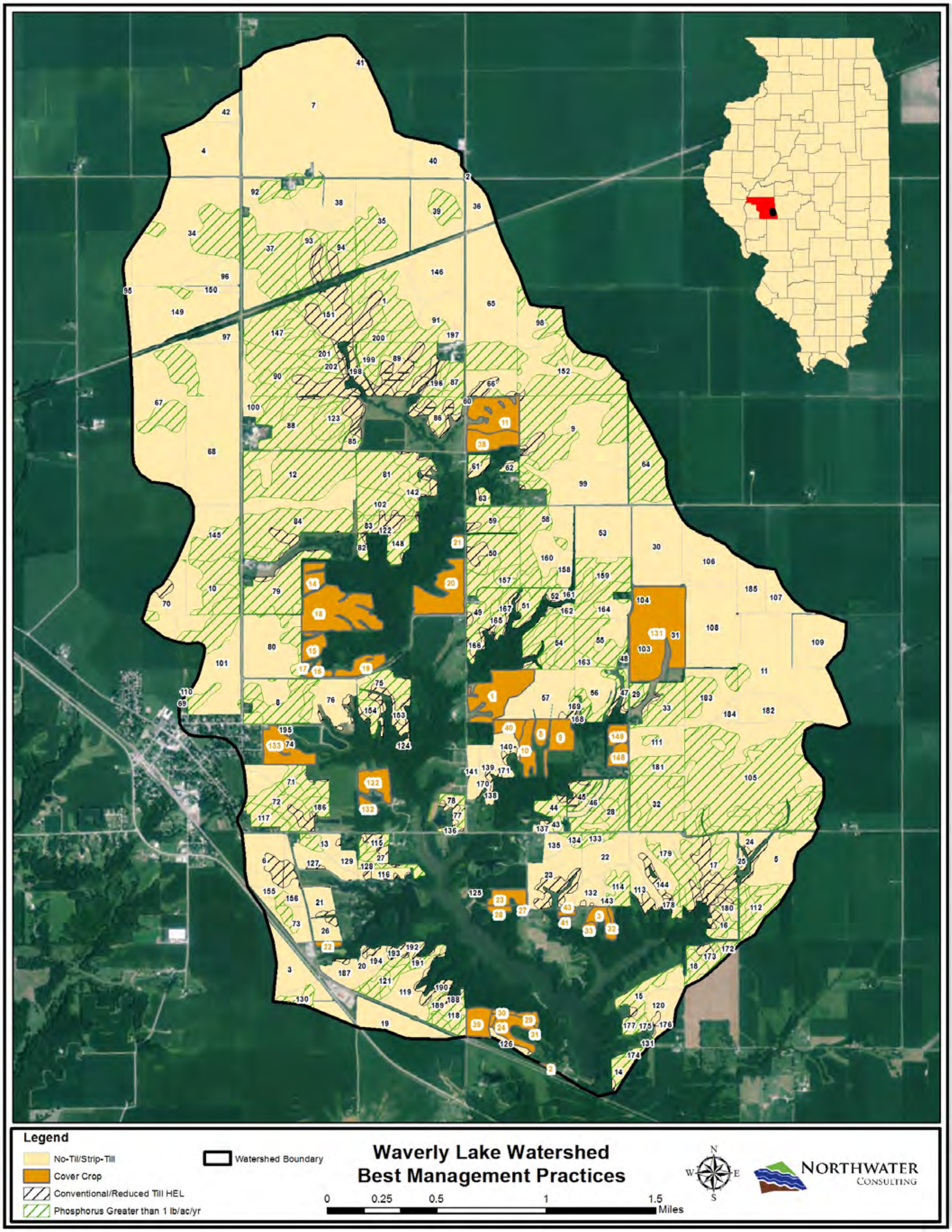


Figure 39 - Waverly Lake Watershed BMPs (2)

8.2.1 Best Management Practice Summary & Load Reductions

This section provides a brief description of each BMP and their expected load reductions.

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. Cover crops are only recommended for fields where no-till is currently being practiced or where willing landowners expressed interest.

Cover Crops

Cover Crops are proposed at 35 locations in the watershed for a total of 330 acres. If all 330 acres of cover crops are implemented, the following load reductions are expected:

- 485 lbs/yr of nitrogen
- 66 lbs/y of phosphorus
- 47 tons/yr of sediment

It is believed that as more producers shift toward non-conventional tillage systems, such as strip-till or no-till, the acreage of farm ground where cover crops can be reasonably implemented will also increase.

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 and, therefore, is recommended for all fields in the watershed where conventional or reduced tillage is occurring. 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.

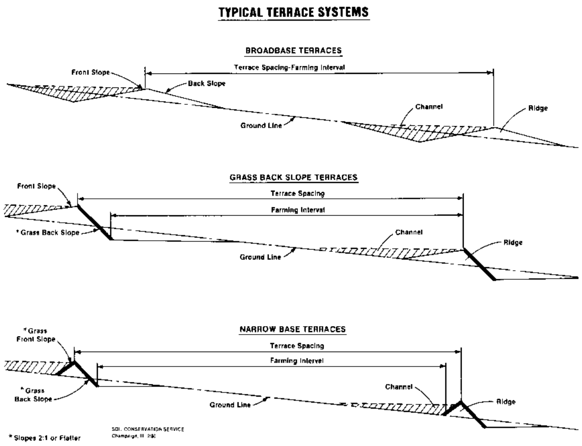
No-till

No-Till or strip till is proposed for all fields where conventional and reduced tillage is occurring (Figure 39). These BMPs are recommended at 202 locations in the watershed for a total of 4,334 acres. If all 4,334 acres are treated, the following load reductions are expected:

- 8,956 lbs/yr nitrogen
- 1,753 lbs/yr phosphorus
- 1,843 tons/yr sediment

Water and Sediment Control Basins (WASCB)/Terrace

Earth embankment and/or channel constructed across 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. Terraces, similar to a WASCB in design, are placed in areas where concentrated flow paths are less defined, such as long, wide-sloping fields. These practices are both popular with landowners in the watershed and applicable in many situations.



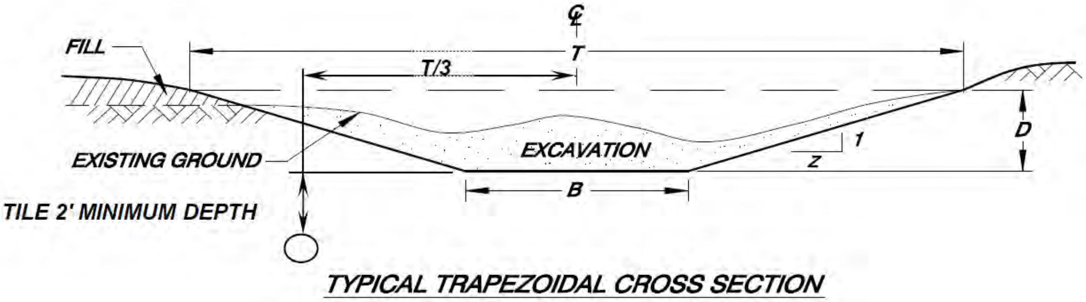
WASCBs are recommended at 35 locations for a total of 109 basins or 16,350 feet (150-foot length average) to treat 666 acres. Twelve out of the 35 locations are maintenance of existing basins that are beyond their effective lifespan and are not functioning properly. Maintenance activities include excavation behind the basin, raising ridge height and replacing risers.

One practice is on city property and is a maintenance project along a gravel roadway; this practice is intended to divert rather than store and filter water. If all WASCBs are implemented to treat 666 acres, expected load reductions, including gully stabilization, will total:

- 1,082 lbs/yr of nitrogen
- 452 lbs/yr of phosphorus
- 429 tons/yr of sediment

Water & Sediment Control Basin

Grassed Waterways



A grassed 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 the watershed in areas with very large drainage areas and low-moderate slopes. Although these practices are not popular with local producers, they are often the only feasible practice in a field that drains a very large area.

Grassed Waterways are recommended at 12 locations for a total of 15,367 feet or 18.3 acres. Two recommended waterways include the maintenance of existing structures and include widening, shaping and re-seeding (0.5 acres). If implemented to treat 1,197 acres, the load reductions, including gully stabilization for all grassed waterways, are expected to be:

- 2,050 lbs/yr of nitrogen
- 475 lbs/yr of phosphorus
- 478 tons/yr of sediment

Constructed Wetland

A constructed wetland is a shallow water area constructed by creating an earth embankment or excavation area. Constructed wetlands can include a water control structure and are designed to mimic natural wetland hydrology, store sediment and filter nutrients. Constructed wetlands have been identified in areas where hydric soils support their establishment or where local topography does not allow for the construction of a pond.


Constructed Wetland

Wetlands are recommended at 11 locations in the watershed for a total wetland area of 3 acres. If implemented to treat 214 acres, expected load reductions, including gully stabilization, are:

- 257 lbs/yr of nitrogen
- 80 lbs/yr of phosphorus
- 85 tons/yr of sediment

Filter Strip, Grass Conversion, & Field Border

A filter strip is a narrow 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 similar to filter strips but are located along field edges adjacent to timbered areas; they can range in width from 30 – 120 feet. Grass conversion consists of removing land from production and planting native grasses. Grass conversion is only recommended where willing landowners have expressed interest to do so.


Filter Strip

In the Waverly Lake Watershed, **field borders** are recommended at 22 locations for a total of 61.6 acres. If all 61.6 acres are planted to treat 888 acres, the following load reductions are expected:

- 1,759 lbs/yr of nitrogen
- 350 lbs/yr of phosphorus
- 267 tons/yr of sediment

Filter strips are recommended at 3 locations for a total of 1.3 acres. If implemented to treat 21 acres, the following load reductions are expected:

- 194 lbs/yr of nitrogen
- 73 lbs/yr of phosphorus
- 88.6 tons/yr of sediment

Grass conversion is recommended at 6 locations totaling 16.3 acres. Expected load reductions are:

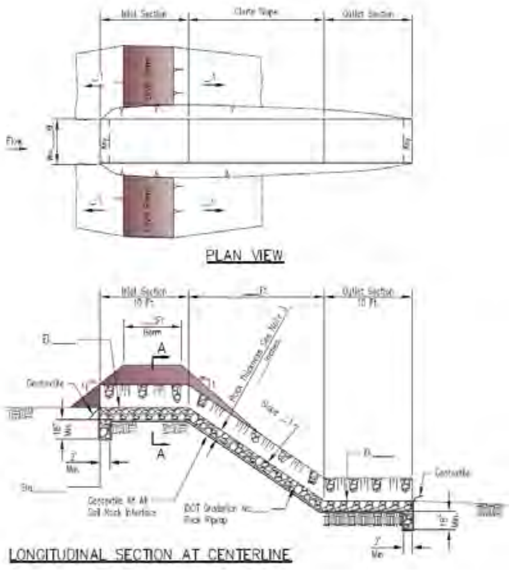
- 42 lbs/yr of nitrogen
- 5 lbs/yr of phosphorus
- 2.2 tons/yr of sediment

Grade Control Structure

A grade control structure consists of a constructed berm or a rock/modular block structure (NRCS detail provided below) designed to address gully erosion and control vertical downcutting. In the Waverly Lake watershed, grade control structures are recommended at locations where slopes are very steep and gully erosion is considered very severe; areas where other practices are just not feasible. Rock riffles are also possible at locations where grade control is required and can be used in place of the practices below; rock riffles are further described below in the section on streambank stabilization.

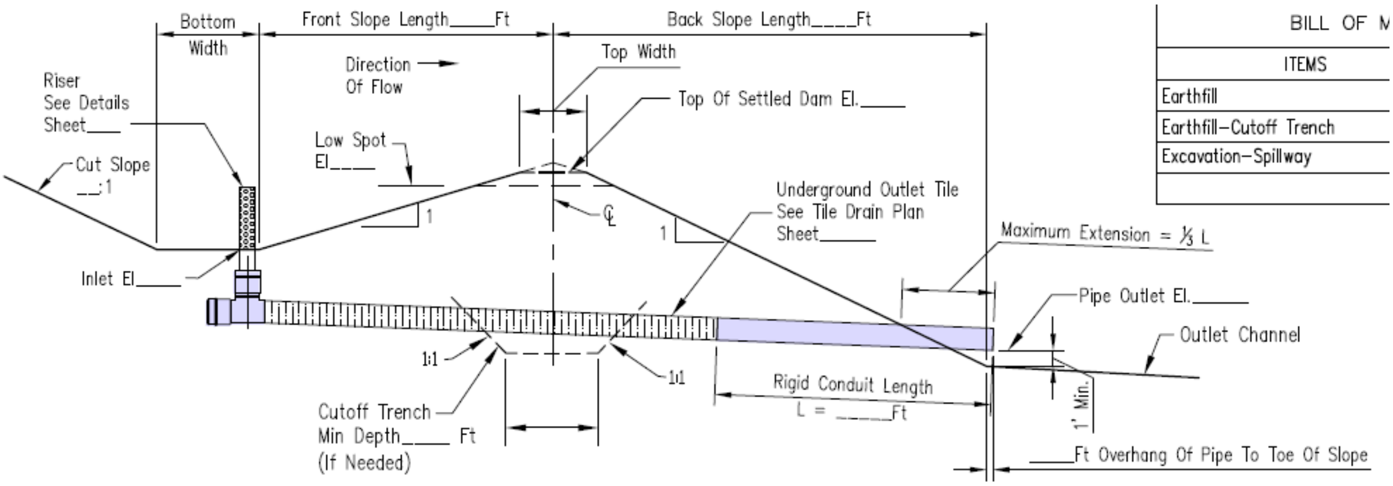
Rock Chute

NRCS Grade Control Detail



Grade control structures are recommended at 19 locations for a total of 33 individual structures. If implemented to treat 253 acres, the expected load reductions, including gully stabilization, are:

- 191 lbs/yr of nitrogen
- 94.4 lbs/yr of phosphorus
- 107.3 tons/yr of sediment



CROSS SECTION OF DAM ON ℄ OF PIPE PRINCIPAL SPILLWAY

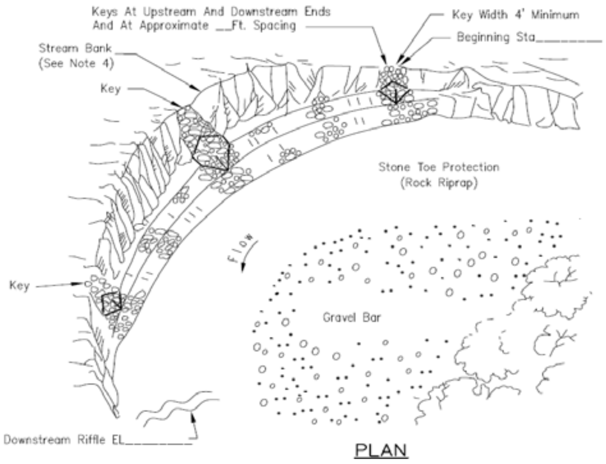
Streambank Stabilization; Stone-Toe Protection & Riffle

Streambank stabilization consists of both the placement of rock riffles and the installation of stone-toe protection to stabilize eroding streambanks and control stream grade, if necessary. Stream channel incision or deepening can lead to bank erosion and often times, grade control or rock riffles are needed in combination with stone-toe protection. In the Waverly Lake watershed, 233 feet of stone-toe protection and 6 stream riffles are recommended at 7 locations. Locations were selected based on sediment load, landowner willingness, accessibility and cost effectiveness. Streambank stabilization is not feasible or required throughout much of the heavily forested areas of Woods Creek and other major tributaries where accessibility is a major concern.

If implemented, expected load reductions for all stone-toe protection and riffles are:

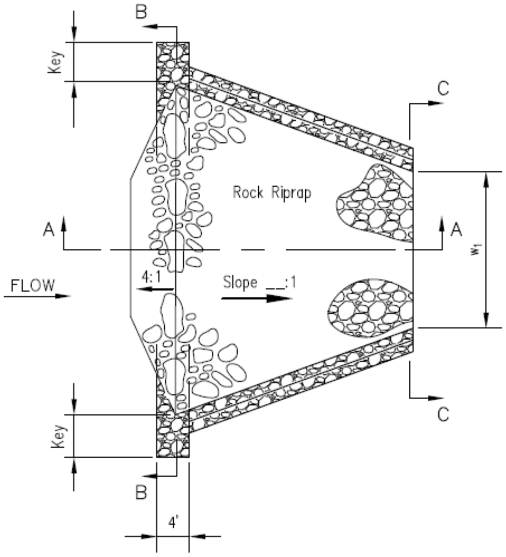
- 361 lbs/yr of nitrogen
- 162 lbs/yr of phosphorus
- 180 tons/yr of sediment

NRCS Stone-Toe Detail



Stone-Toe Protection

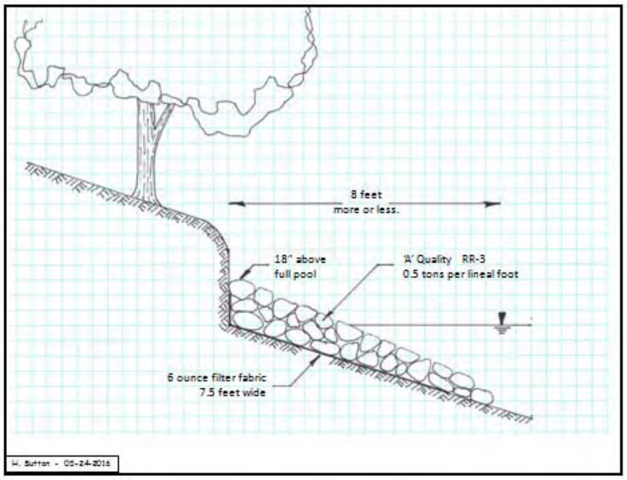
NRCS Riffle Detail



Rock Riffle

Shoreline Stabilization

Stabilizing sections of shoreline to reduce in-lake sediment delivery should be targeted to those areas with the highest rates of erosion. This can be accomplished by installing rip-rap or another form of armoring at the base of each bank. Typically, shoreline stabilization consists of placing rock on or directly adjacent to the eroding lake bank to dissipate wave energy and eliminate erosion. For shallower areas with more gradual slopes, rock can be placed away from the bank creating breakwater. Where water depths are greater and the littoral zone slope is too great, rock is placed on the bank and above the lakes' full pool elevation. The creation of breakwater is only feasible in a limited number of locations within Waverly Lake and, therefore, the placement of rock on the bank is recommended.



Application of Rock; Shoreline Stabilization

Shoreline stabilization is required for 6,238 feet within Waverly Lake and 180 feet within Franklin Lake for a total of 6,418 feet (See Figure 40). Stabilizing all recommended shoreline areas will result in annual load reductions of:

- 1,055 lbs/yr of nitrogen
- 472 lbs/yr of phosphorus
- 531 tons/yr of sediment

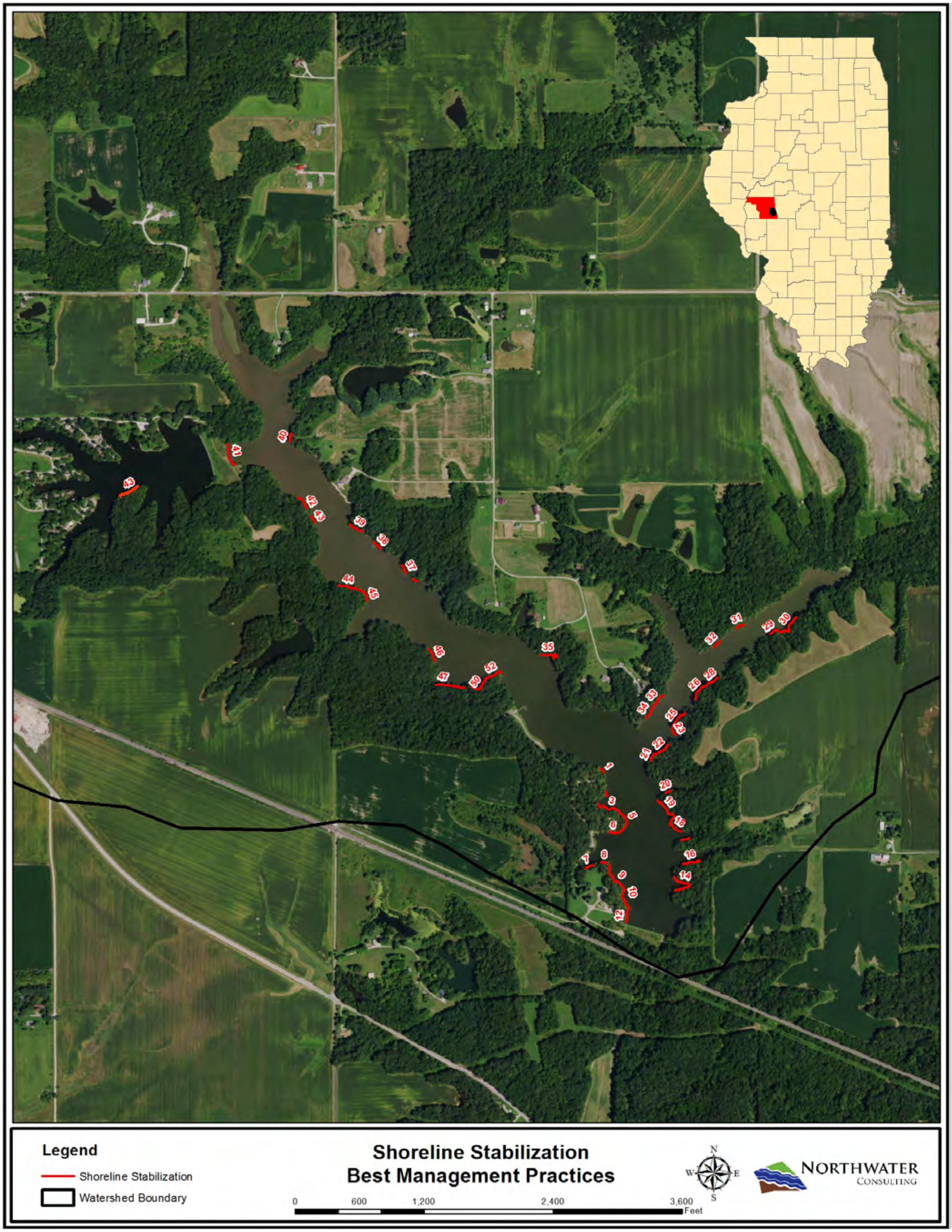


Figure 40 - Waverly Lake Watershed Shoreline Stabilization

Detention Basin/Pond

Pond; Otter Lake, IL

A detention basin or pond is a sediment or water impoundment made by constructing an earthen dam. In the Waverly Lake watershed, 34 ponds are recommended to treat 696 acres. These structures will trap sediments and nutrients from runoff and will control gully erosion in steep forested draws.

If all ponds are installed in the watershed, expected load reductions are:

- 1,628 lbs/yr of nitrogen
- 441 lbs/yr of phosphorus
- 413 tons/yr of sediment

In-Lake/Low Flow Dam

An in-lake or low flow dam is an embankment or sheet-pile wall installed within the lake or within major lake tributaries to trap sediment and nutrients while still maintaining flow to the lake. These structures are installed only a few feet above normal pool elevation and at locations where a large storage area is available. One large structure is recommended within Waverly Lake and five additional structures are recommended at tributary inflows immediately adjacent to the lake. The total estimated length of these dams is 1,960 feet.

Lake and watershed sediment is predominately fine-grained silt and clay faction with little coarse-grained sediment. As a result, sediment trapping with a low-flow dam will require significant storage capacity to achieve desired trapping efficiency. Sediment trapping is dependent on the ratio of inflow to storage capacity; a minimum trap efficiency of 30% is desired. According to Brune's Curve, a ratio of 0.012 is needed to achieve a 30% trapping efficiency for fine-grained sediments.

If all six structures are installed to treat 6,236 acres, expected annual load reductions are:

- 4,707 lbs/yr of nitrogen
- 1,984 lbs/yr of phosphorus
- 2,077 tons/yr of sediment.

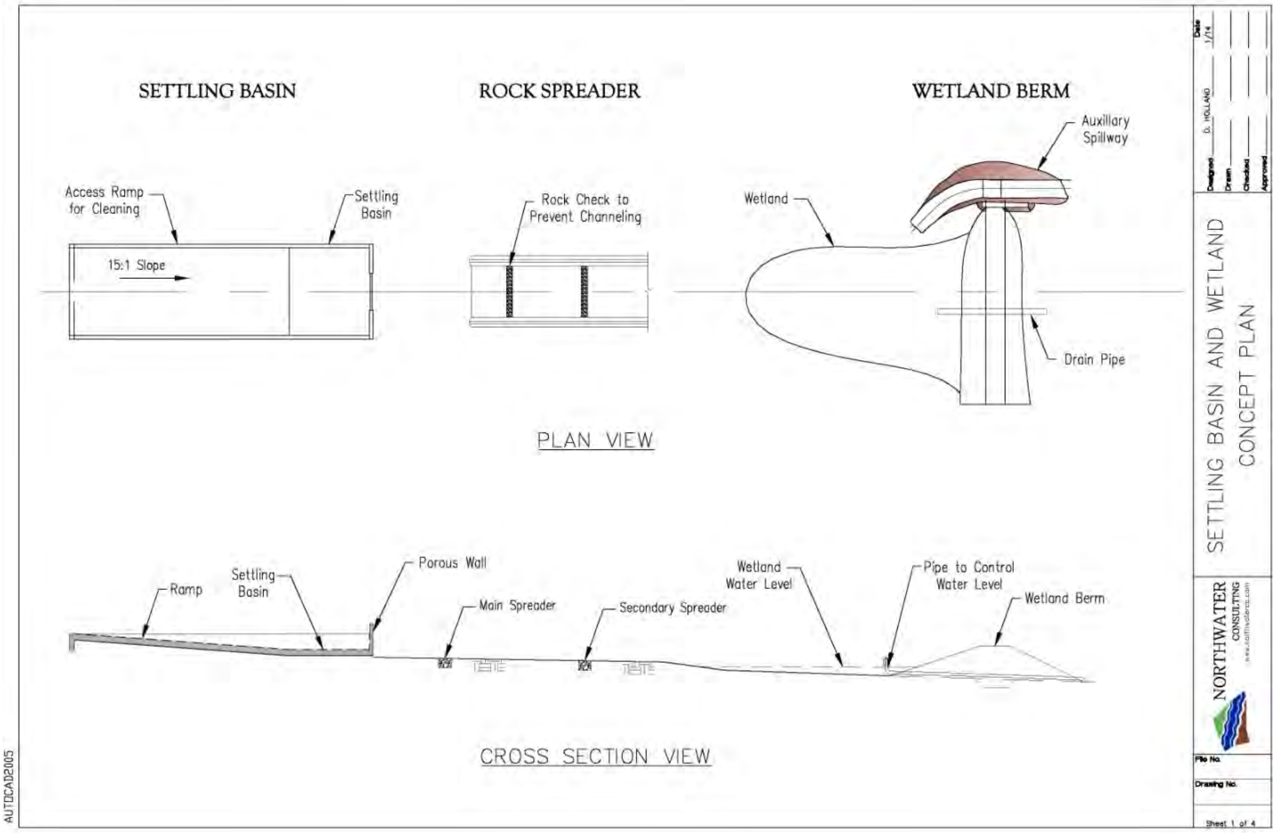
Section 8.2.2 provides additional details on three primary options for an in-lake/low flow dam within the lake.

Livestock Feed Area Waste 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. A conceptual design is presented below.

Only one system is recommended to treat 2.6 acres in the watershed. If this system is implemented, the following load reductions are expected:

- 19 lbs/yr nitrogen
- 4.1 lbs/yr phosphorus
- 0.3 tons/yr sediment



Pasture Management & Fencing

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

Stream fencing is recommended for one pasture in the watershed; 6,708 feet of fence, up to 3 crossings and some minor riparian area restoration.

If this system is implemented to treat 25.4 acres, the following load reductions are expected:

- 94 lbs/yr of nitrogen
- 11 lbs/yr of phosphorus
- 1.9 tons/yr of sediment

Stream fencing

8.2.2 In-Lake/Low Flow Dam Options

The feasibility of a low-flow sediment dam or dams in the upstream portion of Waverly Lake was evaluated by Benton & Associates and is included in this section. Based on a site assessment and review of the lake tributaries and sediment regime, it is believed such a BMP is a feasible practice to reduce sediment entering the main body of the lake and could allow lake sediment management to be more cost effective in the long term.

As evidenced by the aerial photographs below dating from 1998 through 2016, the upper end of the lake has retained significant sediment over the years. It is noticeable both upstream and downstream of the Clevenger Road bridge, as a peninsula has developed south of the bridge, and previously ponded areas north of the bridge are now grown up in vegetation. The water pool in the northeast branch of the lake has also diminished significantly, as evidenced by the existing vegetative growth in that area where it was once inundated with water.

Figure 41 - 1998 Waverly Lake Imagery

Figure 42 - 2005 Waverly Lake Imagery

Figure 43 - 2006 Waverly Lake Imagery

Figure 44 - 2007 Waverly Lake Imagery

Figure 45 - 2010 Waverly Lake Imagery

Figure 46 - 2011 Waverly Lake Imagery

Figure 47 - 2014 Waverly Lake Imagery

Figure 48 - 2016 Waverly Lake Imagery

Based on average sedimentation rates from surveys conducted between 1952 and 2009, annual sediment load delivered to Waverly Lake is estimated at 8,300 tons per year; the 2015 estimate presented in previous sections is 7,074 tons per year. Using 8,300 tons, this equates to approximately 9,360 cubic-yards, or 5.8 acre-feet per year, when applying a sediment density of 66 pounds per cubic-foot (1,782 pounds per cubic yard), which was the average unit weight of sediments as determined by the 2009 Illinois State Water Survey (ISWS) 2009 Sedimentation Survey. Approximately 86% of the annual sediment load is delivered to the lake upstream of the potential in-lake dam sediment location shown as Option "A" on the Sediment Dam Location Options graphic which follows. This equals approximately 7,130 tons, or 5.0 acre-feet per year of loading in the westerly branch of the lake.

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

Based on lake sediment analysis performed in 2009 by the Illinois State Water Survey, the lake sediment is predominately fine-grained with little coarse-grained sediment. As a result, sediment trapping with a low-flow dam will be less efficient and may require significant storage capacity to achieve desired trapping efficiency.

The total estimated annual runoff or inflow for the entire watershed is 8,791 acre-feet based on modeling performed for the watershed by Northwater. Of that total, approximately 7,608 acre-feet per year would be received by the potential sediment dam location shown as Option "A". Of that 7,608 acre-feet per year, the sediment dam shown as Option "B" would receive 1,715 acre-feet per year and Option "C" would receive 5,893 acre-feet per year.

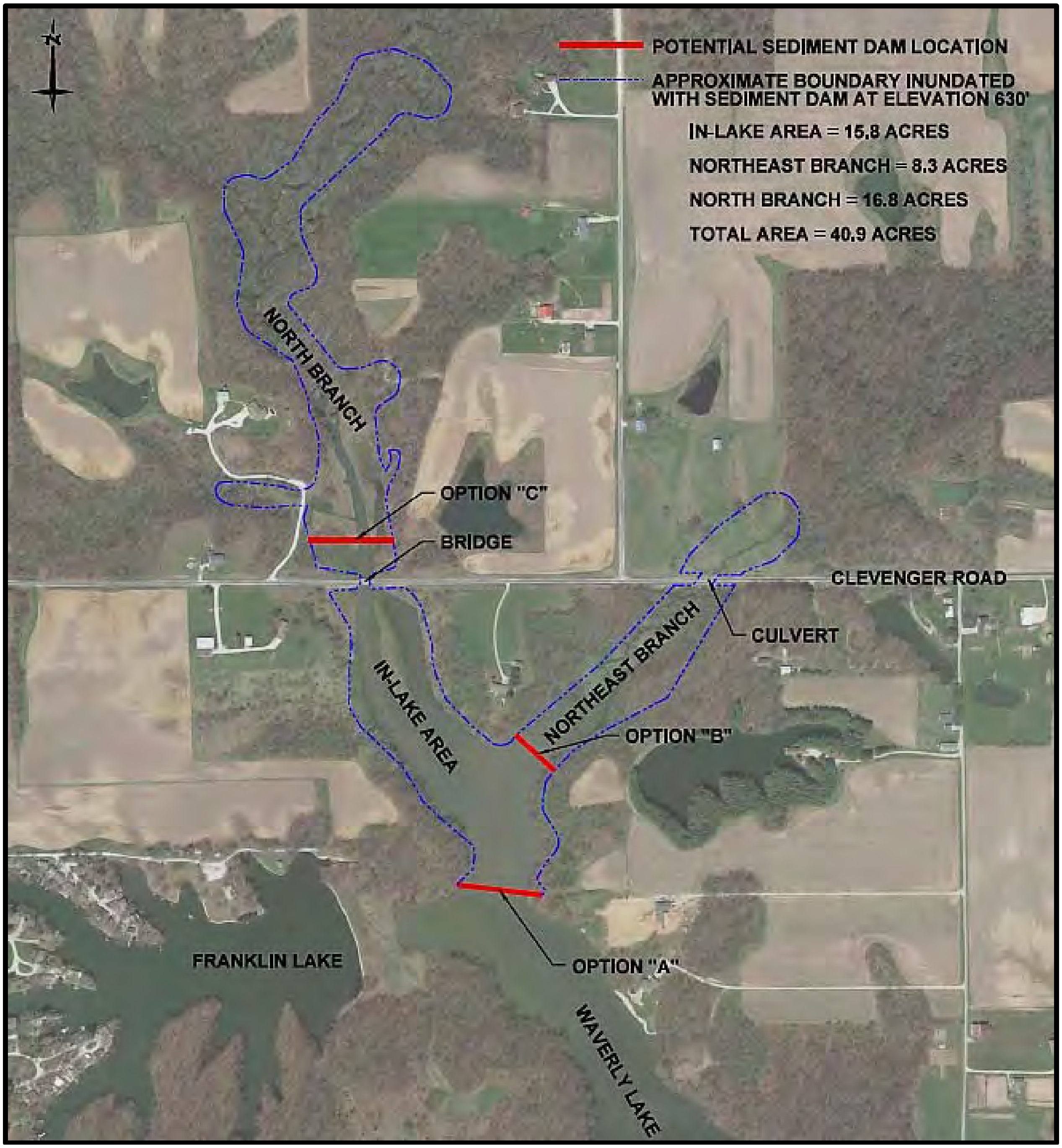


Figure 49 - In-Lake/Low Flow Sediment Dam Options

Pool elevation of Waverly Lake is 629 feet NGVD as determined by the spillway elevation at the south end of the lake. This is the elevation that must be the benchmark used for determining the height of a potential sediment dam.

Based on a preliminary review of upstream impacts of a low-flow sediment dam, there are factors that place constraints on the potential elevation of the dam above water pool and spillway elevation. A significant limiting factor is the bridge on Clevenger Road that crosses the creek and upper portion of the lake, and is proposed to be replaced in the very near future. The bottom of the bridge deck has been designed to remain above the water elevation of a 10-year frequency flood event. The proposed bottom elevation of the bridge is 634.76 feet NGVD. Differing heights of in-lake dams were analyzed to explore the hydraulic impact to the bridge and the water level upstream of the bridge. If an in-lake dam was constructed at the location shown as Option "A" with a top elevation one foot above the spillway elevation, a 10-year flood event would raise the water surface elevation at the Clevenger Road bridge to 634.67 feet. If the in-lake dam was constructed with a top elevation two feet above the spillway elevation, a 10-year flood event would raise the water surface elevation at the Clevenger Road bridge to 635.48 feet, which is above the bottom elevation of the bridge. Therefore, the elevation of an in-lake dam will be limited by the Clevenger Road bridge, and should be no higher than one foot above spillway elevation.

Another option is to construct two sediment dams in lieu of Option "A"; one in the northeast branch shown as Option "B" and one upstream of Clevenger Road to trap sediment prior to entering the upper portions of the lake shown as Option "C". Though dams in these locations could be effective in trapping sediment from a significant portion of the watershed, reservoir capacity is diminished due to the upper portion of the lake not being included. The location shown as Option 'B" is on City-owned property, but would inundate portions of adjacent properties and raise the water elevation at Clevenger Road and the existing culvert under the road. The effects to the adjacent properties and roadway crossing would have to be further analyzed prior to determining a feasible top elevation. Another challenge to an Option "C" sediment dam in this location is that it would be located on property that is not owned by the City. Therefore, both for construction and future maintenance, land acquisition of some sort would likely be required. Access to this area for construction and future maintenance is also more difficult as it is located in a wooded ravine area with steep side slopes and little access from nearby roadways.


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

Sediment trapping is dependent on the ratio of inflow to storage capacity; the feasibility analysis was performed based on achieving a minimum trap efficiency of 30%. According to Brune's Curve, a ratio of 0.012 is needed to achieve a 30% trapping efficiency for fine-grained sediments. Based on the inflow of the lake, a minimum of 91.3 acre-feet of reservoir capacity is necessary to achieve a 30% trapping efficiency if a sediment dam were constructed at the location shown as Option "A" with a top elevation one foot above the spillway. This would inundate approximately 40.9 acres, which equates to a necessary average water depth throughout the inundated area of approximately 2.2 feet. For a sediment dam at the Option "B" location, approximately 8.3 acres would be inundated and 20.6 acre-feet of reservoir storage would be required, which equates to a necessary average water depth throughout the inundated area of 2.5 feet. For a sediment dam located at the Option "C" location, approximately 15.8 acres would be inundated and 70.7 acre-feet of reservoir capacity would be required, which equates to a necessary average water depth of 4.2 feet throughout the inundated area. Estimates of reservoir capacities based on USGS Topographic Maps indicate that if a sediment dam or dams were constructed with top elevations one foot above spillway elevation, the necessary reservoir capacity may not be achievable without additional dredging or excavation to increase capacity.

Additional storage capacity can be obtained through excavation, dredging, or a combination of the two practices upstream of the potential dam locations. Dredging back to the original bottom of the lake of an approximately 6.2-acre area upstream of the potential Option "A" sediment dam location would yield approximately 16,300 cubic yards (10.1 acre-feet) of additional storage area. Based on sediment depths recorded in the 2009 ISWS bathymetric survey, approximately 1.5 to 2.0 feet of sediment could be removed from the area to bring the dredged channel back to the original bottom of the lake. The potential dredge area south of the bridge is all within the lake and, therefore, on property owned by the City of Waverly, which could be routinely dredged in the future as sediment accumulates. Additional storage capacity could also be achieved if the location of the Option "A" dam were moved further south in the body of the lake, therefore, utilizing more of the existing reservoir for sediment trapping. This would allow for more potential dredged area within the lake on City-owned property, but would sacrifice a portion of the lake that is currently utilized for recreational activities.

Additional excavation north of Clevenger Road is also a possibility to increase reservoir capacity. If an approximately 4-acre area was excavated to a depth of 8 feet, an additional 32 acre-feet of reservoir capacity could be achieved. A combination of dredging and excavation is also a possibility directly upstream of the northeast branch on City-owned property. Approximately 2.75 acres of area which is currently partially in-lake and partially vegetated could be excavated to a depth of 8 feet, which could potentially yield an additional 22 acre-feet of reservoir capacity. If the additional excavation and dredging was performed in conjunction with construction of sediment dams, necessary reservoir capacity could be achieved.

Due to a continual reduction of storage capacity in upstream areas as sediment is trapped, a low-flow dam will require that the up-gradient areas be dredged or excavated periodically. Assuming that no other BMPs were implemented in the watershed and 5 acre-feet of sediment per year was coming to the lake, and assuming a 30% trapping efficiency of sediment dams, approximately 1.5 acre-feet per year of sediment would be trapped. The frequency of dredging or excavation to be performed in the future would then be determined by the amount of reservoir storage capacity achieved with the combination of sediment dams, dredging, and excavation and the effectiveness of additional BMPs in the watershed.

Disposal and dewatering of dredged and excavated materials must also be taken into consideration. The City owns property adjacent the lake on the westerly side near the south end that could potentially serve as a disposal site for dredged sediment.

In order to proceed with construction of a sediment dam, an engineering study is necessary to gather more accurate estimates of storage volume, areas of inundation, and to develop plans and cost estimates for permitting and construction. Also to be considered and further analyzed are factors related to disposal and dewatering of dredged or excavated material. Upstream effects would also need to be more closely analyzed. Upstream areas of concern include the Clevenger Road bridge, an existing residential driveway northwest of the bridge, an existing culvert beneath Clevenger Road, and various properties which would become normally inundated due to the higher water elevation. This would likely require topographic and bathymetric surveying, geotechnical sampling, hydraulic modeling and outlining permitting requirements and strategies.

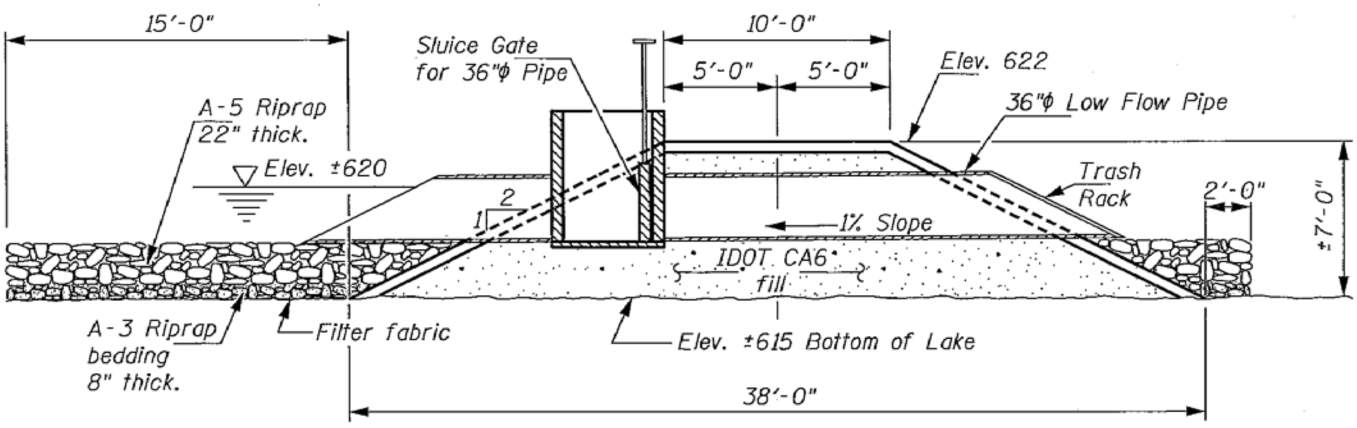
A summary of the potential components of each of the sediment dam location options is below. The options can be considered individually, or as a combination of options.

- Option “A”
    - Sediment Dam Construction in lake with top elevation 1’ above spillway elevation
    - Approximately 40.9 acres inundated by sediment dam construction
    - 91.3 acre-feet of reservoir capacity needed for 30% trapping efficiency
    - Dredging of approximately 16,300 cubic yards of sediment in lake north of sediment dam
    - Excavation of 4 acres in the north branch to a depth of 8 feet
    - Excavation/dredging of 2.75 acres to a depth of 8 feet in the northeast branch

- Option “B”
    - Sediment Dam Construction in lake with top elevation 1’ above spillway elevation
    - Excavation/dredging of 2.75 acres to a depth of 8 feet in the northeast branch
    - Approximately 8.3 acres inundated by sediment dam construction
    - 20.6 acre-feet of reservoir capacity needed for 30% trapping efficiency

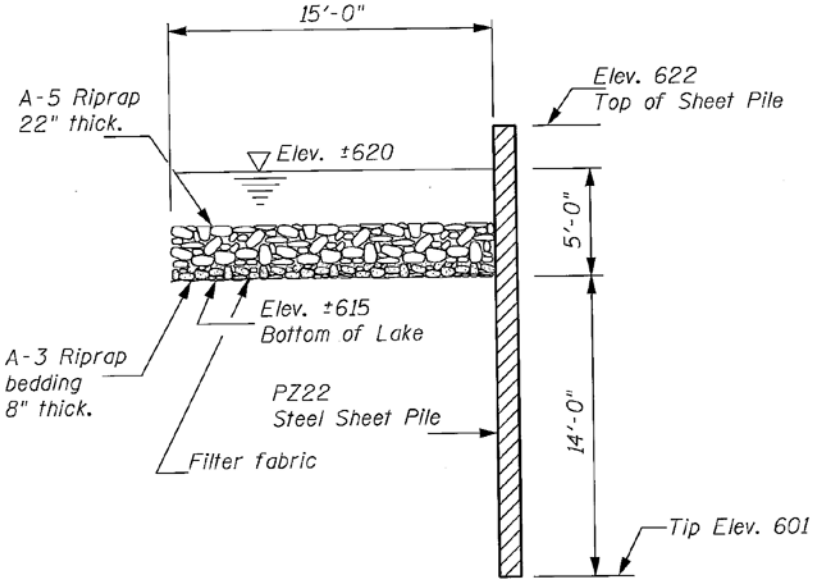
- Option “C”
    - Sediment Dam Construction north of lake with top elevation 1’ above spillway elevation
    - Excavation of 4 acres in the north branch to a depth of 8 feet
    - Approximately 16.8 acres inundated by sediment dam construction
    - 70.7 acre-feet of reservoir capacity needed for 30% trapping efficiency

Two cross-section drawings of sediment dam options developed by Hurst-Rosche Engineers for Otter Lake in Macoupin County are provided in Figure 50 below.



SECTION THRU PROPOSED DAM

AT LOW FLOW PIPE



SECTION THRU SHEET PILE DAM

Figure 50 - Example Details of an Embankment Dam (above) & Driven Sheet Pile Dam (Below)

Two general cost options for a sediment dam construction were considered based on the evaluation. The cost comparisons are based on figures developed for Otter Lake and Lake Carlinville:

1. An embankment dam installed on the lakebed and deltaic sediment fan.
2. Installation of a steel sheet pile wall, with a low-flow section notched lower to provide the low flow weir.

Table 44 - In-Lake/Low Flow Sediment Dam Construction Costs

Option "A" Embankment Dam				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	380	$700.00	$266,000.00
Contingencies (10%)				$26,600.00
			Total	**$292,600.00**

Option "B" Embankment Dam				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	230	$700.00	$161,000.00
Contingencies (10%)				$16,100.00
			Total	**$177,100.00**

Option "C" Embankment Dam				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	370	$700.00	$259,000.00
Contingencies (10%)				$25,900.00
			Total	**$284,900.00**

Option "A" Sheet Pile				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	380	$525.00	$199,500.00
Contingencies (10%)				$19,950.00
			Total	**$219,450.00**

Option "B" Sheet Pile				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	230	$525.00	$120,750.00
Contingencies (10%)				$12,075.00
			Total	**$132,825.00**

Option "C" Sheet Pile				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Construction	Feet	370	$525.00	$194,250.00
Contingencies (10%)				$19,425.00
			Total	**$213,675.00**

Additional costs not listed are variable and may include access roads, dredging, holding lagoons, sediment sampling and analysis, environmental clearances, engineering, and permitting. Permitting of dredging and sediment disposal sites requires consultation and coordination with multiple regulating agencies and typically requires sampling and analysis of the existing sediments to be dredged. Sediment characteristics, presence and concentration of regulated contaminants, and settling time are some of the variable and determining factors that influence the required size and location of holding lagoons which would receive dredged sediments, which in turn impacts engineering and permitting costs associated with the construction.

Based on the construction costs and the apparent site conditions, driven steel sheet pile walls appear to be the most viable construction solution, specifically for the dam construction materials pending sub-surface soils analysis.

8.2.3 Supplemental Nonpoint Source Management Measures

Two additional management measures are proposed or should be considered to help achieve water quality targets. These measures focus on in-lake management, specifically, dredging, nutrient management, and septic systems.

Lake Dredging

The dredging of phosphorus-rich sediment from the lake bottom is the only feasible technique for addressing legacy phosphorus bound to lake sediment. The TMDL calculations estimate that 243 lbs/yr of phosphorus is released from lake bed sediment on an annual basis. Selective dredging will help to reduce internal phosphorus loading and increase lake storage capacity.

Septic Systems

The Morgan County Health Department only conducts inspections immediately following the installation of a new system or when a complaint is filed. No formal inspection and maintenance program exists within the county however the Health Department will periodically host workshops for septic system contractors. The primary recommendation to address septic systems includes a watershed-wide inspection and maintenance program directed to all homes not currently connected to a WWTP. Educating homeowners may also be effective at addressing issues relating to septic systems. The development of a brochure or existing literature regarding septic maintenance should be distributed to stakeholders throughout the watershed.

As noted in Section 4.12.2, there are an estimated 14 failing septic systems within the watershed. It can be assumed that an inspection and maintenance program targeted at homes on septic will capture all or most of the failing septic systems within the watershed.

It can also be assumed that addressing failing septic systems will result in 100% reduction in phosphorus and nitrogen and no reductions in sediment. If all potentially failing septic systems are addressed, it is estimated that annual load reductions total 170 lbs/yr for phosphorus and 434 lbs/yr for nitrogen.

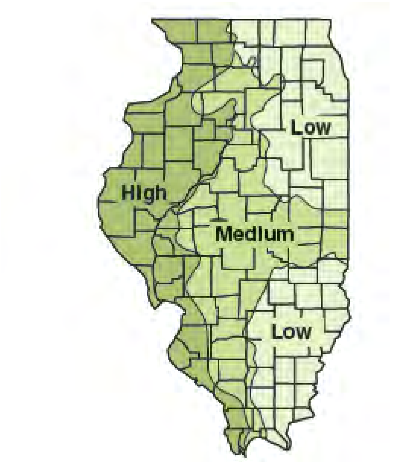
Nutrient Management

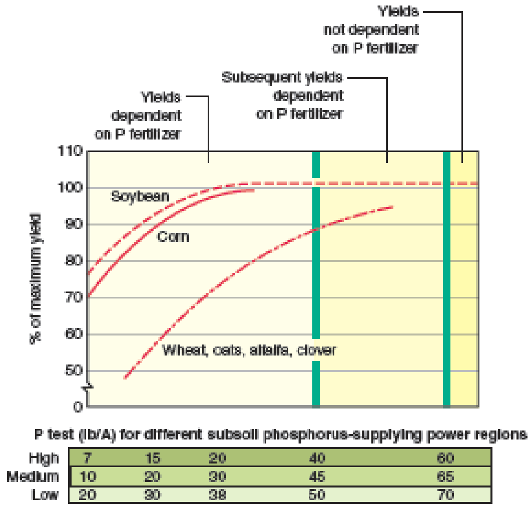
Nutrient management is the practice of using nutrients essential for plant growth such as nitrogen and phosphorus fertilizers in proper quantities and at appropriate times for optimal economic and environmental benefits. Nutrient management is a non-structural practice that can be applied to all fields 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 the Illinois Council on Best Management Practices (IL CBMP) 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 nitrogen and phosphorus.

As described in the 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 pounds per acre 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 pounds per acre 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 use to manage crop nutrient loss: variable rate technology (VRT) and deep fertilizer placement. VRT can improve the efficacy of fertilization and promote more environmentally sound placement of fertilizer 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).

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 (as long as 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).

Implementing a nutrient management plan can reduce phosphorus losses by up to 12% and 15% for tile nitrogen. If nutrient management was applied to all 4,260 acres of crop fields within the watershed, expected annual load reductions would total 2,196 lbs for nitrogen and 720 lbs for phosphorus.

9.0 Cost Estimates

BMP costs were calculated based on professional judgment and expertise, rates provided by the NRCS, and unit costs used in other similar watershed plans. Many of the estimates are based on field visits and known quantities for a particular practice. Cost estimates should be considered as estimates only and revisited during implementation as required.

9.1 Cost Estimates

General cost estimates and assumptions include:

1. Estimates for filter strips, field borders, and grass conversion include land prep and seeding at $700/ac.
2. No-Till and strip-till assume $40/ac for 1 year.
3. Cover crops assume $40/ac for 1 year.
4. Streambank stabilization assumes $85/ft plus engineering and permitting.
5. Shoreline stabilization assumes $85/ft plus permitting.
6. Riffles, cattle crossings, and grade control structures range from $3,000 – $8,000 plus engineering.
7. Grass waterways assume $3,000 - $4,000 per acre plus tile and engineering.
8. WASCBs range from $1,000 - $2,500 each plus tile and engineering. WASCB maintenance is estimated at $500/basin and is a one-time expenditure.

9. Wetlands are based on professional judgment and include a water control structure and engineering.
10. Low-flow/low-head dams are based on construction figures provided in Section 8.2.2 plus a rough estimate based on professional judgment for costs associated with unknown variables such as access roads, dredging, holding lagoons, sediment sampling and analysis, environmental clearances, engineering, and permitting.
11. Stream fencing assumes $3.50/foot plus some riparian area restoration cost and engineering
12. Nutrient Management Plan cost is estimated to be $16.00 an acre, based on the Sangamon County SWCD rates.

Table 45 provides a detailed breakdown of cost estimates for all BMPs, as well as cost per unit of loading reduced. The total cost of implementing all BMPs is estimated to be **$8,892,622.00**. Average cost per pound of nitrogen removed is $354.63; average cost per pound of phosphorus removed is $1,204.24 and the average cost for a ton of sediment removed is $1,357.74. Overall, filter strips, no-till/strip-till, nutrient management, grassed waterways and field borders appear to be the most cost effective practices. No-till/strip-till are both cost effective and will result in large overall load reductions if adopted throughout the watershed. In-Lake/low-flow dams are costly projects, however, these practices treat very large areas and will result in large overall load reductions; despite the cost, low-flow/in-lake dams should be considered as an effective lake management measure or a short- to medium-term objective.

Table 45 - Waverly Lake Watershed BMP Cost Summary

TYPE	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorus Reduction	Cost/ton Sediment Reduction
Cover Crop	330 (ac)	$13,200.00	$27.22	$200.00	$280.85
No-Till/Strip-Till	4,334 (ac)	$173,360.00	$19.36	$98.89	$94.06
Filter Strip	1.3 (ac)	$1,435.00	$7.40	$19.66	$16.20
Field Border	61.6 (ac)	$48,245.00	$27.43	$137.84	$180.69
Grass Conversion	16.3 (ac)	$12,017.00	$286.12	$2,403.40	$5,462.27
Grade Control	33 (#)	$149,600.00	$783.25	$1,584.75	$1,394.22
Streambank/Riffle	233 (ft) / 6 (#)	$55,765.00	$154.47	$344.23	$309.81
Livestock Waste System	1 (#)	$28,000.00	$1,505.38	$6,829.27	$93,333.33
Livestock Fencing/Crossing	6,708 (ft) / 3 (#)	$39,000.00	$415.78	$3,577.98	$20,526.32
Grassed Waterway	15,367 (ft) / 18.3 (ac)	$116,940.00	$57.04	$246.29	$244.75
In-Lake Low-flow[1] Dam	1,960 (ft)	$6,412,500.00	$1,362.33	$3,232.92	$3,087.68
WASCB	109 (#) / 16,350 (ft)	$199,239.00	$184.14	$440.79	$464.43
Wetland	3 (ac)	$102,200.00	$397.20	$1,282.31	$1,198.12
Pond	39 (#)	$897,800.00	$551.47	$2,035.83	$2,174.90

TYPE	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorus Reduction	Cost/ton Sediment Reduction
Lake Shoreline Stabilization	6,418 (ft)	$545,541.00	$517.10	$1,155.81	$1,028.16
Nutrient Management (Plan)	4,620 (ac)	$87,780.00	$39.97	$121.92	N/A
Septic Systems[2]	14 (#)	$10,000.00	N/A	N/A	N/A
Dredging[3]	N/A	N/A	N/A	N/A	N/A
Total		**$8,892,622.00**	**$354.63**	**$1,204.24**	**$1,357.74**

[1] – Estimate includes substantial "unknown" costs; see Section 8.2.2 for construction costs

[2] – Cost estimate for implementation of inspection and outreach program only

[3] – Quantities and cost unknown

In addition to the costs presented in this section for BMP implementation, there will be costs associated with education and outreach. It is estimated that costs for education and outreach could range from $10,000 - $20,000 per year, which includes staff time to contact and educate landowners, organize workshops, and develop grant applications, for example.

10.0 Water Quality Targets

This section will describe water quality targets and those implementation actions required to meet targets.

Water quality targets for the Waverly Lake watershed are generated directly from the phosphorus TMDL and the Illinois Nutrient Loss Reduction Strategy. Phosphorus targets are based on TMDL estimates, whereas the nitrogen reduction target is based on the Illinois Nutrient Loss Reduction Strategy target of 45%. Given that much of the phosphorus is likely a function of eroded sediment, a sediment reduction percentage representing the TMDL phosphorus target is recommended.

In order to meet standards for Waverly Lake, an 82-85% reduction in phosphorus is required. Additionally, a 45% reduction in nitrogen and an 82% reduction in sediment are recommended. Table 46 compares water quality targets to expected BMP load reductions. Results indicate that widespread BMP implementation will result in the attainment of water quality standards for phosphorus. Factoring in conservative pollutant removal efficiencies associated with recommended BMPs, it is reasonable to conclude that wide-spread implementation will meet and exceed the current reduction targets. The sediment and nitrogen targets will be exceeded if all practices are implemented. Furthermore, installing upstream practices will not only reduce total watershed loadings but will have the added and cumulative benefit of extending the lifespan and pollutant removal efficiency of downstream BMPs such as the recommended low-flow or in-lake dams.

The conversion of conventional and reduced tillage systems to no-till or strip-till will result in large overall percentage reductions to nutrients and sediment. It is believed that the largest benefit to water quality will be realized with a large-scale shift away from conventional tillage, especially on HEL ground. Although costly, installing a series of in-lake or low-flow dams will treat the majority of the watershed and achieve large overall reductions in phosphorus and sediment. Lake shoreline stabilization, grassed waterways, ponds, WASCBs, and field borders combined will reduce phosphorus loads by 25% and sediment loads by 30%; these structural practices will address major sources of watershed nutrients and sediment and should be considered a priority if landowners are willing.

Table 46 – Waverly Lake BMP Load Reductions & Water Quality Targets

TYPE	Quantity	N Reduction (% of total load)	P Reduction (% of total load)	Sediment Reduction (% of total load)
Cover Crop	330 (ac)	1.26%	0.75%	0.66%
No-Till/Strip-Till	4,334 (ac)	23.2%	19.93%	26.05%
Filter Strip	1.3 (ac)	0.5%	0.83%	1.25%
Field Border	61.6 (ac)	4.56%	3.98%	3.77%
Grass Conversion	16.3 (ac)	0.11%	0.06%	0.03%
Grade Control	33 (#)	0.49%	1.07%	1.52%
Streambank/Riffle	233 (ft) / 6 (#)	0.94%	1.84%	2.54%
Livestock Waste System	1 (#)	0.05%	0.05%	0.004%
Livestock Fencing/Crossing	6,708 (ft) / 3 (#)	0.24%	0.12%	0.03%
Grassed Waterway	15,367 (ft) / 18.3 (ac)	5.31%	5.4%	6.75%
In-Lake Low-flow Dam	1,960 (ft)	12.19%	22.55%	29.36%
WASCB	109 (#) / 16,350 (ft)	2.8%	5.14%	6.06%
Wetland	3 (ac)	0.67%	0.91%	1.21%
Pond	39 (#)	4.22%	5.01%	5.84%
Lake Shoreline Stabilization	6,418 (ft)	2.73%	5.37%	7.50%
Nutrient Management (Plan)	4,620 (ac)	5.69%	8.19%	0%
Septic Systems	14 (#)	1.12%	1.93%	0%
Dredging	N/A	0%	2.76%	N/A
Total		**66%**	**86%**	**93%**

11.0 Critical Areas & Priority Projects

Critical areas are those BMP locations throughout the watershed where implementation activities should be focused. These areas should have willing landowners and provide the greatest "bang-for-the-buck" and benefit to lake water quality. The upper quartile of cost per pound of phosphorus removed was used to define the location of critical areas for no-till/strip-till. Potential landowner willingness and City ownership boundaries were used to prioritize critical areas for all other BMPs.

11.1 No-Till/Strip-Till

Fields with conventional and reduced tillage are responsible for the majority of the nutrient and sediment load from crop ground. Per-acre loading rates are significantly higher on HEL ground that is in a conventional or reduced tillage system. The upper quartile for no-till and strip-till include those locations were the cost per pound of phosphorus removed is less than $164.00. Fifty-one fields, or 590 acres, fall within the upper quartile and represent the potential for annual reductions of 2,282 lbs nitrogen, 626 lbs phosphorus, and 791 tons of sediment. Of the 590 recommended acres, 161 acres, or 30% of the area, is considered HEL.

Table 47 summarizes expected reductions from priority sites and compares results of the upper quartile to the total expected load reductions for all recommended no-till/strip-till. Results indicate that addressing 14% (590 acres) of the total BMP area will accomplish 25% of the total expected no-till/strip-till nitrogen reduction, 36% of the phosphorus reduction and 43% of the sediment reduction. The estimated annual cost to address 590 acres is $47,200.00. Figure 51 depicts the location of priority areas.

Table 47 - Load Reduction Summary; Priority No-Till/Strip-Till

Acres	% of BMP Area	N reduction (lbs/yr)	% of Total Load Reduction	P Reduction (lbs/yr)	% of Total Load Reduction	Sediment Reduction (tons/yr)	% of Total Load Reduction
590	14%	2,282	25%	626	36%	791	43%

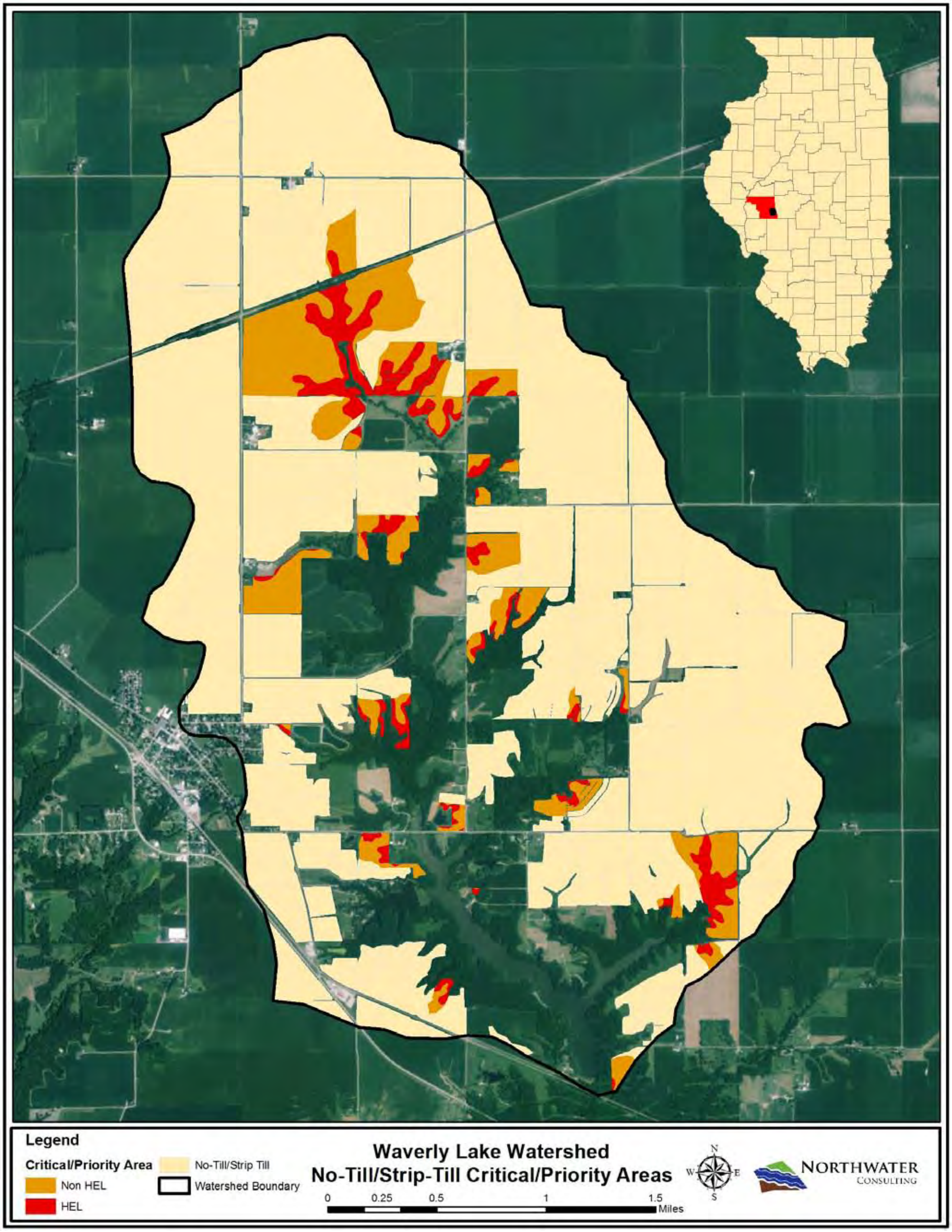


Figure 51 - Waverly Lake Watershed Priority Areas - No-Till/Strip-Till

11.2 Watershed BMPs

Priority locations presented in this section are either owned by the City of Waverly or represent those individual BMPs where willing landowners have expressed interest during a site visit. These BMPs exclude no-till/strip-till recommendations presented in the previous section.

It is more likely than not that the projects summarized below will have the greatest chance of being implemented and, therefore, should receive consideration. Further prioritization should be based on cost and expected load reductions. Appendix C contains a table that includes load reductions, cost estimates, quantities by BMP type and number and can be used to select those individual practices that will achieve the greatest total load reductions or lowest cost per pound/ton of pollutant reduced.

Table 48 summarizes nitrogen, phosphorus and sediment reductions for all priority BMPs where landowner willingness likely exists. Results indicate that the majority of expected load reductions for all BMPs can be achieved at locations where a responsible entity, such as the City of Waverly, maintains ownership or where potentially willing landowners have been identified (See Figure 52).

The City and private landowners have the potential to make substantial reductions in nutrient and sediment loading to the lake, however, cost must be considered. Working with willing private landowners in the watershed will result in high overall load reductions at a much lower cost. The high cost associated with practices on City-owned property is a result of shoreline stabilization (over $500,000) and the construction of all in-lake/low flow dams (over $6 million). Despite the high cost, the City should consider exploring the installation of at least one in-lake/low flow dam, at least two ponds, and all high-priority shoreline stabilization concurrent with efforts on private ground to implement BMPs within the watershed (See Figure 53).

Table 48 - Load Reduction Summary; Watershed BMPs

Responsible Entity	Total Cost	N Reduction (lbs/yr)	% Total Load Reduction	P Reduction (lbs/yr)	% Total Load Reduction	Sediment Reduction (tons/yr)	% Total Load Reduction
City of Waverly	$7,259,361.30	6,028	39%	2,544	46%	2,690	57%
Franklin Outing Club/Village of Franklin	$56,435.74	153	1%	43	1%	51	1%
Private Landowner	$718,642.00	5,657	37%	1,623	29%	1,589	34%
Total	**$8,034,439**	**11,838**	**76%**	**4,210**	**76%**	**4,331**	**92%**

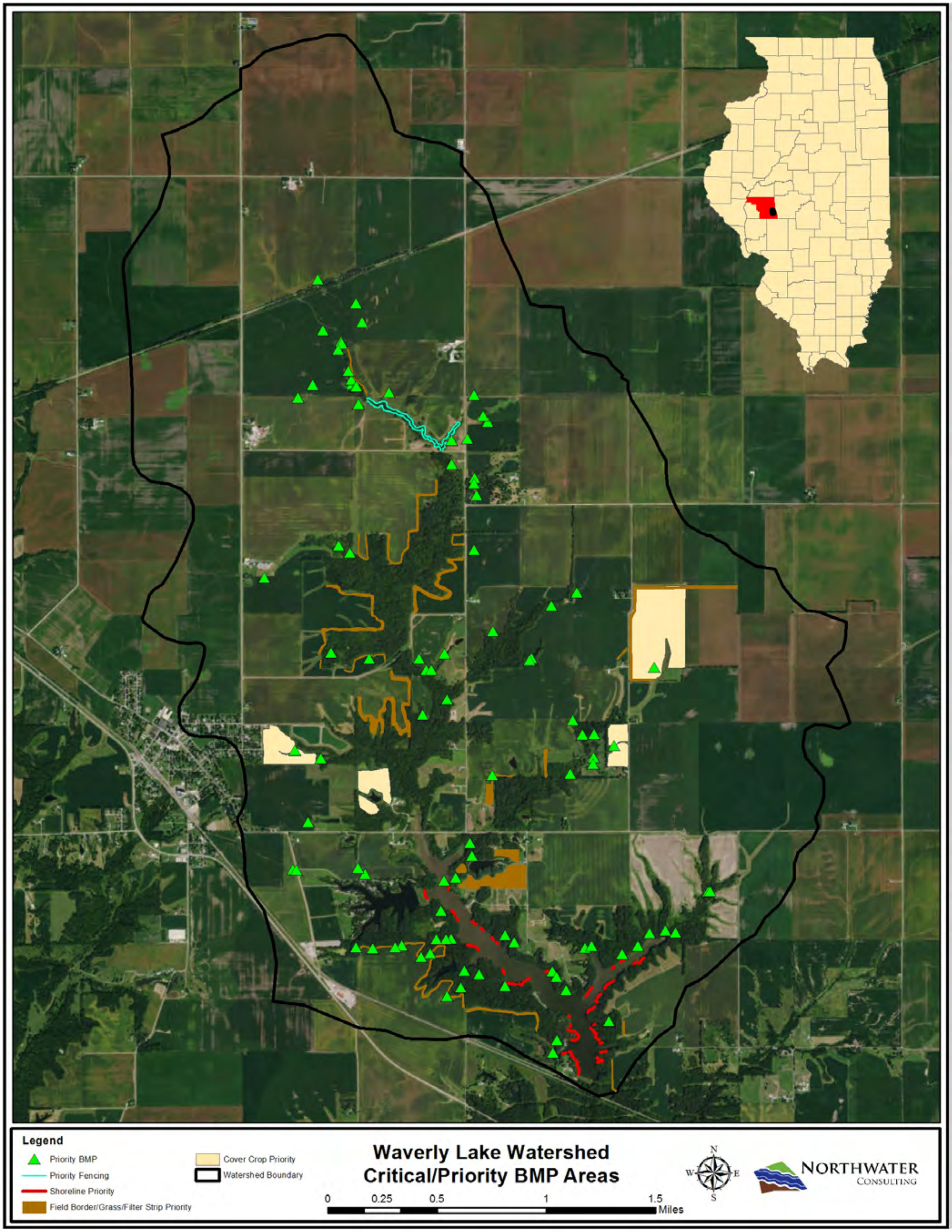


Figure 52 - Waverly Lake Watershed Priority BMPs

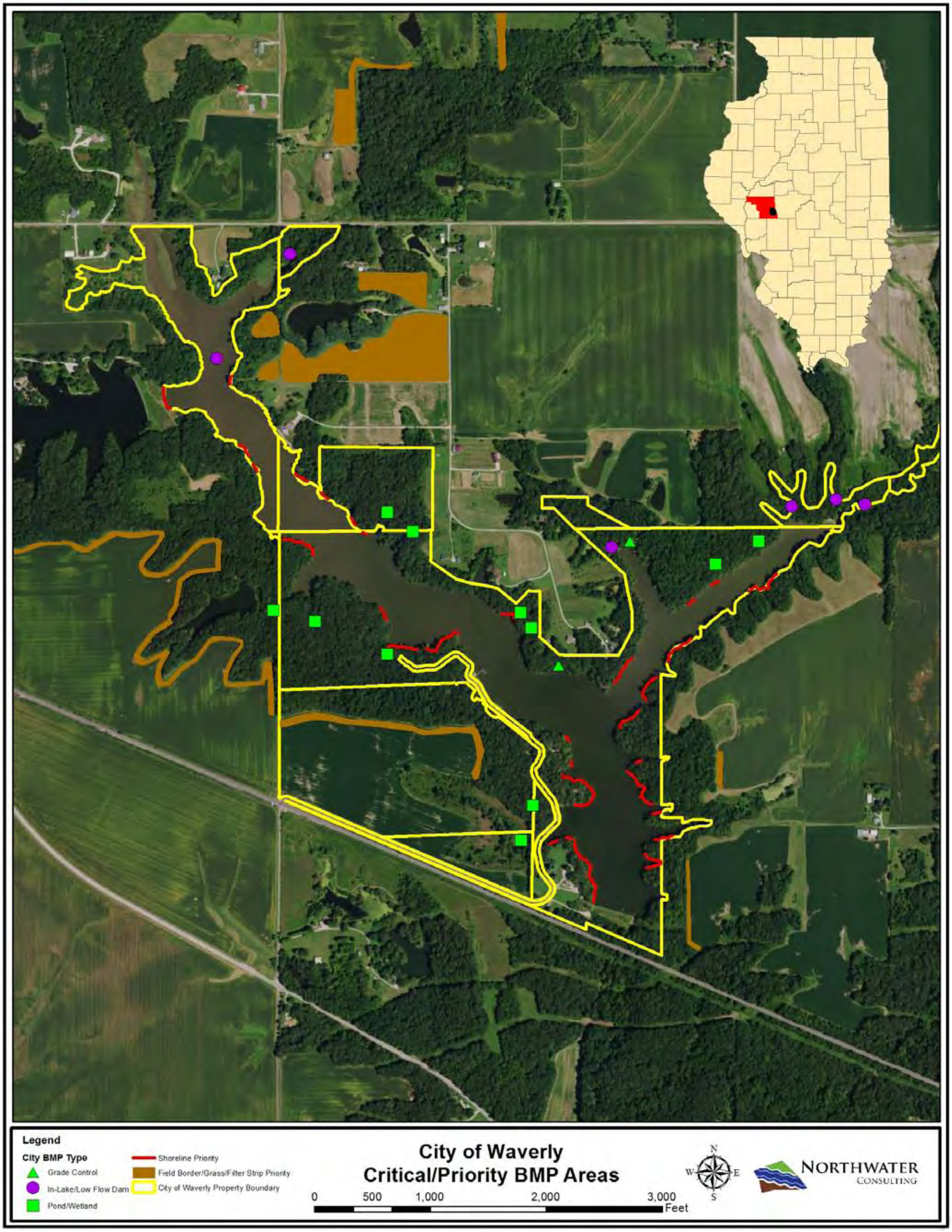


Figure 53 - City of Waverly Priority BMPs

12.0 Technical & Financial Assistance

Eleven entities are listed below, each potentially responsible for project implementation and some, a likely source of funding. For those that can provide funding specific to the Waverly Lake watershed, descriptions of the programs or financial assistance mechanisms are provided. Entities that may not have a direct avenue to a funding apparatus are listed under the Technical Assistance section.

With implementation, primary responsibility lies with the owner of the land first; any agency or entity also providing a role in implementation will need to work with willing landowners but do not have the primary decision-making authority. All implementation is completely voluntary.

City of Waverly (City) The City is the owner of Waverly Lake and has ownership and stewardship responsibility for the lake, as well as surrounding forested areas. A map of BMPs on City-owned property is presented in the previous section.

> **Financial Assistance:** The City has resources it can allocate to be used as match for 319 funds, EQIP cost-share or as contributions to watershed or in-lake conservation practices. The City can also provide direct funding for projects or capital improvements on land it owns and manages, such as Waverly Lake and its adjacent forested ground.

Village of Franklin The Village owns ground in the Waverly Lake Watershed and has responsibility for a small acreage on the Eastern boundary of the watershed.

> **Financial Assistance:** As with Waverly, Franklin can allocate resources for grant funds or direct funding.

Franklin Outing Club The club owns and manages Franklin Lake and the residential areas immediately adjacent to the Lake.

> **Financial Assistance:** The Franklin Lake Outing Club can allocate resources for grant funds or direct funding to projects that directly benefit Franklin Lake or are beneficial to both Franklin and Waverly Lake.

Farmer/Landowner In the Waverly Lake watershed, there are varying business arrangements on who farms the land and makes important conservation decisions. If the farmer is the landowner, then the farmer–landowner is considered the primary responsible party. If the person/entity who owns the land is an absentee owner, then it could be either the farmer-tenant or the absentee landowner is the responsible party. In some cases, the conservation practices decisions are made together in a collaborative fashion by the tenant and landowner. Frequently, the lease terms will determine who makes conservation decisions on the agricultural parcel.

> **Financial Assistance:** Private funds can come from foundations, individual farmers, and landowners and can be used as cash match for Section 319 funds or as private contributions to Waverly Lake conservation activity.

Natural Resources Conservation Service (NRCS) The United States Department of Agriculture has local offices in most Illinois counties which include the NRCS. The Morgan County NRCS office services the Waverly Lake watershed. The NRCS provides both conservation technical assistance and financial assistance to farmers and landowners. One of the programs frequently used for financial assistance is the Environmental Quality Incentive Program (EQIP). Most applicable to the Waverly Lake watershed, the EQIP program provides cost sharing for implementation of approved conservation program practices. The farmer/landowner applies to the NRCS for conservation program funds and they are assisted by NRCS staff to complete the application process, certify the practices and make payments.

Three additional programs administered by the NRCS are also relevant to the watershed and are discussed below; the Conservation Stewardship Program (CSP); the Regional Conservation Partnership Program (RCPP) and the Agricultural Conservation Easement Program (ACEP).

Financial Assistance:

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

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

NRCS/USDA RCPP: The Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of other NRCS programs. RCPP encourages partners to join in efforts with producers to increase restoration and sustainable use of soil, water, wildlife and related natural resources on regional or watershed scales. Through RCPP, NRCS and its partners help producers install and maintain conservation activities in selected project areas.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/rcpp/

NRCS CSP: Through CSP, the NRCS provides conservation program payments. CSP participants will receive an annual land use payment for operation-level environmental benefits they produce. Under CSP, participants are paid for conservation performance: the higher the operational performance, the higher their payment.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/

NRCS ACEP: The ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect and enhance enrolled wetlands.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/

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

Financial Assistance:

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

https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

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

https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-enhancement/index

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

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

https://www.fws.gov/partners/

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

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

Projects may include structural BMPs, such as detention basins and filter strips, non-structural BMPs such as construction erosion control ordinances and setback zones to protect community water supply wells. Technical assistance and information/education programs are also eligible. Section 319 funds are reimbursable and require a match of either cash or in-kind services, or a combination of both cash and in-kind contributions, and will be a major source of funding for implementation activities in the Waverly Lake watershed. Applications for Section 319 funding are due August 1st of each year.

http://www.epa.illinois.gov/topics/water-quality/watershed-management/nonpoint-sources/section-319/index.

Trees Forever They work with communities to empower people through hands-on planting projects. Trees Forever is a nonprofit charitable organization, headquartered in Marion, Iowa, and founded in 1989. They help communities with local tree-planting projects by providing technical, planning, and financial assistance. They also local committees engage others in the projects they work on.

Financial Assistance: Trees Forever manages the Illinois Buffer Partnership Program. The Illinois Buffer Partnership promotes and showcases the voluntary conservation efforts of Illinois farmers and landowners. Each year, 10-20 Illinois Buffer Partnership participants are selected to receive financial and technical assistance. Types of conservation projects eligible for the Illinois Buffer Partnership Program include: riparian buffers, livestock buffers, streambank stabilization projects, wetland development, pollinator habitat, rain gardens and agroforestry projects. Cost-share funds are available in an amount up to $2,000 for 50 percent of the expenses that remain after Conservation Reserve Program (CRP) or other federal, state or local funding has been applied to their project.

http://www.treesforever.org/

12.1 Technical Assistance

Illinois Department of Agriculture (IDOA) The IDOA's Bureau of Land and Water Resources distributes funds to Illinois' 98 soil and water conservation districts for programs aimed at reducing soil loss and protecting water quality. It also helps to organize the state's soil survey every two years to track progress toward the goal of reducing soil loss on Illinois cropland to tolerable levels. If funding becomes available, the Bureau may be able to provide technical and financial support for streambank stabilization.

Soil Water Conservation District (SWCD) In many Illinois counties, it is the local county SWCD that takes a lead role in providing information, guidance and funding arrangements for local conservation practices on farmland in the county.

Illinois Department of Natural Resources (IDNR) IDNR provides technical assessments of streams for the IDOA's streambank stabilization program. The request for local assessment assistance comes through the local SWCD. The IDNR also manages other state programs related to wildlife and forestry, and oversees the state portion of the Conservation Reserve and Enhancement Program.

Illinois Stewardship Alliance The ISA is a membership-based organization whose mission it is promotes environmentally sustainable, economically viable, socially just, local food systems through policy development, advocacy, and education. Most relevant to the Waverly Lake watershed is ISA's work to promote cover crops and educate producers on their benefits. ISA is already active in the watershed and was responsible for organizing a local cover crop and soil heath workshop. ISA staff can assist with landowner outreach and education programs related to conservation.

Illinois Council on Best Management Practices The C-BMP is a coalition of agricultural organizations and agribusinesses, including Illinois Farm Bureau, Illinois Corn Growers Association, Illinois Soybean Association, Illinois Pork Producers Association, Illinois Fertilizer and Chemical Association, Syngenta, GROWMARK, and Monsanto. C-BMP was founded in 1999 and works to assist and encourage adoption of BMPs to protect and enhance natural resources and the sustainability of agriculture in Illinois. C-BMP can assist with producer outreach and education, as well as research.

American Farmland Trust The mission of the AFT is to protect farmland, promote sound farming practices, and keep farmers on the land. AFT advocates for programs and policies that protect farmland, food and the environment; they conduct education and outreach and promote conservation. AFT can assist with producer outreach and education and can help to foster local partnerships.

Illinois Department of Public Health (IDPH) Malfunctioning or improperly constructed and maintained private sewage disposal systems can pose serious health hazards. The Illinois Department of Public Health (IDPH) regulates the installation of all private sewage disposal systems that have no surface discharge (such as septic tanks and seepage fields), as well as those that discharge treated effluent up to 1,500 gallons per day to the ground surface (such as sand filters and aerobic treatment systems). Staff also review and approve plans for private sewage disposal systems and alternative private sewage disposal systems before construction. IDPH can help provide information on existing septic systems and assist with education and outreach.

In addition to the programs of conservation technical assistance provided by the SWCD, NRCS, EPA, IDOA, FSA, USFWS and IDNR, there are conservation technical assistance resources provided through the University of Illinois Cooperative Extension Service (Coop Ext.) and by private professional consultants. Many producers rely upon private consultants: certified crop advisors (CCA) or Technical Service Providers (TSP) for technical expertise. Technical assistance relevant to Waverly Lake can also come from non-profit organizations, such as the Illinois Stewardship Alliance (ISA), the Illinois Council on Best Management Practices (C-BMP) and the American Farmland Trust (AFT).

13.0 Implementation Milestones, Objectives & Schedule

Implementation milestones and goals are intended to be measured by NRCS EQIP and CRP contracts, 319 funded cost-share measures, City of Waverly, the Village of Franklin, the Franklin Lake Outing Club, and NRCS/SWCD-initiated projects. The goals are meant to be both measurable and realistic. Specific milestones and a schedule/timeframe are presented in Table 49. Direct outreach and communication one-on-one with landowners is vital to the success of future implementation activities and will be a component of every effort to secure the adoption of the BMPs listed below. This communication and outreach will also help to ensure practices are maintained over time.

An aggressive 10-year implementation schedule is presented in Table 49. Some practices described in years 1 and 2 are accompanied by a written commitment by the landowner, the City of Waverly, and the Franklin Lake Outing Club contingent on funding; successful education and outreach up to this point has resulted in landowners willing to implement a substantial number of specific practices. The implementation milestones or objectives presented in this section are intended to be achievable and realistic over a 10-year period.

Milestones noted after 10 years are considered long-term and will require significant capital expenditures. Long-term milestones focus more on in-lake management measures and the wide-spread adoption of strip-till/no-till. These practices will help to ensure water quality targets are met and maintained.

Grade/Control/Riffle

Table 49 - Implementation Milestones & Timeframe

Timeframe	Milestone
Years 1-2	1. Continue one-one-one communication with willing producers 2. Stabilize 1,200 feet of shoreline protection at critical locations 3. Install or conduct maintenance of 40 WASCBs 4. Plant 100 acres of cover crops 5. Convert conventional tillage to strip-till or no-till on 500 acres 6. Complete nutrient management (plans) on 260 acres 7. Install 5 ponds; 1 on City property 8. Install 8 acres of grassed waterways 9. Install 20 acres of field borders 10. Convert 61 acres of crop ground to permanent grass 11. Install stream fencing on one pasture 12. Install 1 acre of wetland 13. Install 2 rock riffles and 180 feet of stone-toe protection 14. Install 10 grade control structures
Years 3-5	1. Continue one-one-one communication with willing producers 2. Stabilize 1,200 feet of shoreline protection at critical locations 3. Install or conduct maintenance of 40 WASCBs 4. Plant 100 acres of cover crops 5. Convert conventional tillage to strip-till or no-till on 500 acres 6. Complete nutrient management (plans) on 1,000 acres 7. Install 10 ponds 8. Install 10 acres of grassed waterways 9. Install 2 acres of wetland 10. Install 4 rock riffles and 50 feet of stone-toe protection 11. Install 20 acres of field borders 12. Install 1.3 acres of filter strips 13. Install 10 grade control structures 14. Install 1 in-lake/low flow dam 15. Implement septic system maintenance and inspection program
Years 6 -10	1. Continue one-one-one communication with willing producers 2. Stabilize 1,000 feet of shoreline protection at critical locations 3. Install or conduct maintenance of 29 WASCBs 4. Plant 130 acres of cover crops 5. Convert conventional tillage to strip-till or no-till on 500 acres 6. Complete nutrient management (plans) on 1,000 acres 7. Install 10 ponds 8. Install 10 acres of grassed waterways 9. Install 20 acres of field borders 10. Install 10 grade control structures 1. Install 1 in-lake/low flow dams and consider dredging
10 + Years	11. Continue one-one-one communication with willing producers 12. Stabilize 3,000 feet of shoreline protection at critical locations 13. Convert conventional tillage to strip-till or no-till on 2,800 acres 14. Complete nutrient management (plans) on 2,000 acres 15. Install 14 ponds 16. Install 1 livestock waste system 17. Install 4 in-lake/low flow dams

Table 50 summarizes BMP milestones or objectives, those responsible entities and the primary technical/financial assistance available. The implementation milestones or objectives presented below will meet water quality targets and are divided between those that are realistic within a 10-year period and those that should be pursued as long-term management measures. Given the high cost and limited resources available, it is anticipated that more than 10 years will be required to fully meet TMDL and water quality targets and maintain water quality over time.

Table 50 - Summary Table; Implementation Objectives, Responsible Parties & Technical Assistance

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
Watershed BMPs/Education & Outreach (1-10 years)		
BMP: Cover Crops ***Objective:*** Install 330 acres	Landowner/SWCD/NRCS/City of Waverly/Village of Franklin	**Technical Assistance**: SWCD/NRCS/AFT/ISA **Funding Mechanism**: 319 Grant/Private Funds/NRCS & USDA Programs
BMP: No-Till/Strip Till **Objective**: Convert 1,500 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ NRCS & USDA Programs
BMP: Ponds **Objective:** Install 28 ponds	Landowners/City of Waverly	**Technical Assistance:** NRCS/SWCD/Consultants **Funding Mechanism:** 319 Grant/Private Funds
BMP: Wetland Creation **Objective:** Install 3 acres wetlands	Landowner/SWCD/NRCS/City of Waverly/Franklin Outing Club	**Technical Assistance**: SWCD/NRCS/Consultants/ USFWS **Funding Mechanism**: 319/Private Funds
BMP: Shoreline Stabilization **Objective:** Stabilize 3,400 feet of shoreline	City of Waverly/Franklin Outing Club	**Technical Assistance:** Consultant **Funding Mechanism:** 319 Grant/Private Funds
BMP: Grassed waterway **Objective:** Install 18 acres	Landowner/SWCD/NRCS/Village of Franklin	**Technical Assistance:** SWCD /NRCS /FSA / Consultants **Funding Mechanism**: 319 Grant/ NRCS & USDA Programs
BMP: Filter strips **Objective:** Install 1.3 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA/ Consultants **Funding Mechanism**: 319 Grant/NRCS & USDA Programs/Trees Forever
BMP: Field Borders **Objective:** Install 61 acres	Landowner/SWCD/NRCS/City of Waverly	**Technical Assistance:** SWCD /NRCS /FSA /Consultants **Funding Mechanism**: 319 Grant/NRCS & USDA Programs/Private Funds
BMP: Grass Conversion **Objective:** Convert 16 acres	Landowner/NRCS	**Technical Assistance:** NRCS /FSA /Consultants **Funding Mechanism**: NRCS & USDA Programs/Private Funds
BMP: Streambank Stabilization/Riffle **Objective:** Install 233 ft stone-toe protection and 6 riffles	Landowners SWCD/NRCS/IDOA	**Technical Assistance:** SWCD/NRCS/Consultants **Funding Mechanism:** 319 Grant/Private Funds
BMP: Grade Control **Objective:** Install 33 structures	Landowners /NRCS/City of Waverly	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/NRCS & USDA Programs/Private Funds

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
BMP: WASCB **Objective:** Install or conduct maintenance on 109 WASCBs	Landowner/SWCD/NRCS	**Technical Assistance**: SWCD/NRCS/Consultant **Funding Mechanism:** NRCS Programs/Private Funds
BMP: Pasture Fencing **Objective:** Install 6,708 feet and 3 crossings	Landowners/NRCS	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** NRCS EQIP/319 Grant/Trees Forever
BMP: Nutrient Management (plans) **Objective:** On 2,620 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ NRCS & USDA Programs
BMP: Septic System Maintenance **Objective:** Initiate Septic System Inspection & Maintenance Program	Landowner/City of Waverly/IDPH	**Technical Assistance**: IDPH **Funding Mechanism**: 319 Grant/Private or City Funds
BMP: In-Lake/Low Flow Dam **Objective:** Install 2	City of Waverly	**Technical Assistance**: Consultant **Funding Mechanism**: 319 Grant/City Funds
BMP: Education and Outreach **Objective:** Stakeholder engagement	AFT/ISA/SWCD/NRCS/Coop Ext.	**Technical Assistance:** SWCD/NRCS/ISA/AFT/C - BMP/Coop Ext. **Funding Mechanism:** 319 Grant/City Funds
Long Term Management Measures (10+ years)		
BMP: Education and Outreach **Objective:** Stakeholder engagement	AFT/ISA/SWCD/NRCS/Coop Ext.	**Technical Assistance:** SWCD/NRCS/ISA/AFT/C-BMP /Coop Ext. **Funding Mechanism:** 319 Grant/City Funds
BMP: Shoreline Stabilization **Objective:** Stabilize 3,000 feet of shoreline	City of Waverly	**Technical Assistance:** Consultant **Funding Mechanism:** 319 Grant/Private Funds
BMP: No-Till/Strip Till **Objective**: Convert 2,800 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ NRCS & USDA Programs
BMP: Nutrient Management (plans) **Objective:** On 2,000 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ NRCS & USDA Programs
BMP: Ponds **Objective:** Install 14 ponds	Landowners/City of Waverly	**Technical Assistance:** NRCS/SWCD/Consultants **Funding Mechanism:** 319 Grant/Private Funds
BMP: Livestock Waste System **Objective:** Install 1 system	Landowner/NRCS	**Technical Assistance**: NRCS/ Consultant **Funding Mechanism**: 319 Grant / NRCS EQIP/ Private Funds
BMP: In-Lake/Low Flow Dam **Objective:** Install 4	City of Waverly	**Technical Assistance**: Consultant **Funding Mechanism**: 319 Grant/City Funds

14.0 Information & Education

Northwater Consulting, in partnership with staff from the NRCS and the City of Waverly, actively conducted education and outreach throughout the watershed. Outreach and education activities included:

1. An initial public meeting on December 9th, 2015 to describe the watershed plan and TMDL, as well as next steps. This meeting was attended by over thirty-five individuals representing landowners and watershed residents, producers, agency and city staff. Meeting notifications were sent by direct mail and in the local newspaper and a watershed and TMDL fact sheet was distributed to attendees (Appendix C).
2. Individual, one-on-one landowner/producer meetings on-site to discuss resource concerns and to gauge willingness to implement specific BMPs. Staff from the City of Waverly conducted an initial mailing or phone call to discuss the planning project and to introduce Northwater Consulting. Northwater followed up with each landowner/producer and scheduled a series of meetings. Over 15 site visits were performed to discuss new and existing BMPs.
3. One public landowner/producer meeting organized and hosted by the Morgan County NRCS and SWCD. The first meeting, held on March 1st in Franklin, was attended by 18 landowners and agency representatives. The meeting included a presentation on soil health and a discussion of cost-share options.
4. Regular progress updates were provided to the City of Waverly.
5. A half-day cover crop workshop on November 22nd, 2016. Nineteen landowners were in attendance. The workshop included a presentation by local producers using cover crops; the presentation focused on their experiences followed by a question and answer period. The second presentation described sol health in general and was also followed by a question and answer period. This workshop also included a field visit to a local farm using cover crops.
6. A final public meeting on December 14th, 2016 to present results of the watershed assessment and TMDL. This meeting was attended by over twenty individuals representing landowners and watershed residents, producers, agency, and city staff. Meeting notifications were sent by direct mail and in the local newspaper.

Moving forward into implementation, outreach with watershed landowners should continue. Relationships exist with those producers engaged in a Section 319 grant application, a potential RCPP project application and dialog and communication will continue as any practices are designed and ultimately constructed. Private consultants and NRCS staff will work directly with these producers on practice survey and design and follow up, once construction is complete to verify each BMP is built according to specifications. The City of Waverly intends to develop an Operation and Maintenance (O&M) plan with each landowner that will define and guide construction requirements and future maintenance activities.

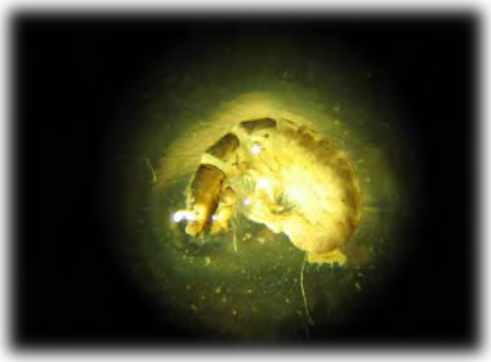
The City of Waverly, NRCS and SWCD will continue outreach efforts into the future to encourage the adoption of additional BMPs; work is currently underway to enroll producers in cover crops and strip-till and this effort will continue. Enrollment into existing programs, such as CRP and EQIP, will also continue, guided by the local NRCS and SWCD and supported by the City. The City will work to implement recommended supplemental management measures on its property as resources permit following completion of any near-term grants, such as a Section 319 grant for targeted BMP implementation.

15.0 Water Quality Monitoring Strategy

The purpose of the monitoring strategy for the Waverly Lake watershed is to utilize existing monitoring data (existing IEPA stations) and continue to monitor the condition and health of the lake and watershed in a consistent and on-going manner. In addition, the strategy seeks to add three watershed monitoring stations to isolate inflows from major lake tributaries, as well as Woods Creek where stream monitoring data is absent; monitoring data is only available within the lake.

The strategy allows for evaluation of the overall health of the watershed and its changes through time. Another key purpose is to assess the effectiveness of plan implementation projects, and their cumulative watershed-scale contribution towards achieving the goals and objectives of the plan. While programmatic monitoring tracks progress through achievement of actions, this section outlines a strategy to directly monitor the effectiveness of the actions.

Monitoring environmental criteria, as outlined in this strategy, is an effective way to measure progress toward meeting water quality objectives. One potential problem with in-stream indicators is the issue of isolating dependent variables. There are likely many variables influencing the monitoring results, so making conclusions with regard to one specific constituent should be done with caution. It should be noted, however, that the indicators are excellent for assessing overall changes in a watershed's condition.



Hydrosychidae sp.

Three IEPA monitoring stations exist within Waverly Lake (Table 51 and Figure 54). One additional site on Woods Creek and one on each of the two major tributaries noted in Figure 54 are also proposed to evaluate watershed and stream conditions and establish a baseline. Given the historical data currently available, it is recommended that monitoring continue at existing lake sites, ideally, under direction from the IEPA. The proposed monitoring categories and associated recommendations are summarized in Table 52. Monitoring activities should be coordinated with the IEPA and additional resources should be sought, such as the RiverWatch program through the National Great Rivers Research and Education Center (NGRREC) or through volunteers, as needed. Physical and biological data should be collected at the Woods Creek monitoring site to augment water quality information, since no biological data exists.

Due to the uncertainty in securing resources for edge-of-field monitoring to measure the effectiveness of BMPs, it is recommended that a more detailed monitoring plan be developed alongside future implementation actions, if funding permits.

Table 51 - Existing & Proposed Monitoring Sites & Description

Station ID	Site Description	Notes
SDC-1	Waverly Lake near dam	Existing IEPA monitoring site
SDC-2	Waverly Lake, approximately 1,700 ft North of dam	Existing IEPA monitoring site
SDC-3	Waverly Lake, approximately 275 ft North of boat launch on West side of lake	Existing IEPA monitoring site
ST-1	Woods Creek, approximately 1,100 ft upstream of Clevenger Rd	New monitoring site on Woods Creek
ST-2	Unnamed Tributary, approximately 100 ft upstream of Clevenger Rd	New tributary monitoring site
ST-3	Unnamed Tributary, approximately 1,700 ft West of N Lyons Rd	New tributary monitoring site

Table 52 - Summary of Monitoring Categories & Recommendations

Monitoring Category	Summary of Recommendations
Stream flow	Measure stream flow during every sample event, if conditions permit.
Ambient water quality	Utilize IEPA and local volunteers or City staff to execute regular monitoring for water quality at all stream and lake sites.
Physical & biologic assessment	Develop and execute stream monitoring for fish, macroinvertebrates, habitat, and channel morphology on Woods Creek.
BMP effectiveness	Monitor BMP effectiveness of specific practices or cluster of practices. Develop a detailed monitoring plan in combination with implementation activities.
Storm event runoff monitoring	Conduct monitoring during storm event at each stream site.
Trends in water quality	Establish baseline conditions for stream sites. Monitor/track changes and trends in lake water quality; continue to evaluate lake water quality parameters as IEPA data becomes available.

Orangethroat Darter

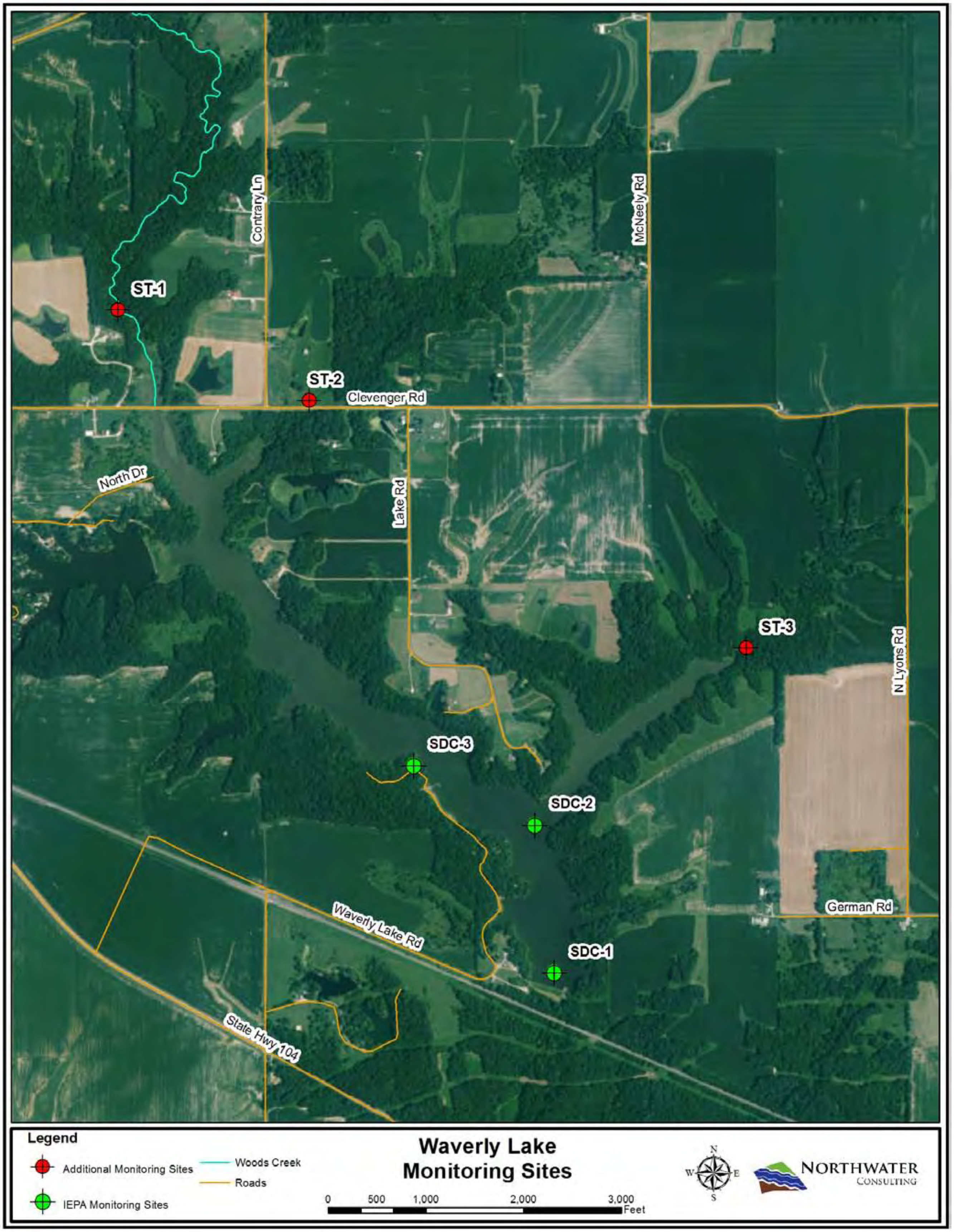


Figure 54 - Monitoring Locations

15.1 Water Quality Monitoring

Seasonal or monthly and storm-event water quality monitoring should be considered for all three additional stream monitoring stations in the watershed (Figure 54). Efforts should focus initially on collecting base-flow and storm-event data, followed by a regular sampling program. Regular monitoring should occur at a minimum of three times per year to capture seasonal variations in water quality; conduct storm event monitoring to supplement results. Monthly monitoring is preferred, if funding permits.

Table 53 includes the minimum parameters that should be considered for monitoring. Quantitative benchmarks that indicate impairment conditions are also illustrated in this table. The establishment of baseline conditions is important in order to evaluate trends and changes in water quality over time through implementation. Parameters, such as total phosphorus, total suspended sediment, and total nitrogen, should be analyzed considering flow volumes in order to make relative comparisons year to year, as concentrations of pollutants vary with flow volumes. The water quality monitoring results may also be used to calibrate the nonpoint source pollution load model and make revised annual loading estimates throughout implementation.

Table 53 - Baseline Water Quality Analysis Parameters

Analyte	Benchmark Indicators
Total Phosphorus	Less than 0.05 mg/l (IL standard)
Total Nitrogen	Less than 10 mg/L (based on IL Nitrate standard)
Total Suspended Sediment (TSS)	Less than 15 mg/L (based on AQI max value)
Turbidity	Less than 14 NTU (IL Lake Assessment Criteria)
Dissolved Oxygen	No less than 6.0 mg/l (IEPA standards)
Temperature	Less than 90° F (IEPA standards)
pH	Between 6.5 – 9.0 (IEPA standards)
Flow	--

15.2 Stream Bioassessment

Aquatic stream monitoring should be considered annually or at the maximum of 3- to 5-year increments. One station on Woods Creek is recommended. Table 54 shows the typical stream bioassessment techniques that can be applied to the monitoring program.

Table 54 - Stream Bioassessment Metrics

Monitoring	Definition	Benchmark Indicators
Fish Index of Biologic Integrity (fIBI)[1]	Index based on presence and populations of non-native and native fish species and their tolerance to degraded stream conditions.	**No Impairment** (≥41) – good resource quality and fully supporting aquatic life **Moderate Impairment** (<41 and >20) – fair resource quality and not supporting aquatic life **Severe Impairment** (≤20) – poor resource quality and not supporting aquatic life
Macroinvertebrate Index of Biologic	Index indicative of stream quality based on the macroinvertebrate species and populations.	**No Impairment** (≥41.8) – good resource quality and fully supporting aquatic life

Monitoring	Definition	Benchmark Indicators
Integrity (mIBI)[1]		**Moderate Impairment** (<41.8 and >20.9) – fair resource quality and not supporting aquatic life **Severe Impairment** (≤20.9) – poor resource quality and not supporting aquatic life
Qualitative Habitat Evaluation Index (QHEI)[2]	Index indicative of habitat quality that incorporates substrate, in-stream cover, channel morphology, riparian zone, bank erosion and riffle/pool condition.	**Excellent** (>70) **Good** (55-69) **Fair** (43-54) **Poor** (30-42) **Very Poor** (<30)
Channel Morphology	Establish fixed cross-section and longitudinal profile of channel along a 1,500-foot-long fixed reach. Monitor regularly to assess changes in channel.	Entrenchment ratio Width/depth ratio bankfull Bed material Cross-sectional area Water slope

1 – From: IEPA Illinois Integrated Water Quality Report and Section 303(d) List, 2016; Guidelines for using Biological Information

2 – From: State of Ohio Environmental Protection Agency Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

Flow monitoring

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Appendix A: Nonpoint Source Pollution Load Model Methodology (SWAMM)

Waverly Lake Watershed SWAMM Direct Runoff Pollutant Load Model Methodology

NORTHWATER
CONSULTING

8/6/2016

sWAMM™

Spatial Watershed
Assessment & Management
Model

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Pollutant Loading Model Methodology

1.0 Introduction

A GIS spatially based pollution load model or SWAMM (Spatial Watershed Assessment and Management Model) was developed to estimate field level pollutant loading from direct runoff for nitrogen, phosphorus and sediment in the Waverly Lake watershed. Constructed using soils, landuse and precipitation data, the model provides annual event loading for individual land parcels within the watershed. Results are organized through a unique combination of landuse and soils, delineated into individual units of pollution loading. Accepted equations for calculating runoff and soil erosion are integrated into the model to provide realistic estimations of the quantity and distribution of pollution loading throughout the study area. Model results were compared to TMDL outputs to confirm results were within and acceptable range. A time period of 2000 to 2014 was used for generating rainfall values.

The GIS data set is organized in such a way that results can easily be queried by land units and by landuse. Results can also be analyzed based on user defined boundaries and presented in map format, easily overlaid on existing base maps. The model includes 3,217 unique records from which to assess pollution loading. The following methodology document provides key model equations and values, references and summary statistics.

2.0 Methodology

The custom SWAMM consists of two primary components:

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

2.1 USLE Component

The overall analysis methodology modified by Northwater from*:*

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

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

- 1:24,000 NRCS Soil Survey Geographic Database (SSURGO) Digital Soils.
- Selected appropriate soil types and relevant USLE factors identified and calculated from SSURGO soils dataset and information from the Natural Resource Conservation Service.
- USLE erosion calculated with the following equation: LS * K * C * R * P.

Table 1 - USLE factors

C factor	K factor	LS factor	R factor	P factor
Conventional High – 0.45 Conventional Reduced – 0.43 Wheat/No-Till – 0.06 Spring-Till – 0.23 No-Till with Cover Crop – 0.04	Values included in SSURGO tabular data	Values included in SSURGO tabular data; calculated from slope and slope length values	180	0.5-1

2.2 EMC Component

A) All formulas and selected variables are derived from: *STEPL (Spreadsheet Tool for Estimation of Pollutant Load) Version 3, Tetra Tech, 2004.*

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

1. *Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) Technical Guide, Version 1.0 Release 1, November 2004.*
2. *Lower DuPage River Watershed Plan Pollution Load Model Methodology, 2010.*
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8. *Northwater Consulting. 2014 Spatial Watershed Assessment and Management Model; Big Ditch & Big & Long Creek Watersheds. Prepared for the Agricultural Watershed Institute, Decatur, IL.*
9. *Northwater Consulting. 2015-2016 Spatial Watershed Assessment and Management Model; Delevan Lake Watershed. Prepared for Berrini & Associates.*
10. *Northwater Consulting. 2016 Spatial Watershed Assessment and Management Model; Lake Springfield Watershed. Prepared for the Sangamon County SWCD.*

C) Precipitation: annual precipitation, number of rain days and correction factors using the following weather station: Jacksonville. A 14-year average was generated for the period 2000-2014.

Table 2 – Rainfall Factors

Average Number of Rain Days	Rain Days Correction Factor	P Value (inches)
113.2	0.435	0.71

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

Polygon distance from major stream (ft) $^{\wedge-0.2069}$

Table 3 - Pollutant Load Model Values

Rain days	Correction Factor (precipitation and rain days)	Curve Number (by soil hydrologic group)	Runoff (by soil hydrologic group in inches)	EMC for P, TSS
Table 2	Table 2	Table 4	Calculated using the following equation: $Q = \frac{((P-(IaXS))^{2}}{P + 0.8 X S}$ $S = \frac{1000}{CN} - 10$ Q = Runoff (inches) P = Precipitation (inches) S = Potential max retention (inches) CN = Curve Number Ia = Initial abstraction factor; set to 0 for annual runoff	Table 4

Table 4 - Event Mean Concentrations & Curve Numbers

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Cemetery	3.1	0.46	84	49	69	79	84
Confinement (High)	7.1	1.8	240	89	92	94	95
Farm Building (High)	6.8	0.42	280	89	88	91	93
Farm Building (High with Detention)	4.1	0.25	168	77	85	87	92
Farm Building (Medium)	6.8	0.42	160	61	75	83	87
Farm Building (Medium with Detention)	4.1	0.25	96	57	72	81	86
Farm Building (Medium Franklin Lake)	3.4	0.17	48	55	70	79	84
Farm Building (Low)	6.8	0.42	72	51	68	79	84
Farm Building (Low with Detention)	4.1	0.25	43	46	65	77	82
Farm Building (Low Franklin Lake)	3.4	0.17	36	44	63	75	80
Feed Area (High)	13.5	2.6	390	89	92	94	95
Feed Area (Medium)	10.1	1.5	240	77	85	90	92
Forest (normal CN)	1.4	0.15	60	36	60	73	79
Forest (normal CN with Detention)	1	0.105	36	32	56	69	75
Forest (normal CN Franklin Lake)	0.8	0.075	30	30	54	67	73
Forest (Moderate CN)	1.4	0.18	70	38	62	75	81
Forest (Moderate CN with Detention)	1	0.105	42	34	58	71	77
Forest (Moderate CN Franklin Lake)	0.8	0.075	35	32	56	69	75
Forest (High CN)	1.4	0.19	80	40	64	77	83
Grassland (prairie)	0.7	0.13	30	30	58	71	78
Grassland (prairie with detention)	0.5	0.08	18	26	54	67	74
Grassland (prairie Franklin Lake)	0.35	0.065	12	24	52	65	72
Grassland (waterway)	0.8	0.15	40	49	69	79	84
Grassland (waterway with detention)	0.6	0.1	20	45	65	75	80
Grassland (waterway Franklin Lake)	0.5	0.075	15	43	63	73	78
Grassland (field border)	0.7	0.13	30	30	58	71	78
Grassland (field border with detention)	0.5	0.08	18	26	54	67	74
Grassland (field border Franklin Lake)	0.35	0.065	15	24	52	65	72
Grassland (Franklin Waste)	1	0.2	30	30	58	71	78
Industrial (High)	2.4	0.31	215	89	92	94	95
Industrial (Franklin Lake)	1.44	0.19	108	85	88	90	91
Institutional (High)	3.2	0.4	206	89	92	94	95
Open Water - Pond	0.375	0.025	1.5	100	100	100	100

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Open Water - Stream	1.25	0.11	3.1	100	100	100	100
Other Agriculture (Organic with Detention)	3.5	0.29	N/A*	60	71	78	81
Pasture (High)	10.1	0.9	300	75	84	89	91
Pasture (Medium)	6	0.6	150	68	79	86	89
Pasture (Medium with Detention)	3.6	0.36	75	49	69	79	84
Pasture (Low)	3.6	0.36	70	39	58	71	78
Pasture (Low with Detention)	2.16	0.22	43	30	55	69	76
Railroad	2	0.34	240	89	89	89	89
Railroad (with detention)	1.3	0.22	144	85	85	85	85
Railroad (Franklin Lake)	1	0.17	120	83	83	83	83
Residential Farm (High)	3.3	0.5	260	77	85	90	92
Residential Farm (High with Detention)	1.98	0.3	130	72	80	85	87
Residential Farm (High Franklin Lake)	1.86	0.25	70	70	78	83	85
Residential Farm (Medium)	3.1	0.42	130	61	75	83	87
Residential Farm (Medium with Detention)	1.86	0.25	70	57	72	81	86
Residential Farm (Medium Franklin Lake)	1.55	0.21	65	55	70	79	84
Residential Farm (Low)	3.1	0.42	65	51	68	79	84
Residential Farm (Low with Detention)	1.86	0.25	40	46	65	77	82
Residential Farm (Low Franklin Lake)	1.8	0.21	33	44	63	75	80
Roads	2.3	0.34	153	98	98	98	98
Roads (with Detention)	1.61	0.24	107	94	94	94	94
Roads (Franklin Lake)	1.15	0.17	76	92	92	92	92
Row Crops (Conventional Tillage High)	7.1	0.6	N/A*	73	82	89	92
Row Crops (Conventional Tillage High with detention)	5.3	0.42	N/A*	69	78	84	88
Row Crops (Conventional Tillage)	7.1	0.6	N/A*	72	81	88	91
Row Crops (Conventional Tillage with detention)	5.3	0.42	N/A*	69	78	84	88
Row Crops (Conventional Franklin Lake)	4	0.3	N/A*	67	76	82	86
Row Crops (Reduced Tillage)	7.1	0.6	N/A*	71	80	87	90
Row Crops (Reduced Tillage with detention)	5.3	0.42	N/A*	67	76	82	86
Row Crops (Reduced Franklin Lake)	4	0.3	N/A*	65	74	80	84
Row Crops (Spring Till)	7.1	0.6	N/A*	71	80	87	90
Row Crops (Spring Till with Detention)	5.3	0.42	N/A*	67	76	82	86
Row Crops (No Till)	6	0.5	N/A*	67	78	85	89
Row Crops (No Till with detention)	4.5	0.35	N/A*	63	74	81	85
Row Crops (No Till and Cover Crop)	5	0.42	N/A*	64	75	82	85
Row Crops (No-Till Wheat with Detention)	3.75	0.3	N/A*	61	72	80	84
Row Crops (No-Till Wheat Franklin Lake)	2.5	0.2	N/A*	59	70	78	82
Urban Open Space	2.5	0.15	60	49	69	79	84
Urban Open Space (with Detention)	1.9	0.1	36	45	65	75	80
Urban Open Space (Franklin Lake)	1.25	0.09	30	43	63	73	78
Urban Residential (High)	3.2	0.5	206	81	88	91	93
Urban Residential (High with Detention)	1.92	0.3	124	77	85	89	92

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Urban Residential (Medium)	3.2	0.5	160	61	75	83	87
Urban Residential (Medium with Detention)	1.92	0.3	96	57	72	81	86
Urban Residential (Low)	3.2	0.5	160	54	70	80	85
Wetland	0.7	0.01	1	85	85	85	85
Wetland (Franklin Lake)	0.35	0.005	0.5	83	83	83	83
Warehousing (Medium with Detention)	1.2	0.31	153	61	75	83	87

* Replaced by USLE

3.0 Model Calibration

No direct model calibration was performed due to the lack of any in-stream data. Model verification was performed by comparing model results against TMDL estimates and in-lake phosphorus concentrations as well as average per acre loading results for similar watersheds in the Midwest. The verification served three purposes:

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

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

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

4.0 Model Notes

1. A local and specialized landuse layer was created to represent actual landuse/landcover layer by interpreting recent aerial imagery and digitizing/labeling polygons. The landuse layer was corrected to represent current conditions and verified through field assessments.
2. Data on field specific tillage practices and existing BMPs was incorporated and accounted for.
3. High, medium and low developed areas were determined based on a visual interpretation of density. High areas generally represent greater than 50% impervious, medium 25-50% impervious and low, less than 25%.
4. Model accounts for areas with detention in place or any locations where BMPs currently exist.
5. Pasture was classified into high, medium and low based on pasture quality and the observed impact to water quality during a windshield survey.
6. All perennial streams and the lake were used for proximity calculations to determine delivery ratios.
7. Steep forested areas were accounted for by adjusting CN's based on slope.

Appendix B: Bathtub Model; Additional Documentation

Waverly Lake Modeling – Additional Documentation
Bathtub Model Version 6.20 (03/06/2014) Data Input Values

The Bathtub Model developed for the Waverly Lake TMDL work involved modification of a limited number of parameters from default values. The parameters reflecting the Waverly Lake watershed, lake area, estimated P inputs, and calibration factors are listed below. Following the table on key parameters, the entire input data files used for the modeling work are provided in a series of tables based on the line by line organization within the data text file.

Scenarios for which output is provided are:

- (Case 1b) calibration run to mean total phosphorus for 2015 monitoring;
- (Case 1c) calibration run to median total phosphorus for 2015 monitoring;
- (Case 3b) reduction scenario to achieve a total phosphorus concentration in the lake of 0.05 mg/L for the Case 1b calibration; and
- (Case 3c) reduction scenario to achieve a total phosphorus concentration in the lake of 0.05 mg/L for the Case 1c calibration.

Key Parameters

Parameter	Case 1b	Case 1c	Case 3b	Case 3c	Description
AVERAGING PERIOD	1	1	1	1	Averaging period in years
PRECIPITATION	1.0	1.0	1.0	1.0	Precipitation in meters
PHOSPHORUS BALANCE	1	1	1	1	Option 01: 2nd Order, Avail P
DISPERSION	1	1	1	1	Option 01: Fischer-Numeric
PHOSPHORUS CALIBRATION	1	1	1	1	Option 01: Decay Rates
P DECAY RATE	1.94	2.52	1.94	2.52	Calibration factor
Atmospheric Phosphorus Loading	0.03	0.03	0.03	0.03	Atmospheric Loading (mg/m^2-yr)
Surface Area	0.4241	0.4241	0.4241	0.4241	Surface Area (km^2)
Mean Depth	2.1336	2.1336	2.1336	2.1336	Mean Depth (meters)
Length	2.31	2.31	2.31	2.31	Length (km)
Mixed Layer Depth	2.1336	2.1336	2.1336	2.1336	Mixed Layer Depth (meters)
Internal Phosphorus Loading	2.3	2.3	1.32	1.36	Internal P Loading (mg/m^2-day)
Drainage Area	25.45958	25.45958	25.45958	25.45958	Drainage Area in km^2
Flow	6.699	6.699	6.699	6.699	Flow (hm^3/yr)
Tributary Total P	541	541	81	97	Tributary inflow (µg/L)

Complete Data Input Tables

The separation of tables is according to the order of data within the text file saved from within the Bathtub Model. The tables generally correspond to input pages available within the Model. In some cases, data entered on a single line in the text file is divided over several rows to allow more detail to be provided on the input parameters.

Lake Waverly

4,"Global Parameters"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"AVERAGING PERIOD (YRS)"	1, 0	1, 0	1, 0	1, 0	Mean, CV
2	"PRECIPITATION (METERS)"	1, 0	1, 0	1, 0	1, 0	Mean, CV
3	"EVAPORATION (METERS)"	0.82, 0	0.82, 0	0.82, 0	0.82, 0	Mean, CV
4	"INCREASE IN STORAGE (METERS)"	0, 0	0, 0	0, 0	0, 0	Mean, CV

12,"Model Options"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"CONSERVATIVE SUBSTANCE"	0	0	0	0	00 Not Computed
2	"PHOSPHORUS BALANCE"	1	1	1	1	01 2nd Order, Avail P
3	"NITROGEN BALANCE"	0	0	0	0	00 Not Computed
4	"CHLOROPHYLL-A"	0	0	0	0	00 Not Computed
5	"SECCHI DEPTH"	0	0	0	0	00 Not Computed
6	"DISPERSION"	1	1	1	1	01 Fischer-Numeric
7	"PHOSPHORUS CALIBRATION"	1	1	1	1	01 Decay Rates
8	"NITROGEN CALIBRATION"	0	0	0	0	00 None
9	“ERROR ANALYSIS”	1	1	1	1	01 Model & Data
10	"AVAILABILITY FACTORS"	0	0	0	0	00 Ignore
11	"MASS-BALANCE TABLES"	1	1	1	1	01 Use Estimated Concs
12	"OUTPUT DESTINATION"	2	2	2	2	02 Excel Worksheet

17,"Model Coefficients"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"DISPERSION RATE"	1, 0.7	1, 0.7	1, 0.7	1, 0.7	Mean, CV
2	"P DECAY RATE"	1.94, 0.27	2.52. 0.45	1.94, 0.27	2.52, 0.45	Mean, CV
3	"N DECAY RATE"	1, 0.55	1, 0.55	1, 0.55	1, 0.55	Mean, CV
4	"CHL-A MODEL"	1, 0.26	1, 0.26	1, 0.26	1, 0.26	Mean, CV
5	"SECCHI MODEL"	1, 0.1	1, 0.1	1, 0.1	1, 0.1	Mean, CV
6	"ORGANIC N MODEL"	1, 0.12	1, 0.12	1, 0.12	1, 0.12	Mean, CV
7	"TP-OP MODEL"	1, 0.15	1, 0.15	1, 0.15	1, 0.15	Mean, CV
8	"HODV MODEL"	1, 0.15	1, 0.15	1, 0.15	1, 0.15	Mean, CV
9	"MODV MODEL"	1, 0.22	1, 0.22	1, 0.22	1, 0.22	Mean, CV
10	"BETA M2/MG"	0.025, 0	0.025, 0	0.025, 0	0.025, 0	Mean, CV
11	"MINIMUM QS"	0.1, 0	0.1, 0	0.1, 0	0.1, 0	Mean, CV
12	"FLUSHING EFFECT"	1, 0	1, 0	1, 0	1, 0	Mean, CV
13	"CHLOROPHYLL-A CV"	0.62, 0	0.62, 0	0.62, 0	0.62, 0	Mean, CV
14	"Avail Factor - TP"	0.33, 0	0.33, 0	0.33, 0	0.33, 0	Mean, CV
15	"Avail Factor - Ortho P"	1.93, 0	1.93, 0	1.93, 0	1.93, 0	Mean, CV
16	"Avail Factor - TN"	0.59, 0	0.59, 0	0.59, 0	0.59, 0	Mean, CV
17	"Avail Factor - Inorganic N"	0.79, 0	0.79, 0	0.79, 0	0.79, 0	Mean, CV

5,"Atmospheric Loads"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	Mean, CV
2	"TOTAL P"	0.03, 0	0.03, 0	0.03, 0	0.03, 0	Mean, CV
3	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	Mean, CV
4	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	Mean, CV
5	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	Mean, CV

1,"Reservoir"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	Outflow Segment	0	0	0	0	Out of Reservoir
1	Segment Group	1	1	1	1	
1	Surface Area (km2)	0.4241	0.4241	0.4241	0.4241	Mean
1	Mean Depth (m)	2.1336	2.1336	2.1336	2.1336	Mean
1	Length (km)	2.31	2.31	2.31	2.31	Mean
1	Mixed Layer Depth (m)	2.1336, 0	2.1336, 0	2.1336, 0	2.1336, 0	Mean, CV
1	Hypolimnetic Thickness (m)	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	Non-Algal Turb.	0.2, 0.5	0.2, 0.5	0.2, 0.5	0.2, 0.5	Mean, CV

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
	(1/m)					
1	Conserv.	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	Total P	2.3, 0	2.3, 0	1.32, 0	1.36, 0	Mean, CV
1	Total N	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"CONSERVATIVE SUB"	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	Mean, CV, CF mean, CF CV
1	Total P (MG/M3)	138, 0.038, 1, 0	0.99, 0.08, 1, 0	138, 0.038, 1, 0	0.99, 0.08, 1, 0	Mean, CV, CF mean, CF CV
1	TOTAL N (MG/M3)	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	Mean, CV, CF mean, CF CV
1	CHL-A (MG/M3)	15, 0.2, 1, 0	15, 0.2, 1, 0	15, 0.2, 1, 0	15, 0.2, 1, 0	Mean, CV, CF mean, CF CV
1	SECCHI (M)	2, 0.2, 1, 0	2, 0.2, 1, 0	2, 0.2, 1, 0	2, 0.2, 1, 0	Mean, CV, CF mean, CF CV
1	ORGANIC N (MG/M3)	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	Mean, CV, CF mean, CF CV
1	TP – Ortho P (MG/M3)	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	Mean, CV, CF mean, CF CV
1	HOD-V (MG/M3-DAY)	100, 0.1, 1, 0	100, 0.1, 1, 0	100, 0.1, 1, 0	100, 0.1, 1, 0	Mean, CV, CF mean, CF CV
1	MOD-V (MG/M3-DAY)	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	0, 0, 1, 0	Mean, CV, CF mean, CF CV

1,"Tributaries"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"Inlet"					
1	Segment number	1	1	1	1	
1	Type	1	1	1	1	01 Monitored Inflow
1	Drainage Area (km2)	25.45958	25.45958	25.45958	25.45958	
1	Flow (hm3/yr)	6.699, 0.011	6.699, 0.011	6.699, 0.011	6.699, 0.011	Mean, CV
1	UNKNOWN Input	0	0	0	0	"0" at end of line
1	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"TOTAL P"	541, 1	541, 1	81, 1	97, 1	Mean, CV
1	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	Mean, CV
1	"LandUses"	0, 0, 0, 0, 0, 0, 0, 0	0, 0, 0, 0, 0, 0, 0, 0	0, 0, 0, 0, 0, 0, 0, 0	0, 0, 0, 0, 0, 0, 0, 0	Drainage area by landuse category

0,"Channels"
No information included on this data input page

8,"Land Use Export Categories"

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
1	"landuse1"					
1	"Runoff"	0, 0	0, 0	0, 0	0, 0	
1	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
1	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
1	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
1	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
1	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
2	"landuse2"					
2	"Runoff"	0, 0	0, 0	0, 0	0, 0	
2	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
2	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
2	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
2	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
2	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
3	"landuse3"					
3	"Runoff"	0, 0	0, 0	0, 0	0, 0	
3	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
3	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
3	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
3	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
3	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
4	"landuse4"					
4	"Runoff"	0, 0	0, 0	0, 0	0, 0	
4	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
4	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
4	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
4	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
4	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
5	""					
5	"Runoff"	0, 0	0, 0	0, 0	0, 0	
5	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
5	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
5	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
5	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
5	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
6	""					
6	"Runoff"	0, 0	0, 0	0, 0	0, 0	
6	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	

No.	Description	Case 1b	Case 1c	Case 3b	Case 3c	Comment
6	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
6	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
6	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
6	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
7	""					
7	"Runoff"	0, 0	0, 0	0, 0	0, 0	
7	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
7	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
7	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
7	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
7	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	
8	""					
8	"Runoff"	0, 0	0, 0	0, 0	0, 0	
8	"CONSERVATIVE SUBST."	0, 0	0, 0	0, 0	0, 0	
8	"TOTAL P"	0, 0	0, 0	0, 0	0, 0	
8	"TOTAL N"	0, 0	0, 0	0, 0	0, 0	
8	"ORTHO P"	0, 0	0, 0	0, 0	0, 0	
8	"INORGANIC N"	0, 0	0, 0	0, 0	0, 0	

Additional Waverly Lake Modeling Documentation

The following documentation provides additional information on the source of the input parameters and the modeling strategy to determine the loading capacity to Waverly Lake for which the predicted total phosphorus concentration is predicted to attain the 0.05 mg/L standard.

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Project Number: *152387* *Sheet No.* *1* *of* *4*
Project Name: *Waverly Lake TMDL Model*
Prepared by: *JMC* *Date:* *5/26/2016*
Checked by: *Date:*
Title: *Model Input Calculations*

Objective:

Develop an input dataset for running the Bathtub model to predict phophorus concentrations in Waverly Lake.

Given:

Sedimentation Survey of Waverly City Reservoir - October 13, 2009

Water Quality Data for stations in the Lake.

Predicted loadings from the Basin.
USGS Basin Size Delineation from StreamStats.

NOTE: Client changes P input from Septic in Jan-17 This revised input form documents revisions to the TMDL model. Changes are highlighted.

Data:

Length from Google Earth of longest reach = 2.31 km.
Lake Volume (from Oct 2009) = 230.5 million gallons

Depth (feet)	Given Volume in the Lake (million gallons)	Volume of Layer (million gallons)
0 - 1	230.5	32.2
1 - 2	198.3	29.2
2 - 3	169.1	27.1
3 - 4	142	24.6
4 - 5	117.4	22.2
5 - 6	95.2	19.4
6 - 7	75.8	16.6
7 - 8	59.2	14.1
8 - 9	45.1	12.1
9 - 10	33	10.4
10 - 11	22.6	8.6
11 - 12	14	6.5
12 - 13	7.5	4.4
13 - 14	3.1	2.4
14 - 15	0.7	0.7
15 - 16	0	

Average Layer Volume 15.4 million gallons
Average Depth by Volume 7 feet = 2.1 meters 1 ft = 0.3048 m

Lake Surface Area 104.8 acres = 0.42 km^2 1 acre = 43,560 square feet
1 km = 1,000 m
Total Watershed 9.83 sq mi. = 6,291 acres 1 sq. mi. = 640 acres

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Project Number: *152387* *Sheet No.* *2* *of* *4*
Project Name: *Waverly Lake TMDL Model*
Prepared by: *JMC* *Date:* *5/26/2016*
Checked by: *MEL* *Date:* *6/1/2016*
Title: *Model Input Calculations*

Internal Load (milligrams per square meter per day)

From phosphorus water quality data calculation sheet, internal sediment loading is:

302,355 mg/day 243.3 lbs/yr (Added by MEL 6/1/16)

Lake Shore loading from Watershed Model = 557 lbs/year **(Jan-17 total shoreline is 566 lbs/yr with 9 lbs/yr in Franklin L.)**

557.0 lbs/yr = 692,191 mg/day
1 year = 365 days
1 lb = 453,590 mg

Total mass load = 994,545 mg/day
Lake Surface Area 104.8 acres = 424,111 square meters
1 acre = 4047 square meters

Internal Load = 2.3 (load from shoreline and sediments)

Annual Runoff Flowrate provided by Jeff Boeckler as 5,431 acre-feet per year.

5,431 acre-feet/yr = 6.699 hm^3/yr
1 acre-foot = 43,560 cubic feet
1 cubic meter = 35.3 cubic feet
1 cubic hectometer = 1,000,000 cubic meters

TP Watershed Loading (without Lake Shore) provided by Jeff Boeckler

Upland	6,261.9	lbs/yr				
Streambank	867	lbs/yr	Septic P Load	608	lbs/yr	(from Jeff Boeckler 5/28/16)
Gully Erosion	687	lbs/yr		**170**	lbs/yr	(from Jeff Boeckler 1/18/17)
Franklin L. Shore	9	lbs/yr	Revised Total	8,424	lbs/yr	(revised total 5/28/16)
Total	7,825			7,995	lbs/yr	(revised total 1/18/17 incl Franklin L.)

Convert the loading to a concentration based on the runoff flowrate.

$$\frac{7{,}995 \text{ lbs/yr}}{6.699 \text{ hm}^3\text{/yr}}$$

= 529 ppb - initial
= 570 ppb - with Septic P
541 ppb - revised Septic P

1 lb = 453,590,000 micrograms (µg)
1 m^3 = 1,000 L

The reductions in mass loading will be calculated on the next page.

Note - Case 1 and Case 1a are calibrated versions of the BATHTUB Model with an input of 529 ppb prepared prior to addition of Septic P Load on 5/28/16

Note - Case 1b and Case 1c are re-calibrated versions of the BATHTUB Model with an input of 570 ppb - with Case 1b calibrated to mean TP in lake and Case 1c calibrated to median TP in the lake (Apr-Oct 2015)

Note - Case 2b and Case 2c are reduction scenarios achieving TP = 0.05 mg/L with only tributary reductions while Case 3b and Case 3c incorporate partial reduction of internal P loading.

Note - Case 1d replaces 1b; 1e replaces 1c; 3d replaces 3 b; 3e replaces 3c for revised Septic Loading

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Project Number: *152387* *Sheet No.* *3* *of* *4*
Project Name: *Waverly Lake TMDL Model*
Prepared by: *JMC* *Date:* *5/26/2016*
Checked by: *MEL* *Date:* *6/1/2016*
Title: *Model Input Calculations*

Mass Loadings (initial inputs) *Note - Page 4 contains revised values with Septic P loading included*

It is assumed that the internal sediment loading will be decreased at a 50% rate to the watershed reductions.

In other words, a 50% reduction = 50% reduction in watershed + 25% reduction in internal sediment load.

Scale Factor	Tributary Load (ppb)	Sediment Load (mg/day)	Lake Shore (mg/day)	Internal Load ($mg/m^2/day$)	Total Load (lbs/day)
1 (base)	529	692,191	302,355	2.3	23.6
0.5	265	346,095	151,177	1.2	11.8
0.4	212	276,876	120,942	0.9	9.4
0.3	159	207,657	90,706	0.7	7.1
0.29	153	200,735	87,683	0.7	6.8
0.28	148	193,813	84,659	0.7	6.6
0.27	143	186,892	81,636	0.6	6.4
0.26	138	179,970	78,612	0.6	6.1
0.25	132	173,048	75,589	0.6	5.9
0.24	127	166,126	72,565	0.6	5.7
0.23	122	159,204	69,542	0.5	5.4
0.22	116	152,282	66,518	0.5	5.2
0.21	111	145,360	63,494	0.5	5.0
0.2	106	138,438	60,471	0.5	4.7
0.19	101	131,516	57,447	0.4	4.5
0.18	95	124,594	54,424	0.4	4.2
0.17	90	117,672	51,400	0.4	4.0
0.16	85	110,751	48,377	0.4	3.8
0.15	79	103,829	45,353	0.4	3.5
0.14	74	96,907	42,330	0.3	3.3
0.13	69	89,985	39,306	0.3	3.1
0.12	63	83,063	36,283	0.3	2.8
0.11	58	76,141	33,259	0.3	2.6
0.1	53	69,219	30,235	0.2	2.4
0.09	48	62,297	27,212	0.2	2.1
0.08	42	55,375	24,188	0.2	1.9
0.07	37	48,453	21,165	0.2	1.7
0.06	32	41,531	18,141	0.1	1.4
0.05	26	34,610	15,118	0.1	1.2

Note: Tributary contribution to Total Load revised 6/1/16 as calculations were checked.

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Project Number: 152387 *Sheet No.* 4 *of* 4
Project Name: Waverly Lake TMDL Model
Prepared by: JML *Date:* 1/19/2017
Checked by: MEL *Date:* 1/19/2017
Title: Model Input Calculations

Mass Loadings (Jan-17 revised scenarios - lower Septic P and Franklin Shoreline added)

It is assumed that the internal sediment loading will be decreased at a 50% rate to the watershed reductions.

In other words, a 50% reduction = 50% reduction in watershed + 25% reduction in internal sediment load.

Scale Factor	Tributary Load		Internal Load		Case 1d	Case 1e		Total Load
	(lbs/yr)	(mg/L)	(lbs/yr)	(mg/m^2/day)	(mg/L)	(mg/L)		(lbs/day)
1 (base)	7995	0.541	800.3	2.30	0.137	0.122		24.1
0.50	3998	0.271	600.2	1.73	0.094	0.085		12.6
0.40	3198	0.216	560.2	1.61	0.083	0.075		10.3
0.30	2399	0.162	520.2	1.50	0.072	0.065		8.0
0.29	2319	0.157	516.2	1.48	0.070	0.063		7.8
0.28	2239	0.151	512.2	1.47	0.069	0.062		7.5
0.27	2159	0.146	508.2	1.46	0.068	0.061		7.3
0.26	2079	0.141	504.2	1.45	0.066	0.060		7.1
0.25	1999	0.135	500.2	1.44	0.065	0.059		6.8
0.24	1919	0.130	496.2	1.43	0.064	0.058		6.6
0.23	1839	0.124	492.2	1.41	0.062	0.056		6.4
0.22	1759	0.119	488.2	1.40	0.061	0.055		6.2
0.21	1679	0.114	484.2	1.39	0.059	0.054		5.9
0.20	1599	0.108	480.2	1.38	0.058	0.052		5.7
0.19	1519	0.103	476.2	1.37	0.056	0.051		5.5
0.18	1439	0.097	472.2	1.36	0.055	0.050	Case 3e	5.2
0.17	1359	0.092	468.2	1.35	0.053	0.048		5.0
0.16	1279	0.087	464.2	1.33	0.052	0.047		4.8
0.15	1199	0.081	460.2	1.32	0.050	0.046	Case 3d	4.5
0.14	1119	0.076	456.2	1.31	0.049	0.044		4.3
0.13	1039	0.070	452.2	1.30	0.047	0.043		4.1
0.12	959	0.065	448.2	1.29	0.045	0.041		3.9
0.11	879	0.060	444.2	1.28	0.043	0.040		3.6
0.10	800	0.054	440.2	1.27	0.041	0.038		3.4
0.09	720	0.049	436.2	1.25	0.040	0.036		3.2
0.08	640	0.043	432.2	1.24	0.037	0.034		2.9
0.07	560	0.038	428.2	1.23	0.035	0.033		2.7
0.06	480	0.032	424.2	1.22	0.033	0.030		2.5
0.05	400	0.027	420.2	1.21	0.031	0.029		2.2

🟨 Results prepared by Jared Lebo verified by Martin Lebo - 1/19/17.

Case 1d and 1e include the septic P loading through tributaries updated 1/18/17 and Franklin Shoreline.

Case 1d is the recalibrated version of Case 1 with a sedimentation coefficient of 1.94. (for 2015 mean)

Case 1e is the recalibrated version of Case 1a with a sedimentation coefficient of 2.52. (for 2015 median)

Case 3d and 3e are the final runs for Case 1d and 1e, respectively, that achieve a TP = 0.050 mg/L

Evaluation of Internal P loading for use in Bathtub Model

Lakewide Average and C1 and C2 Concentrations

Date	C1	C2	Average	comment
4/12/1999	0.044	0.045	0.044	
6/4/1999	0.161	0.045	0.154	
7/8/1999	0.068	0.076	0.069	
8/5/1999	0.063	0.052	0.063	
10/21/1999	0.047	0.053	0.047	
6/2/2003	0.085	0.111	0.087	
7/1/2003	0.079	0.209	0.087	
8/4/2003	0.144	0.127	0.143	
10/9/2003	0.093	0.085	0.092	
4/17/2006	0.076		0.076	no depth >10 ft
6/14/2006	0.078		0.078	no depth >10 ft
7/12/2006	0.115		0.115	no depth >10 ft
8/30/2006	0.088		0.088	no depth >10 ft
10/24/2006	0.060		0.060	no depth >10 ft
4/7/2010	0.071	0.068	0.071	
6/15/2010	0.218		0.218	no depth >10 ft
7/13/2010	0.117	0.505	0.142	
9/3/2010	0.127		0.127	no depth >10 ft
10/20/2010	0.110	0.121	0.110	
4/13/2015	0.109	0.127	0.110	
6/1/2015	0.180	0.255	0.184	
7/1/2015	0.171	0.224	0.174	
7/23/2015	0.107	0.342	0.122	
10/21/2015	0.101		0.101	no depth >10 ft

Lake Summary Statistics (Whole Lake Averages)

Median-all	0.097	AVG-all	0.107
Median-2015	0.122	AVG-2015	0.138

Notes on Derived Parameters - Internal P Loading

Average is a volume weighted average where C1 is 93.53% and C2 is 6.47% Volumes were determined from Waverly Reservoir October 2009 report.

C1	0-10 ft	93.53	Percent
C2	> 10 ft	6.47	Percent

Volume 11-14 ft	14.0	MG	6.47%
Area 11-14 ft	80708	m2	19.03%

Derived from Waverly Reservoir October 2009 report

Internal P accumulation in waters >10 ft depth by year

Year	Rate	Unit	Comment
1999	0.027	mg/L/month	Jun 4 to Jul 8 - 1 deep point
2003	0.101	mg/L/month	Jun 2 to Jul 1 - 1 deep point
2010	0.134	mg/L/month	Apr 7 to Jul 13 - 1 deep point
2015	0.055	mg/L/month	Apr 13 to Jul 23 Regression

Use regression for 2015 accumulation rate in deep water to derive an internal load
Note - accumulated load is concentration change rate x volume - adjusted to daily rate.

11-14 ft	96696	mg/day
0-11 ft	205659	mg/day

Lake areas with depth >10 ft
Reasonable assumption is other areas of lake have release rate of 50% of deep areas on average. Area of lake 11-14 ft is 19.03% of total.

Sediment Total	302355	mg-P/day
Lake Area	424111	sq m
Shoreline P Input	692191	mg/day
Total Internal Input (Sediment+Shoreline)	2.35	mg-P/m2/day

Lake Statistics (11-14 ft layer)

868925.9	cubic feet
868925.9	square feet
19.94779	acres
0.190342	fraction 11-14 ft

Appendix C: BMP Table, Public Involvement Documentation & Responsiveness Summary

BMP Type	BMP Number	BMP Code	BMP Type 2	Quantity 1	Unit 1	Quantity 2	Unit 2	Quantity 3	Unit 3	Responsible Party	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)	Total Cost	Cost/lb N Reduced	Cost/lb P Reduced	Cost/ton Sediment Reduced
Fence	59	1	Crossing	2565.00	feet	1	crossing	N/A	N/A	Landowner	37.64	4.26	0.55	$14,000.00	$371.95	$3,289.67	$25,623.66
Fence	60	2	Crossing	4150.00	feet	2	crossing	N/A	N/A	Landowner	56.19	6.68	1.35	$25,000.00	$444.95	$3,742.19	$18,555.34
Field Border	66	4	N/A	740.00	feet	0.5	acres	N/A	N/A	Landowner	4.54	0.68	0.41	$550.00	$121.22	$806.02	$1,346.73
Field Border	67	5	N/A	3195.00	feet	5.8	acres	N/A	N/A	Landowner	67.24	11.49	6.39	$4,460.00	$66.33	$388.21	$697.63
Field Border	69	6	N/A	1345.00	feet	1	acres	N/A	N/A	Landowner	20.54	2.86	1.49	$800.00	$38.96	$279.93	$536.89
Field Border	70	7	N/A	4158.00	feet	5.6	acres	N/A	N/A	Landowner	98.45	18.09	10.81	$4,220.00	$42.86	$233.33	$390.27
Field Border	71	8	N/A	5100.00	feet	10.4	acres	N/A	N/A	Landowner	105.86	27.30	26.23	$7,780.00	$73.49	$285.01	$296.58
Field Border	86	9	N/A	1.14	acres	N/A	N/A	N/A	N/A	Landowner	5.49	0.82	0.50	$898.00	$163.62	$1,088.70	$1,792.09
Field Border	88	10	N/A	2.60	acres	N/A	N/A	N/A	N/A	Landowner	19.49	4.60	3.79	$1,920.00	$98.53	$417.05	$507.25
Field Border	91	12	N/A	750.00	feet	0.54	acres	N/A	N/A	Landowner	20.55	4.66	4.11	$580.00	$28.22	$124.50	$141.23
Field Border	92	13	N/A	630.00	feet	0.35	acres	N/A	N/A	Landowner	9.77	1.83	1.37	$345.00	$35.31	$188.85	$252.73
Field Border	100	14	N/A	5264.00	feet	7.7	acres	N/A	N/A	Landowner	174.79	31.25	21.93	$5,590.00	$31.98	$178.87	$254.92
Field Border	115	15	N/A	6836.00	feet	6	acres	N/A	N/A	Landowner	125.78	32.09	32.93	$4,800.00	$38.16	$149.58	$145.75
Field Border	116	16	N/A	160.00	feet	0.11	acres	N/A	N/A	Landowner	2.19	0.34	0.22	$1,100.00	$501.32	$3,236.98	$4,922.96
Field Border	136	17	N/A	1416.00	feet	0.9	acres	N/A	N/A	Landowner	16.42	4.12	3.88	$830.00	$50.53	$201.28	$213.80
Field Border	137	18	N/A	3676.00	feet	3.9	acres	N/A	N/A	Landowner	83.17	19.70	17.92	$3,030.00	$36.43	$153.83	$169.04
Filter Strip	82	2	N/A	300.00	feet	0.33	acres	N/A	N/A	Landowner	26.83	4.98	3.65	$400.00	$14.91	$80.34	$109.65
Filter Strip	119	3	N/A	1290.00	feet	0.9	acres	N/A	N/A	Landowner	166.30	67.99	84.92	$900.00	$5.41	$13.24	$10.60
Grade Control	13	3	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	2.87	1.30	1.41	$6,100.00	$2,125.51	$4,688.66	$4,317.56
Grade Control	73	8	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	6.96	3.50	8.33	$6,800.00	$976.90	$1,941.77	$816.03
Grade Control	79	10	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	1.20	0.64	0.75	$4,600.00	$3,822.28	$7,192.04	$6,111.65
Grade Control	81	11	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	5.98	2.75	3.08	$4,600.00	$769.84	$1,671.64	$1,491.71
Grade Control	85	23	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	20.63	9.28	10.23	$6,000.00	$290.90	$646.60	$586.49
Grade Control	117	13	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	23.14	14.12	14.12	$9,500.00	$410.46	$672.94	$672.96
Grade Control	121	14	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	11.27	8.03	10.27	$3,600.00	$319.31	$448.58	$350.59
Grade Control	145	15	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	0.89	0.28	0.21	$2,600.00	$2,912.41	$9,428.39	$12,199.59
Grade Control	148	16	Riffle	4.00	Number	N/A	N/A	N/A	N/A	Landowner	15.68	7.63	8.44	$13,800.00	$879.99	$1,809.80	$1,634.59
Grade Control	149	17	Riffle	1.00	Number	N/A	N/A	N/A	N/A	Landowner	3.05	1.41	1.51	$2,800.00	$918.21	$1,988.26	$1,854.59
Grass Conversion	124	1	N/A	0.85	acres	N/A	N/A	N/A	N/A	Landowner	2.88	0.35	0.16	$695.00	$241.64	$1,958.26	$4,423.23
Grass Conversion	125	2	N/A	1.80	acres	N/A	N/A	N/A	N/A	Landowner	3.89	0.52	0.29	$1,360.00	$349.49	$2,604.65	$4,612.98
Grass Conversion	126	3	N/A	11.00	acres	N/A	N/A	N/A	N/A	Landowner	25.16	2.98	1.37	$7,800.00	$309.99	$2,617.17	$5,674.74
Grass Conversion	127	4	N/A	1.27	acres	N/A	N/A	N/A	N/A	Landowner	4.29	0.47	0.15	$989.00	$230.34	$2,104.37	$6,465.78
Grass Conversion	128	5	N/A	0.52	acres	N/A	N/A	N/A	N/A	Landowner	2.10	0.23	0.08	$464.00	$221.18	$1,982.12	$5,740.30
Grass Conversion	129	6	N/A	0.87	acres	N/A	N/A	N/A	N/A	Landowner	3.83	0.43	0.15	$709.00	$185.34	$1,664.42	$4,850.91
Grassed Waterway	50	1	N/A	1941.00	feet	2.7	acres	N/A	N/A	Landowner	359.47	62.91	77.92	$16,015.00	$44.55	$254.56	$205.53
Grassed Waterway	53	2	N/A	2924.00	feet	4	acres	N/A	N/A	Landowner	670.44	162.95	163.34	$29,195.00	$43.55	$179.16	$178.74
Grassed Waterway	55	3	N/A	779.00	feet	0.9	acres	N/A	N/A	Landowner	115.05	28.10	25.53	$5,300.00	$46.07	$188.64	$207.57
Grassed Waterway	58	4	N/A	2123.00	feet	2.5	acres	N/A	N/A	Landowner	116.12	29.82	27.40	$15,000.00	$129.18	$502.95	$547.37
Grassed Waterway	61	5	N/A	2367.00	feet	1.6	acres	N/A	N/A	Landowner	100.04	26.43	23.32	$14,720.00	$147.14	$556.95	$631.33
Grassed Waterway	72	5	With Grade	1123.00	feet	0.8	acres	N/A	N/A	Landowner	50.97	17.60	27.42	$6,860.00	$134.60	$389.83	$250.17
Grassed Waterway	84	6	Maintenance	250.00	feet	0.29	acres	N/A	N/A	Landowner	10.69	1.20	0.82	$1,600.00	$149.68	$1,331.48	$1,954.31
Grassed Waterway	93	7	WASCB	1460.00	feet	2.01	acres	N/A	N/A	Landowner	297.51	87.92	85.84	$7,700.00	$25.88	$87.58	$89.70
Grassed Waterway	94	8	N/A	850.00	feet	1.2	acres	N/A	N/A	Landowner	210.63	32.15	25.46	$7,000.00	$33.23	$217.70	$274.98
Grassed Waterway	99	9	N/A	550.00	feet	0.76	acres	N/A	N/A	Landowner	58.56	16.47	14.58	$5,800.00	$99.05	$352.25	$397.76
Grassed Waterway	106	10	N/A	1000.00	feet	1.4	acres	N/A	N/A	Village of Franklin	24.01	5.70	4.30	$6,550.00	$272.86	$1,148.95	$1,522.73
Grassed Waterway	144	11	Maintenance	0.20	acres	330	feet	N/A	N/A	Landowner	36.44	3.46	1.92	$1,200.00	$32.93	$346.96	$624.45
Pond	23	11	Wetland	1.00	Number	N/A	N/A	N/A	N/A	Landowner	25.15	6.94	6.90	$14,000.00	$556.76	$2,016.05	$2,030.15
Pond	27	4X	Wetland	1.00	Number	0.3	acres	N/A	N/A	Landowner	3.31	1.30	1.36	$17,000.00	$5,129.69	$13,055.98	$12,540.41
Pond	64	22	Upstream WASCB	1.00	Number	N/A	N/A	N/A	N/A	Landowner	524.87	121.05	100.55	$28,800.00	$54.87	$237.93	$286.42
Pond	102	26	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	33.46	7.26	6.81	$29,000.00	$866.61	$3,995.24	$4,259.22
Pond	104	27	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	15.47	6.19	6.64	$23,500.00	$1,518.95	$3,794.79	$3,537.01
Pond	134	28	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	55.93	13.99	13.56	$17,200.00	$307.52	$1,229.27	$1,268.74
Pond	135	29	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	52.27	14.38	14.37	$21,500.00	$411.35	$1,495.62	$1,496.08
Pond	143	29	N/A	1.00	Number	3	Riffles	N/A	N/A	Landowner	62.10	20.03	20.33	$17,800.00	$286.66	$888.50	$875.68
Riffle	14	1	N/A	1.00	Number	85	ft	N/A	N/A	Landowner	39.36	17.71	19.68	$14,000.00	$355.73	$790.52	$711.49
Riffle	140	1	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	81.73	36.39	40.39	$5,000.00	$61.18	$137.40	$123.79
Riffle	147	2	N/A	3.00	Number	N/A	N/A	N/A	N/A	Landowner	203.62	91.62	101.80	$14,000.00	$68.76	$152.81	$137.52
Stone Toe	3	1	N/A	85.00	feet	N/A	N/A	N/A	N/A	Landowner	13.52	6.08	6.76	$7,825.00	$578.82	$1,286.23	$1,157.60

Stone Toe	122	2	N/A	41.00	feet	N/A	N/A	N/A	N/A	Landowner	9.80	4.41	4.90	$7,460.00	$761.38	$1,691.99	$1,522.76
Stone Toe	123	3	N/A	78.00	feet	N/A	N/A	N/A	N/A	Landowner	9.33	4.20	4.66	$5,180.00	$555.38	$1,234.21	$1,110.87
Stone Toe	139	4	N/A	29.24	feet	N/A	N/A	N/A	N/A	Landowner	3.74	1.68	1.87	$2,300.00	$614.97	$1,369.05	$1,229.95
WASCB	12	2	N/A	5.00	Number	750	feet	N/A	N/A	Landowner	0.30	0.11	0.01	$8,800.00	$29,597.64	$79,686.33	$627,809.09
WASCB	54	4	Waterway	15.00	Number	2.4	acres	N/A	N/A	Landowner	302.88	109.01	91.14	$31,860.00	$105.19	$292.26	$349.58
WASCB	56	5	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	2.62	0.79	0.51	$4,300.00	$1,640.78	$5,415.13	$8,368.28
WASCB	57	6	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	5.81	1.92	1.53	$3,800.00	$653.97	$1,982.83	$2,476.18
WASCB	62	7	Maintenance	5.00	Number	N/A	N/A	N/A	N/A	Landowner	22.88	11.27	11.39	$4,250.00	$185.77	$377.11	$373.01
WASCB	63	8	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	31.35	20.37	23.59	$2,024.00	$64.57	$99.35	$85.82
WASCB	65	9	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	9.90	4.97	5.04	$17,200.00	$1,737.03	$3,463.75	$3,409.45
WASCB	68	10	Maintenance	1.00	Number	N/A	N/A	N/A	N/A	Landowner	1.75	0.51	0.29	$850.00	$485.86	$1,651.53	$2,962.20
WASCB	74	11	Maintenance	2.00	Number	N/A	N/A	N/A	N/A	Landowner	5.62	2.32	2.47	$1,700.00	$302.24	$733.49	$688.37
WASCB	75	12	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	7.08	2.34	1.78	$3,160.00	$446.31	$1,349.13	$1,771.06
WASCB	77	13	Maintenance	3.00	Number	N/A	N/A	N/A	N/A	Landowner	30.66	11.66	10.33	$2,450.00	$79.90	$210.14	$237.06
WASCB	78	14	Waterway	10.00	Number	N/A	N/A	N/A	N/A	Landowner	143.80	59.00	50.39	$22,100.00	$153.68	$374.55	$438.59
WASCB	80	15	Grade	4.00	Number	N/A	N/A	N/A	N/A	Landowner	33.60	15.21	15.20	$10,500.00	$312.46	$690.27	$690.92
WASCB	83	16	N/A	3.00	Number	N/A	N/A	N/A	N/A	Landowner	19.27	10.32	10.03	$5,625.00	$291.88	$545.25	$560.87
WASCB	87	17	Maintenance	2.00	Number	N/A	N/A	N/A	N/A	Landowner	4.09	1.37	1.13	$1,700.00	$415.37	$1,240.06	$1,507.89
WASCB	108	29	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	3.83	1.74	1.93	$2,300.00	$600.27	$1,318.34	$1,191.77
WASCB	109	30	Maintenance	4.00	Number	N/A	N/A	N/A	N/A	Landowner	7.88	3.51	3.35	$3,000.00	$380.78	$855.90	$896.02
WASCB	110	31	Maintenance	1.00	Number	N/A	N/A	N/A	N/A	Landowner	1.43	0.52	0.48	$1,000.00	$700.53	$1,928.96	$2,101.32
WASCB	111	32	Maintenance	1.00	Number	N/A	N/A	N/A	N/A	Landowner	6.41	2.23	1.84	$1,000.00	$156.08	$448.67	$543.02
WASCB	112	33	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	7.35	3.15	4.63	$2,300.00	$313.02	$730.81	$496.36
WASCB	113	34	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	12.93	4.55	5.52	$2,300.00	$177.83	$505.06	$416.39
WASCB	114	35	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	5.04	1.97	3.36	$2,300.00	$456.53	$1,168.80	$684.39
WASCB	118	36	Maintenance	8.00	Number	N/A	N/A	N/A	N/A	Landowner	129.69	59.80	63.60	$6,500.00	$50.12	$108.70	$102.20
WASCB	120	37	Maintenance	9.00	Number	N/A	N/A	N/A	N/A	Landowner	85.74	34.81	32.95	$7,250.00	$84.55	$208.26	$220.01
WASCB	133	38	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	38.92	14.21	13.59	$4,100.00	$105.35	$288.58	$301.66
WASCB	138	39	Maintenance	4.00	Number	N/A	N/A	N/A	N/A	Landowner	19.83	9.30	9.52	$3,200.00	$161.38	$344.21	$336.13
WASCB	141	40	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	28.95	11.53	11.19	$2,970.00	$102.58	$257.58	$265.33
WASCB	142	41	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	9.77	7.35	7.34	$5,900.00	$604.09	$802.32	$803.32
Wetland	1	1	Grade	0.40	acres	140	feet	1	grade	Landowner	131.37	46.14	52.52	$1,200.00	$9.13	$26.01	$22.85
Wetland	2	2	N/A	0.80	acres	N/A	N/A	N/A	N/A	Landowner	6.53	0.80	0.35	$8,000.00	$1,224.24	$10,027.48	$22,959.87
Wetland	24	3	N/A	0.30	acres	140	feet	N/A	N/A	Landowner	4.00	1.61	1.70	$7,000.00	$1,750.14	$4,357.56	$4,116.82
Wetland	103	8	N/A	0.25	acres	N/A	N/A	N/A	N/A	Landowner	1.88	0.70	0.70	$10,500.00	$5,573.54	$15,021.52	$14,930.45
Wetland	130	9	N/A	0.15	acres	N/A	N/A	N/A	N/A	Landowner	8.27	2.85	2.95	$8,000.00	$967.29	$2,805.24	$2,712.24
Wetland	146	10	N/A	0.20	acres	N/A	N/A	N/A	N/A	Landowner	19.60	2.65	0.63	$7,800.00	$398.02	$2,947.98	$12,393.94
Wetland	159	12	Maintenance	1.00	Number	0.2	acres	N/A	N/A	City of Waverly	8.38	1.55	0.93	$8,000.00	$954.77	$5,167.03	$8,569.13
Cover Crop	131	N/A	N/A	62.90	acres	N/A	N/A	N/A	N/A	Landowner	98.23	15.06	12.33	8805.34662	$89.64	$584.72	$714.29
Cover Crop	148	N/A	N/A	10.31	acres	N/A	N/A	N/A	N/A	Landowner	14.46	1.58	0.68	1443.30886	$99.84	$913.73	$2,117.29
Field Border	90	11	N/A	2179.00	feet	2.6	acres	N/A	N/A	City of Waverly	25.17	2.95	0.98	$1,920.00	$76.30	$650.93	$1,952.34
Grade Control	33	5	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	3.07	1.38	1.50	$6,000.00	$1,956.05	$4,345.05	$3,993.61
Grade Control	35	6	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	3.06	1.38	1.52	$5,000.00	$1,632.09	$3,611.72	$3,286.47
In-Lake/Low Flow Dam	18	1	N/A	380.00	Number	350	feet	N/A	N/A	City of Waverly	3,202.69	1,469.03	1,578.91	$1,112,500.00	$347.36	$757.30	$704.60
In-Lake/Low Flow Dam	26	2	N/A	230.00	feet	N/A	N/A	N/A	N/A	City of Waverly	545.19	274.07	267.74	$937,500.00	$1,719.60	$3,420.61	$3,501.54
In-Lake/Low Flow Dam	34	3	Wetland	250.00	feet	2	acres	N/A	N/A	City of Waverly	179.62	41.45	35.82	$937,500.00	$5,219.31	$22,615.49	$26,169.40
In-Lake/Low Flow Dam	39	4	Wetland	400.00	feet	1.2	acres	N/A	N/A	City of Waverly	56.25	15.40	15.43	$1,200,000.00	$21,334.00	$77,917.05	$77,766.90
In-Lake/Low Flow Dam	40	5	Wetland	350.00	feet	1	acres	N/A	N/A	City of Waverly	107.49	22.54	20.40	$1,112,500.00	$10,349.91	$49,352.99	$54,531.39
In-Lake/Low Flow Dam	41	6	Wetland	350.00	feet	1.4	acres	N/A	N/A	City of Waverly	615.89	161.08	158.11	$1,112,500.00	$1,806.32	$6,906.64	$7,036.09
Maintenance	20	1	Diversion; Road to basin	50.00	feet	N/A	N/A	N/A	N/A	City of Waverly	0.81	0.36	0.39	$2,000.00	$2,473.91	$5,583.39	$5,064.36
Pond	21	9	With Grade	1.00	Number	2	Grade	N/A	N/A	City of Waverly	55.05	20.28	21.02	$40,000.00	$726.62	$1,972.27	$1,903.14
Pond	22	10	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	70.14	24.63	26.02	$32,000.00	$456.24	$1,299.05	$1,229.78
Pond	29	12	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	43.31	15.14	15.50	$30,000.00	$692.76	$1,981.16	$1,934.94
Pond	30	13	With Grade	1.00	Number	1	Grade	N/A	N/A	City of Waverly	8.54	3.50	3.72	$38,000.00	$4,447.42	$10,868.77	$10,210.02
Pond	31	14	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	2.32	0.92	0.95	$30,000.00	$12,920.55	$32,756.56	$31,471.15
Pond	32	15	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	1.49	0.50	0.48	$30,000.00	$20,085.93	$59,871.16	$62,331.32
Pond	36	16	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	2.12	0.64	0.59	$30,000.00	$14,176.68	$46,728.39	$50,833.16
Pond	37	17	N/A	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	5.76	2.17	2.25	$30,000.00	$5,209.39	$13,797.46	$13,319.29
Pond	157	31	Maintenance	1.00	Number	N/A	N/A	N/A	N/A	City of Waverly	3.14	1.15	1.21	$15,000.00	$4,770.90	$13,077.17	$12,366.68
Wetland	46	6	N/A	140.00	feet	0.3	acres	N/A	N/A	City of Waverly	53.75	17.90	19.21	$18,700.00	$347.89	$1,044.90	$973.69

Shoreline Stabilization	1	N/A	N/A	42.08	feet	N/A	N/A	N/A	N/A	City of Waverly	13.46	6.06	6.73	$3,576.57	$265.62	$590.28	$531.25
Shoreline Stabilization	2	N/A	N/A	42.47	feet	N/A	N/A	N/A	N/A	City of Waverly	5.44	2.45	2.72	$3,610.36	$664.06	$1,475.69	$1,328.13
Shoreline Stabilization	3	N/A	N/A	239.08	feet	N/A	N/A	N/A	N/A	City of Waverly	22.95	10.33	11.48	$20,321.77	$885.42	$1,967.59	$1,770.83
Shoreline Stabilization	4	N/A	N/A	61.77	feet	N/A	N/A	N/A	N/A	City of Waverly	23.72	10.67	11.86	$5,250.78	$221.35	$491.90	$442.71
Shoreline Stabilization	5	N/A	N/A	227.93	feet	N/A	N/A	N/A	N/A	City of Waverly	1.82	0.82	0.91	$19,373.98	$10,625.00	$23,611.11	$21,250.00
Shoreline Stabilization	6	N/A	N/A	55.84	feet	N/A	N/A	N/A	N/A	City of Waverly	7.15	3.22	3.57	$4,746.73	$664.06	$1,475.69	$1,328.12
Shoreline Stabilization	7	N/A	N/A	77.88	feet	N/A	N/A	N/A	N/A	City of Waverly	9.97	4.49	4.98	$6,619.88	$664.06	$1,475.69	$1,328.12
Shoreline Stabilization	8	N/A	N/A	50.61	feet	N/A	N/A	N/A	N/A	City of Waverly	6.48	2.92	3.24	$4,301.92	$664.06	$1,475.69	$1,328.13
Shoreline Stabilization	9	N/A	N/A	266.82	feet	N/A	N/A	N/A	N/A	City of Waverly	34.15	15.37	17.08	$22,679.49	$664.06	$1,475.69	$1,328.13
Shoreline Stabilization	10	N/A	N/A	149.38	feet	N/A	N/A	N/A	N/A	City of Waverly	38.24	17.21	19.12	$12,697.51	$332.03	$737.85	$664.06
Shoreline Stabilization	11	N/A	N/A	107.18	feet	N/A	N/A	N/A	N/A	City of Waverly	1.71	0.77	0.86	$9,110.53	$5,312.50	$11,805.55	$10,625.00
Shoreline Stabilization	12	N/A	N/A	121.44	feet	N/A	N/A	N/A	N/A	City of Waverly	77.72	34.98	38.86	$10,322.49	$132.81	$295.14	$265.62
Shoreline Stabilization	13	N/A	N/A	73.64	feet	N/A	N/A	N/A	N/A	City of Waverly	9.43	4.24	4.71	$6,259.12	$664.06	$1,475.69	$1,328.13
Shoreline Stabilization	14	N/A	N/A	184.89	feet	N/A	N/A	N/A	N/A	City of Waverly	1.48	0.67	0.74	$15,715.96	$10,625.00	$23,611.11	$21,250.01
Shoreline Stabilization	15	N/A	N/A	59.70	feet	N/A	N/A	N/A	N/A	City of Waverly	19.10	8.60	9.55	$5,074.44	$265.62	$590.28	$531.25
Shoreline Stabilization	16	N/A	N/A	165.54	feet	N/A	N/A	N/A	N/A	City of Waverly	26.49	11.92	13.24	$14,070.70	$531.25	$1,180.56	$1,062.50
Shoreline Stabilization	17	N/A	N/A	74.27	feet	N/A	N/A	N/A	N/A	City of Waverly	2.38	1.07	1.19	$6,312.53	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	18	N/A	N/A	132.66	feet	N/A	N/A	N/A	N/A	City of Waverly	2.12	0.96	1.06	$11,276.10	$5,312.50	$11,805.56	$10,625.00
Shoreline Stabilization	19	N/A	N/A	311.50	feet	N/A	N/A	N/A	N/A	City of Waverly	2.49	1.12	1.25	$26,477.39	$10,625.00	$23,611.12	$21,250.00
Shoreline Stabilization	20	N/A	N/A	45.04	feet	N/A	N/A	N/A	N/A	City of Waverly	4.32	1.95	2.16	$3,828.10	$885.42	$1,967.59	$1,770.83
Shoreline Stabilization	21	N/A	N/A	103.65	feet	N/A	N/A	N/A	N/A	City of Waverly	16.58	7.46	8.29	$8,810.50	$531.25	$1,180.56	$1,062.50
Shoreline Stabilization	22	N/A	N/A	134.70	feet	N/A	N/A	N/A	N/A	City of Waverly	2.16	0.97	1.08	$11,449.59	$5,312.50	$11,805.56	$10,625.00
Shoreline Stabilization	23	N/A	N/A	61.53	feet	N/A	N/A	N/A	N/A	City of Waverly	5.91	2.66	2.95	$5,229.66	$885.42	$1,967.59	$1,770.83
Shoreline Stabilization	24	N/A	N/A	46.93	feet	N/A	N/A	N/A	N/A	City of Waverly	0.38	0.17	0.19	$3,989.09	$10,625.00	$23,611.08	$21,250.00
Shoreline Stabilization	25	N/A	N/A	159.37	feet	N/A	N/A	N/A	N/A	City of Waverly	15.30	6.88	7.65	$13,546.37	$885.42	$1,967.59	$1,770.83
Shoreline Stabilization	26	N/A	N/A	140.14	feet	N/A	N/A	N/A	N/A	City of Waverly	53.81	24.22	26.91	$11,911.64	$221.35	$491.90	$442.71
Shoreline Stabilization	27	N/A	N/A	112.40	feet	N/A	N/A	N/A	N/A	City of Waverly	107.91	48.56	53.95	$9,554.34	$88.54	$196.76	$177.08
Shoreline Stabilization	28	N/A	N/A	56.87	feet	N/A	N/A	N/A	N/A	City of Waverly	18.20	8.19	9.10	$4,833.98	$265.63	$590.28	$531.25
Shoreline Stabilization	29	N/A	N/A	170.61	feet	N/A	N/A	N/A	N/A	City of Waverly	65.52	29.48	32.76	$14,502.27	$221.35	$491.90	$442.71
Shoreline Stabilization	30	N/A	N/A	188.04	feet	N/A	N/A	N/A	N/A	City of Waverly	3.01	1.35	1.50	$15,983.61	$5,312.50	$11,805.56	$10,625.00
Shoreline Stabilization	31	N/A	N/A	86.41	feet	N/A	N/A	N/A	N/A	City of Waverly	2.07	0.93	1.04	$7,345.11	$3,541.67	$7,870.37	$7,083.33
Shoreline Stabilization	32	N/A	N/A	81.25	feet	N/A	N/A	N/A	N/A	City of Waverly	2.60	1.17	1.30	$6,906.32	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	33	N/A	N/A	136.02	feet	N/A	N/A	N/A	N/A	City of Waverly	3.26	1.47	1.63	$11,561.28	$3,541.67	$7,870.37	$7,083.33
Shoreline Stabilization	34	N/A	N/A	139.51	feet	N/A	N/A	N/A	N/A	City of Waverly	4.46	2.01	2.23	$11,858.19	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	35	N/A	N/A	208.36	feet	N/A	N/A	N/A	N/A	City of Waverly	3.33	1.50	1.67	$17,710.90	$5,312.50	$11,805.56	$10,625.00
Shoreline Stabilization	36	N/A	N/A	51.79	feet	N/A	N/A	N/A	N/A	City of Waverly	1.24	0.56	0.62	$4,402.28	$3,541.67	$7,870.37	$7,083.33
Shoreline Stabilization	37	N/A	N/A	80.92	feet	N/A	N/A	N/A	N/A	City of Waverly	1.29	0.58	0.65	$6,877.83	$5,312.50	$11,805.57	$10,625.00
Shoreline Stabilization	38	N/A	N/A	82.77	feet	N/A	N/A	N/A	N/A	City of Waverly	1.32	0.60	0.66	$7,035.34	$5,312.50	$11,805.56	$10,625.00
Shoreline Stabilization	39	N/A	N/A	131.36	feet	N/A	N/A	N/A	N/A	City of Waverly	4.20	1.89	2.10	$11,165.86	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	40	N/A	N/A	74.87	feet	N/A	N/A	N/A	N/A	City of Waverly	2.40	1.08	1.20	$6,364.09	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	41	N/A	N/A	216.15	feet	N/A	N/A	N/A	N/A	City of Waverly	6.92	3.11	3.46	$18,372.48	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	42	N/A	N/A	137.57	feet	N/A	N/A	N/A	N/A	City of Waverly	4.40	1.98	2.20	$11,693.69	$2,656.25	$5,902.78	$5,312.50
Shoreline Stabilization	43	N/A	N/A	68.48	feet	N/A	N/A	N/A	N/A	City of Waverly	1.64	0.74	0.82	$5,821.10	$3,541.67	$7,870.38	$7,083.33
Shoreline Stabilization	44	N/A	N/A	250.65	feet	N/A	N/A	N/A	N/A	City of Waverly	96.25	43.31	48.12	$21,305.28	$221.35	$491.90	$442.71
Shoreline Stabilization	45	N/A	N/A	79.82	feet	N/A	N/A	N/A	N/A	City of Waverly	1.92	0.86	0.96	$6,784.61	$3,541.67	$7,870.37	$7,083.33
Shoreline Stabilization	46	N/A	N/A	119.41	feet	N/A	N/A	N/A	N/A	City of Waverly	2.87	1.29	1.43	$10,149.71	$3,541.67	$7,870.37	$7,083.34
Shoreline Stabilization	47	N/A	N/A	133.27	feet	N/A	N/A	N/A	N/A	City of Waverly	102.35	46.06	51.17	$11,327.71	$110.68	$245.95	$221.35
Shoreline Stabilization	48	N/A	N/A	81.23	feet	N/A	N/A	N/A	N/A	City of Waverly	23.39	10.53	11.70	$6,904.39	$295.14	$655.86	$590.28
Shoreline Stabilization	49	N/A	N/A	54.49	feet	N/A	N/A	N/A	N/A	City of Waverly	1.74	0.78	0.87	$4,631.65	$2,656.25	$5,902.77	$5,312.50
Shoreline Stabilization	50	N/A	N/A	150.29	feet	N/A	N/A	N/A	N/A	City of Waverly	144.28	64.93	72.14	$12,774.68	$88.54	$196.76	$177.08
Shoreline Stabilization	51	N/A	N/A	80.32	feet	N/A	N/A	N/A	N/A	City of Waverly	3.21	1.45	1.61	$6,827.62	$2,125.00	$4,722.22	$4,250.00
Shoreline Stabilization	52	N/A	N/A	129.22	feet	N/A	N/A	N/A	N/A	City of Waverly	20.68	9.30	10.34	$10,983.79	$531.25	$1,180.56	$1,062.50
WASCB	105	27	N/A	6.00	Number	N/A	N/A	N/A	N/A	Landowner	44.90	24.26	24.85	$15,000.00	$334.05	$618.38	$603.58
Wetland	150	11	N/A	0.20	acres	1	Number	N/A	N/A	Franklin Outing Club	11.44	2.57	3.43	$10,000.00	$873.86	$3,891.77	$2,918.33
Shoreline Stabilization	43	N/A	N/A	180.00	feet	N/A	N/A	N/A	N/A	Franklin Outing Club	20.78	6.50	12.90	$15,300.00	$736.28	$2,355.66	$1,186.05
Cover Crop	133	N/A	N/A	17.04	acres	N/A	N/A	N/A	N/A	Village of Franklin	37.64	8.26	9.27	2385.74224	$63.39	$288.72	$257.34
WASCB	107	28	N/A	1.00	Number	N/A	N/A	N/A	N/A	Village of Franklin	5.15	2.22	2.07	$3,500.00	$679.39	$1,576.14	$1,690.09
Feed Area System	152	1	Wetland	1.00	Number	N/A	N/A	N/A	N/A	Landowner	18.65	4.09	0.29	$28,000.00	$1,501.60	$6,850.29	$97,381.14
Field Border	49	1	N/A	1260.00	feet	1	acres	N/A	N/A	Landowner	142.36	27.73	18.65	$800.00	$5.62	$28.84	$42.91
Field Border	51	2	N/A	1000.00	feet	0.76	acres	N/A	N/A	Landowner	157.80	27.57	21.00	$632.00	$4.01	$22.92	$30.09

Field Border	52	3	N/A	3512.00	feet	2.6	acres	N/A	N/A	Landowner	289.02	59.83	41.95	$1,920.00	$6.64	$32.09	$45.76
Field Border	151	19	N/A	1890.00	feet	2.6	acres	N/A	N/A	Landowner	147.15	25.08	16.85	$1,920.00	$13.05	$76.56	$113.92
Field Border	153	20	N/A	2650.00	feet	3.6	acres	N/A	N/A	Landowner	127.66	22.15	15.10	$2,620.00	$20.52	$118.31	$173.47
Field Border	155	21	N/A	875.00	feet	1.2	acres	N/A	N/A	Landowner	68.86	14.51	12.10	$940.00	$13.65	$64.79	$77.66
Field Border	160	22	N/A	505.00	feet	0.7	acres	N/A	N/A	Landowner	47.14	10.14	8.59	$590.00	$12.52	$58.20	$68.70
Filter Strip	48	1	Native Grasses	80.00	feet	0.05	acres	N/A	N/A	Landowner	0.81	0.10	0.02	$135.00	$167.62	$1,324.06	$7,956.62
Grade Control	4	1	Pond	4.00	Number	1	pond	N/A	N/A	Landowner	24.63	10.09	11.89	$17,200.00	$698.31	$1,705.20	$1,446.46
Grade Control	7	2	N/A	4.00	Number	N/A	N/A	N/A	N/A	Landowner	29.52	12.73	13.80	$18,000.00	$609.71	$1,414.44	$1,304.71
Grade Control	25	4	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	2.87	1.33	1.45	$7,000.00	$2,441.06	$5,271.10	$4,839.55
Grade Control	45	7	N/A	3.00	Number	N/A	N/A	N/A	N/A	Landowner	2.52	1.19	1.24	$12,000.00	$4,754.01	$10,086.03	$9,691.84
Grade Control	76	9	N/A	2.00	Number	N/A	N/A	N/A	N/A	Landowner	11.23	5.35	5.83	$12,000.00	$1,068.42	$2,243.62	$2,058.13
Grade Control	101	12	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	16.48	9.77	9.18	$6,000.00	$364.11	$614.36	$653.48
Grade Control	162	18	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	5.70	2.33	2.49	$6,000.00	$1,053.41	$2,579.35	$2,411.91
Pond	5	1	Pond	1.00	Number	N/A	N/A	N/A	N/A	Landowner	109.34	29.17	27.97	$28,000.00	$256.09	$959.83	$1,001.03
Pond	6	2	Pond	1.00	Number	N/A	N/A	N/A	N/A	Landowner	9.25	3.50	3.71	$28,000.00	$3,027.89	$8,005.64	$7,540.56
Pond	8	3	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	24.88	9.57	10.38	$28,000.00	$1,125.35	$2,925.35	$2,698.14
Pond	9	4	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	15.56	3.55	2.69	$28,000.00	$1,799.85	$7,883.85	$10,426.50
Pond	11	5	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	16.86	5.77	6.11	$28,000.00	$1,660.67	$4,854.97	$4,582.94
Pond	15	6	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	59.55	10.34	5.59	$28,000.00	$470.20	$2,707.20	$5,011.48
Pond	16	7	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	14.74	4.91	4.85	$28,000.00	$1,899.35	$5,705.43	$5,775.38
Pond	19	8	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	30.96	13.70	15.11	$28,000.00	$904.36	$2,044.41	$1,853.54
Pond	38	18	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	17.64	4.97	4.73	$25,000.00	$1,417.05	$5,033.06	$5,288.27
Pond	42	19	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	19.15	4.90	4.31	$25,000.00	$1,305.43	$5,097.10	$5,802.09
Pond	43	20	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	22.85	6.96	6.66	$25,000.00	$1,094.29	$3,594.46	$3,751.60
Pond	44	21	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	9.96	2.62	2.19	$25,000.00	$2,510.78	$9,558.52	$11,415.30
Pond	89	24	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	29.99	7.83	6.77	$25,000.00	$833.49	$3,192.01	$3,691.91
Pond	97	25	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	31.73	8.56	8.70	$25,000.00	$787.87	$2,919.90	$2,874.49
Pond	154	30	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	143.75	34.71	31.02	$25,000.00	$173.92	$720.32	$806.05
Pond	158	32	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	25.28	6.79	6.70	$28,000.00	$1,107.64	$4,123.90	$4,181.52
Pond	161	33	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	82.26	23.20	23.10	$25,000.00	$303.91	$1,077.70	$1,082.14
WASCB	10	1	Grade	1.00	Number	70	feet	N/A	N/A	Landowner	4.96	2.22	2.44	$6,000.00	$1,210.53	$2,703.54	$2,456.38
WASCB	17	3	Terrace	1.00	Number	280	feet	N/A	N/A	Landowner	6.65	3.56	3.88	$2,500.00	$376.04	$702.11	$645.12
WASCB	98	26	Maintenance	4.00	Number	N/A	N/A	N/A	N/A	Landowner	29.25	8.69	5.98	$2,000.00	$68.38	$230.17	$334.54
WASCB	156	42	N/A	1.00	Number	N/A	N/A	N/A	N/A	Landowner	10.77	4.86	5.17	$3,800.00	$352.96	$782.58	$734.62
Wetland	28	5	Grade	0.20	acres	110	feet	1	grade	Landowner	8.05	2.19	2.11	$17,000.00	$2,111.82	$7,770.58	$8,049.08
Wetland	47	7	N/A	0.05	acres	N/A	N/A	N/A	N/A	Landowner	4.00	0.76	0.80	$6,000.00	$1,498.87	$7,905.21	$7,484.18
No-Till/Strip-Till	1	N/A	N/A	56.48	acres	N/A	N/A	N/A	N/A	Landowner	147.24	31.62	34.98	$4,518.26	$30.69	$142.88	$129.16
No-Till/Strip-Till	2	N/A	N/A	0.25	acres	N/A	N/A	N/A	N/A	Landowner	0.47	0.07	0.06	$19.66	$42.00	$262.23	$304.39
No-Till/Strip-Till	3	N/A	N/A	21.35	acres	N/A	N/A	N/A	N/A	Landowner	15.13	2.18	3.71	$1,707.69	$112.86	$783.69	$459.93
No-Till/Strip-Till	4	N/A	N/A	49.18	acres	N/A	N/A	N/A	N/A	Landowner	78.81	11.97	9.69	$3,934.30	$49.92	$328.60	$405.99
No-Till/Strip-Till	5	N/A	N/A	31.03	acres	N/A	N/A	N/A	N/A	Landowner	66.11	10.28	8.56	$2,482.79	$37.55	$241.57	$290.18
No-Till/Strip-Till	6	N/A	N/A	27.95	acres	N/A	N/A	N/A	N/A	Landowner	26.53	7.00	16.39	$2,236.35	$84.28	$319.46	$136.41
No-Till/Strip-Till	7	N/A	N/A	253.79	acres	N/A	N/A	N/A	N/A	Landowner	349.63	52.48	41.84	$20,302.98	$58.07	$386.84	$485.26
No-Till/Strip-Till	8	N/A	N/A	34.80	acres	N/A	N/A	N/A	N/A	Landowner	75.02	15.76	17.19	$2,784.39	$37.11	$176.62	$161.97
No-Till/Strip-Till	9	N/A	N/A	104.33	acres	N/A	N/A	N/A	N/A	Landowner	215.18	36.76	33.87	$8,346.59	$38.79	$227.08	$246.40
No-Till/Strip-Till	10	N/A	N/A	38.99	acres	N/A	N/A	N/A	N/A	Landowner	78.53	18.02	20.77	$3,118.85	$39.71	$173.04	$150.15
No-Till/Strip-Till	11	N/A	N/A	90.59	acres	N/A	N/A	N/A	N/A	Landowner	129.21	20.68	17.81	$7,246.93	$56.09	$350.38	$406.92
No-Till/Strip-Till	12	N/A	N/A	64.28	acres	N/A	N/A	N/A	N/A	Landowner	136.42	20.74	16.80	$5,142.70	$37.70	$248.00	$306.17
No-Till/Strip-Till	13	N/A	N/A	9.86	acres	N/A	N/A	N/A	N/A	Landowner	11.56	2.52	2.88	$789.04	$68.27	$313.53	$274.12
No-Till/Strip-Till	14	N/A	N/A	6.73	acres	N/A	N/A	N/A	N/A	Landowner	18.70	3.72	3.90	$538.40	$28.79	$144.90	$138.22
No-Till/Strip-Till	15	N/A	N/A	18.64	acres	N/A	N/A	N/A	N/A	Landowner	43.54	6.46	5.08	$1,491.05	$34.25	$230.72	$293.68
No-Till/Strip-Till	16	N/A	N/A	10.99	acres	N/A	N/A	N/A	N/A	Landowner	29.98	5.76	5.88	$879.04	$29.32	$152.72	$149.55
No-Till/Strip-Till	17	N/A	N/A	43.81	acres	N/A	N/A	N/A	N/A	Landowner	163.20	41.38	50.33	$3,504.48	$21.47	$84.68	$69.63
No-Till/Strip-Till	18	N/A	N/A	8.27	acres	N/A	N/A	N/A	N/A	Landowner	22.62	3.31	2.55	$661.97	$29.27	$200.04	$259.64
No-Till/Strip-Till	19	N/A	N/A	24.15	acres	N/A	N/A	N/A	N/A	Landowner	30.22	5.12	4.91	$1,931.96	$63.94	$377.04	$393.62
No-Till/Strip-Till	20	N/A	N/A	7.44	acres	N/A	N/A	N/A	N/A	Landowner	6.27	1.15	2.40	$595.00	$94.83	$518.81	$247.46
No-Till/Strip-Till	21	N/A	N/A	10.37	acres	N/A	N/A	N/A	N/A	Landowner	17.41	3.07	2.91	$829.32	$47.63	$270.49	$285.11
No-Till/Strip-Till	22	N/A	N/A	21.03	acres	N/A	N/A	N/A	N/A	Landowner	44.12	6.14	4.41	$1,682.74	$38.14	$273.86	$381.80
No-Till/Strip-Till	23	N/A	N/A	33.78	acres	N/A	N/A	N/A	N/A	Landowner	78.72	15.46	16.07	$2,702.44	$34.33	$174.79	$168.19
No-Till/Strip-Till	24	N/A	N/A	5.92	acres	N/A	N/A	N/A	N/A	Landowner	10.87	1.99	1.96	$473.67	$43.59	$237.64	$241.57

No-Till/Strip-Till	25	N/A	N/A	1.74	acres	N/A	N/A	N/A	N/A	Landowner	3.52	0.76	0.84	$139.52	$39.66	$184.07	$166.02
No-Till/Strip-Till	26	N/A	N/A	8.45	acres	N/A	N/A	N/A	N/A	Landowner	6.06	1.06	2.16	$675.78	$111.57	$636.38	$312.79
No-Till/Strip-Till	27	N/A	N/A	9.64	acres	N/A	N/A	N/A	N/A	Landowner	26.92	5.46	5.80	$771.55	$28.66	$141.39	$132.93
No-Till/Strip-Till	28	N/A	N/A	25.73	acres	N/A	N/A	N/A	N/A	Landowner	55.96	8.01	5.99	$2,058.53	$36.79	$257.00	$343.94
No-Till/Strip-Till	29	N/A	N/A	5.05	acres	N/A	N/A	N/A	N/A	Landowner	11.15	2.28	2.45	$403.74	$36.22	$176.71	$164.85
No-Till/Strip-Till	30	N/A	N/A	52.05	acres	N/A	N/A	N/A	N/A	Landowner	83.79	12.69	10.23	$4,164.18	$49.70	$328.20	$407.16
No-Till/Strip-Till	31	N/A	N/A	27.57	acres	N/A	N/A	N/A	N/A	Landowner	41.02	6.11	4.83	$2,205.88	$53.78	$360.78	$456.75
No-Till/Strip-Till	32	N/A	N/A	40.01	acres	N/A	N/A	N/A	N/A	Landowner	96.68	15.29	12.99	$3,200.52	$33.10	$209.28	$246.33
No-Till/Strip-Till	33	N/A	N/A	21.65	acres	N/A	N/A	N/A	N/A	Landowner	51.17	9.05	8.62	$1,732.18	$33.85	$191.38	$200.89
No-Till/Strip-Till	34	N/A	N/A	123.22	acres	N/A	N/A	N/A	N/A	Landowner	206.68	35.34	32.61	$9,857.38	$47.69	$278.92	$302.32
No-Till/Strip-Till	35	N/A	N/A	58.09	acres	N/A	N/A	N/A	N/A	Landowner	100.45	16.69	14.97	$4,647.22	$46.26	$278.36	$310.49
No-Till/Strip-Till	36	N/A	N/A	13.79	acres	N/A	N/A	N/A	N/A	Landowner	21.78	3.47	2.97	$1,103.51	$50.66	$317.89	$371.02
No-Till/Strip-Till	37	N/A	N/A	75.50	acres	N/A	N/A	N/A	N/A	Landowner	126.78	25.51	26.99	$6,040.14	$47.64	$236.79	$223.82
No-Till/Strip-Till	38	N/A	N/A	27.17	acres	N/A	N/A	N/A	N/A	Landowner	49.95	11.28	12.87	$2,173.81	$43.52	$192.75	$168.88
No-Till/Strip-Till	39	N/A	N/A	43.27	acres	N/A	N/A	N/A	N/A	Landowner	66.23	10.48	8.91	$3,461.36	$52.26	$330.25	$388.54
No-Till/Strip-Till	40	N/A	N/A	23.28	acres	N/A	N/A	N/A	N/A	Landowner	37.28	5.95	5.11	$1,862.79	$49.97	$313.04	$364.66
No-Till/Strip-Till	41	N/A	N/A	2.23	acres	N/A	N/A	N/A	N/A	Landowner	3.80	0.61	0.52	$178.03	$46.89	$293.43	$341.46
No-Till/Strip-Till	42	N/A	N/A	10.12	acres	N/A	N/A	N/A	N/A	Landowner	16.18	2.46	2.00	$809.76	$50.05	$328.68	$404.87
No-Till/Strip-Till	43	N/A	N/A	2.50	acres	N/A	N/A	N/A	N/A	Landowner	5.00	0.89	0.86	$199.88	$39.94	$223.52	$232.50
No-Till/Strip-Till	44	N/A	N/A	7.15	acres	N/A	N/A	N/A	N/A	Landowner	19.49	3.80	3.93	$571.66	$29.32	$150.25	$145.28
No-Till/Strip-Till	45	N/A	N/A	8.67	acres	N/A	N/A	N/A	N/A	Landowner	24.77	4.96	5.24	$693.24	$27.99	$139.67	$132.41
No-Till/Strip-Till	46	N/A	N/A	3.59	acres	N/A	N/A	N/A	N/A	Landowner	7.44	1.03	0.73	$287.15	$38.61	$279.41	$394.42
No-Till/Strip-Till	47	N/A	N/A	3.30	acres	N/A	N/A	N/A	N/A	Landowner	9.02	2.41	3.01	$263.74	$29.24	$109.30	$87.58
No-Till/Strip-Till	48	N/A	N/A	0.60	acres	N/A	N/A	N/A	N/A	Landowner	1.27	0.22	0.21	$48.11	$37.83	$217.29	$231.47
No-Till/Strip-Till	49	N/A	N/A	14.11	acres	N/A	N/A	N/A	N/A	Landowner	33.10	5.68	5.26	$1,129.14	$34.11	$198.73	$214.60
No-Till/Strip-Till	50	N/A	N/A	25.44	acres	N/A	N/A	N/A	N/A	Landowner	61.81	12.44	13.16	$2,035.07	$32.92	$163.60	$154.63
No-Till/Strip-Till	51	N/A	N/A	10.13	acres	N/A	N/A	N/A	N/A	Landowner	22.63	4.96	5.55	$810.41	$35.80	$163.55	$146.04
No-Till/Strip-Till	52	N/A	N/A	3.06	acres	N/A	N/A	N/A	N/A	Landowner	5.30	1.07	1.13	$245.00	$46.22	$229.98	$217.58
No-Till/Strip-Till	53	N/A	N/A	38.16	acres	N/A	N/A	N/A	N/A	Landowner	62.55	9.35	7.42	$3,052.59	$48.80	$326.32	$411.31
No-Till/Strip-Till	54	N/A	N/A	33.10	acres	N/A	N/A	N/A	N/A	Landowner	71.59	11.75	10.40	$2,647.91	$36.99	$225.27	$254.50
No-Till/Strip-Till	55	N/A	N/A	28.40	acres	N/A	N/A	N/A	N/A	Landowner	56.04	8.96	7.71	$2,271.67	$40.53	$253.52	$294.82
No-Till/Strip-Till	56	N/A	N/A	25.61	acres	N/A	N/A	N/A	N/A	Landowner	57.18	9.26	8.08	$2,049.00	$35.84	$221.27	$253.66
No-Till/Strip-Till	57	N/A	N/A	35.24	acres	N/A	N/A	N/A	N/A	Landowner	71.10	10.48	8.16	$2,819.55	$39.65	$269.00	$345.61
No-Till/Strip-Till	58	N/A	N/A	34.10	acres	N/A	N/A	N/A	N/A	Landowner	67.93	11.41	10.34	$2,728.38	$40.17	$239.15	$263.88
No-Till/Strip-Till	59	N/A	N/A	18.22	acres	N/A	N/A	N/A	N/A	Landowner	44.32	8.29	8.30	$1,458.00	$32.90	$175.77	$175.69
No-Till/Strip-Till	60	N/A	N/A	0.16	acres	N/A	N/A	N/A	N/A	Landowner	0.68	0.22	0.29	$13.09	$19.27	$60.84	$45.50
No-Till/Strip-Till	61	N/A	N/A	5.57	acres	N/A	N/A	N/A	N/A	Landowner	67.79	25.77	36.55	$445.60	$6.57	$17.29	$12.19
No-Till/Strip-Till	62	N/A	N/A	2.36	acres	N/A	N/A	N/A	N/A	Landowner	7.53	2.00	2.48	$188.83	$25.08	$94.63	$76.17
No-Till/Strip-Till	63	N/A	N/A	3.04	acres	N/A	N/A	N/A	N/A	Landowner	17.83	5.43	7.15	$243.55	$13.66	$44.86	$34.04
No-Till/Strip-Till	64	N/A	N/A	39.57	acres	N/A	N/A	N/A	N/A	Landowner	74.77	12.02	10.39	$3,165.68	$42.34	$263.43	$304.57
No-Till/Strip-Till	65	N/A	N/A	91.55	acres	N/A	N/A	N/A	N/A	Landowner	153.99	23.22	18.62	$7,323.65	$47.56	$315.36	$393.23
No-Till/Strip-Till	66	N/A	N/A	18.08	acres	N/A	N/A	N/A	N/A	Landowner	47.05	11.20	13.17	$1,446.61	$30.75	$129.21	$109.85
No-Till/Strip-Till	67	N/A	N/A	133.20	acres	N/A	N/A	N/A	N/A	Landowner	210.31	33.32	28.36	$10,655.75	$50.67	$319.77	$375.68
No-Till/Strip-Till	68	N/A	N/A	77.78	acres	N/A	N/A	N/A	N/A	Landowner	117.68	17.66	14.08	$6,222.66	$52.88	$352.27	$441.93
No-Till/Strip-Till	69	N/A	N/A	0.21	acres	N/A	N/A	N/A	N/A	Landowner	0.39	0.08	0.09	$16.87	$43.31	$202.40	$183.40
No-Till/Strip-Till	70	N/A	N/A	28.27	acres	N/A	N/A	N/A	N/A	Landowner	53.70	11.78	13.20	$2,261.58	$42.11	$192.05	$171.32
No-Till/Strip-Till	71	N/A	N/A	21.63	acres	N/A	N/A	N/A	N/A	Landowner	46.62	9.09	9.39	$1,730.67	$37.12	$190.42	$184.29
No-Till/Strip-Till	72	N/A	N/A	26.17	acres	N/A	N/A	N/A	N/A	Landowner	44.61	11.59	14.49	$2,093.23	$46.93	$180.58	$144.48
No-Till/Strip-Till	73	N/A	N/A	12.96	acres	N/A	N/A	N/A	N/A	Landowner	20.89	3.67	3.47	$1,036.70	$49.63	$282.69	$298.83
No-Till/Strip-Till	74	N/A	N/A	17.04	acres	N/A	N/A	N/A	N/A	Landowner	37.64	8.26	9.27	$1,363.28	$36.22	$164.98	$147.05
No-Till/Strip-Till	75	N/A	N/A	15.74	acres	N/A	N/A	N/A	N/A	Landowner	36.38	6.84	6.88	$1,258.95	$34.61	$183.97	$183.11
No-Till/Strip-Till	76	N/A	N/A	26.69	acres	N/A	N/A	N/A	N/A	Landowner	54.58	9.29	8.53	$2,135.00	$39.12	$229.86	$250.30
No-Till/Strip-Till	77	N/A	N/A	4.53	acres	N/A	N/A	N/A	N/A	Landowner	10.16	2.75	3.50	$362.41	$35.68	$131.80	$103.64
No-Till/Strip-Till	78	N/A	N/A	3.41	acres	N/A	N/A	N/A	N/A	Landowner	6.06	1.45	1.74	$272.70	$45.03	$188.57	$156.96
No-Till/Strip-Till	79	N/A	N/A	35.94	acres	N/A	N/A	N/A	N/A	Landowner	103.94	27.39	33.94	$2,875.05	$27.66	$104.97	$84.72
No-Till/Strip-Till	80	N/A	N/A	47.93	acres	N/A	N/A	N/A	N/A	Landowner	96.27	15.70	13.79	$3,834.24	$39.83	$244.29	$278.07
No-Till/Strip-Till	81	N/A	N/A	39.27	acres	N/A	N/A	N/A	N/A	Landowner	103.34	18.53	17.87	$3,141.43	$30.40	$169.53	$175.79
No-Till/Strip-Till	82	N/A	N/A	3.13	acres	N/A	N/A	N/A	N/A	Landowner	10.49	2.41	2.78	$250.21	$23.85	$103.84	$90.08
No-Till/Strip-Till	83	N/A	N/A	11.06	acres	N/A	N/A	N/A	N/A	Landowner	28.02	6.62	7.76	$885.13	$31.58	$133.61	$114.01
No-Till/Strip-Till	84	N/A	N/A	73.61	acres	N/A	N/A	N/A	N/A	Landowner	164.67	32.81	34.47	$5,889.08	$35.76	$179.48	$170.85

No-Till/Strip-Till	85	N/A	N/A	3.85	acres	N/A	N/A	N/A	N/A	Landowner	10.33	2.39	2.77	$308.37	$29.85	$128.85	$111.21
No-Till/Strip-Till	86	N/A	N/A	17.42	acres	N/A	N/A	N/A	N/A	Landowner	106.56	33.67	45.00	$1,393.20	$13.07	$41.37	$30.96
No-Till/Strip-Till	87	N/A	N/A	8.14	acres	N/A	N/A	N/A	N/A	Landowner	17.72	2.84	2.44	$651.08	$36.74	$229.45	$266.36
No-Till/Strip-Till	88	N/A	N/A	43.74	acres	N/A	N/A	N/A	N/A	Landowner	114.95	21.11	20.79	$3,499.38	$30.44	$165.75	$168.32
No-Till/Strip-Till	89	N/A	N/A	36.18	acres	N/A	N/A	N/A	N/A	Landowner	183.51	56.53	74.82	$2,894.09	$15.77	$51.20	$38.68
No-Till/Strip-Till	90	N/A	N/A	53.35	acres	N/A	N/A	N/A	N/A	Landowner	240.41	69.41	89.55	$4,267.72	$17.75	$61.48	$47.66
No-Till/Strip-Till	91	N/A	N/A	27.11	acres	N/A	N/A	N/A	N/A	Landowner	46.56	6.75	5.14	$2,168.56	$46.58	$321.04	$421.55
No-Till/Strip-Till	92	N/A	N/A	11.01	acres	N/A	N/A	N/A	N/A	Landowner	15.88	2.89	2.83	$881.09	$55.49	$304.66	$311.61
No-Till/Strip-Till	93	N/A	N/A	28.45	acres	N/A	N/A	N/A	N/A	Landowner	50.41	11.00	12.29	$2,275.73	$45.14	$206.91	$185.16
No-Till/Strip-Till	94	N/A	N/A	20.81	acres	N/A	N/A	N/A	N/A	Landowner	47.80	12.78	15.94	$1,664.88	$34.83	$130.27	$104.43
No-Till/Strip-Till	95	N/A	N/A	6.92	acres	N/A	N/A	N/A	N/A	Landowner	9.94	1.58	1.35	$553.91	$55.73	$351.08	$411.57
No-Till/Strip-Till	96	N/A	N/A	12.24	acres	N/A	N/A	N/A	N/A	Landowner	16.92	2.49	1.93	$979.50	$57.90	$394.02	$508.32
No-Till/Strip-Till	97	N/A	N/A	7.34	acres	N/A	N/A	N/A	N/A	Landowner	10.49	1.65	1.39	$587.20	$55.96	$356.53	$423.45
No-Till/Strip-Till	98	N/A	N/A	23.72	acres	N/A	N/A	N/A	N/A	Landowner	38.87	6.14	5.21	$1,897.57	$48.82	$309.06	$364.39
No-Till/Strip-Till	99	N/A	N/A	47.71	acres	N/A	N/A	N/A	N/A	Landowner	77.70	12.51	10.84	$3,816.49	$49.12	$305.11	$352.11
No-Till/Strip-Till	100	N/A	N/A	7.27	acres	N/A	N/A	N/A	N/A	Landowner	11.95	1.80	1.43	$581.74	$48.66	$323.74	$405.42
No-Till/Strip-Till	101	N/A	N/A	67.09	acres	N/A	N/A	N/A	N/A	Landowner	126.68	24.36	24.91	$5,367.38	$42.37	$220.31	$215.46
No-Till/Strip-Till	102	N/A	N/A	17.15	acres	N/A	N/A	N/A	N/A	Landowner	41.18	6.02	4.63	$1,371.69	$33.31	$227.85	$296.07
No-Till/Strip-Till	103	N/A	N/A	24.57	acres	N/A	N/A	N/A	N/A	Landowner	42.79	6.88	5.95	$1,965.76	$45.94	$285.86	$330.55
No-Till/Strip-Till	104	N/A	N/A	10.75	acres	N/A	N/A	N/A	N/A	Landowner	14.41	2.07	1.55	$859.98	$59.67	$415.80	$554.47
No-Till/Strip-Till	105	N/A	N/A	184.63	acres	N/A	N/A	N/A	N/A	Landowner	356.24	58.38	51.57	$14,770.63	$41.46	$253.03	$286.44
No-Till/Strip-Till	106	N/A	N/A	35.89	acres	N/A	N/A	N/A	N/A	Landowner	54.03	8.17	6.57	$2,870.91	$53.14	$351.60	$437.26
No-Till/Strip-Till	107	N/A	N/A	13.82	acres	N/A	N/A	N/A	N/A	Landowner	21.14	2.79	1.83	$1,105.36	$52.30	$395.98	$602.84
No-Till/Strip-Till	108	N/A	N/A	57.85	acres	N/A	N/A	N/A	N/A	Landowner	83.48	12.49	9.92	$4,627.81	$55.44	$370.39	$466.37
No-Till/Strip-Till	109	N/A	N/A	33.95	acres	N/A	N/A	N/A	N/A	Landowner	46.41	7.35	6.25	$2,715.80	$58.52	$369.59	$434.58
No-Till/Strip-Till	110	N/A	N/A	0.26	acres	N/A	N/A	N/A	N/A	Landowner	0.56	0.12	0.14	$21.11	$37.97	$174.45	$156.33
No-Till/Strip-Till	111	N/A	N/A	21.94	acres	N/A	N/A	N/A	N/A	Landowner	45.27	6.56	4.98	$1,755.46	$38.78	$267.75	$352.44
No-Till/Strip-Till	112	N/A	N/A	23.42	acres	N/A	N/A	N/A	N/A	Landowner	53.07	7.90	6.23	$1,873.78	$35.31	$237.20	$300.86
No-Till/Strip-Till	113	N/A	N/A	9.82	acres	N/A	N/A	N/A	N/A	Landowner	21.76	4.30	4.49	$785.30	$36.10	$182.61	$174.88
No-Till/Strip-Till	114	N/A	N/A	12.61	acres	N/A	N/A	N/A	N/A	Landowner	23.82	3.92	3.48	$1,008.79	$42.35	$257.41	$290.19
No-Till/Strip-Till	115	N/A	N/A	4.47	acres	N/A	N/A	N/A	N/A	Landowner	11.32	2.75	3.28	$357.25	$31.56	$129.79	$109.06
No-Till/Strip-Till	116	N/A	N/A	7.17	acres	N/A	N/A	N/A	N/A	Landowner	8.16	1.78	4.17	$573.97	$70.37	$321.67	$137.66
No-Till/Strip-Till	117	N/A	N/A	10.13	acres	N/A	N/A	N/A	N/A	Landowner	14.72	3.83	4.78	$810.80	$55.07	$211.90	$169.54
No-Till/Strip-Till	118	N/A	N/A	13.76	acres	N/A	N/A	N/A	N/A	Landowner	31.38	5.35	4.93	$1,101.17	$35.09	$205.72	$223.50
No-Till/Strip-Till	119	N/A	N/A	22.76	acres	N/A	N/A	N/A	N/A	Landowner	32.77	6.26	6.58	$1,820.49	$55.55	$290.94	$276.62
No-Till/Strip-Till	120	N/A	N/A	11.84	acres	N/A	N/A	N/A	N/A	Landowner	16.83	3.01	3.01	$947.59	$56.30	$314.81	$314.39
No-Till/Strip-Till	121	N/A	N/A	15.03	acres	N/A	N/A	N/A	N/A	Landowner	30.40	4.86	4.18	$1,202.15	$39.54	$247.33	$287.65
No-Till/Strip-Till	122	N/A	N/A	0.75	acres	N/A	N/A	N/A	N/A	Landowner	3.62	1.20	1.64	$60.28	$16.63	$50.04	$36.79
No-Till/Strip-Till	123	N/A	N/A	19.29	acres	N/A	N/A	N/A	N/A	Landowner	75.76	19.85	24.53	$1,542.93	$20.37	$77.73	$62.90
No-Till/Strip-Till	124	N/A	N/A	1.45	acres	N/A	N/A	N/A	N/A	Landowner	7.10	2.18	2.88	$115.78	$16.31	$53.19	$40.25
No-Till/Strip-Till	125	N/A	N/A	0.49	acres	N/A	N/A	N/A	N/A	Landowner	1.40	0.33	0.39	$38.93	$27.82	$117.59	$100.29
No-Till/Strip-Till	126	N/A	N/A	3.69	acres	N/A	N/A	N/A	N/A	Landowner	4.47	0.59	0.42	$294.86	$66.00	$502.50	$704.58
No-Till/Strip-Till	127	N/A	N/A	12.80	acres	N/A	N/A	N/A	N/A	Landowner	10.01	1.92	4.17	$1,024.32	$102.30	$532.22	$245.47
No-Till/Strip-Till	128	N/A	N/A	1.91	acres	N/A	N/A	N/A	N/A	Landowner	3.39	0.60	0.57	$152.74	$45.00	$254.61	$267.49
No-Till/Strip-Till	129	N/A	N/A	5.53	acres	N/A	N/A	N/A	N/A	Landowner	10.38	1.59	1.29	$442.53	$42.63	$279.02	$342.35
No-Till/Strip-Till	130	N/A	N/A	16.50	acres	N/A	N/A	N/A	N/A	Landowner	28.69	4.87	4.47	$1,319.95	$46.00	$270.87	$295.57
No-Till/Strip-Till	131	N/A	N/A	0.65	acres	N/A	N/A	N/A	N/A	Landowner	1.25	0.21	0.19	$52.22	$41.63	$250.90	$280.30
No-Till/Strip-Till	132	N/A	N/A	9.23	acres	N/A	N/A	N/A	N/A	Landowner	13.12	2.26	2.19	$738.33	$56.28	$326.92	$336.89
No-Till/Strip-Till	133	N/A	N/A	4.05	acres	N/A	N/A	N/A	N/A	Landowner	9.05	1.36	1.09	$324.02	$35.80	$237.51	$296.35
No-Till/Strip-Till	134	N/A	N/A	2.79	acres	N/A	N/A	N/A	N/A	Landowner	6.45	0.94	0.72	$223.51	$34.65	$238.33	$312.09
No-Till/Strip-Till	135	N/A	N/A	6.02	acres	N/A	N/A	N/A	N/A	Landowner	8.88	1.43	1.30	$481.74	$54.22	$337.63	$370.66
No-Till/Strip-Till	136	N/A	N/A	1.31	acres	N/A	N/A	N/A	N/A	Landowner	3.93	1.21	1.61	$104.43	$26.56	$86.40	$64.74
No-Till/Strip-Till	137	N/A	N/A	2.01	acres	N/A	N/A	N/A	N/A	Landowner	3.20	0.75	0.89	$160.94	$50.28	$215.38	$181.34
No-Till/Strip-Till	138	N/A	N/A	1.75	acres	N/A	N/A	N/A	N/A	Landowner	3.63	0.65	0.63	$139.99	$38.59	$215.13	$223.00
No-Till/Strip-Till	139	N/A	N/A	6.85	acres	N/A	N/A	N/A	N/A	Landowner	9.06	1.64	1.66	$548.22	$60.51	$334.04	$330.23
No-Till/Strip-Till	140	N/A	N/A	8.43	acres	N/A	N/A	N/A	N/A	Landowner	11.06	2.02	2.06	$674.12	$60.93	$333.24	$327.07
No-Till/Strip-Till	141	N/A	N/A	7.85	acres	N/A	N/A	N/A	N/A	Landowner	14.98	1.88	1.11	$628.00	$41.93	$334.59	$563.27
No-Till/Strip-Till	142	N/A	N/A	3.97	acres	N/A	N/A	N/A	N/A	Landowner	6.26	1.30	1.45	$317.49	$50.75	$243.38	$218.32
No-Till/Strip-Till	143	N/A	N/A	1.57	acres	N/A	N/A	N/A	N/A	Landowner	2.28	0.34	0.29	$125.88	$55.13	$370.42	$440.59
No-Till/Strip-Till	144	N/A	N/A	21.38	acres	N/A	N/A	N/A	N/A	Landowner	43.87	7.45	6.83	$1,710.28	$38.98	$229.46	$250.30

No-Till/Strip-Till	145	N/A	N/A	37.95	acres	N/A	N/A	N/A	N/A	Landowner	71.47	13.74	14.05	$3,035.90	$42.48	$220.92	$216.08
No-Till/Strip-Till	146	N/A	N/A	34.58	acres	N/A	N/A	N/A	N/A	Landowner	48.44	7.19	5.65	$2,766.49	$57.11	$384.61	$489.42
No-Till/Strip-Till	147	N/A	N/A	36.77	acres	N/A	N/A	N/A	N/A	Landowner	118.70	23.40	24.39	$2,941.35	$24.78	$125.69	$120.60
No-Till/Strip-Till	148	N/A	N/A	9.92	acres	N/A	N/A	N/A	N/A	Landowner	27.41	5.70	6.17	$793.21	$28.94	$139.16	$128.51
No-Till/Strip-Till	149	N/A	N/A	61.98	acres	N/A	N/A	N/A	N/A	Landowner	91.73	14.47	12.25	$4,958.52	$54.06	$342.76	$404.84
No-Till/Strip-Till	150	N/A	N/A	3.79	acres	N/A	N/A	N/A	N/A	Landowner	5.61	0.87	0.72	$302.89	$53.99	$348.38	$420.05
No-Till/Strip-Till	151	N/A	N/A	32.87	acres	N/A	N/A	N/A	N/A	Landowner	272.87	94.23	129.82	$2,629.45	$9.64	$27.90	$20.25
No-Till/Strip-Till	152	N/A	N/A	67.71	acres	N/A	N/A	N/A	N/A	Landowner	124.59	19.87	17.04	$5,416.93	$43.48	$272.64	$317.97
No-Till/Strip-Till	153	N/A	N/A	7.72	acres	N/A	N/A	N/A	N/A	Landowner	24.81	6.76	8.51	$617.44	$24.89	$91.32	$72.56
No-Till/Strip-Till	154	N/A	N/A	8.58	acres	N/A	N/A	N/A	N/A	Landowner	26.25	6.73	8.23	$686.10	$26.13	$101.96	$83.39
No-Till/Strip-Till	155	N/A	N/A	9.79	acres	N/A	N/A	N/A	N/A	Landowner	9.44	2.55	6.54	$783.51	$82.97	$307.45	$119.75
No-Till/Strip-Till	156	N/A	N/A	8.02	acres	N/A	N/A	N/A	N/A	Landowner	12.07	2.16	2.07	$641.25	$53.14	$297.46	$309.49
No-Till/Strip-Till	157	N/A	N/A	13.19	acres	N/A	N/A	N/A	N/A	Landowner	32.86	5.37	4.72	$1,055.05	$32.11	$196.64	$223.44
No-Till/Strip-Till	158	N/A	N/A	7.09	acres	N/A	N/A	N/A	N/A	Landowner	12.32	1.64	1.09	$567.49	$46.05	$346.43	$521.45
No-Till/Strip-Till	159	N/A	N/A	24.75	acres	N/A	N/A	N/A	N/A	Landowner	49.39	8.27	7.47	$1,979.83	$40.09	$239.50	$265.21
No-Till/Strip-Till	160	N/A	N/A	15.48	acres	N/A	N/A	N/A	N/A	Landowner	29.94	4.63	3.84	$1,238.24	$41.36	$267.15	$322.51
No-Till/Strip-Till	161	N/A	N/A	0.44	acres	N/A	N/A	N/A	N/A	Landowner	0.77	0.14	0.14	$34.95	$45.67	$246.81	$249.05
No-Till/Strip-Till	162	N/A	N/A	2.58	acres	N/A	N/A	N/A	N/A	Landowner	4.54	0.66	0.50	$206.39	$45.45	$314.55	$415.43
No-Till/Strip-Till	163	N/A	N/A	3.71	acres	N/A	N/A	N/A	N/A	Landowner	8.33	1.34	1.16	$296.50	$35.57	$221.04	$255.18
No-Till/Strip-Till	164	N/A	N/A	19.09	acres	N/A	N/A	N/A	N/A	Landowner	35.73	5.73	4.95	$1,527.50	$42.75	$266.57	$308.90
No-Till/Strip-Till	165	N/A	N/A	3.89	acres	N/A	N/A	N/A	N/A	Landowner	12.92	3.01	3.51	$311.36	$24.10	$103.32	$88.82
No-Till/Strip-Till	166	N/A	N/A	4.82	acres	N/A	N/A	N/A	N/A	Landowner	17.43	4.49	5.50	$385.54	$22.12	$85.89	$70.08
No-Till/Strip-Till	167	N/A	N/A	7.06	acres	N/A	N/A	N/A	N/A	Landowner	22.10	5.37	6.39	$565.12	$25.57	$105.21	$88.43
No-Till/Strip-Till	168	N/A	N/A	0.66	acres	N/A	N/A	N/A	N/A	Landowner	1.97	0.50	0.61	$53.17	$27.04	$106.40	$87.40
No-Till/Strip-Till	169	N/A	N/A	3.18	acres	N/A	N/A	N/A	N/A	Landowner	8.26	1.92	2.24	$254.44	$30.82	$132.18	$113.66
No-Till/Strip-Till	170	N/A	N/A	2.45	acres	N/A	N/A	N/A	N/A	Landowner	3.03	0.52	0.50	$195.71	$64.63	$377.58	$390.99
No-Till/Strip-Till	171	N/A	N/A	3.18	acres	N/A	N/A	N/A	N/A	Landowner	6.11	0.99	0.86	$254.08	$41.59	$256.62	$293.95
No-Till/Strip-Till	172	N/A	N/A	3.07	acres	N/A	N/A	N/A	N/A	Landowner	8.39	1.28	1.04	$245.64	$29.28	$192.22	$236.73
No-Till/Strip-Till	173	N/A	N/A	6.30	acres	N/A	N/A	N/A	N/A	Landowner	19.67	4.08	4.40	$504.32	$25.64	$123.75	$114.58
No-Till/Strip-Till	174	N/A	N/A	2.51	acres	N/A	N/A	N/A	N/A	Landowner	6.06	0.99	0.88	$200.46	$33.09	$202.07	$228.96
No-Till/Strip-Till	175	N/A	N/A	1.79	acres	N/A	N/A	N/A	N/A	Landowner	3.69	0.64	0.59	$142.99	$38.71	$224.72	$241.84
No-Till/Strip-Till	176	N/A	N/A	4.68	acres	N/A	N/A	N/A	N/A	Landowner	6.58	1.27	1.34	$374.49	$56.91	$295.23	$278.80
No-Till/Strip-Till	177	N/A	N/A	3.14	acres	N/A	N/A	N/A	N/A	Landowner	7.04	1.22	1.14	$250.99	$35.65	$205.38	$219.43
No-Till/Strip-Till	178	N/A	N/A	4.94	acres	N/A	N/A	N/A	N/A	Landowner	16.14	3.90	4.62	$395.49	$24.51	$101.49	$85.60
No-Till/Strip-Till	179	N/A	N/A	22.48	acres	N/A	N/A	N/A	N/A	Landowner	58.91	10.32	9.74	$1,798.65	$30.53	$174.36	$184.74
No-Till/Strip-Till	180	N/A	N/A	3.21	acres	N/A	N/A	N/A	N/A	Landowner	8.58	1.71	1.79	$256.96	$29.93	$150.58	$143.61
No-Till/Strip-Till	181	N/A	N/A	14.23	acres	N/A	N/A	N/A	N/A	Landowner	32.97	5.00	4.05	$1,138.31	$34.53	$227.47	$281.36
No-Till/Strip-Till	182	N/A	N/A	23.81	acres	N/A	N/A	N/A	N/A	Landowner	31.91	4.93	4.06	$1,904.63	$59.68	$386.72	$468.64
No-Till/Strip-Till	183	N/A	N/A	36.03	acres	N/A	N/A	N/A	N/A	Landowner	63.24	10.07	8.62	$2,882.65	$45.58	$286.32	$334.60
No-Till/Strip-Till	184	N/A	N/A	4.93	acres	N/A	N/A	N/A	N/A	Landowner	6.75	1.04	0.86	$394.60	$58.47	$379.61	$461.11
No-Till/Strip-Till	185	N/A	N/A	19.10	acres	N/A	N/A	N/A	N/A	Landowner	29.88	3.95	2.59	$1,527.72	$51.13	$387.12	$589.32
No-Till/Strip-Till	186	N/A	N/A	5.63	acres	N/A	N/A	N/A	N/A	Landowner	11.57	2.42	2.63	$450.03	$38.90	$185.87	$170.90
No-Till/Strip-Till	187	N/A	N/A	10.54	acres	N/A	N/A	N/A	N/A	Landowner	8.26	1.48	3.06	$843.39	$102.16	$569.43	$275.19
No-Till/Strip-Till	188	N/A	N/A	0.58	acres	N/A	N/A	N/A	N/A	Landowner	1.85	0.52	0.66	$46.14	$25.00	$88.67	$69.42
No-Till/Strip-Till	189	N/A	N/A	3.27	acres	N/A	N/A	N/A	N/A	Landowner	7.40	1.69	1.95	$261.73	$35.37	$154.71	$134.56
No-Till/Strip-Till	190	N/A	N/A	2.43	acres	N/A	N/A	N/A	N/A	Landowner	4.73	1.30	1.67	$194.02	$41.03	$148.92	$116.26
No-Till/Strip-Till	191	N/A	N/A	5.14	acres	N/A	N/A	N/A	N/A	Landowner	12.19	2.50	2.68	$411.55	$33.76	$164.61	$153.49
No-Till/Strip-Till	192	N/A	N/A	1.36	acres	N/A	N/A	N/A	N/A	Landowner	1.21	0.24	0.52	$109.17	$90.51	$462.04	$210.57
No-Till/Strip-Till	193	N/A	N/A	3.60	acres	N/A	N/A	N/A	N/A	Landowner	4.42	1.24	3.25	$288.18	$65.16	$231.51	$88.76
No-Till/Strip-Till	194	N/A	N/A	3.02	acres	N/A	N/A	N/A	N/A	Landowner	2.62	0.53	1.18	$241.47	$92.18	$457.96	$205.30
No-Till/Strip-Till	195	N/A	N/A	1.16	acres	N/A	N/A	N/A	N/A	Landowner	2.71	0.71	0.87	$92.59	$34.17	$131.03	$106.28
No-Till/Strip-Till	196	N/A	N/A	7.86	acres	N/A	N/A	N/A	N/A	Landowner	20.56	4.53	5.10	$628.52	$30.56	$138.62	$123.23
No-Till/Strip-Till	197	N/A	N/A	5.52	acres	N/A	N/A	N/A	N/A	Landowner	6.07	1.00	0.93	$441.71	$72.83	$441.62	$472.79
No-Till/Strip-Till	198	N/A	N/A	6.36	acres	N/A	N/A	N/A	N/A	Landowner	106.20	39.54	55.75	$508.93	$4.79	$12.87	$9.13
No-Till/Strip-Till	199	N/A	N/A	11.41	acres	N/A	N/A	N/A	N/A	Landowner	30.48	4.72	3.91	$912.66	$29.94	$193.28	$233.13
No-Till/Strip-Till	200	N/A	N/A	3.77	acres	N/A	N/A	N/A	N/A	Landowner	9.62	1.30	0.89	$301.73	$31.36	$231.89	$339.01
No-Till/Strip-Till	201	N/A	N/A	5.32	acres	N/A	N/A	N/A	N/A	Landowner	21.28	5.30	6.39	$425.31	$19.98	$80.25	$66.60
No-Till/Strip-Till	202	N/A	N/A	7.98	acres	N/A	N/A	N/A	N/A	Landowner	30.86	8.24	10.31	$638.34	$20.68	$77.49	$61.90
Cover Crop	1	N/A	N/A	26.73	acres	N/A	N/A	N/A	N/A	Landowner	42.56	4.56	1.84	$3,742.00	$87.93	$820.99	$2,034.45
Cover Crop	2	N/A	N/A	0.83	acres	N/A	N/A	N/A	N/A	Landowner	1.26	0.14	0.06	$115.99	$91.99	$825.06	$1,796.81

Cover Crop	3	N/A	N/A	4.65	acres	N/A	N/A	N/A	N/A	Landowner	3.98	0.46	0.27	$650.88	$163.55	$1,405.98	$2,368.85
Cover Crop	8	N/A	N/A	4.52	acres	N/A	N/A	N/A	N/A	Landowner	5.39	0.70	0.46	$633.36	$117.55	$902.69	$1,378.92
Cover Crop	9	N/A	N/A	11.11	acres	N/A	N/A	N/A	N/A	Landowner	18.34	2.45	1.68	$1,555.00	$84.78	$634.02	$925.46
Cover Crop	10	N/A	N/A	8.85	acres	N/A	N/A	N/A	N/A	Landowner	12.48	1.53	0.89	$1,238.88	$99.26	$809.32	$1,388.60
Cover Crop	11	N/A	N/A	21.02	acres	N/A	N/A	N/A	N/A	Landowner	35.30	6.37	6.24	$2,943.26	$83.38	$461.86	$471.80
Cover Crop	14	N/A	N/A	6.88	acres	N/A	N/A	N/A	N/A	Landowner	7.99	0.96	0.53	$962.83	$120.54	$1,005.50	$1,813.99
Cover Crop	15	N/A	N/A	6.68	acres	N/A	N/A	N/A	N/A	Landowner	7.54	1.02	0.71	$935.41	$124.02	$918.05	$1,317.93
Cover Crop	16	N/A	N/A	3.31	acres	N/A	N/A	N/A	N/A	Landowner	4.07	0.54	0.37	$463.64	$114.01	$853.28	$1,247.09
Cover Crop	17	N/A	N/A	0.59	acres	N/A	N/A	N/A	N/A	Landowner	0.63	0.08	0.06	$82.68	$131.46	$976.56	$1,409.81
Cover Crop	18	N/A	N/A	36.21	acres	N/A	N/A	N/A	N/A	Landowner	54.26	5.95	2.59	$5,069.75	$93.43	$852.44	$1,956.41
Cover Crop	19	N/A	N/A	8.06	acres	N/A	N/A	N/A	N/A	Landowner	12.62	1.57	0.95	$1,128.72	$89.43	$717.91	$1,192.77
Cover Crop	20	N/A	N/A	24.09	acres	N/A	N/A	N/A	N/A	Landowner	37.35	4.38	2.30	$3,372.82	$90.29	$770.53	$1,467.12
Cover Crop	21	N/A	N/A	1.43	acres	N/A	N/A	N/A	N/A	Landowner	2.17	0.29	0.20	$200.12	$92.13	$686.66	$996.70
Cover Crop	22	N/A	N/A	1.97	acres	N/A	N/A	N/A	N/A	Landowner	0.61	0.09	0.13	$275.69	$451.48	$3,211.39	$2,067.87
Cover Crop	23	N/A	N/A	7.07	acres	N/A	N/A	N/A	N/A	Landowner	9.55	1.18	0.69	$989.50	$103.65	$841.28	$1,429.79
Cover Crop	24	N/A	N/A	10.20	acres	N/A	N/A	N/A	N/A	Landowner	8.58	0.94	0.48	$1,427.37	$166.44	$1,524.68	$2,961.02
Cover Crop	27	N/A	N/A	0.47	acres	N/A	N/A	N/A	N/A	Landowner	0.57	0.07	0.04	$66.36	$116.78	$921.78	$1,481.52
Cover Crop	28	N/A	N/A	1.95	acres	N/A	N/A	N/A	N/A	Landowner	2.70	0.33	0.19	$272.38	$100.99	$828.20	$1,438.82
Cover Crop	29	N/A	N/A	2.31	acres	N/A	N/A	N/A	N/A	Landowner	3.35	0.36	0.15	$324.05	$96.63	$888.71	$2,092.56
Cover Crop	30	N/A	N/A	1.23	acres	N/A	N/A	N/A	N/A	Landowner	1.89	0.19	0.06	$172.12	$90.86	$906.46	$2,955.86
Cover Crop	31	N/A	N/A	0.35	acres	N/A	N/A	N/A	N/A	Landowner	0.32	0.05	0.04	$49.38	$152.11	$1,073.85	$1,329.67
Cover Crop	32	N/A	N/A	2.79	acres	N/A	N/A	N/A	N/A	Landowner	3.73	0.42	0.20	$390.95	$104.72	$924.63	$1,925.06
Cover Crop	33	N/A	N/A	1.45	acres	N/A	N/A	N/A	N/A	Landowner	2.31	0.39	0.36	$202.54	$87.76	$517.20	$559.01
Cover Crop	38	N/A	N/A	12.45	acres	N/A	N/A	N/A	N/A	Landowner	16.73	2.04	1.18	$1,743.16	$104.20	$853.93	$1,481.19
Cover Crop	39	N/A	N/A	8.99	acres	N/A	N/A	N/A	N/A	Landowner	13.06	1.35	0.48	$1,259.12	$96.41	$930.77	$2,618.82
Cover Crop	40	N/A	N/A	5.84	acres	N/A	N/A	N/A	N/A	Landowner	7.92	0.76	0.18	$817.88	$103.33	$1,081.65	$4,659.40
Cover Crop	41	N/A	N/A	2.24	acres	N/A	N/A	N/A	N/A	Landowner	2.28	0.25	0.13	$313.34	$137.56	$1,249.91	$2,379.32
Cover Crop	42	N/A	N/A	0.92	acres	N/A	N/A	N/A	N/A	Landowner	0.87	0.08	0.02	$128.15	$147.45	$1,585.71	$5,412.60
Cover Crop	43	N/A	N/A	0.69	acres	N/A	N/A	N/A	N/A	Landowner	0.65	0.07	0.03	$96.84	$149.41	$1,469.87	$3,494.57
Cover Crop	132	N/A	N/A	13.42	acres	N/A	N/A	N/A	N/A	Landowner	13.96	1.81	1.27	$1,879.35	$134.58	$1,036.93	$1,481.67

Lake Waverly Education & Outreach Strategy

IEPA Grant # 3191502

FINAL 10/4/2015

The Education and Outreach Strategy (EOS) describes the goals of the outreach component of the Watershed Plan and TMDL.

Education & Outreach Strategy Approach & Tasks:

The Watershed Consultant and City of Waverly will focus on the following methods/tasks under this EOS:

1. **Develop landowner contact list:** A detailed mailing and/or contact list will be generated representing all watershed landowners. The City of Waverly and the Illinois Stewardship Alliance will be responsible for compiling landowner information. This information will be used to inform producers/landowners of public meetings, the cover crop workshop and to request property access to discuss BMPs on critical fields.

2. **Mail introductory post card:** An initial postcard will be developed and sent to potential landowners advising them of the current watershed plan and TMDL process and how to get involved, and contact information. The watershed consultant and City will be responsible for this task. A draft postcard is provided below.

3. **Host an initial public meeting:** A public notice will be developed and advertised locally of the date and agenda for the first public meeting. The initial meeting will focus on describing the process, current watershed characteristics and conditions and to solicit input on watershed problems/needs. Next steps will also be discussed. The initial meeting will be held in December 2015. The watershed consultant and City will be responsible for this task.

4. **Contact by phone and conduct one-on-one meeting with interested landowners:** Direct one-on-one contact will be the primary strategy to educate key landowners, evaluate watershed problem or opportunity areas and to encourage the future adoption of BMPs. On-on-one contact will focus on priority landowners or land parcels. Sites will be selected based on results of the windshield survey and following an interpretation of aerial imagery and the identification of problem areas. The strategy is to meet with producers/landowners that: 1) require or are interested in a specific BMP or 2) own property not visible during the windshield survey. Individual landowner meetings will include an evaluation of the property and a discussion on potential BMPs; we will gauge willingness to implement and use this information to formulize an implementation approach upon completion of the plan and TMDL. The watershed consultant will be responsible for this task; the City will assist with landowner introductions.

5. **Cover crop workshop/field day:** We will organize and host a minimum of one cover crop workshop or field day to educate interested producers on the benefits of cover crops. The Illinois Stewardship Alliance and watershed consultant will be responsible for this task.

6. **Final public meeting:** A public notice will be developed and advertised locally a minimum of 30 days prior to the meeting which is expected in November or December of 2016. The public

notice will include the date and agenda for the second and final public meeting. The final meeting, to be held in November or December, 2016 will focus results of the watershed study and characterization, recommended BMPs and the TMDL. The watershed consultant and City will be responsible for this task. The watershed consultant will develop a Responsiveness Summary based on questions and comments received during the final meeting to be included in the final report.

Proposed Schedule

Task	Aug – Oct 2015	Nov - Jan 2016	Feb – Apr 2016	May -Jul 2016	Aug – Oct 2016	Nov -Jan 2016
1	X					
2	X					
3	X					
4	X	X	X			
5			X	X		
6					X	X

Proposed/Estimated Budget:

Task	Est. Budget
1	$0
2	$200
3	$1,200
4	$9,500
5	$2,000
6	$1,200

***All costs are accounted for within the current 319 budget**

Proposed Educational Materials

DRAFT Landowner Postcard

You are receiving this postcard because you either own or actively farm ground located in the land area draining to Waverly Lake. Over the years, the lake, which is an important source of drinking water, has been losing capacity due to sedimentation; the lake also contains high levels of phosphorus. In response to this, The City of Waverly has applied for and received funding to complete a lake and watershed plan and to identify projects that will reduce sediment and nutrients from entering the lake. This plan is the first step in securing future cost-share funding for lake and watershed improvement practices. As a landowner in the watershed, your opinions and input are important. It is our hope that you will consider taking part in this program. Your input will be critical in order to develop future projects that can limit soil and nutrients from entering the lake as well as benefit your operation. We would like to evaluate sites where projects could have a positive impact on both your farm ground and the water quality in Waverly Lake. Success in this planning phase will mean additional opportunities down the road. If you have any questions or would like to learn more and participate, please contact Mayor Scott Duewer at XXX or Jeff Boeckler, watershed contractor at 217-725-3181. A public information meeting is scheduled for December XXX, 2015 at City Hall to learn more about the project and gather local input. We hope you can join us!

Waverly Lake Watershed

TMDL & Watershed Plan Fact Sheet

Over the years, Waverly Lake, which is an important source of drinking water, has been losing capacity due to sedimentation; the lake also contains high levels of phosphorus. In response to this, The City of Waverly has applied for and received funding to complete a Total Maximum Daily Load (TMDL), a lake and watershed plan and to identify projects that will reduce sediment and nutrients from entering the lake. A TMDL is the sum of the allowable amounts of a single pollutant (nutrients, metals, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses; it is not associated with any type of regulation and participation is voluntary. A Watershed Plan and TMDL is the first step in securing future cost-share funding for lake and watershed improvement practices.

Lake & Watershed Characteristics

- 108 acre lake
- 6,270 acre watershed
- Water supply for Waverly, Apple Creek Water Cooperative and an emergency water supply for Franklin
- Lake looses an average of 1.54 million gallons of capacity each year due to sedimentation
- Impaired for phosphorus, sediment and in 2014, Atrazine
- Watershed 73% crop land, 12% forested and 6% grassland
- 619 tons/yr of sediment from lake shoreline erosion alone
- Best Management Practices have been installed to address sedimentation but more work can be done

TMDL & Watershed Planning Process

- 1-year process
- Complete a watershed assessment and characterization
- Quantify sources of sediment: lake bank and streambank, crop ground, forested areas etc.
- Quantify sources of phosphorus and nitrogen: crop ground, lake bank and streambank erosion, runoff from pasture or residential areas
- Model sediment and nutrient loading to determine how much of a reduction to the lake is needed
- Identify voluntary conservation practices such as water and sediment control basins, waterways, ponds, rock stabilization structures, filter strips, no-till, cover crops, in-lake sediment dam, wetlands
- Meet with individual landowners to discuss voluntary practices
- Calculate the expected sediment and nutrient savings
- Prioritize voluntary projects based on need
- Estimate costs and a schedule
- Apply for a grant to install needed practices

Next Steps

- Winter 2016 – streambank survey (weather permitting), evaluate map layers for the watershed and work on report sections
- Spring 2016 – Meet with interested landowners to evaluate property and discuss voluntary conservation practices
- Spring-Summer 2016 – complete sediment and nutrient modeling
- Summer – Fall 2016 – finalize draft report and hold a final public meeting

Outcomes

- A plan that clearly identifies what, where and how much is needed to minimize sediment and nutrients to the lake
- Voluntary commitments from residents and landowners to participate
- Funding to provide cost-share to assist in implementing voluntary practices
- A lake that meets the State's phosphorus standard and a reduction in the loss of reservoir capacity due to sedimentation

For more information or to schedule a property visit contact:

Jeff Boeckler, Northwater Consulting (217) 725-3181 or jeff@northwaterco.com

NOTICE OF PUBLIC MEETING

Waverly Lake Watershed

(Morgan County)

The City of Waverly will hold a public meeting on

December 9th, 2015 (6:30 pm)

at the

American Legion
130 East State St, Waverly, IL

The purpose of this meeting is to provide an opportunity for the public to receive information on a Total Maximum Daily Load (TMDL) concerning impairments to water body segments within the Waverly Lake Watershed. The segments and potential causes of impairment are: Waverly Lake (total phosphorus).

This process and subsequent report will include watershed characterization, data analysis and selection of potential models that will be used to determine the pollutant loading capacity and reductions necessary to meet designated uses and water quality standards.

The IEPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act. A TMDL is the sum of the allowable amounts of a single pollutant (nutrients, metals, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses.

Stakeholders and participants will also be asked for input and ideas to be applied to the draft Stage 1 report later in 2016. An additional public meeting will be held to discuss the next stage of the TMDL and results of the Stage 1 report.

Questions about the TMDL should be directed to the project manager, Jeff Boeckler. See contact information below.

Jeff Boeckler
Northwater Consulting
960 Clocktower Drive, Suite F
Springfield, IL 62704
PH: (217) 725-3181
Fax: (866) 308-2898
E-mail: jeff@northwaterco.com

NOTICE OF PUBLIC MEETING

Waverly Lake Watershed
(Morgan County)

The City of Waverly will hold a public meeting on

December 14th, 2016 (6:30 pm)

at the

American Legion
130 East State St, Waverly, IL

The purpose of this meeting is to provide an opportunity for the public to receive information on a Total Maximum Daily Load (TMDL) concerning impairments to water body segments within the Waverly Lake Watershed. The segments and potential causes of impairment are: Waverly Lake (total phosphorus).

The draft TMDL Report includes watershed characterization, data analysis, pollutant loading capacity and reductions necessary to meet designated uses and water quality standards, and a watershed-based implementation plan.

The IEPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act. A TMDL is the sum of the allowable amounts of a single pollutant (nutrients, metals, etc.) that a waterbody can receive from all contributing sources and still meet water quality standards or designated uses. The implementation plan is intended to identify practices and solutions that will result in pollutant reductions.

The draft Waverly Lake TMDL Report will be available online at: http://www.epa.illinois.gov/public-notices/general-notices/index .

A hard copy of the draft report will also be available at Waverly City Hall during business hours.

Questions about the draft TMDL Report should be directed to the project manager, Jeff Boeckler. See contact information below.

Closure of the Meeting Record

The meeting record will close as of midnight, January 14, 2017. Written comments need not be notarized but must be postmarked before midnight and mailed to:

Jeff Boeckler
Northwater Consulting
960 Clocktower Drive, Suite F
Springfield, IL 62704
PH: (217) 725-3181
Fax: (866) 308-2898
E-mail: jeff@northwaterco.com

Responsiveness Summary

Waverly Lake Watershed Implementation Plan & Total Maximum Daily Load

The responsiveness summary responds to any questions and comments received during the public comment period from November 14th, 2016 through January 14th, 2017.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. The Waverly Lake watershed TMDL report contains a plan detailing the actions necessary to reduce pollutant loads to the impaired water bodies and ensure compliance with applicable water quality standards. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations thereunder.

Background

The Watershed targeted for TMDL development is Waverly Lake (IL_SDC) in Morgan County. The Waverly Lake watershed encompasses and area of approximately 6,270 acres (9.8 square miles). Landuse in the watershed is predominately agriculture. Waverly lake consists of 107 acres and is used as a water source for the City of Waverly and an emergency water supply for the Village of Franklin, Illinois. The waterbody is listed on the Illinois EPA 2016 Section 303(d) List as being impaired for total phosphorus and total suspended solids. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303 (d) list. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Therefore, a TMDL was developed for total phosphorus. The City of Waverly contracted with Northwater Consulting to prepare a TMDL report for the Waverly Lake watershed.

Public Meetings

Public meetings were held at the American Legion building in Waverly on December 9th, 2015 and December 14th, 2016. The City of Waverly and Illinois EPA provided public notice for both meetings by placing display ads in the local Waverly Newspaper. In addition, a direct mailing was sent to approximately 190 individuals in the watershed. These notices gave the date, time, location, and purpose of the meeting. The notice also provided references to obtain additional information about this specific site, the TMDL program and other related information. The draft TMDL report was available for review at the Waverly City Hall and also on the Agency's web page at http://www.epa.state.il.us/public-notices/.

A public meeting started at 6:30 p.m. on Wednesday, December 14th, 2016. It was attended by approximately 20 people and concluded at 8:00 p.m. with the meeting record remaining open until midnight, January 14th, 2017.

Questions & Comments

1. No Comments Received