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ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

Upper Fox River/Flint Creek Watershed TMDL Stage 1 Report

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Executive Summary

As required by Section 303(d) of the Clean Water Act (CWA), the Illinois Environmental Protection Agency (Illinois EPA) is required to identify and list all state waters that fail to meet water quality standards and designated uses. This list is referred to as the 303(d) list and is revisited every two years to either remove those waters that have attained their designated uses, or to include additional waters not previously deemed impaired. Waterbodies included on the 303(d) list require Total Maximum Daily Load (TMDL) development.

A TMDL is an estimation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. It assesses contributing point and nonpoint sources to identify pollutant reductions necessary to attain water quality standards. A TMDL identifies the potential source of impairment and provides reduction estimates to meet water quality standards. Pollutant reductions are then allocated to contributing sources, thus triggering the need for pollutant controls and increased management responsibilities amongst sources in the watershed.

The Fox River watershed is located in Cook, Grundy, Kane, Kendall, Lake, La Salle, McHenry and Will Counties in far northeastern Illinois, and extends north into Wisconsin. The Fox River watershed is divided into two portions: the Upper Fox River and Lower Fox River watershed. The Upper Fox River Flint Creek sub-watershed contains 16 impaired segments that are identified for TMDL development. One of which will be delisted in 2010. The waterbody classification applicable to the Upper Fox River/Flint Creek watershed is the General Use classification which includes designated uses such as aquatic life, aesthetic quality, and primary contact recreation uses. The identified impairments include dissolved oxygen (DO), fecal coliform, pH and total phosphorus. The water quality standard criteria identified for these impairments provide an explicit assessment as to whether or not these waterbodies are in compliance.

Available data used for assessing these waterbodies originated from numerous water quality stations within the Upper Fox River watershed. Data were obtained from both Legacy and modernized US EPA Storage and Retrieval (STORET) databases, Lake County, Fox River Study Group, and Illinois EPA database. Data relevant to impairments were compiled for each impaired waterbody and summary statistics were calculated to further characterize each pollutant.

Various models were recommended for TMDL development, the level of which was primarily based on the complexity of the system and the availability of data. After a careful data review, it is likely that the dissolved oxygen impairment in the lake segment is related to excessive phosphorus concentrations, and therefore a phosphorus TMDL was recommended. The ENSR Lake Response Model (ENSR LRM) was suggested to evaluate total phosphorus loading in all phosphorus impaired segments. A load duration curve was recommended for the preparation of river fecal coliform TMDLs and the Simple Method (loading estimates based on runoff volume and concentrations) was recommended for lake fecal coliform TMDLs. The River and Stream Water Quality Model (QUAL2K) was recommended for DO and pH.

1.0 Introduction

This Stage 1 Total Maximum Daily Load (TMDL) report is presented as partial fulfillment by the Illinois Environmental Protection Agency (Illinois EPA) and the United States Environmental Protection Agency (US EPA) in the development of TMDLs, as part of that state's Clean Water Act (CWA) Section 303(d) compliance. The purpose of the project is to develop TMDLs for 15 impaired waterbodies in the Upper Fox River/Flint Creek watershed in Illinois.

Section 303(d) of the CWA and US EPA's Water Quality Planning Regulations (40 CFR Part 130) require states to develop TMDLs for impaired waterbodies that are not supporting designated uses or meeting water quality standards. A TMDL is a calculation of the maximum amount of pollutants that a waterbody can receive and still meet the water quality standards necessary to protect the designated beneficial use (or uses) for that waterbody. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and water quality conditions, so that states and local communities can establish water quality based controls to reduce pollutants from both point and nonpoint sources and restore and maintain the quality of their water resources.

Water is an essential resource for the inhabitants of the Earth and protecting this resource is the goal for many across the globe. United States policies and regulations, such as the CWA, were created and are implemented to help maintain the quality of our water resources in the United States. The US EPA, via the CWA, charged each state with developing water quality standards (WQS). These WQS are laws or regulations that states authorize to protect and/or enhance water quality, to ensure that a waterbody's designated use (or uses) is (are) not compromised by poor water quality and to protect public health and welfare. In general, WQS consist of three elements:

- The designated beneficial use (e.g., recreation, protection of aquatic life, aesthetic quality, and public and food processing water supply) of a waterbody or segment of a waterbody,
- The water quality criteria necessary to support the designated beneficial use of a waterbody or segment of a waterbody, and
- An anti-degradation policy, so that water quality improvements are conserved, maintained and protected.

The Illinois Pollution Control Board (IPCB) established its WQS in Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter 1: Pollution Control Board, Part 302: Water Quality Standards. Every two years Illinois EPA submits the Illinois Integrated Water Quality Report and Section 303(d) List. This report documents surface and groundwater conditions throughout the state. The 303(d) List portion of this report identifies impaired surface water bodies, grouped by watershed, and identifies suspected causes and sources of impairment. These waters are prioritized for TMDL development into high, medium, and low categories based on designated use and pollution severity and are then targeted for TMDL development. Non-pollutant causes of impairment, such as habitat degradation and aquatic algae are not directly addressed by the TMDL, but may be addressed by reducing pollutants which a TMDL is developed. For example, some implementation activities to reduce phosphorus can reduce excessive algae and improve habitat.

A TMDL is a calculation of the maximum load a waterbody can be receive without exceeding water quality standards or result in non attainment of a designated use. A watershed's TMDL report consists of data analysis to quantitatively assess water quality, documentation of waterbodies or segments of waterbodies that are impaired, and identification of potential contributing sources to impairment. Based on these data, the amount and type of load reduction that is needed to bring water quality into compliance is calculated. The TMDL report provides the scientific basis for states and local communities to establish water quality-based controls to reduce pollutant loads from both point (i.e., wasteload allocations) and non-point sources (i.e., load allocations).

Illinois EPA uses a three-stage approach to develop TMDLs for a watershed:

- **Stage 1** – Watershed characterization, historical dataset evaluation, data analysis, methodology selection, data gap identification;
- **Stage 2** – Data collection to fill in data gaps, if necessary; and
- **Stage 3** – Model calibration, TMDL scenarios, and implementation plans.

The purpose of Stage 1 is to characterize the watershed background; verify impairments in the listed waterbody by comparing observed data with water quality standards or appropriate targets; evaluate spatial and temporal water quality variation; provide a preliminary assessment of potential sources contributing to impairments; and describe potential TMDL development approaches. If available water quality data collected for the watershed are deemed sufficient by Illinois EPA, Stage 2 may be omitted and Stage 3 will be completed. If sufficient water quality data or supporting information are lacking for an impaired waterbody, then Stage 2 field sampling will be conducted in order to obtain necessary data to complete Stage 3.

This report documents Stage 1 in the Illinois EPA approach for TMDL development. The report is organized into seven main sections. Section 1.0 discusses the definition of TMDLs and targeted impaired waterbodies in the Upper Fox River/Flint Creek watershed, for which TMDLs will be developed. Section 2.0 describes the characteristics of the watershed, and Section 3.0 briefly discusses the process of public participation and involvement. Section 4.0 describes the applicable water quality standards and water quality assessment. Section 5.0 presents the assessment and analysis of available water quality data. Section 6.0 provides a description of each impaired segment's watershed and potential sources. Section 7.0 discusses the methodology selection for the TMDL development, the data gaps, and provides recommendations for additional data collection, if necessary.

1.1 Definition of a Total Maximum Daily Load (TMDL)

According to the 40 CFR Part 130.2, the TMDL (the maximum load a waterbody can be receive without exceeding water quality standards or result in non attainment of a designated use) for a waterbody is equal to the sum of the individual loads from point sources (i.e., wasteload allocations or WLAs), and load allocations (LAs) from nonpoint sources (including natural background conditions). Section 303(d) of the CWA also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. In equation form, a TMDL may be expressed as follows:

$$\mathbf{TMDL = WLA + LA + MOS}$$

Where:

WLA =	Waste Load Allocation (i.e., loadings from point sources);
LA =	Load Allocation (i.e., loadings from nonpoint sources including natural background); and
MOS =	Margin of Safety.

TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measures [40 CFR, Part 130.2 (i)]. US EPA recommends that all TMDLS and associated LA and WLAs be expressed in terms of daily increments but may include alternative non-daily expression of pollutant loads to facilitate implementation of the applicable water quality standard. Numerous methods have been developed that help account for the variability of waterbodies and allow for the derivation of a daily load from a non-daily load. Such methods can account for factors such as seasonality, flow, critical conditions, etc. and translate a non-daily load (e.g. annual, monthly, seasonal) to a daily load. TMDLs also shall take into account the seasonal variability of pollutant loading and hydrology to ensure water quality standards are met in all seasons and during all hydrologic conditions. Though not required by CWA, Illinois EPA requires that an implementation plan be developed for each watershed, which may be used as a guideline for local stakeholders to restore water quality. This implementation plan will include recommendations for implementing best management practices (BMPs), cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and time frame for completion of implementation activities.

The MOS accounts for the lack of knowledge or uncertainty concerning the true relationship between loading and attainment of water quality standards. This uncertainty is often a product of data gaps, either temporally or spatially, in the measurement of water quality. The MOS should be proportional to the anticipated level of uncertainty; the higher the uncertainty, the greater the MOS. The MOS is generally based on a qualitative assessment of the relative amount of uncertainty as a matter of best professional judgment (BPJ). The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS, but is already factored in during the TMDL development process. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they sufficiently account for the MOS.

1.2 Targeted Waterbodies for TMDL Development

In May 2008, Illinois EPA prepared a draft Illinois Integrated Water Quality Report and Section 303(d) List-2008 (commonly referred to as the 303(d) List) to fulfill the requirement of Section 305(b), 303(d) and 314 of the CWA (Illinois EPA, 2008). Under US EPA's review and approval, the report presents a detailed water quality assessment process and results for streams and lakes in the State of Illinois. The water quality assessments are based on biological, physicochemical, physical habitat, and toxicity data. Each waterbody is assigned one or more designated uses which may include aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact (recreation), public and food processing water supply, and fish consumption. The degree of support (attainment) of a designated use in a waterbody (or segment) is assessed as Fully Supporting (good), Not Supporting (fair), or Not Supporting (poor). Waters in which at least one applicable use is not fully supported is designated as "impaired." Potential causes and sources of impairment are also identified for these waters. The 303(d) List is prioritized on a watershed basis based on the requirements of 40 CFR Part 130.7(b)(4). Watershed boundaries are based on United States Geological Survey (USGS) ten-digit hydrologic units, to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (Illinois EPA, 2008). TMDL development is also conducted on a watershed basis so that the impaired waters upstream of an individual segment may be addressed at the same time.

Table 1-1 presents the 2008 Integrated Report (303(d)) List and Stream Assessment Report impaired segments for the Upper Fox River watershed (excluding the Chain of Lakes subwatershed). The table includes impaired designated uses and potential causes. The segments in bold font are scheduled for TMDL development and are the focus of this report. TMDLs will not be developed for phosphorus impaired lakes with surface area of less than 20 acres since the Illinois phosphorus standard applies only to those lakes where surface acreage is 20 or more acres. Nor will TMDLs be developed for segments impaired by water quality variables that do not have numerical WQS.

Two river segments and 14 lakes are identified as impaired and selected for TMDL development in the Upper Fox River/Flint Creek watershed (Illinois EPA, 2008). One segment listed as a lake is scheduled to be delisted in 2010. This segment is an emergent wetland and not an open water resource and therefore should not be treated as such. Table 1-1 summarizes these waterbodies, designated uses, and impairments identified by the Illinois EPA. The designated uses for these waterbodies are primarily aquatic life with some aesthetic quality and primary contact recreation uses. Water quality criteria applicable to these waters are the General Use Water Quality Standards. The identified causes for impairment that have numerical WQS include dissolved oxygen (DO), fecal coliform, pH and total phosphorus. Although there is a numerical standard for DO, DO is considered a non-pollutant by Illinois EPA. The Illinois EPA will ascertain potential causes for low dissolved oxygen using the TMDL process and will develop a TMDL only if the cause is attributable to a pollutant that has a numerical WQS. For example, if a lake suffers from low DO due to excessive algal densities which is related to elevated phosphorus concentrations, the Illinois EPA will develop a phosphorus TMDL for this waterbody. A TMDL will not be developed for pollutants listed as causes of impairment without numeric WQS, such as total suspended solids, sedimentation/siltation, and cause unknown. For these causes, the TMDL implementation plan can potentially address the impairment by reducing TMDL parameters that are associated with this impairment. Waterbodies and water quality variables targeted for TMDL development are listed in Table 1-2.

Table 1-1: Illinois 2008 Integrated Report 303(d) and Assessment Report Information for Upper Fox River Watershed, Excluding the Chain of Lakes

Water ID	Water Name	Size (Miles/ Acres)	Priority	Designated Use	Potential Cause(s)
IL_DT-22	**Fox R.**	**7.83**	**Medium**	**Aquatic Life** **Primary Contact Recreation** Fish Consumption	**pH, Dissolved Oxygen**, Sedimentation/Siltation, Total Suspended Solids **Fecal Coliform** Polychlorinated biphenyls
IL_DT-23	**Fox R.**	**7.61**	**Medium**	**Aquatic Life** Fish Consumption	**Dissolved Oxygen,** Cause Unknown Polychlorinated biphenyls
IL_DTRA-W-C1	Fiddle Creek	1.93	Medium	Aquatic Life	Cause Unknown, Dissolved Oxygen, Total Phosphorus, Sedimentation/Siltation
IL_DTR-W-C3	Slocum Lake Drain	1.08	Medium	Aquatic Life	Total Phosphorus, Sedimentation/Siltation
IL_DTR-W-D1	Slocum Lake Drain	0.92	Medium	Aquatic Life	Total Phosphorus, Sedimentation/Siltation
IL_DTZS-01	Flint Cr.	10.13	Medium	Aquatic Life	Cause Unknown
IL_RTP	**Slocum**	**211.00**	**Medium**	**Aesthetic Quality**	Total Phosphorus, Total Suspended Solids
IL_RTS	Zurich	228.00	Medium	Aesthetic Quality	Total Suspended Solids
IL_RTZD	Mccullom	245.00	Medium	Aesthetic Quality	Cause Unknown
IL_RTZF	**Tower (Lake)**	**69.00**	**Medium**	**Aesthetic Quality** **Primary Contact Recreation**	**Total Phosphorus**, Total Suspended Solids **Fecal Coliform**
IL_RTZI	**Island**	**78.20**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_RTZQ	**Timber Lake (South)**	**33.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_RTZR	**Echo**	**25.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_RTZT	**Barrington**	**91.00**	**Medium**	**Aesthetic Quality** **Primary Contact Recreation**	**Total Phosphorus**, Total Suspended Solids **Fecal Coliform**
IL_RTZU	**Honey**	**66.00**	**Medium**	**Aesthetic Quality** **Primary Contact Recreation**	**Total Phosphorus**, **Fecal Coliform**
IL_STK	**Lake Fairview**	**20.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_STN[1]	**Broberg Marsh**	**77.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_STO	**Lake Napa Suwe**	**61.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_STT	Seven Acre	6.50	Medium	Aesthetic Quality	Total Phosphorus, Total Suspended Solids
IL_STV	**Woodland (Highland)**	**7.70**	**Medium**	**Aquatic Life** Aesthetic Quality	**Dissolved Oxygen,** Total Phosphorus, Total Suspended Solids Total Phosphorus, Total Suspended Solids
IL_STY	Heron Pond	7.90	Medium	Aesthetic Quality	Total Phosphorus

Table 1-1: Illinois 2008 Integrated Report 303(d) and Assessment Report Information for Upper Fox River Watershed, Excluding the Chain of Lakes

Water ID	Water Name	Size (Miles/ Acres)	Priority	Designated Use	Potential Cause(s)
IL_UTI	**Drummond Lake**	**21.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_UTP	Columbus Park Lake	7.00	Medium	Aesthetic Quality	Total Phosphorus, Total Suspended Solids
IL_UTS	Lakeland Estates	14.00	Medium	Aesthetic Quality	Total Phosphorus
IL_UTT	North Tower Lake	7.00	Medium	Aesthetic Quality	Total Phosphorus
IL_VTI	**Grassy (Lake)**	**41.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_VTZJ	**Louise**	**38.00**	**Medium**	**Aesthetic Quality**	**Total Phosphorus**, Total Suspended Solids
IL_VTZY	Taylor	8.30	Medium	Aesthetic Quality	Total Phosphorus, Total Suspended Solids
IL_WTB	Lochanora	10.30	Medium	Aesthetic Quality	Total Phosphorus

[1] Broberg Marsh is an emergent wetland, not a lake. It should not have been assessed/listed as such and will be delisted in the 2010 Integrated Water Quality Report.

[2]Dissolved oxygen does not appear on the 303(d) list because it is not considered a pollutant. However, it does appear on the 305(b) as a cause of impairment,

Those parameters in bold have numeric standards and will have TMDL allocations.

Table 1-2: Waterbodies targeted for TMDL development in the Upper Fox River/Flint Creek Watershed

Segment ID	Waterbody Name	Waterbody size (acres or miles)	Impairment
IL_RTZT	Barrington	91	Fecal coliform, Total Phosphorus
IL_UTI	Drummond Lake	21	Total Phosphorus
IL_RTZR	Echo	25	Total Phosphorus
IL_DT-22	Fox R.	7.83	Dissolved oxygen, fecal coliform, pH
IL_DT-23	Fox R.	7.61	Dissolved oxygen
IL_VTI	Grassy (Lake)	41	Total Phosphorus
IL_RTZU	Honey	66	Fecal coliform, Total Phosphorus
IL_RTZI	Island	78.2	Total Phosphorus
IL_STK	Lake Fairview	20	Total Phosphorus
IL_STO	Lake Napa Suwe	61	Total Phosphorus
IL_VTZJ	Louise	38	Total Phosphorus
IL_RTP	Slocum	211	Total Phosphorus
IL_RTZQ	Timber Lake (South)	33	Total Phosphorus
IL_RTZF	Tower (Lake)	69	Fecal coliform, Total Phosphorus
IL_STV	Woodland (Highland)	7.7	Dissolved oxygen

Broberg Marsh is an emergent wetland and not a lake. It should not have been assessed/listed as such and will be delisted in the 2010 Integrated Water Quality Report

2.0 Watershed Characterization

As part of the Stage 1 report, relevant geologic and hydrologic characteristics and general information are obtained for the watershed of interest. This section describes the general characteristics of the Upper Fox River watershed including location (Section 2.1), topography (Section 2.2), land use (Section 2.3), soil information (Section 2.4), population (Section 2.5), climate and precipitation (Section 2.6) and hydrology (Section 2.7).

2.1 Watershed Location

A watershed is a geographic area that shares a hydrologic connection - all the water within that area drains to a common waterway. Water movement can be influenced by topography, soil composition and water recharge (i.e. precipitation, snow melt, groundwater) ("What is a Watershed", 2007). Watersheds are important because pollution at the water's source may impact water quality in all downgradient areas including its convergence with a common waterway. Understanding the watershed is an essential step in the TMDL process – an essential tool in maintaining water quality standards within Illinois.

The Fox River watershed spans across two states, Wisconsin and Illinois. The Fox River headwaters are located in Wisconsin. The river flows south into Illinois along the western portion of the Chicago Metropolitan suburban area. The watershed as a whole drains approximately 2,654 square miles (sq mi) with 1,723 sq mi located within Illinois (IDNR 1995) (Figure 2-1). The Fox River flows 115.1 miles from Wisconsin, through several Illinois Counties (Grundy, Kane, Kendall, Lake, La Salle, McHenry and Will) before discharging into the Illinois River at Ottawa.

The Illinois EPA 2008 Integrated Report (303(d)) List and Stream Assessment Report (Illinois EPA, 2008) divides the Fox River watershed into two portions: Upper Fox River watershed (USGS HUC:07120006) and the Lower Fox River watershed (USGS HUC:07120007) (Figure 2-1). The Illinois portion of the Upper Fox River is further divided into five smaller sub-watersheds (10-digit hydrologic unit codes). Three of these sub-watersheds (Nippersink Creek, North Branch Nippersink Creek and Squaw Creek) drain through a hydraulically connected system of lakes, commonly known as the Chain of Lakes, to the Fox River. The remaining two, Flint Creek (HUC: 0712000611) and Poplar Creek (HUC: 0712000612), comprise the southern portion of the Upper Fox River watershed and drain approximately 355 square miles (57%) of the Illinois portion of the Upper Fox River watershed. The impaired segments within the southern portion of the Upper Fox River (i.e., non Chain of Lakes) watershed are within the Flint Creek sub-watershed.

This Upper Fox River/Flint Creek watershed drains 169 square miles in Lake, McHenry and Cook, representing 27% of the Illinois portion of the Upper Fox River watershed. The Upper Fox River/Chain of Lakes watershed drains to the Fox River at the upstream end of the Fox River in the Upper Fox River/Flint Creek watershed, adding an additional 267 square miles to the drainage area within Illinois (total Illinois 436 sq mi). The impaired portion of these subbasins is approximately 401 square miles and is illustrated on Figure 2-2. Figure 2-2 also identifies those waterbodies that are listed for TMDL development in the Upper Fox River/Flint Creek watershed.

2.2 Topography

Topography influences soil types, precipitation, and subsequently watershed hydrology and pollutant loading. For the Upper Fox River/Flint Creek watershed, a USGS 30-meter resolution Digital Elevation Model (DEM) was obtained from the Illinois Natural Resources Geospatial Data Clearinghouse, and two foot topography developed by Lake County from LIDAR imagery to characterize the topography. Figure 2-3 displays elevations in color ramp throughout the watershed.

Figure 2-1: Fox River Watershed

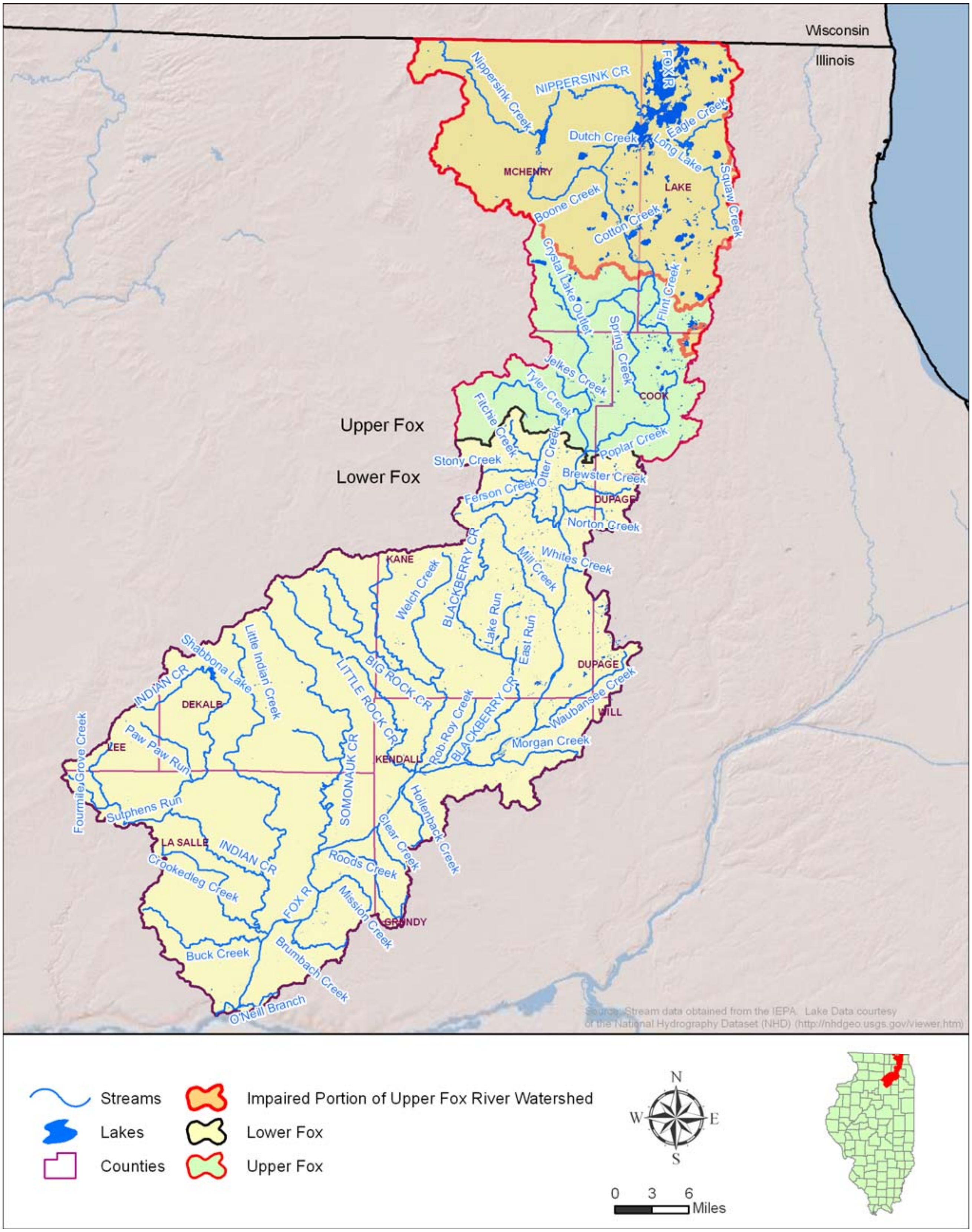


Figure 2-2: Upper Fox River/Flint Creek Impaired Watershed Map

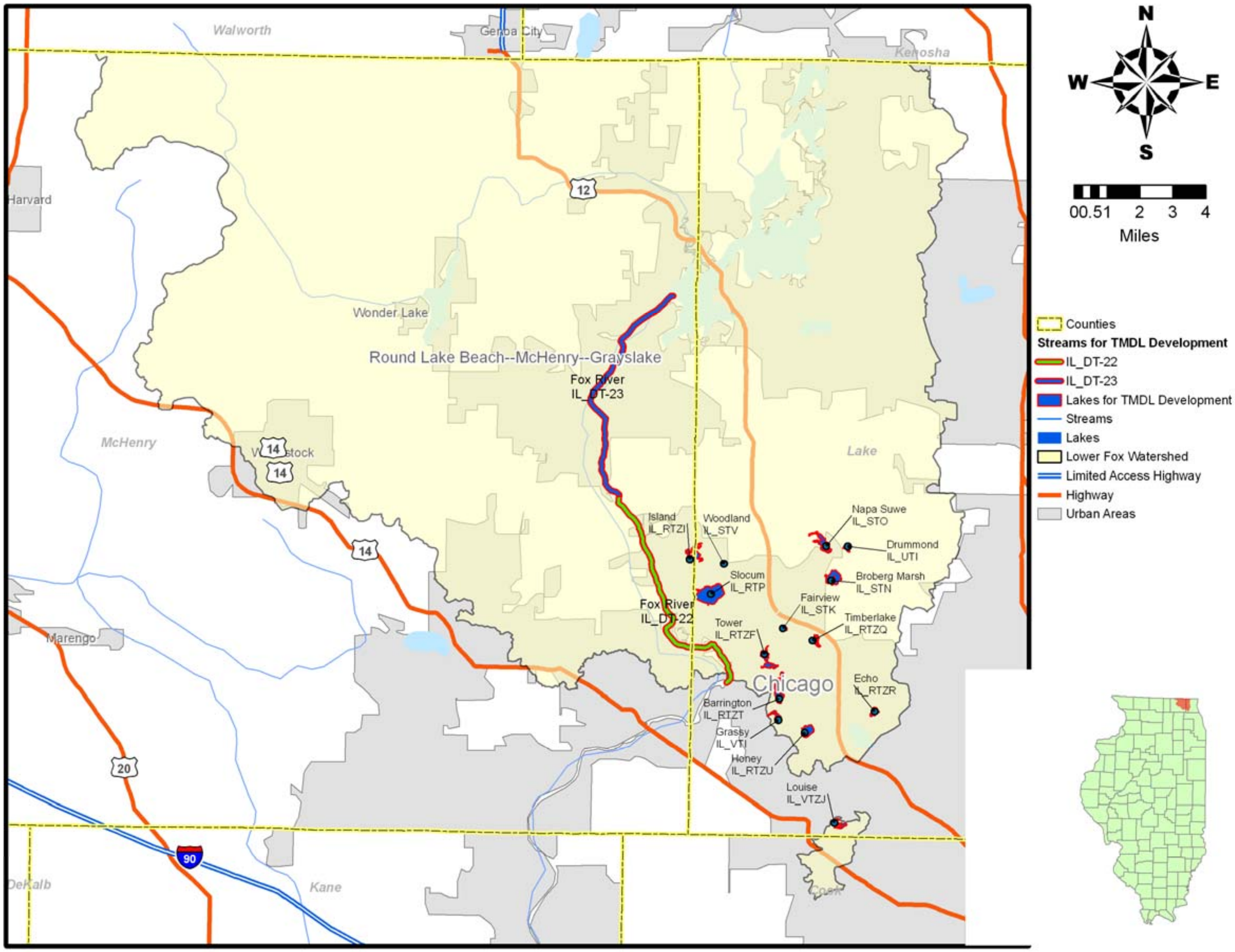
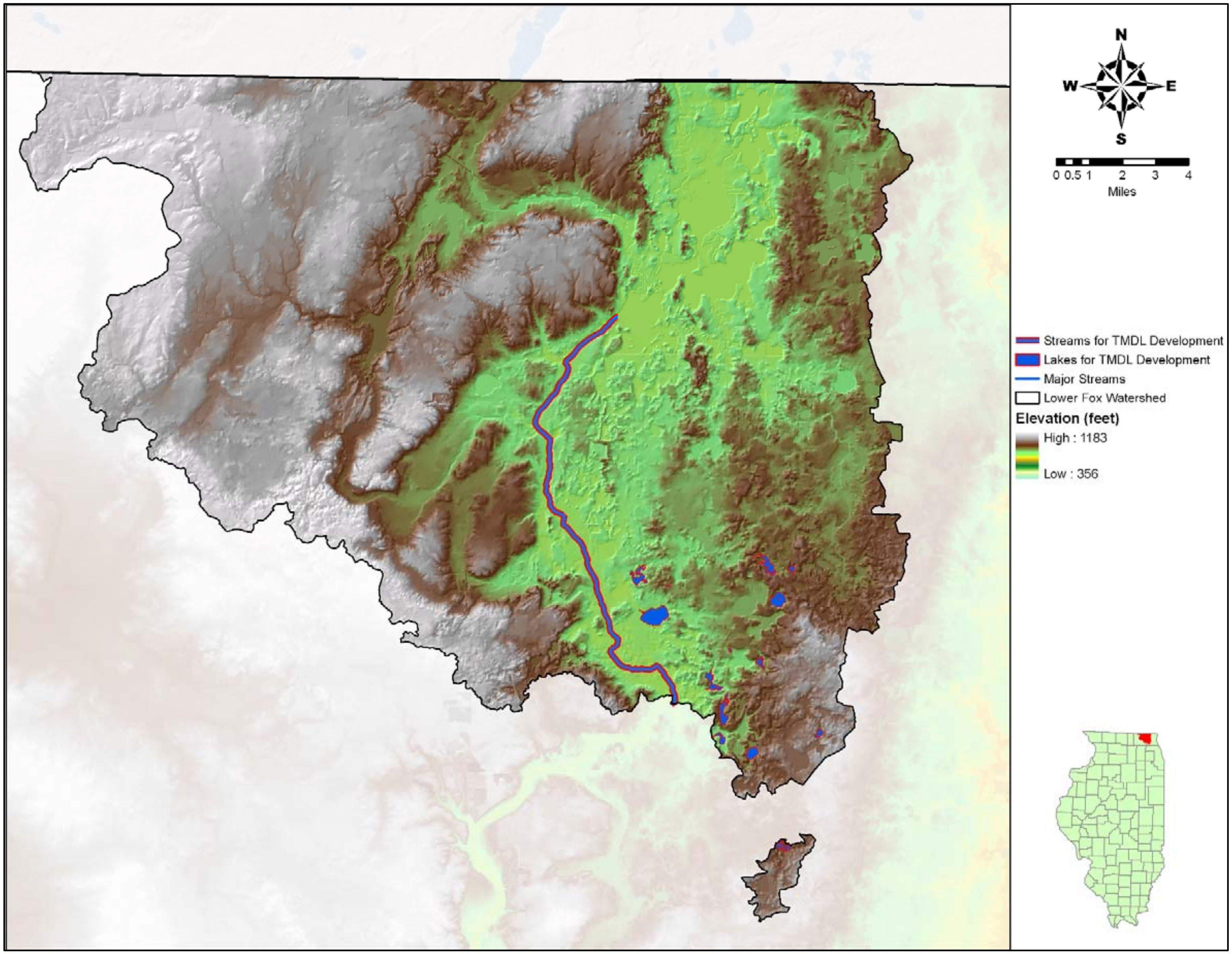


Figure 2-3: Upper Fox River/Flint Creek Impaired Watershed Digital Elevation Model (DEM)



In general, the higher elevations are located in the western portion of the watershed with a gradation to a lower elevation in the west/northwest toward the Upper Fox River and Chain of Lakes. Elevations to the east are also higher than the area surrounding the Fox River and Chain of Lakes, resulting in an overall surface water flow toward the center of the watershed. The percent change of elevation across the Upper Fox River/Flint Creek watershed is approximately 38% and ranges from 1183 feet to 730 feet.

The Fox River flows southward from Wisconsin at 793 feet through the Chain of Lakes and exits the chain at about 732 feet. Water level within the Chain of Lakes is artificially maintained by the dam at McHenry (also known as the Stratton Dam), which was constructed in 1907. Although the dam impounds water, the Chain of Lakes was naturally formed by glaciers. The stream gradient of the Fox River downstream to the terminus of the impaired waterbody watershed is minimal (approximately 1 foot), with the lowest point along the river with an elevation of 730 feet.

2.3 Land use

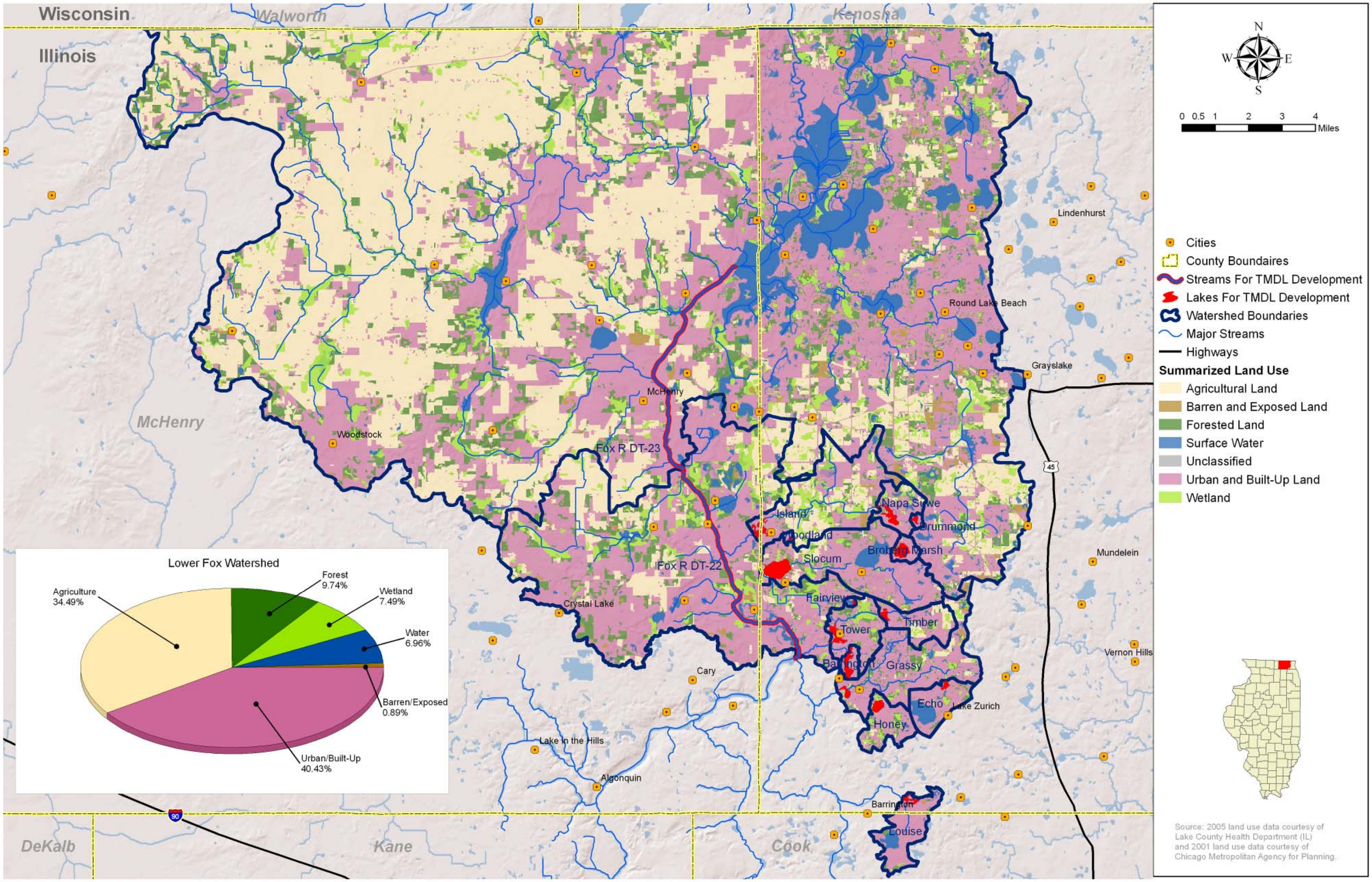
Land use is as dynamic as the water moving throughout a watershed. It is constantly changing and has a large impact on water quality. Land use data for the impaired portion of Upper Fox River/Flint Creek watershed within Lake County were obtained from Lake County Stormwater Management Commission (SMC). This data set is an update of the 2000 land use inventory data set for the County. The Lake County 2000 land use code definitions have been retained for the most part, but have been modified to identify land uses of special interest to the County and municipalities in 2005.

Land use data for the rest of the watershed were extracted from the 2001 land use inventory provided by the Chicago Metropolitan Agency for Planning (C-MAP). Land use is aggregated to 48 categories, and was created using black and white orthorectified aerial photography that was captured in April 2001. In addition to orthorectified aerial photography for the region, numerous GIS reference layers and several internet resources were used to support the Land Use Inventory. Land use interpretation methods and the consequent classification were conducted using a systematic approach working in thematic waves. The minimum land use classification area size was 1 acre or 2.5 acres (within the City of Chicago 0.5 acre or 1 acre), depending upon the type of land use being classified. Land use categories define homogeneous areas and represent features as they appear on the earth's surface. They are not generalized to any other geography. 2005 land use extents of Lake County were used to remove the exact portion of 2001 land use. The two layers were then merged. Land use codes from each data set were used to define the appropriate description and then combined into the appropriate classes, such as urban, agriculture, forest, water, wetland, barren or exposed lands.

Much of the Upper Fox River/Flint Creek watershed was forested prior to 1840. These forests were clear cut and converted to row crop agriculture. The progression of land use changes from agriculture to residential and urban use has increased with time. Urban land use now dominates in the impaired portion of the Upper Fox River/Flint Creek watershed with 40% of the area classified as urban (Figure 2-4). Agricultural areas (i.e. row crops, grain, grazing, and pasture) still comprise a large portion of the land use (37%), however. Much of the urban land is located in the near the Chain of Lakes and in the southern portion of the watershed. Forested land accounts for only 10% of the land use. Surface water and wetlands each comprise about 7% of the watershed.

It is noted that Chicago Metropolitan Agency for Planning (C-MAP) is finalizing the consolidated land use data for the six northeast Illinois Counties. This data will be used for Stage 3 work once available.

Figure 2-4: Land Use in the Impaired Portion of the Upper Fox River/Flint Creek Watershed



2.4 Soils

Soils data and Geographic Information Systems (GIS) files from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Upper Fox River/Flint Creek watershed. General soils data and map unit delineations for the country are provided as part of the Soil Survey Geographic (SSURGO) database. Field mapping methods using national standards are used to construct the soil maps in the SSURGO database. Mapping scales generally range from 1:12,000 to 1:63,360; SSURGO is the most detailed level of soil mapping prepared by the NRCS. A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. The SSURGO database contains many soil characteristics associated with each map unit.

SSURGO data were analyzed based on drainage class (Figure 2-5), hydrologic group (Figure 2-6) and K-factor (Figure 2-7), a coefficient of the Universal Soil Loss Equation (USLE). The drainage class, as stated in the SSURGO database is, “The natural drainage condition of the soil [which] refers to the frequency and duration of wet periods” (Soil Survey Staff, “Table Column Descriptions”). Poorly drained soils can be found in areas where there is frequent flooding such as land adjacent to lakes and streams. Excessively drained areas are also present around the lakes and may be natural in nature or due to anthropogenic sources such as construction of residential and paved areas. The western portion in the higher elevation areas are well to excessively drained (Figure 2-5). The eastern portion of the watershed is for the most part, is poorly drained.

Soils that remain saturated or inundated for a sufficient length of time become hydric through a series of chemical, physical, and biological processes. Once a soil takes on hydric characteristics, it retains those characteristics even after the soil is drained. Therefore, hydric soils are the best indicator of what is or once was a wetland (SMC 2007). Wetlands help control flooding by retaining water when it rains and then releasing it slowly back into lakes and streams. The longer a soil is inundated the more likely it is that it will become hydric.

The hydrologic soil group classification identifies soil groups with similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while well-drained sandy soils have the greatest infiltration rates. The United States Department of Agriculture (USDA) has defined four hydrologic groups (A, B, C, or D) for soils. Type A soil has high infiltration while D soil has very low infiltration rate. Figures 2-6 show the distribution of hydrologic soil groups. Generally, areas to the east have a moderately slow infiltration rate (hydrologic group C). Areas near the lakes contain both slow (hydrologic group D) to moderately high infiltration rates (hydrologic group B). High infiltration rates near the lakes may be anthropogenic in nature. The central and much of the western portion of the watershed is mostly hydrologic group B with a moderately high infiltration rate and corresponds to the well drainage class.

A commonly used soil attribute of interest is the K-factor, a dimensionless coefficient used as a measure of a soil’s natural susceptibility to erosion. Factor values range from 0 for water surfaces to 1.00 (although in practice, maximum K-factor values do not generally exceed 0.67). Large K-factor values reflect greater potential soil erodibility.

The compilation of K-factors from the SSURGO data was performed in several steps. Soils are classified in the SSURGO database by map unit symbol. Each map unit symbol is made up of components consisting of several horizons (or layers). The K-factor was determined by selecting the dominant components in the most surficial horizon per each map unit. The distribution of K-factor values in the impaired portion of the Upper Fox River/Flint Creek watershed is shown in Figure 2-7. Areas with the highest K-factor can be found on the western side of the watershed, while the eastern side of the watershed contains moderate to low erosion potential.

Figure 2-5: SSURGO Drainage Class in the Impaired Portion of the Upper Fox River/Flint Creek Watershed

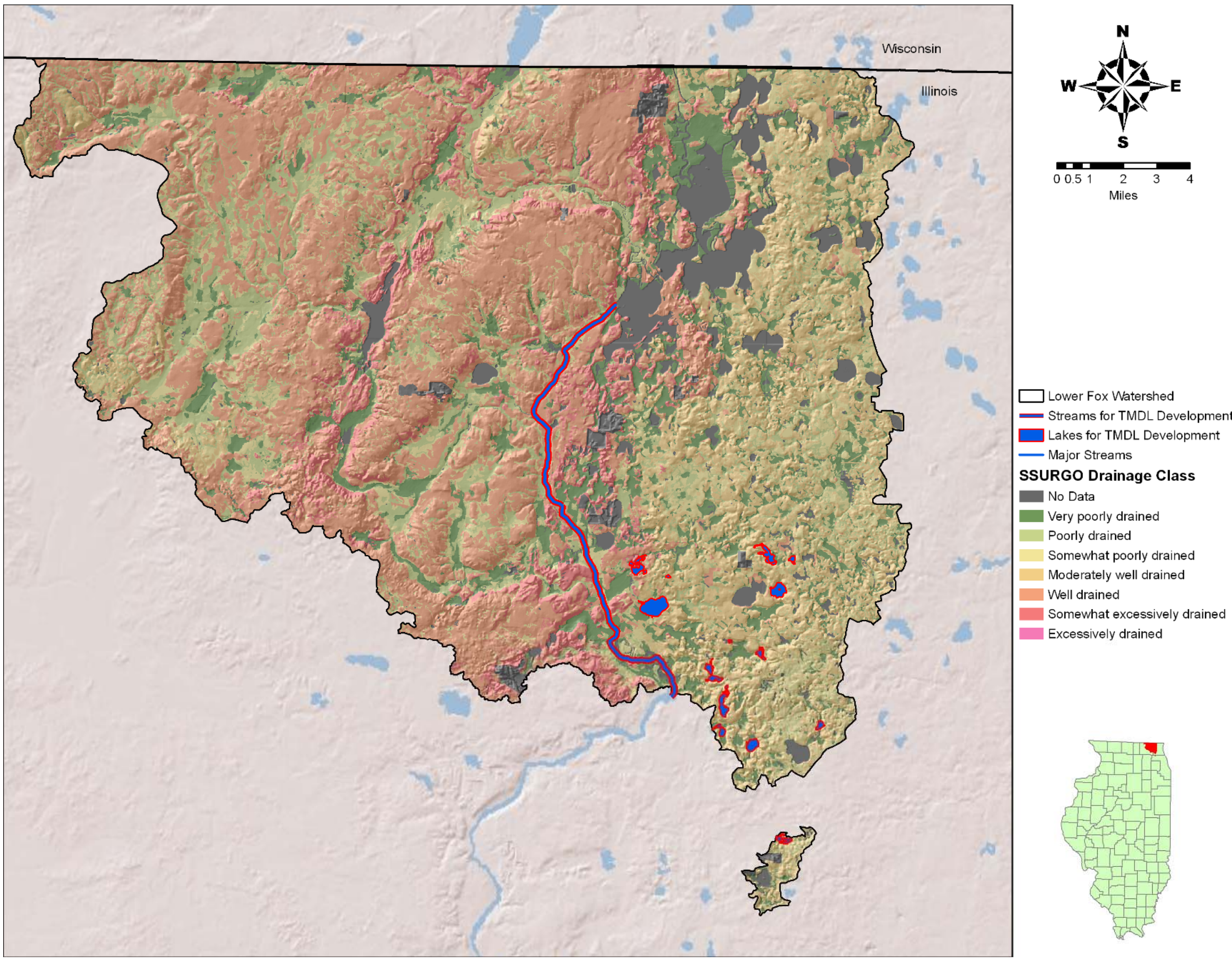


Figure 2-6: SSURGO Hydrologic Group in the Impaired Portion of the Upper Fox River/Flint Creek Watershed

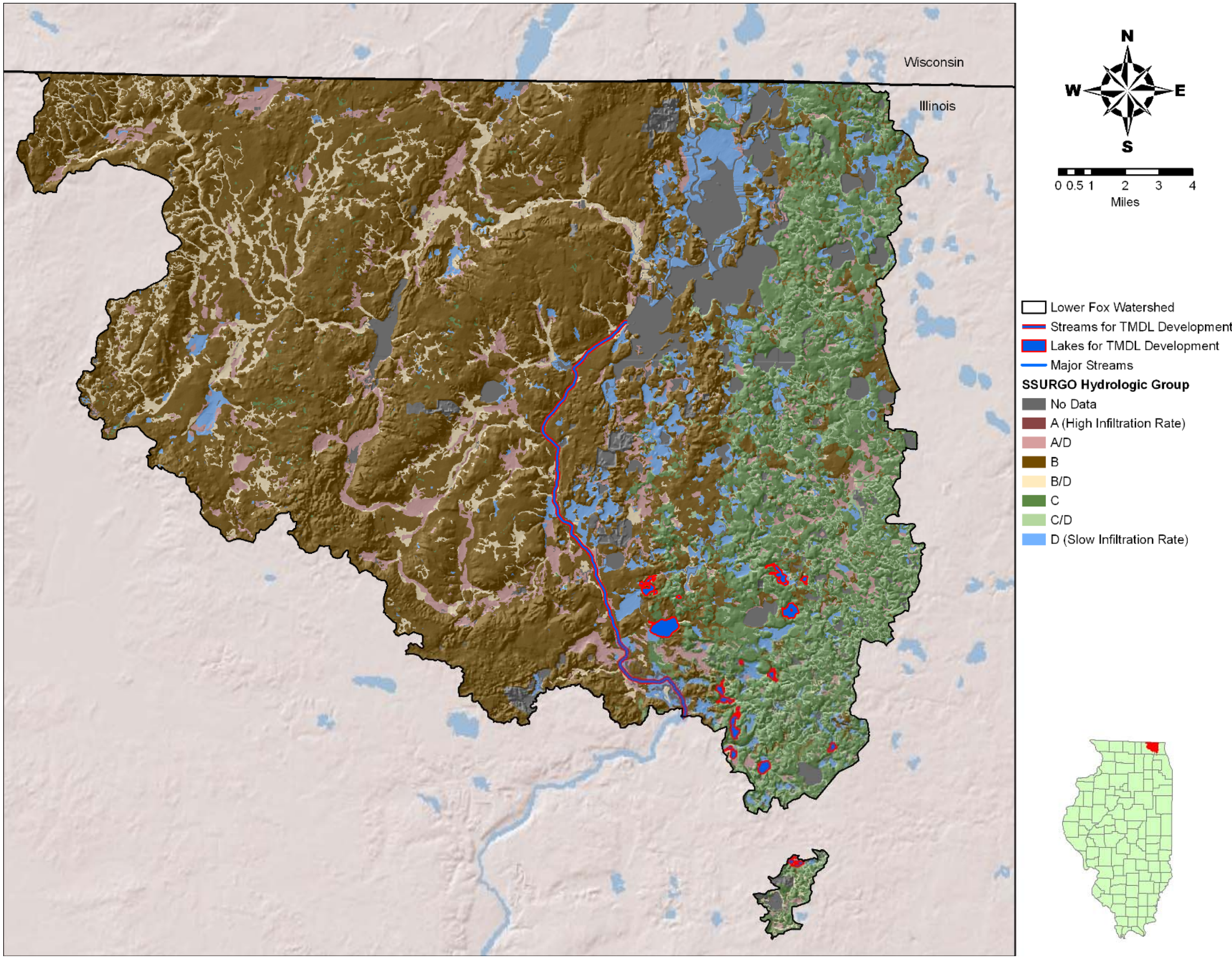
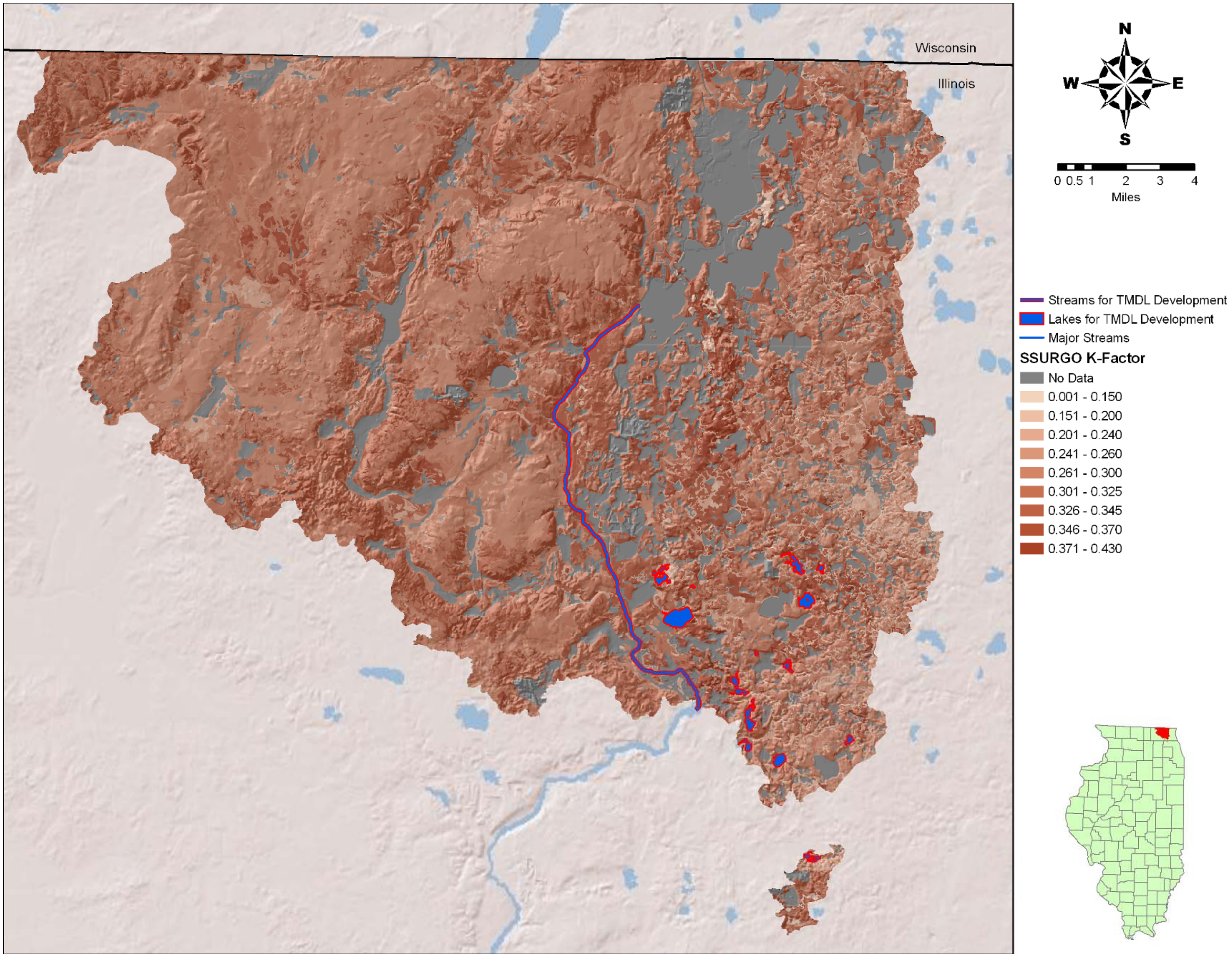


Figure 2-7: SSURGO K-Factor in the Impaired Portion of the Upper Fox River/Flint Creek Watershed



2.5 Population

Circumstances in the Upper Fox River/Flint Creek watershed today are not only the product of the geologic and natural processes that have occurred in the watershed, but also a reflection of human impacts and population growth. Development has changed the watershed's natural drainage system as channelization and dredging have replaced slow moving, shallow streams and wetlands. This alteration has affected the way water runs off of the landscape both in increased volume and velocity, resulting in the potential increase in pollutant transport.

The area surrounding the Chain of Lakes is primarily residential and recreational areas. Land was first developed around the Chain of Lakes for agriculture in the 1840's. Since that time much of the shorelines of the Chain of Lakes have been developed for housing, restaurants, marinas and recreation (Kothandaraman et al., 1977). The Fox River watershed as a whole accounts for nearly 11% of the state of Illinois' population at roughly 1,000,000 individuals (McConkey et al., 2004). Census 2000 data in format of TIGER/Line Shape file were downloaded to analyze the population in the targeted TMDL watershed of this report. Census data were also available for groups of census blocks, but the original census block data were used since it is a finer resolution and, therefore, more precise.

The Upper Fox River/Flint Creek watershed accounts for about 321,000 persons with an average of 1,500 persons per square mile. In comparison, the entire Fox River watershed has about 600 persons per square mile. Census blocks with the highest populations can be found in the central western and northwestern portion part of this watershed near the cities of Round Lake Beach and Woodstock, respectively.

The Illinois Department of Commerce and Economic Opportunity provide population projections by municipality on their website ("Population Projections", 2005). Figure 2-8 depicts the percent population change in the watershed from 2000 to 2030. Table 2-1 provides the most recent census population data and projected population numbers by town. In general, the central portion of the watershed is projected the most growth at an increase by 7000%. The town of Volo with a population of 180 persons in 2000, is projected to grow to 13,686 persons by 2030 – a significant increase at 7500%. Prairie Grove, located west of the Fox River, is project to grow by 1200%. The eastern portion of the watershed will also see growth but not as great as the southwest. Antioch and Lake Villa are proposed to grow by 94-248%, while Round Lake Park is said to increase by 249-377%. This magnitude of growth will result in land use changes and have the potential to impact water quality if these areas are not responsibly developed, utilizing the most effective and innovative technologies to protect the water resources within the Upper Fox River/Flint Creek watershed.

Figure 2-8: Population Projection in the Impaired Portion of the Upper Fox River/Flint Creek Watershed

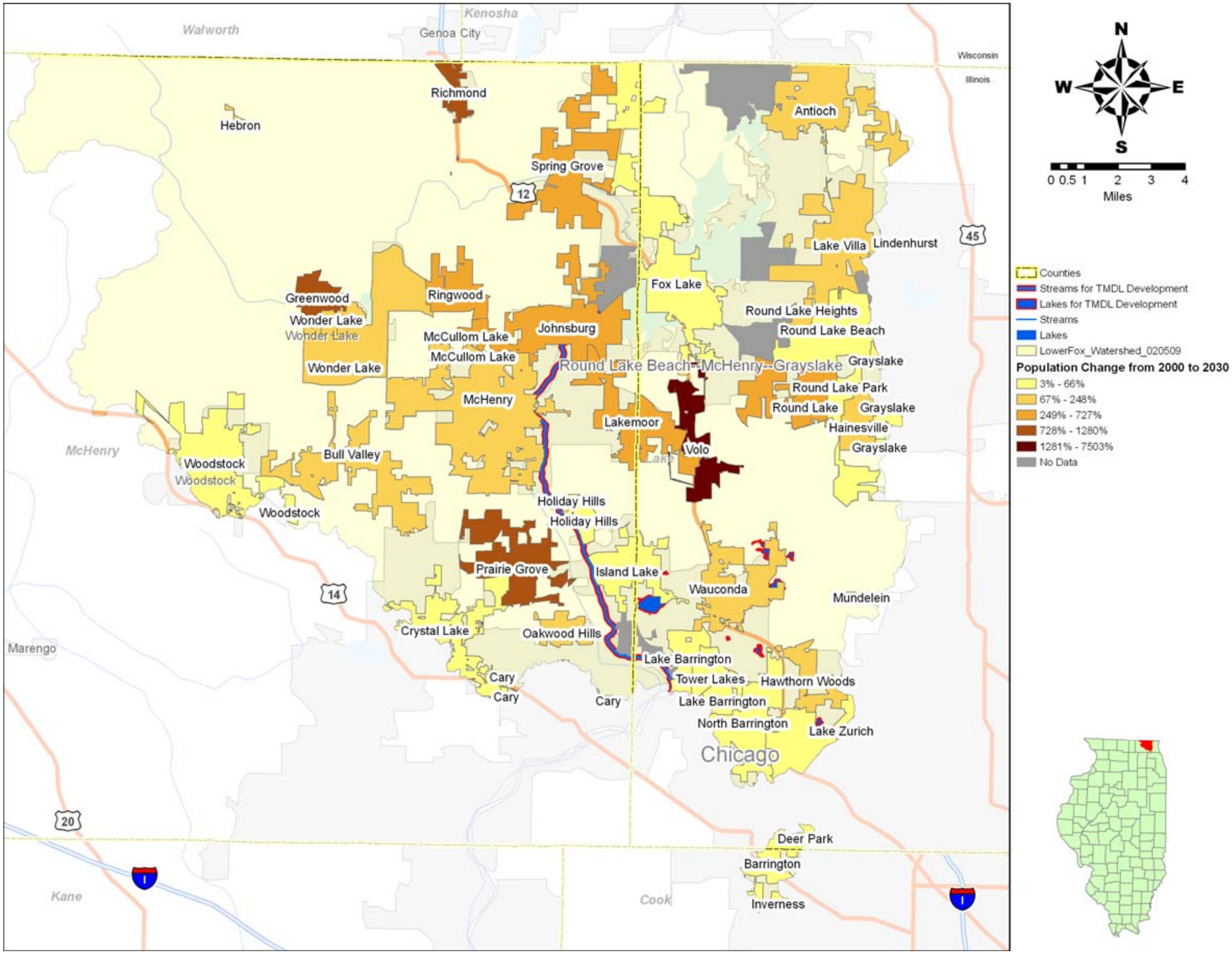


Table 2-1: Population and Projections for the Impaired Portion of the Upper Fox River/Flint Creek Watershed

Town/Village	2000 Population	2000 Population/Mi^2	Projected 2030 Population	Projected 2030 Population/Mi^2	Area (Mi^2)
Antioch	8788	1209	30594	4208	7.3
Barrington	10168	2159	10429	2214	4.7
Bull Valley	726	126	2435	424	5.7
Cary	15531	2930	22036	4158	5.3
Crystal Lake	38000	2234	44363	2608	17.0
Deer Park	3102	834	3846	1034	3.7
Fox Lake	9178	1013	12589	1390	9.1
Grayslake	18506	1969	24094	2563	9.4
Greenwood	244	154	3289	2082	1.6
Hainesville	2129	1145	4118	2214	1.9
Hawthorn Woods	6002	1057	15951	2808	5.7
Hebron	1038	1504	2074	3006	0.7
Holiday Hills	831	857	1053	1086	1.0
Inverness	6749	1050	7069	1099	6.4
Island Lake	8153	2664	13557	4430	3.1
Johnsburg	5391	828	23024	3537	6.5
Lake Barrington	4757	853	5695	1021	5.6
Lakemoor	2788	614	23055	5078	4.5
Lake Villa	5864	913	16546	2577	6.4
Lake Zurich	18104	2662	20571	3025	6.8
Lindenhurst	12539	3051	19843	4828	4.1
McCullom Lake	1038	3579	1997	6885	0.3
McHenry	21501	1790	48502	4038	12.0
Mundelein	30935	3430	34126	3783	9.0
North Barrington	2918	626	3542	760	4.7
Oakwood Hills	2194	1844	4263	3582	1.2
Prairie Grove	960	202	12076	2542	4.8
Ringwood	471	196	1890	787	2.4
Round Lake	5842	1583	27338	7409	3.7
Round Lake Beach	25859	5041	29900	5828	5.1
Round Lake Heights	1347	2245	2552	4254	0.6
Round Lake Park	6038	1973	9954	3253	3.1
Spring Grove	3880	598	18523	2854	6.5
Tower Lakes	1310	1170	1442	1287	1.1
Volo	180	68	13686	5145	2.7
Wauconda	9448	2197	25653	5966	4.3
Wonder Lake	7463	1077	2715	392	6.9
Woodstock	20151	1923	30522	2912	10.5
Richmond	1091	796	15059	10992	1.4

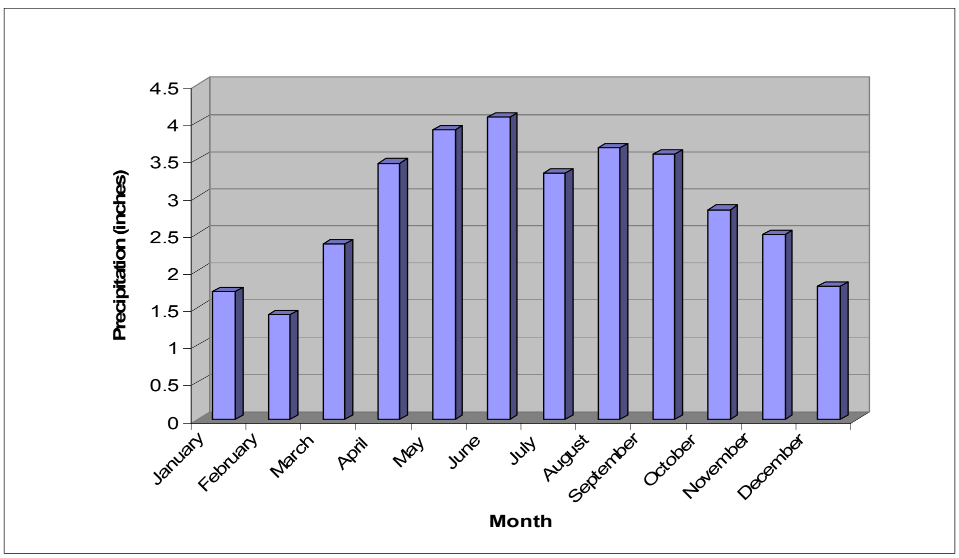
2.6 Climate and Precipitation

Northeast Illinois has a continental climate, with highly variable weather. The temperatures of continental climates are not buffered by the influence of a large waterbody (like an ocean, inland sea or Great Lake). Areas with continental climates often experience wide temperature fluctuations throughout the year. Summer maximum temperatures are generally in the 80s or low 90s while daily high temperatures in the winter are generally between 20 to 30^{o}F (McConkey, 2004). Temperature and precipitation data were obtained from the Illinois State Climatologist Office website. There are several climate monitoring stations within the Upper Fox River/Flint Creek watershed. One of them is in the city of Elgin, which is located approximately 25 miles southwest of the watershed.

Climate data were analyzed for the city of Elgin between the years of 1911 to 2007 although data were not available for all years. Based on the available data, the mean high summer temperature is 82.2° F and the mean low temperature in winter is 15.7° F. Mean annual high temperatures are about 58° F, while mean annual low temperatures are about 38° F.

The mean monthly precipitation in Elgin from 1911-2007 (data not available all years) can be found in Figure 2-9. Elgin receives most of its precipitation in the spring and summer months, with the greatest precipitation occurring in June at around 4.1 inches. The least precipitation is received in February at around 1.4 inches on average. Annual total precipitation averages about 34.5 inches.

Figure 2-9: Mean Monthly Precipitation in Elgin, IL (1911-2007)



2.7 Hydrology

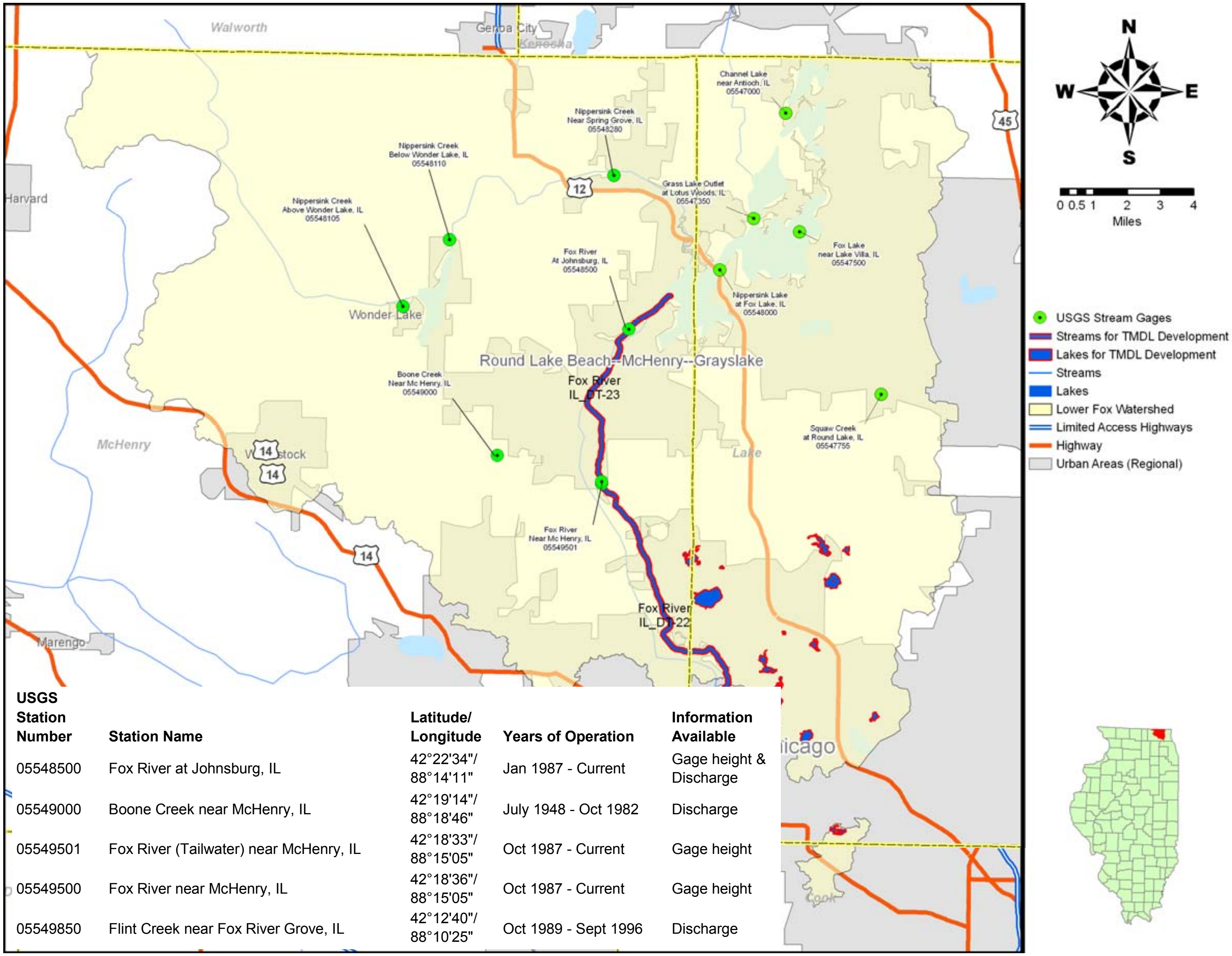
Understanding how water moves and flows is an important component of understanding a watershed. All parameters discussed in the previous sections (i.e. topography, soils, and precipitation) impact hydrology. Hydrological data are available from the United States Geological Survey website (USGS Water Data for the Nation http://waterdata.usgs.gov/nwis). The USGS maintains stream gages throughout the US which monitor conditions such as gage height, stream flow and precipitation at select locations.

There are five USGS gages within the Upper Fox River/Flint Creek watershed (Figure 2-10). There are also eight USGS gages within the upstream watershed, Upper Fox River/Chain of Lakes. Only one Upper Fox River/Flint Creek watershed gage has stream flow (or discharge) information from the past 10 years (Fox River at Johnsburg, IL). Data for this gage are summarized in Figures 2-11 and 2-12. The Fox River at Johnsburg, IL gage (05548500) is located approximately 1.6 miles downstream of the Pistakee Lake outlet and captures surface flow from 1,205 square miles. This gage is a Real Time (continuous monitoring) station and contains data from January 1987 to the present day. However, discharge data are only available at this gage from December 1997 to mid August 1999.

Flow data for the period of record (December 1997 to August 1999) were used to establish a flow duration curve. Duration curves are typically generated based on a long term dataset, however only the period of December 1997 to August 1999 was available. This curve shows the percentage of time flows are met or exceeded based on the period of record. Duration curves can be used to determine the percentage of time a given flow is expected to be equaled or exceed. Alternatively the duration curve could be used to determine the flow that is equaled or exceed for some percentage of time. Flow duration curves were developed by ranking flows from highest to lowest and calculating the probability of occurrence (presented as a percentage or duration interval), where zero corresponds to the highest flow. A flow duration curve and mean monthly stream flow graphic for the Fox River at Johnsburg gage are provided in Figures 2-11 and 2-12.

The highest stream flow generally occurs during the spring and early summer, with late summer-early fall experiencing the lowest flows on average (Figure 2-12). Minimum and maximum mean daily stream flow for the Fox River at Johnsburg gage was 239 and 4610 cfs, respectively. The median daily flow is 953 cfs (Figure 2-11), with a mean daily flow of 1193 cfs.

Figure 2-10: Upper Fox River/Flint Creek Watershed USGS Gage Stations



USGS Station Number	Station Name	Latitude/ Longitude	Years of Operation	Information Available
05548500	Fox River at Johnsburg, IL	42°22'34"/ 88°14'11"	Jan 1987 - Current	Gage height & Discharge
05549000	Boone Creek near McHenry, IL	42°19'14"/ 88°18'46"	July 1948 - Oct 1982	Discharge
05549501	Fox River (Tailwater) near McHenry, IL	42°18'33"/ 88°15'05"	Oct 1987 - Current	Gage height
05549500	Fox River near McHenry, IL	42°18'36"/ 88°15'05"	Oct 1987 - Current	Gage height
05549850	Flint Creek near Fox River Grove, IL	42°12'40"/ 88°10'25"	Oct 1989 - Sept 1996	Discharge

Figure 2-11: Mean Daily Flow Duration Curve for the Fox River at Johnsburg, IL (USGS 05548500) 1997-1999

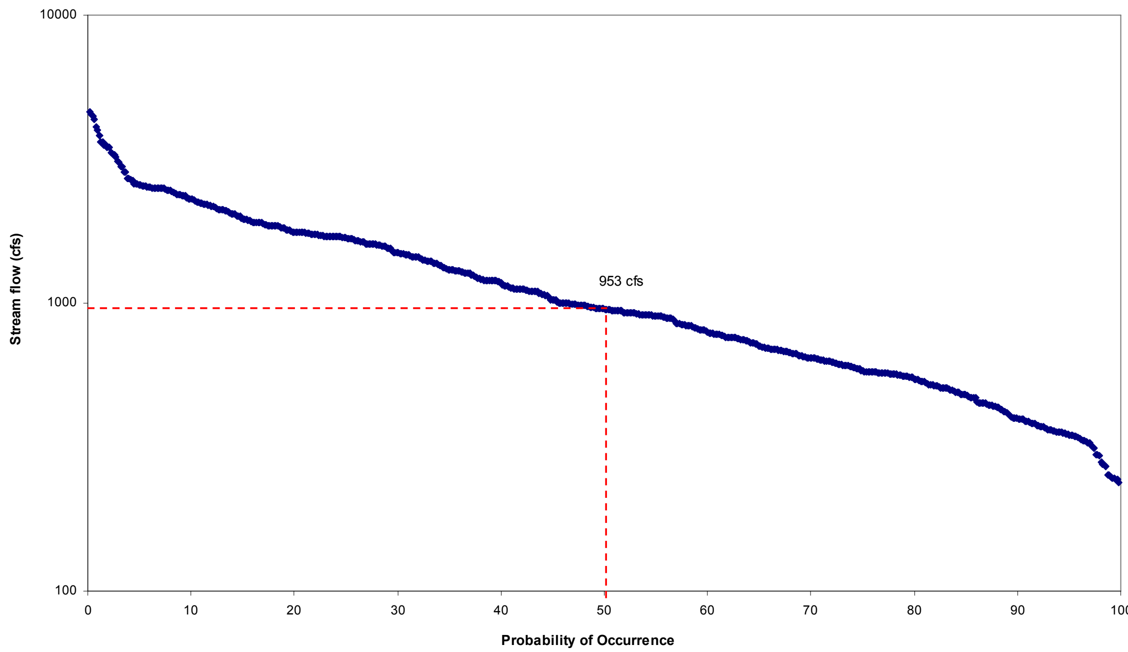
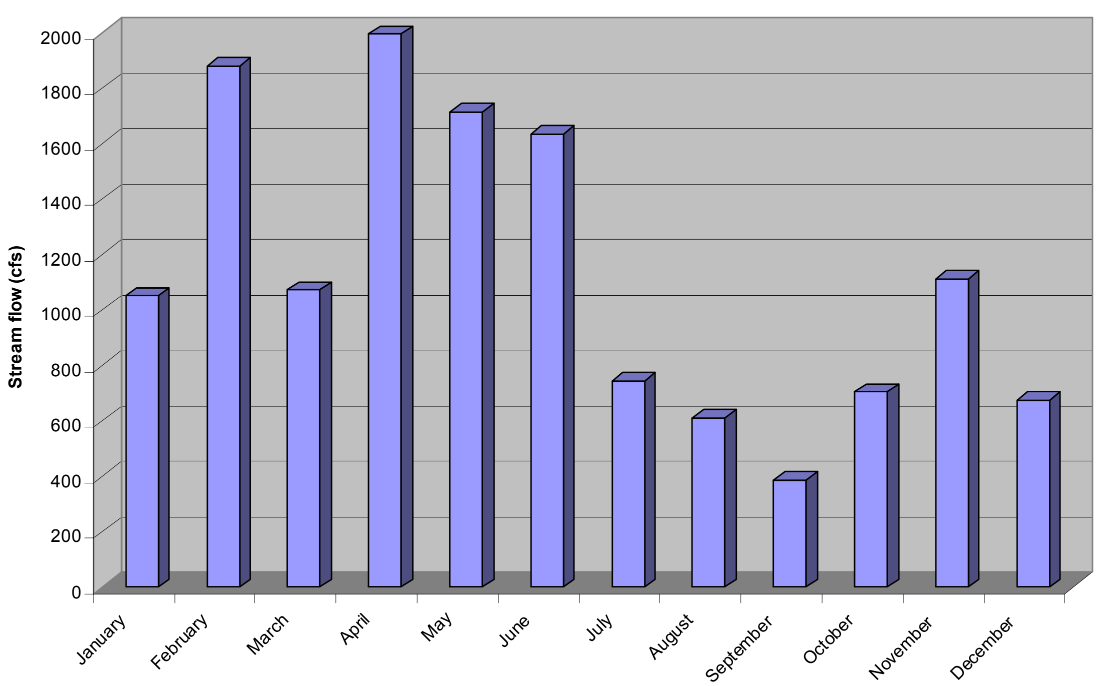


Figure 2-12: Mean Monthly Flow for Fox River at Johnsburg, IL (USGS 05548500) 1997-1999



3.0 Public Participation and Involvement

The Illinois EPA is committed to keeping the watershed stakeholders and general public informed and involved throughout the TMDL process. Success for any TMDL implementation plan relies on a knowledgeable public able to aid in the follow-through needed for their watershed to meet the recommended TMDL. It is important to engage the local citizens as early in the process as possible by providing opportunities to learn and process information. This is to ensure that concerns and issues are identified at an early stage, so that they can be addressed and facilitate maximum cooperation in the implementation of the recommended courses of actions identified in the TMDL process. All stakeholders should have access to enough information to allay concerns, gain confidence in the TMDL process and understand the purpose and the regulatory authority that will implement any recommendations.

Illinois EPA, along with ENSR/AECOM, will hold up to two public meetings within the Upper Fox River/Flint Creek watershed throughout the course of TMDL development. This section will be updated after public meetings have occurred. General information regarding the process of TMDL development in Illinois can be found at http://www.epa.state.il.us/water/tmdl. This link also contains paths to notice of public meetings and other TMDL-related watershed information for the entire state of Illinois.

Background learning about watersheds, watershed management, best management practices and the Clean Water Act (CWA) can be found on the EPA's water website at http://www.epa.gov/watertrain/.

For other reports and studies concerning the Fox River Watershed please visit the Illinois Rivers Decision Support System: Fox River Watershed Investigation website (http://ilrdss.sws.uiuc.edu/fox/). The website contains reports, data and additional links to other sources specifically related to this watershed. Lake County reports can be found at: http://www.lakecountyil.gov/Health/want/LakeReports.htm. This website contains detailed lake reports for lakes sampled by Lake County's Lake Management Unit.

4.0 Applicable Water Quality Standards and TMDL Targets

Water pollution control programs are designed to protect the beneficial uses of the water resources within the state. Each state has the responsibility to set water quality standards that protect these beneficial uses, also called “designated uses.” Illinois waters are designated for various uses including aquatic life, wildlife, agricultural use, primary contact (e.g., swimming, water skiing), secondary contact (e.g., boating, fishing), industrial use, drinking water, food-processing water supply and aesthetic quality. Illinois’ WQS provide the basis for assessing whether the beneficial uses of the state’s waters are being attained.

4.1 Illinois Pollution Control Board

The Illinois Pollution Control Board (IPCB) is responsible for setting WQS to protect designated uses. The federal CWA requires the states to review and update their WQS every three years. Illinois EPA, in conjunction with US EPA, identifies and prioritizes those standards to be developed or revised during the three-year period. The IPCB has established four primary sets (or categories) of narrative and numeric water quality standards for surface waters: general use, public and food processing, secondary contact and indigenous aquatic life, and Lake Michigan basin standards. Each set of standards is intended to help protect various designated uses established for each category.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois WQS are established in the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, 303, Water Quality Standards.

Water resource management activities involving interstate waters are also coordinated with various interstate committees and commissions. The Illinois EPA participates in water resource management activities of the Association of State and Interstate Water Pollution Control Administrators, International Joint Commission of the Great Lakes Water Quality Board, Ohio River Valley Water Sanitation Commission, Upper Mississippi River Conservation Committee, Upper Mississippi River Basin Association, Council of Great Lakes Governors, and other interstate committees, and commissions

4.2 Designated Uses

The waters of Illinois are classified by designated uses assessed in 2008 (Table 4-1). Designated uses applicable to the Upper Fox River/Flint Creek watershed include: aesthetic quality, aquatic life, and primary contact recreation. The corresponding water quality standard classification for these designated uses is the General Use classification.

The General Use classification is defined by IPCB as: The General Use standards will protect the state's water for aquatic life, wildlife, agricultural use, secondary contact use and most industrial uses and ensure the aesthetic quality of the state's aquatic environment. Primary contact uses are protected for all General Use waters whose physical configuration permits such use.

Table 4-1: Illinois Designated Uses and Assessment Levels			
Waterbody Name	**Designated Use**	**Assessed?**	**Assessment Level**
Drummond, Echo, Grassy, Fairview, Napa Suwe, Louise, Slocum, Timberlake, Woodland	Aquatic Life	Yes	Fully Supporting
	Fish Consumption	No	Not Assessed
	Primary Contact	No	Not Assessed
	Secondary Contact	No	Not Assessed
	Aesthetic Quality	Yes	Not Supporting
Barrington, Honey, Tower	Aquatic Life	Yes	Fully Supporting
	Fish Consumption	No	Not Assessed
	Primary Contact	Yes	Not Supporting
	Secondary Contact	No	Not Assessed
	Aesthetic Quality	Yes	Not Supporting
Island	Aquatic Life	Yes	Fully Supporting
	Fish Consumption	No	Not Assessed
	Primary Contact	Yes	Fully Supporting
	Secondary Contact	Yes	Fully Supporting
	Aesthetic Quality	Yes	Not Supporting
Woodland	Aquatic Life	Yes	Not Supporting
	Fish Consumption	No	Not Assessed
	Primary Contact	No	Not Assessed
	Secondary Contact	No	Not Assessed
	Aesthetic Quality	Yes	Not Supporting
Fox River (DT-22)	Aquatic Life	Yes	Not Supporting
	Fish Consumption	Yes	Not Supporting
	Primary Contact	Yes	Not Supporting
	Secondary Contact	No	Not Assessed
	Aesthetic Quality	No	Not Assessed
Fox River (DT-23)	Aquatic Life	Yes	Not Supporting
	Fish Consumption	Yes	Not Supporting
	Primary Contact	Yes	Fully Supporting
	Secondary Contact	Yes	Fully Supporting
	Aesthetic Quality	No	Not Assessed

4.3 Assessing Designated Use Attainment

Designated use attainment is based on waterbody type and applies to aquatic life, fish consumption, primary and secondary contact, and aesthetic quality. The following sections regarding use attainment in Illinois were directly selected and excerpted from Illinois EPA's 305(b) report:

Aquatic life use assessments in streams are typically based on the interpretation of biological information, physicochemical water data and physical-habitat information from the Intensive Basin Survey, Ambient Water Quality Monitoring Network or Facility-Related Stream Survey programs. The primary biological measures used are the fish Index of Biotic Integrity (fIBI; Karr et al. 1986; Smogor 2000, 2005), the new macroinvertebrate Index of Biotic Integrity (mIBI; Tetra Tech, 2004) and the Macroinvertebrate Biotic Index (MBI; Illinois EPA 1994). Physical-habitat information used in assessments includes quantitative or qualitative measures of stream-bottom composition and qualitative descriptors of channel and riparian conditions. Physicochemical water data used include measures of "conventional" parameters (e.g., dissolved oxygen, pH, temperature), priority pollutants, non-priority pollutants, and other pollutants (USEPA 2002 and www.epa.gov/waterscience/criteria/wqcriteria.html). In a minority of streams for which biological information is unavailable, *aquatic life* use assessments are based primarily on physicochemical water data. Physicochemical data (from water and sediment) and habitat information play primary roles in identifying potential causes and sources of *aquatic life* use impairment.

Assessments of *aquatic life* use are based primarily on physical and chemical water quality data collected via the Ambient Lake Monitoring Program, the Illinois Clean Lakes Program, or by non-Illinois EPA persons under an approved quality assurance project plan. The physical and chemical data used for *aquatic life* use assessments include: Secchi-disk transparency, chlorophyll *a*, total phosphorus (epilimnetic samples only), nonvolatile suspended solids (epilimnetic samples only), and percent surface area macrophyte coverage. Data are collected a minimum of five times per year (April through October) from one or more established lake sites. Data are considered usable for assessments if meeting the following minimum requirements (Figure C-2): 1) at least four out of seven months (April through October) of data are available; 2) at least two of these months occur during the peak growing season of June through August (this requirement does not apply to NVSS); and 3) usable data are available from at least half of all lake sites within any given lake each month. A whole-lake TSI value is calculated for the median Secchi-disk transparency, median total phosphorus (epilemnetic sample depths only), and median chlorophyll *a* values. A minimum of two parameter-specific TSI values are required to calculate parameter-specific use support determinations. An assessment is then made based on the parameter-specific use support determinations. The 0.05 mg/L Illinois General Use Water Quality Standard for total phosphorus in lakes (35 Ill. Adm. Code 302.205) has been incorporated into the weighting criteria used to assign point values for the ALI.

Fish consumption use is associated with all water bodies in the state. The assessment of *fish consumption* use is based on water body-specific fish-tissue data and also on fish-consumption advisories issued by the Illinois Fish Contaminant Monitoring Program (FCMP). A list of water bodies having advisories can be found in the Illinois Department of Natural Resources' (IDNR) publication ***2007 Illinois Fishing Information*** (http://dnr.state.il.us/fish/digest/). Fish-consumption advisories are incorporated into the process for assessing *fish consumption* use as explained below.

The FCMP uses the U.S. Food & Drug Administration's (FDA) Action Levels as criteria for determining the need for advisories, except for polychlorinated biphenyls (PCBs), mercury, and chlordane. For these contaminants the FDA criteria have been replaced by a risk-based process developed in the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* (Anderson et al. 1993, herein after referred to as the Protocol). The Protocol requires the determination of a Health Protection Value (HPV) for a contaminant, which is then used with five meal consumption frequencies (eight ounces of uncooked filet): 1) Unlimited (140 meals/year); 2) One meal/week (52 meals/year); 3) One meal/month (12 meals/year); 4) One meal/two months (six meals/year); and 5) Do not eat (0 meals/year). The level of contaminant in fish is then calculated that will not result in exceeding the HPV at each meal consumption frequency. The Protocol also assumes a 50%

reduction of contaminant levels for organic chemicals (not used for mercury) when recommended cleaning and cooking methods are used. The HPVs, target populations, critical health effects to be protected by the HPVs, and the criteria for PCBs, mercury and chlordane for the various meal frequencies, are listed in Table C-13 (*of the 305(b)*) as well as the FDA action levels for other contaminants.

According to Illinois water quality standards, "primary contact" means "*...any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing*" (35 Ill. Adm. Code 301.355). The assessment of *primary contact* use is based on fecal coliform bacteria data. The General Use Water Quality Standard for fecal coliform bacteria specifies that during the months of May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliform bacteria counts shall not exceed a geometric mean of 200/100 ml, nor shall more than 10 percent of the samples during any 30-day period exceed 400/100 ml (35 Ill. Adm. Code 302.209). This standard protects *primary contact* use of Illinois waters by humans. Due to limited state resources, fecal coliform bacteria is not normally sampled at a frequency necessary to apply the General Use standard, i.e., at least five times per month during May through October, and very little data available from others are collected at the required frequency. Therefore, assessment guidelines are based on application of the standard when sufficient data is available to determine standard exceedances; but, in most cases, attainment of *primary contact* use is based on a broader methodology intended to assess the likelihood that the General Use standard is being attained.

To assess *primary contact* use, Illinois EPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period (i.e., 2002 through 2006 for this report). Based on these water samples, geometric means and individual measurements of fecal coliform bacteria are compared to the concentration thresholds in Tables C-16 and C-17 (*of the 305(b*)). To apply the guidelines, the geometric mean of fecal coliform bacteria concentration is calculated from the entire set of May through October water samples, across the five years. No more than 10% of all the samples may exceed 400/100 ml for a water body to be considered Fully Supporting.

According to Illinois water quality standards, "secondary contact" means *"...any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating and any limited contact incident to shoreline activity"* (35 Ill. Adm. Code 301.380). Although secondary contact use is associated with all waters of the state, no specific assessment guidelines have been developed to assess secondary contact use because existing water quality standards have no water quality criterion that specifically address this use. However, consistent with the meanings of these two uses, in any water where primary contact use is assessed as Fully Supporting, secondary contact use is also assessed as Fully Supporting. In all other circumstances secondary contact use is not assessed.

Attainment of *public and food processing water supply* use is assessed only in waters in which the use is currently occurring, as evidenced by the presence of an active public-water-supply intake. The assessment of *public and food processing water supply* use is based on conditions in both untreated and treated water (Table C-21). By incorporating data through programs related to both the federal Clean Water Act and the federal Safe Drinking Water Act, Illinois EPA believes that these guidelines provide a comprehensive assessment of *public and food processing water supply* use.

Assessments of *public and food processing water supply* use recognize that characteristics and concentrations of substances in Illinois surface waters can vary and that a single assessment guideline may not protect sufficiently in all situations. Using multiple assessment guidelines helps improve the reliability of these assessments. When applying these assessment guidelines, Illinois EPA also considers the water-quality substance, the level of treatment available for that substance, and the monitoring frequency of that substance in the untreated water.

Assessments of *aesthetic quality* use are based primarily on physical and chemical water quality data collected by the Illinois EPA through the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program, or by non-Illinois EPA persons under an approved quality assurance project plan. The physical and chemical data used for *aesthetic quality* use assessments include: Secchi-disk transparency, chlorophyll *a*, total phosphorus (epilimnetic samples only), nonvolatile suspended solids (epilimnetic samples only), and percent surface area macrophyte coverage. Data are collected a minimum of five times per year (April through October) from one or more established lake sites. Data are considered usable for assessments if meeting the following minimum requirements: 1) At least four out of seven months (April through October) of data are available, 2) At least two of these months occurs during the peak growing season of June through August (this requirement does not apply to NVSS) and 3) Usable data are available from at least half of all lakes sites within any given lake each month. As outlined in Figure C-3 (*of the 305(b)*), a whole-lake TSI value is calculated for the median Secchi-disk transparency, median total phosphorus (epilimnetic sample depths only), and median chlorophyll *a* values. A minimum of two parameter-specific TSI values are required to calculate a parameter-specific use support determination. An assessment is then made based on the parameter specific use support determinations. The 0.05 mg/L Illinois General Use Water Quality Standard for total phosphorus in lakes (35 Ill. Adm. Code 302.205) has been incorporated into the weighting criteria used to assign point values for the AQI. Table C-25 (*of the 305(b)*) lists the guidelines for identifying potential causes of *aesthetic quality* use impairment.

4.4 Applicable Illinois Water Quality Standards

To make 303(d) listing determinations for aquatic life uses, Illinois EPA first collects biological data and if these data suggest that impairment to aquatic life exists, then a comparison of available water quality data with WQS occurs. Table 4-2 summarizes the applicable General Use WQS for water quality parameters within the Upper Fox River/Flint Creek watershed.

Table 4-2: Applicable Water Quality Standards for the Upper Fox River/Flint Creek Watershed

Parameter	Units	Regulatory Statute	General Use Water Quality Standard
Dissolved Oxygen (above thermocline in thermally stratified waters or entire water column in unstratified waters)[1]	mg/L	Title 35, Subtitle C, Chapter I, Part 302.206	March – July 5.0 instantaneous minimum 6.0 as daily mean averaged over 7 days August – February 3.5 instantaneous minimum 4.0 as daily mean averaged over 7 days 5.5 as daily mean averaged over 30 days
Fecal Coliform	cfu/100 ml	Title 35, Subtitle C, Chapter I, Part 302.209	May – October 200 geometric mean based on a minimum of 5 samples taken over any 30 day period 400 maximum not to be exceeded in more than 10% of samples taken during any 30 day period
pH	SU	Title 35, Subtitle C, Chapter I, Part 302.204	6.5 – 9.0 except for natural causes
Total Phosphorus	mg/L	Title 35, Subtitle C, Chapter I, Part 302.205	Not to exceed 0.05 in any reservoir or lake with a surface area of at least 20 acres or in any stream at the point where it enters any such lake or reservoir

[1]In order for DO to be listed as a cause, the aquatic life use must first be assessed as impaired.

Due to limited state resources, fecal coliform bacteria is not normally sampled at a frequency necessary to apply the General Use standard, i.e., at least five times per month during May through October, and very little data available from others are collected at the required frequency. Therefore, assessment guidelines are based on application of the standard when sufficient data is available to determine standard exceedances; but, in most cases, attainment of *primary contact* use is based on a broader methodology intended to assess the likelihood that the General Use standard is being attained. To assess *primary contact* use, Illinois EPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period (i.e., 2002 through 2006). Based on these water samples, geometric means and individual measurements of fecal coliform bacteria are compared to the concentration thresholds provided in Tables C-16 and C-17 (shown below) of the Illinois 2008 Integrated Report 303(d) and Assessment Report. To apply the guidelines, the geometric mean of fecal coliform bacteria concentration is calculated from the entire set of May through October water samples, across the five years. No more than 10% of all the samples may exceed 400/100 ml for a water body to be considered Fully Supporting.

Table 4-3: Guidelines for Assessing Primary Contact Use in Illinois Streams and Inland Lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	No exceedances of the fecal coliform bacteria standard in the last five years and the geometric mean of all fecal coliform bacteria observations ≤200/100 ml, and ≤10% of all observations exceed 400/100 ml.
Not Supporting (Fair)	One exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) or The geometric mean of all fecal coliform bacteria observations in the last five years ≤200/100 ml, and >10% of all observations in the last five years exceed 400/100 ml or The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, and ≤25% of all observations in the last five years exceed 400/100 ml.
Not Supporting (Poor)	More than one exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) or The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, and >25% of all observations in the last five years exceed 400/100 ml

Table 4-4: Guidelines for Identifying Potential Causes of Impairment of *Primary Contact* (Swimming) Use in Illinois Streams and Inland Lakes

Potential Cause	Basis for Identifying Cause - Numeric Standard[1]
Fecal Coliform	Geometric mean of at least five fecal coliform bacteria observations collected over not more than 30 days during May through October >200/100 ml or > 10% of all such fecal coliform bacteria observations exceed 400/100 ml or Geometric mean of all fecal coliform bacteria observations (minimum of five samples) collected during May through October >200/100 ml or > 10% of all fecal coliform bacteria observation exceed 400/100 ml.

1. The applicable fecal coliform standard (35 Ill. Adm. Code, 302, Subpart B, Section 302.209) requires a minimum of five samples in not more than a 30-day period. However, because this number of samples is seldom available in this time frame the criteria are also based on a minimum of five samples over the most recent five-year period.

4.5 TMDL Targets

In order for a water body to be listed as Full Support, it must meet all of its applicable designated uses. Because WQS are designed to protect those designated uses, a pollutant's numeric WQS is therefore used as the target or endpoint for establishing a TMDL. Table 4-2 summarizes the targets that will be used in the TMDL development for the Upper Fox River/Flint Creek watershed.

Table 4-5: TMDL Targets for Impaired Waterbodies in the Upper Fox River/Flint Creek Watershed

Segment ID	Waterbody Name	Impairment	TMDL Target	Units
IL_RTZT	Barrington	Fecal coliform Total Phosphorus	≤ 200 geomean ≤ 400 <10% samples ≤ 0.05	cfu/100 ml cfu/100 ml mg/L
IL_UTI	Drummond Lake	Total Phosphorus	≤ 0.05	mg/L
IL_RTZR	Echo	Total Phosphorus	≤ 0.05	mg/L
IL_DT-22	Fox R.	Dissolved oxygen Fecal coliform pH	See Table 4-2 ≤ 200 geomean ≤ 400 <10% samples 6.5 – 9.0	 cfu/100 ml cfu/100 ml SU
IL_DT-23	Fox R.	Dissolved oxygen	See Table 4-2	
IL_VTI	Grassy	Total Phosphorus	≤ 0.05	mg/L
IL_RTZU	Honey	Fecal coliform Total Phosphorus	≤ 200 geomean ≤ 400 <10% samples ≤ 0.05	cfu/100 ml cfu/100 ml mg/L
IL_RTZI	Island	Total Phosphorus	≤ 0.05	mg/L
IL_STK	Lake Fairview	Total Phosphorus	≤ 0.05	mg/L
IL_STO	Lake Napa Suwe	Total Phosphorus	≤ 0.05	mg/L
IL_VTZJ	Louise	Total Phosphorus	≤ 0.05	mg/L
IL_RTP	Slocum	Total Phosphorus	≤ 0.05	mg/L
IL_RTZQ	Timber Lake (South)	Total Phosphorus	≤ 0.05	mg/L
IL_RTZF	Tower	Fecal coliform Total Phosphorus	≤ 200 geomean ≤ 400 <10% samples ≤ 0.05	cfu/100 ml cfu/100 ml mg/L
IL_STV	Woodland (Highland)	Dissolved oxygen	See Table 4-2	

5.0 Water Quality Analysis

This section discusses the pollutants of concern for the Upper Fox River/Flint Creek watershed. The available water quality data were analyzed, assessed, and compared with WQS to verify the impairments of the 15 segments (excluding Broberg Marsh). The water quality conditions in the watershed were evaluated by sampling location and time.

Section 5.1 provides a summary of water quality data for each of the impairment variables. Detailed information for each impaired segment and potential sources of impairment are provided in Section 6.0 of this document.

5.1 Monitoring Programs

Illinois EPA maintains a comprehensive monitoring program designed to accommodate varying waterbody types and designated uses. Their ambient water quality monitoring program consists of 214 stream stations that are samples once every six weeks and are analyzed for at least 55 parameters. For pesticide analyses Illinois EPA founded a pesticide monitoring subnetwork that allows for further screening of toxic organic substances. A facility-related stream survey program was also developed that specifically caters to field studies (macroinvertebrate, water chemistry, stream flow, habitat data) to analyze impacts from municipal and industrial dischargers.

For inland lakes, Illinois EPA also conducts an ambient lake monitoring program that is responsible for the sampling of approximately 50 inland lakes. Another lake program is the Clean Lakes Program which is a two-part program consisting of Phase 1 diagnostic-feasibility studies and Phase 2 implementation projects. Lake sampling conducted through the Clean Lakes Program include water sampling twice per month from April through October and monthly from November through March for a one-year period.

Illinois EPA also operates in conjunction with other agencies to monitor its surface waters. Intensive basin surveys are conducted by both Illinois EPA and the Illinois Department of Natural Resources. The data from these surveys provide much of the data used for aquatic life assessments. The Fish Contaminant Monitoring Program (FCMP) focuses on determining the levels of contaminants in sport fish and also is responsible for issuing fish consumption advisories. The FCMP operates under a Memorandum of Agreement (MOA) that details the responsibilities of those cooperating agencies (Departments of Agriculture, Natural Resources, Nuclear Safety, Public Health, and EPA).

Illinois EPA also administered the Volunteer Lake Monitoring Program (VLMP) in 1981. This program consists of citizen volunteers that are trained on lake ecosystems as well as cost-effective methods of collecting data. VLMP monitoring is conducted twice per month from May through October and typically consists of three monitoring stations per site.

Ambient data are also collected through the Lakes Management Unit (LMU) of Lake County. This program has been monitoring Lake County lakes since the late 1960's. Since 2000, 32 different lakes have been studied per year and data have been collected for various parameters. Detailed reports are written for each lake study and can be found at: http://www.lakecountyil.gov/Health/want/LakeReports.htm.

5.2 Water Quality Data

The Upper Fox River/Flint Creek watershed has 15 impaired segments targeted for TMDL development, 13 of which are lakes and two are river segments. Available data used for assessing these waterbodies originated from over 44 water quality stations within the Upper Fox River/Flint Creek watershed. Figure 5-1 shows the water quality data stations that contain data relevant to the impaired segments. Individual sub-watershed maps can be found in Appendix A.

Data used for analysis are a combination of both Legacy and modernized US EPA Storage and Retrieval (STORET) databases, Lake County, Fox River Study Group (FRSG), and Illinois EPA database. The compiled database ranges from 1964 through 2008. The completed water quality database is included in Appendix B.

Data relevant to impairments were compiled for each impaired waterbody and summarized. The following parameters are grouped by impairment and discussed in relation to the relevant Illinois numeric WQS. For all assessments, compliance is determined at the surface of a stream or at the one-foot depth from the lake surface. Time-series plots for each waterbody impairment are presented in Appendix E.

5.2.1 Dissolved Oxygen

Two Fox River segments are targeted for TMDL development due to low DO concentrations. DO was measured 618 times in the Fox River segment DT-22 and 500 times in DT-23 between 1964 and 2008. Two stations were sampled along each impaired segment. DO concentrations were below the instantaneous minimum numerical WQS for March – July of 5.0 mg/L three times in DT-22 and twice in DT-23 (Figure 5-2). DO concentrations below the 5.0 mg/L in DT-22 were recorded in April and June 2006 and June 2008. DO samples less than the WQS in DT-23 were recorded in July 1966 and March 2006. No samples in August through February were below the 3.5 mg/L instantaneous WQS.

Woodland Lake is targeted for TMDL development due to low DO concentrations. Low DO was observed in 2004. Based on the temperature and dissolved oxygen profiles in 2004 (Figure 5-3), Woodland Lake does not thermally stratify and therefore the instantaneous WQS would apply to the entire water column. DO dropped below the 3.5 mg/L instantaneous WQS in August at 5' and 6' water depth.

While DO in Fiddle Creek has historically been below standard, no TMDL will be developed. The Wauconda WWTP, which eventually flows into Slocum Lake, is currently undergoing a WWTP expansion that should address the low DO values observed in the lake. The upgraded facility will eventually expand its daily average discharge to 2.4 MGD with a design capacity of 7.93 MGD. Stringent DO provisions will be included in future permits and part of the design specifications for the new plant will include post-treatment aeration. As such, no TMDL will be required as the new treatment should be able to bring Fiddle Creek back into compliance.

Low dissolved oxygen is likely related to eutrophication which may be caused by point and/or non-point sources. Eutrophication is an environmental phenomenon that occurs when waterbody hypoxia or anoxia is induced from excessive nutrient inputs. In some waterbodies, particularly lakes, estuaries, or even low-flow streams, nutrients can stimulate algal blooms, which can lead to oxygen consumption when the dead plant material decomposes. The decomposing plant material is a source of Biochemical Oxygen Demand (BOD). As the decay sinks to the bottom of the waterbody, the sum of all biological and chemical processes can likewise further consume oxygen, and this process is known as Sediment Oxygen Demand (SOD).

Non-point sources of nutrients include urban and agricultural runoff. Point sources of nutrients are generally wastewater treatment facilities. All active NPDES point sources discharging within each impaired segment's watershed are described in Section 6.0 (and summarized in Appendix D). A general description of non-point sources is also provided in Section 6.0.

Figure 5-1: Upper Fox River/Flint Creek Water Quality Sample Locations

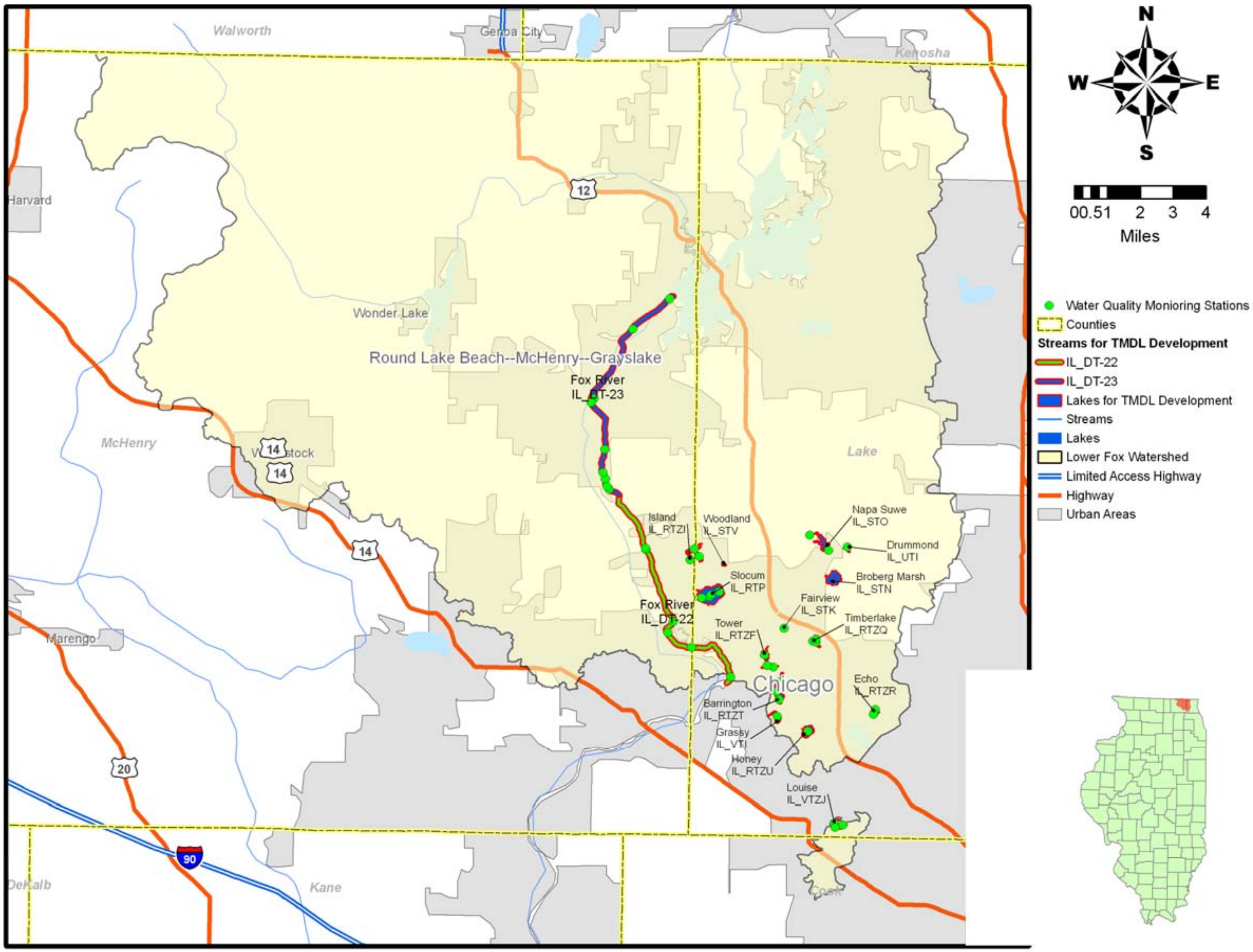


Figure 5-2: Fox River Impaired Segments DT-22 and DT-23 Temperature 1964-2008

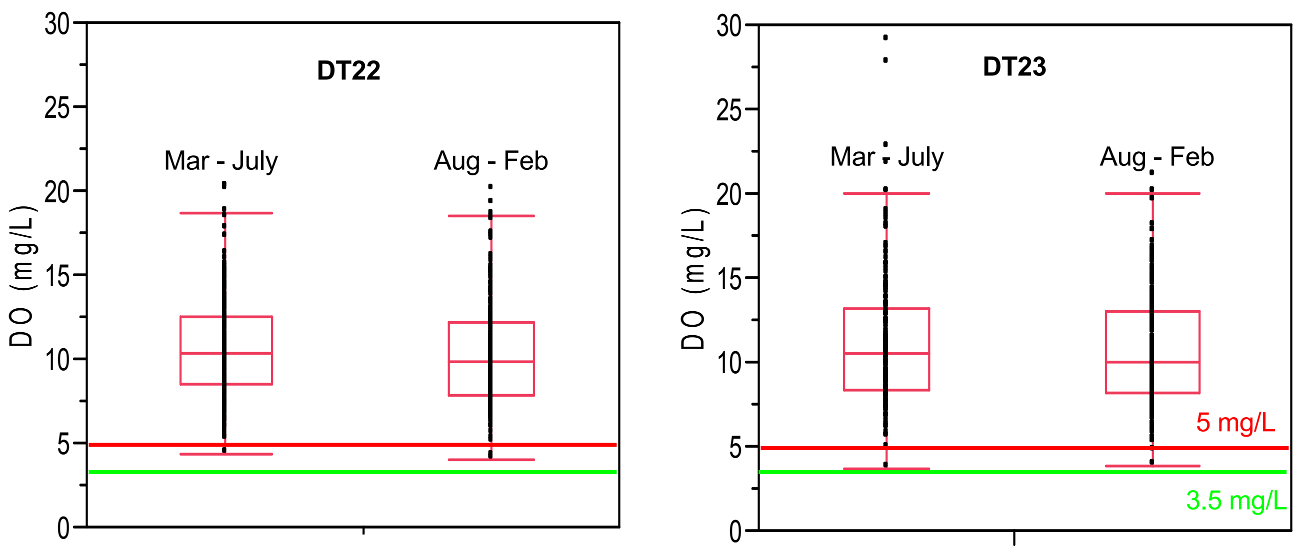
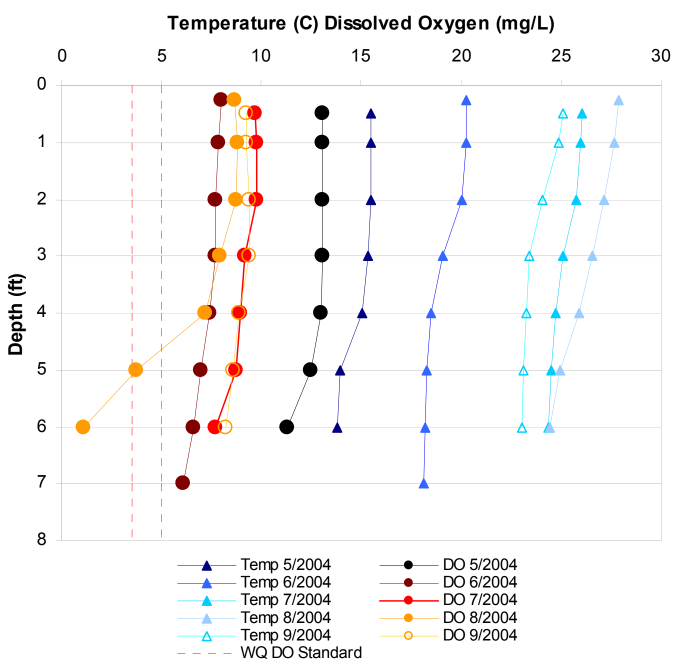


Figure 5-3: Woodland Lake Temperature Dissolved Oxygen Profiles 2004



5.2.2 pH

The Fox River segment DT-22 is targeted for a TMDL due to elevated pH. The WQS for pH is between 6.5 and 9.0 standard units (SU). pH was measured in this segment of the Fox River 657 times from 1964 through 2008. Values ranged from 6.5 to 9.7 SU and observations exceeding 9.0 SU were measured on six occasions: October 1983, March, May and June 1995, and March and October 2003, and represents <1% of the total samples analyzed.

5.2.3 Fecal Coliform

The Fox River (IL_DT-22), Barrington Lake, Honey Lake and Tower Lake are targeted for TMDL development due to excessive fecal coliform numbers. The distribution of fecal coliform for each impaired segment in the Upper Fox River/Flint Creek watershed is presented in Figure 5-4 and is compared to the WQS. The WQS for fecal coliform is a 200 cfu/100ml geometric mean based on a minimum of five samples collected over any 30 day period or a 400 cfu/100ml maximum not to be exceeded in more than 10% of samples collected during any 30 day period.

Figure 5-4 displays fecal coliform data within impaired segments during the WQS compliance period (May – October). Data for the Fox River segment DT-22 includes 191 samples from 1999 through 2008. Twenty three percent of the samples (44) exceeded the 200 cfu/100 ml WQS. Values ranged from 0 to 4900 cfu/100 ml. Fecal coliform was measured in Barrington, Honey and Tower Lakes during 2001. Sixteen samples were collected in Barrington and Tower Lakes, two samples were collected per lake on three occasions in May, two in June and July and once in August. Values in Barrington Lake ranged from 10 to 890 cfu/100 ml. Four of the samples (25%) exceeded the 200 cfu/100 ml WQS. Values in Tower Lake ranged from 10 to 820 cfu/100 ml. Five samples (31%) contained concentrations above the 200 cfu/100 ml WQS. Exceedances in Barrington and Tower Lakes occurred in May and June. Twenty two samples were collected in Honey Lake, two samples per day twice in May, June and July and five times in August. Values ranged from 10 to 1700 cfu/100 ml, with ten samples (45%) exceeding the 200 cfu/100 ml WQS. Exceedances occurred in July and August. The geometric mean of July and August samples was 441 cfu/100 ml, above the WQS.

E. coli, another pathogen indicator species, was also sampled within Barrington, Honey and Tower Lakes during May through August in 2002 - 2007. Although Illinois does not have a numerical standard for *E. coli*, the US EPA document "Ambient Water Quality Criteria for Bacteria – 1986" states a freshwater bathing criteria of a geometric mean from five samples within a 30 day period not exceed 126 cfu/100 ml (US EPA 1986). During this period 102, 108 and 98 samples were collected in Barrington, Honey and Tower Lakes respectively. Samples were collected twice per day up to three times per month. Eleven percent of the Barrington Lake, 24% of Honey Lake and 7% of the Tower Lake samples exceeded the *E. coli* level of 126 cfu/100 ml, but none met the geomean criteria. *E. coli* data for these impaired segments are presented in Figure 5-5.

Sources of bacteria in the Upper Fox River/Flint Creek watershed are likely storm water related. These potential sources may include failing systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife is generally considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. But this source is often difficult to separate from others. All active NPDES point sources discharging within each impaired segment's watershed are described in Section 6.0.

Figure 5-4: Fecal Coliform Impaired Segment Data

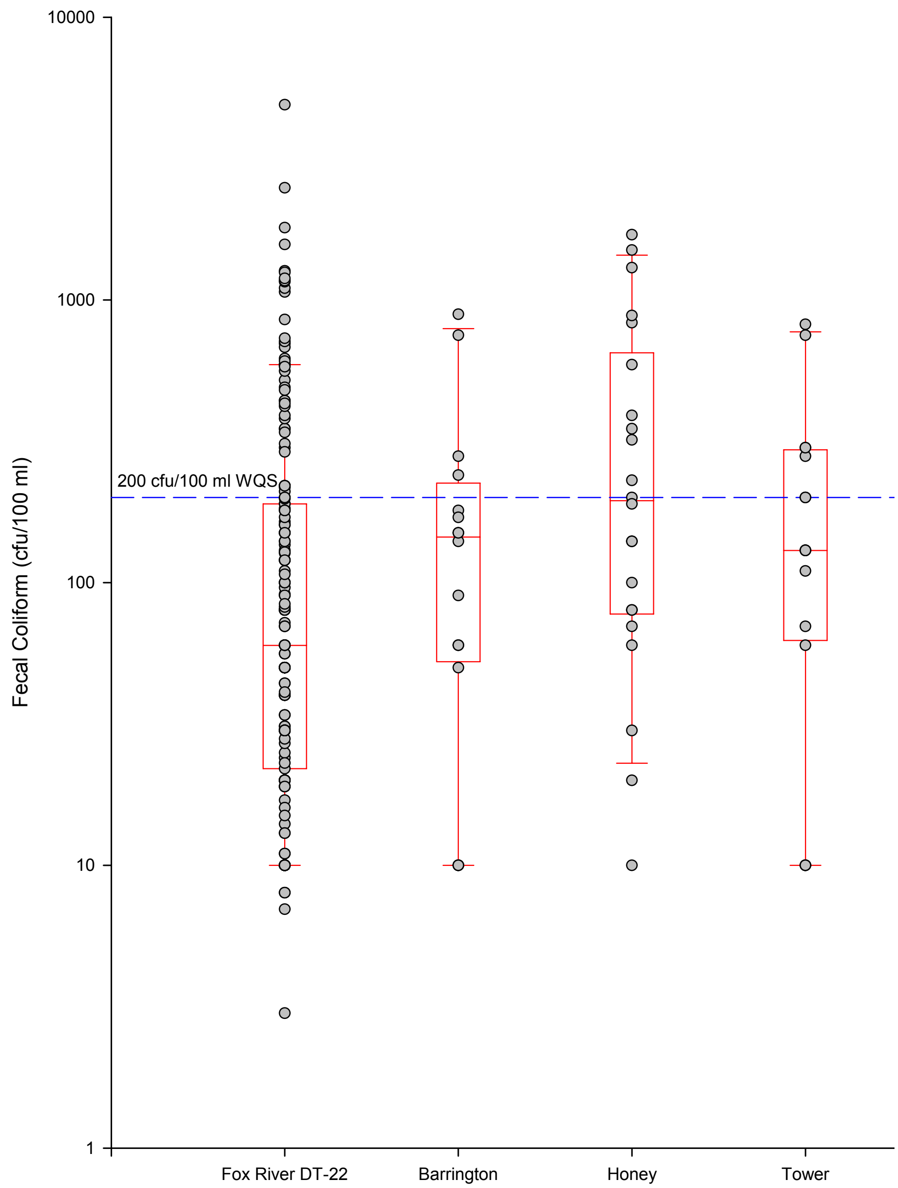
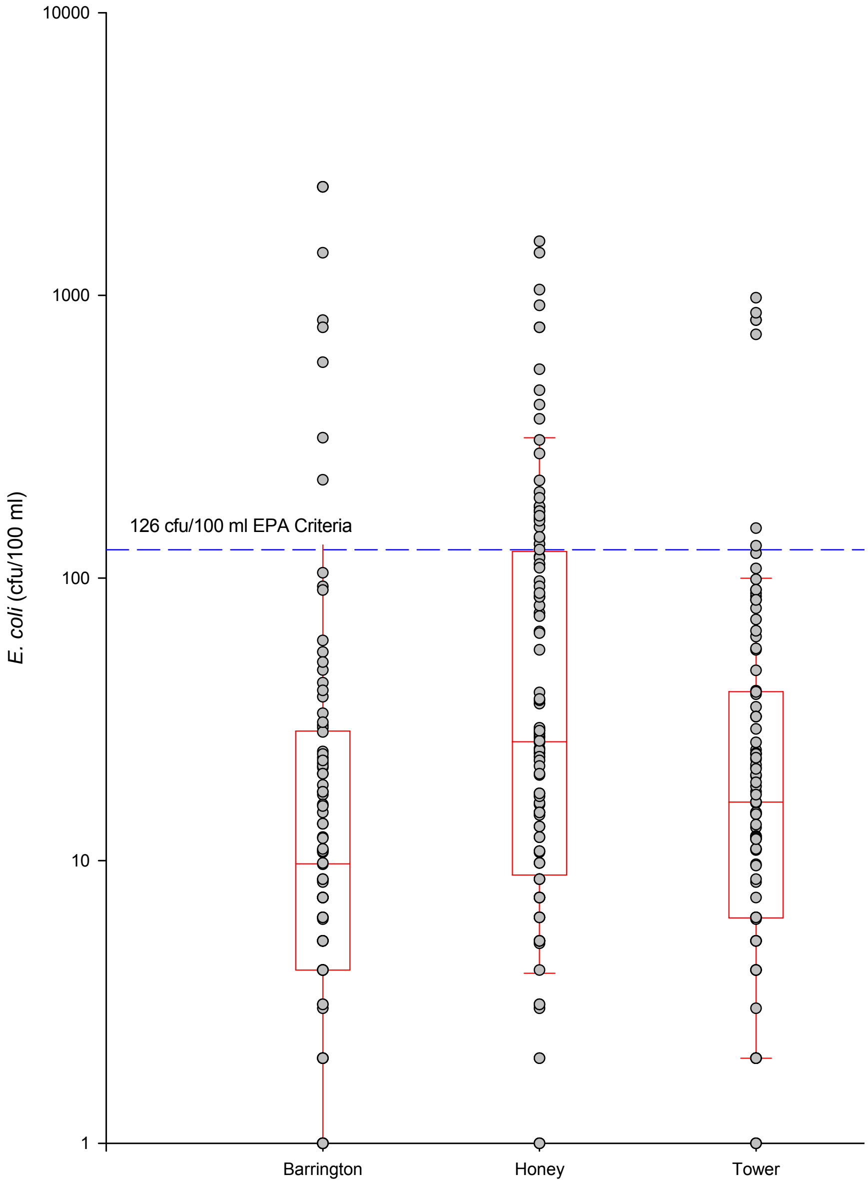


Figure 5-5: E. coli Impaired Segment Data



5.2.4 Total Phosphorus

Compliance with the TP WQS for this report is based on samples collected at three feet or less from the water surface. A three foot depth maximum was used due to a lack of data at the one foot depth for many of the impaired lake segments. The WQS for total phosphorus is a maximum concentration of 0.05 mg/L and is applicable only to lakes with a surface area of 20 acres or greater. Twelve lake segments in the Upper Fox River/Flint Creek watershed are targeted for TP TMDL development.

A database was created for this TMDL analysis and includes 258 total phosphorus samples collected between May 1973 and August 2007 from the 12 impaired segments. Many of the lakes contained data from multiple depths and multiple stations on any given day. To summarize in-lake TP concentrations for the 12 segments, surface water samples (samples collected at water depths less than or equal to three feet) were averaged by date across the lake; 139 individual samples collected at ≤ 3ft (Table 5-1) were averaged to yield 125 data points. A majority of the samples were collected prior to 2005. A summary of the averaged data (125 points) are presented in Table 5-2 and graphically represented as box and whiskers plots in Figure 5-6. Overall 81% of the average TP concentrations were equal to or exceeded the 0.05 mg/L WQS.

Elevated phosphorus concentrations are likely the result of point and non-point sources. Non-point sources of nutrients within the Upper Fox River/Flint Creek watershed include urban and agricultural runoff. Point sources of nutrients are generally from waste water treatment facilities. All active NPDES point sources discharging within each impaired segment's watershed are described in Section 6.0.

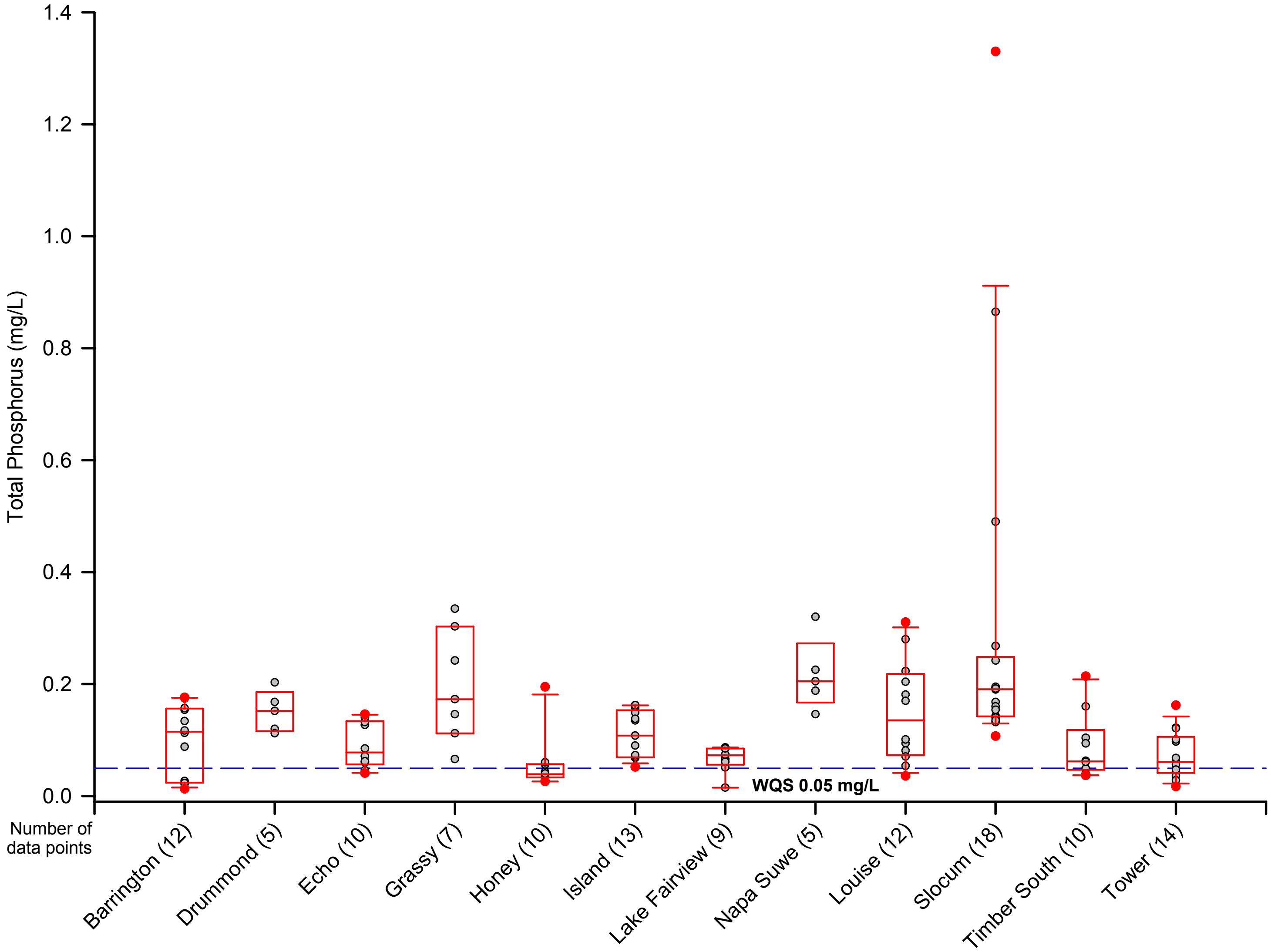
Table 5-1: Upper Fox River/Flint Creek Surface Total Phosphorus Samples by Year

	Total Number of Samples	Number of Stations	Available Data
Barrington	12	1	2001, 2007
Drummond	5	1	2002
Echo	10	1	2000
Grassy	7	1	2000
Honey	10	1	1998,2001
Island	13	1	1998, 2003
Lake Fairview	9	1	2000
Napa Suwe	5	2	2002
Louise	12	1	1998, 2003
Slocum	18	3	1973, 1977, 2001, 2005
Timber South	10	2	1989, 2000, 2007
Tower	14	1	2001,2007
Total	125	16	

Table 5-2: Upper Fox River/Flint Creek Surface Total Phosphorus Concentration Summary								
	Number of Samples	**Number of Averaged Data Points**	**Minimum (mg/L)**	**Maximum (mg/L)**	**Average (mg/L)**	**Median (mg/L)**	**# ≥ WQS (0.05 mg/L)**	**% Exceed WQS (0.05 mg/L)**
Barrington	12	12	0.01	0.18	0.10	0.12	8	67
Drummond	5	5	0.11	0.20	0.15	0.15	5	100
Echo	10	10	0.04	0.15	0.09	0.08	8	80
Grassy	8	7	0.07	0.33	0.20	0.17	7	100
Honey	10	10	0.03	0.20	0.06	0.04	3	30
Island	14	13	0.05	0.16	0.11	0.11	13	100
Lake Fairview	9	9	0.02	0.09	0.07	0.07	8	89
Napa Suwe	10	5	0.15	0.32	0.22	0.21	5	100
Louise	17	12	0.04	0.31	0.15	0.14	11	92
Slocum	18	18	0.11	1.33	0.29	0.19	18	100
Timber South	10	10	0.04	0.21	0.09	0.06	6	60
Tower	16	14	0.02	0.16	0.07	0.06	9	64
Total	**139**	**125**	**0.01**	**1.33**			**101**	**81**

Surface data include samples collected at or less than 3' from the surface. Data were averaged across the lake (i.e., includes multiple stations when available) by date including all depths at or below 3' from the surface.

Figure 5-6: Average Surface Phosphorus Concentrations by Date for Impaired Lakes (1972-2007).



6.0 Impaired segments and Potential Sources

This section provides a brief description of each impaired segment within the Upper Fox River/Flint Creek watershed. Much of the information provided in this section was obtained from the Lake County Health Department (LCHD) Environmental Health Services Lakes Management Unit (LMU) and from the Fox Chain of Lakes Investigation and Water Quality Management Plan (Kothandaraman et al., 1977). The LCHD has been collecting water quality data from lakes since the 1960's. Detailed lake reports have been developed for a number of lakes in the County. For those lakes not covered by LCHD reports, the 1977 study and information provided in the Illinois Integrated Water Quality Report and Section 303(D) List – 2008, were used to characterize the listed segments. Since most of these segments are hydraulically connected, they are discussed in an upstream to downstream order. The LCHD's detailed lake reports can be found in the following website: http://www.lakecountyil.gov/Health/want/LakeReports.htm.

Segment subwatersheds were delineated using ArcMap software based on LCHD, Lake County Stormwater Management Commission (SMC) information and topographic maps (two foot surveys). Land use within each segment subwatershed is based on data provided by Lake County from 2005 land use where available. In areas where 2005 data were not available, 2001 data provided by the Chicago Metropolitan Agency for Plan were used. A majority of the segment watersheds were covered under the Lake County 2005 data. Small portions of some watersheds utilized 2001 data. Figure 6-1 provides a land use map with each impaired segment's watershed boundary. The watershed areas described below do not include the area of the lake itself. Individual subwatershed maps can be found in Appendix A and a summary of all land use, including subwatershed and contributing watersheds, can be found in Appendix C.

Lakes with high watershed-to-lake area ratios have a large portion of the hydrologic budget stemming from surface water flow. Water quality in these lakes is highly dependant on in-flow water quality. In-lake water quality typically declines with increasing watershed-to-lake ratios. Lakes with watershed-to-lake ratios <10:1 are less likely to have eutrophication problems. These ratios have been calculated for all the lake segments and are discussed below.

In addition, the water quality condition of a water body is related to the level of development or urbanization in its watershed. The more developed an area is, the higher the percentage of impervious surface. The Center of Watershed Protection published a document entitled "*Impacts of Impervious Cover on Aquatic Systems*" (2003) which summarizes two dozen studies documenting a strong relationship between impervious cover and stream water quality. They concluded that stream quality declines with increased impervious cover such that drainage areas containing >10% impervious cover were impacted and areas with >25% were impaired (CWP 2003).

Impervious cover (IC) was estimated for each watershed by using the land use data for each segment and multiplying this area by the estimated impervious percentage based on the land use category. The estimated IC percentage was derived from the Center of Watershed Protection's study of the Chesapeake Bay Watershed (CWP 2001). The average of the low and high IC percentage from the Chesapeake Bay study was used for all residential land use since the land use data for the Upper Fox River/Flint Creek is not divided into residential use by density (i.e., low and high).

Active NPDES point sources in the impaired portion of Upper Fox River/Flint Creek watershed are listed and mapped on Figure 6-2. These data were derived from both the publically available Better Assessment Science Integrating Point & Nonpoint Sources (BASINS) program and the inventory of active NPDES dischargers provided by IL EPA. If a point source discharges upstream of an impaired segment, this point source is listed as a potential source within the segment description. Specific information regarding each discharger is provided in Appendix D.

Figure 6-1: Impaired Segment Watershed Land Use

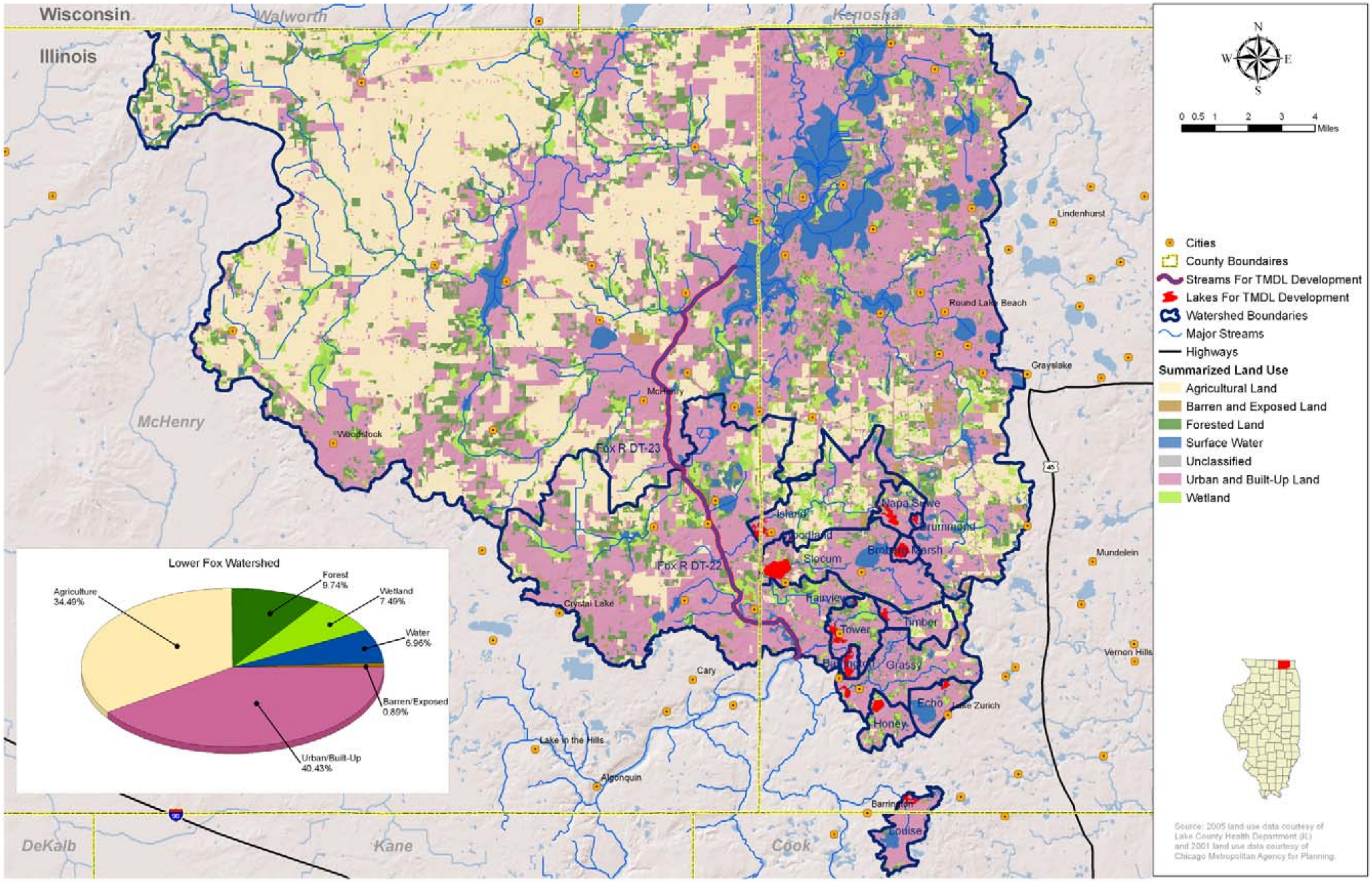
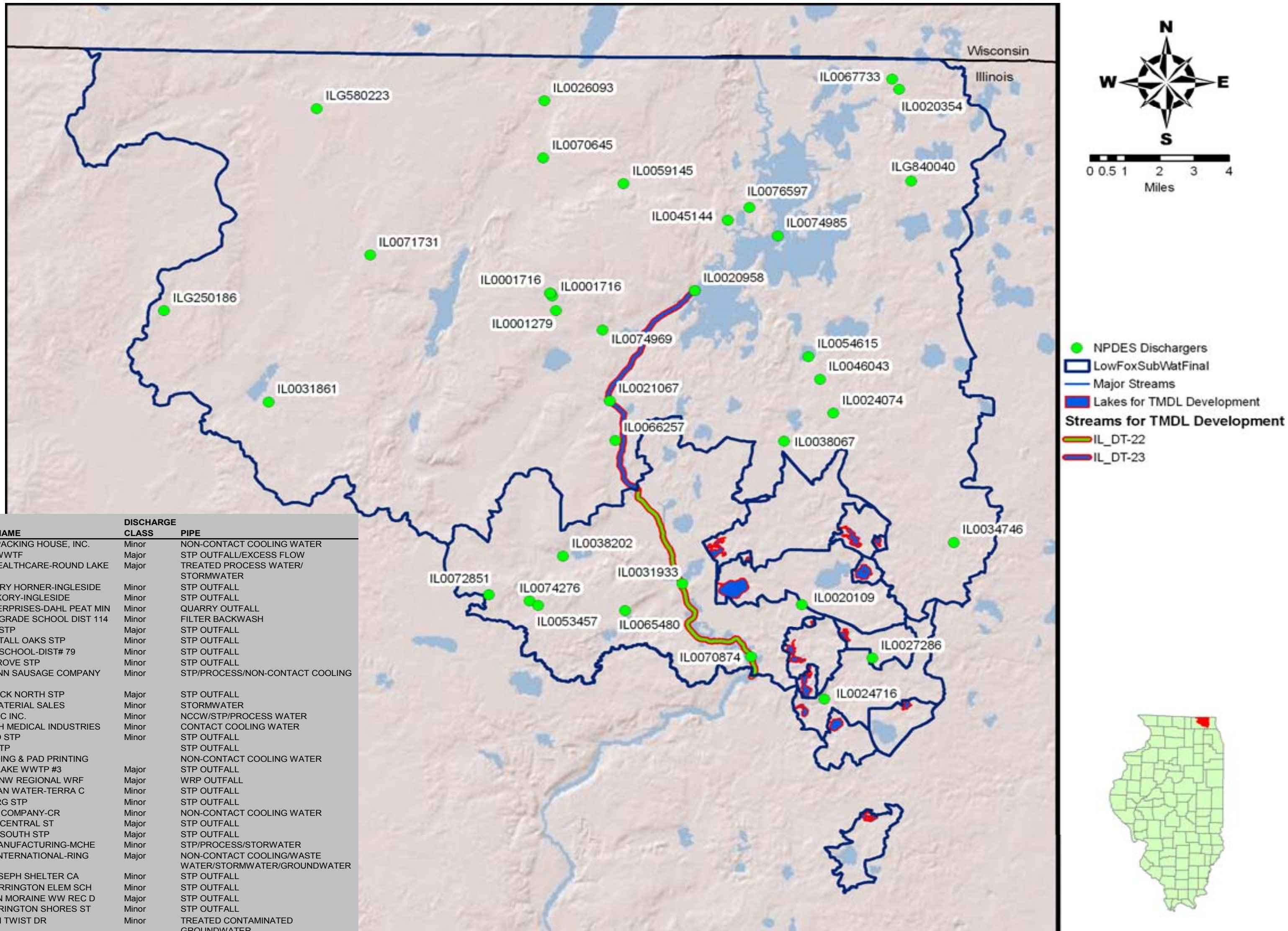


Figure 6-2: Active NPDES Dischargers in the Impaired Portion of the Upper Fox River/Flint Creek Watershed



PERMIT	FACILITY NAME	DISCHARGE CLASS	PIPE
IL0067733	ANTIOCH PACKING HOUSE, INC.	Minor	NON-CONTACT COOLING WATER
IL0020354	ANTIOCH WWTF	Major	STP OUTFALL/EXCESS FLOW
IL0024074	BAXTER HEALTHCARE-ROUND LAKE	Major	TREATED PROCESS WATER/ STORMWATER
IL0054615	CAMP HENRY HORNER-INGLESIDE	Minor	STP OUTFALL
IL0046043	CAMP HICKORY-INGLESIDE	Minor	STP OUTFALL
ILG840040	DAHL ENTERPRISES-DAHL PEAT MIN	Minor	QUARRY OUTFALL
IL0076597	FOX LAKE GRADE SCHOOL DIST 114	Minor	FILTER BACKWASH
IL0020958	FOX LAKE STP	Major	STP OUTFALL
IL0045144	FOX LAKE TALL OAKS STP	Minor	STP OUTFALL
IL0034746	FREMONT SCHOOL-DIST# 79	Minor	STP OUTFALL
IL0074985	SPRING GROVE STP	Minor	STP OUTFALL
IL0038067	KOENEMANN SAUSAGE COMPANY	Minor	STP/PROCESS/NON-CONTACT COOLING
IL0031861	WOODSTOCK NORTH STP	Major	STP OUTFALL
IL0071731	PRAIRIE MATERIAL SALES	Minor	STORMWATER
IL0059145	INTERMATIC INC.	Minor	NCCW/STP/PROCESS WATER
IL0070645	SURGIPATH MEDICAL INDUSTRIES	Minor	CONTACT COOLING WATER
IL0026093	RICHMOND STP	Minor	STP OUTFALL
ILG580223	HEBRON STP		STP OUTFALL
ILG250186	DRG MOLDING & PAD PRINTING		NON-CONTACT COOLING WATER
IL0053457	CRYSTAL LAKE WWTP #3	Major	STP OUTFALL
IL0020958	FOX LAKE NW REGIONAL WRF	Major	WRP OUTFALL
IL0038202	IL AMERICAN WATER-TERRA C	Minor	STP OUTFALL
IL0074969	JOHNSBURG STP	Minor	STP OUTFALL
IL0072851	MATHEWS COMPANY-CR	Minor	NON-CONTACT COOLING WATER
IL0021067	MCHENRY CENTRAL ST	Major	STP OUTFALL
IL0066257	MCHENRY SOUTH STP	Major	STP OUTFALL
IL0001279	MODINE MANUFACTURING-MCHE	Minor	STP/PROCESS/STORWATER
IL0001716	MORTON INTERNATIONAL-RING	Major	NON-CONTACT COOLING/WASTE WATER/STORMWATER/GROUNDWATER
IL0027286	MT. ST. JOSEPH SHELTER CA	Minor	STP OUTFALL
IL0024716	NORTH BARRINGTON ELEM SCH	Minor	STP OUTFALL
IL0031933	NORTHERN MORAINE WW REC D	Major	STP OUTFALL
IL0070874	PORT BARRINGTON SHORES ST	Minor	STP OUTFALL
IL0074276	PRECISION TWIST DR	Minor	TREATED CONTAMINATED GROUNDWATER
IL0065480	SNAP-ON TOOLS-CRYS	Minor	TREATED SANITARY WASTE
IL0020109	WAUCONDA WWTP	Major	STP OUTFALL/EXCESS FLOW

When discussing surface water total phosphorus concentrations in the paragraphs below, the average of surface concentration from all stations and at water depths ≤ 3' on a given sampling date were calculated before determining statistics unless otherwise noted. For example, the minimum value is the minimum average of all in-lake stations sampled on a given day at depths ≤ 3'. These data are presented in Section 5 in Table 5-2 and illustrated on Figure 5-6.

6.1 Fox River DT-23

The Fox River segment DT-23 extends from the McHenry dam on Pistakee Lake to just downstream of the USGS gage (05549000) in Ferndale near Moraine Hills State Park (Figure 2-2, Appendix A). This segment is approximately 7.6 miles and drains 318 square miles within Illinois, including the Chain of Lakes watershed (267 sq mi). The Illinois portion of the drainage area to DT-23 is predominately used for row crop, grain or grazing (38%) and residential (18%). Impervious cover in this portion of the Fox River watershed is estimated at 11%, the threshold where water quality impacts are expected.

This portion of the Fox River is impaired due to low DO (Appendix E). Suspected sources of low DO in this segment include flow and water level manipulation at the McHenry dam located just upstream of this segment; other sources are listed as cause unknown (2008 Integrated Report). Nutrient enrichment also serves as a potential source of DO deficits as it is the driving force behind eutrophication. The role of nutrients, if any, will be further investigated in the Stage 3 report.

There are several NPDES discharges that contribute to the inorganic and organic load to the river that oxidize and consume oxygen which may contribute to low DO conditions (Figure 6-2). Three sanitary waste NPDES dischargers are proximal to the Fox River and include the Village of Fox Lake North West Regional Water Reclamation Facility and two City of McHenry Sewage Treatment Plants (Central and South facilities). Dischargers farther from the river along Dutch Creek, or tributaries to Dutch Creek include Morton International, Modine Manufacturing, and the Johnsburg Sewage Treatment Plant.

6.2 Drummond Lake

Drummond Lake is located in the central eastern portion of the Upper Fox River/Flint Creek watershed (Figure 2-2, Appendix A). It is a small shallow artificially created lake with 20.7 surface acres. It is owned by the Lake County Forest Preserve District (LCFPD). Maximum and mean water depths are 5.0 and 2.2 feet respectively (LCHD 2003). Drummond Lake drains to the south to Lake Napa Suwe. Use of this waterbody is limited to fishing along the banks of the lake.

The watershed encompasses 66 acres resulting in a watershed-to-lake ratio of 3:1. Much of the watershed is classified as Open Space (96%), however the LMU 2002 Summary Report of Drummond Lake (LCHD 2003) suggests that this area is primarily used for agriculture by the Lake County Forest Preserve District. The shoreline of Drummond Lake remains undeveloped and consists of buffer (75%) wetland (10%) and shrub (15%). However, erosion is still a concern with 77% of the shoreline area showing evidence of erosion. Drummond Lake watershed is only 6% impervious.

The LMU 2002 Summary Report of Drummond Lake (LCHD 2003) notes that Drummond Lake does not thermally stratify and DO concentrations are poor. DO concentrations were above the WQS for the 2002 sampling period except at 4' in July, when DO was just below 5.0 mg/L (4.8 mg/L). Although the lake meets the WQS a majority of the time, the LMU considers Drummond Lake DO poor because summertime values are around or slightly above 5.0 mg/L.

Drummond Lake is listed as impaired due to excessive phosphorus concentrations. Water quality data for Drummond Lake is limited to the 2002 study conducted by the LMU. Concentrations of TP ranged from 0.11 to 0.20 mg/L, with an average of 0.15 mg/L (Table 5-2, Figure 5-6, Appendix E). All five samples collected contained concentrations above WQS.

The lake experiences severe summer algal blooms (LCHD 2003) and as a result, poor water clarity. The average Secchi disk transparency in 2002 was only 9.7 inches. Low clarity is related to high total suspended solids (TSS) and algal biomass. The average TSS concentration in 2002 was 52 mg/L and reached a high of 93 mg/L. Sixty two percent of the TSS is attributed to inorganic particles (soils/clays) while 38% is organic (algae) (LCHD 2003). The suspected source of poor DO is also due to severe blooms of planktonic algae. Blooms have been reported as thick as an inch (LCHD 2003). These algal blooms consume oxygen during decomposition and respiration.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Drummond Lake is dominated by intense algal growth and therefore rooted aquatic plant growth is limited. Less than 10% of the lake sediment surface contained plants and consists of three nuisance plant species: Eurasian watermilfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*) and curly leaf pondweed (*Potamogeton crispus*). The lack of light from algae and soil particles is likely limiting rooted plant growth. The lake also supports carp. Carp disturb bottom sediments during rooting and foraging which increases TSS and nutrients while decreasing water clarity.

Sources of phosphorus include internal recycling from sediments (resuspension) and decomposition of organic matter. Potential external sources of phosphorus include stormwater runoff from agricultural areas, fertilizers, failing septic systems, geese feces, and erosion (LCHD 2003). Internal sources are suspected to contribute the largest load during the summer (LCHD 2003). There are no NPDES dischargers located within the Drummond Lake watershed.

6.3 Lake Napa Suwe

Lake Napa Suwe is located in the central eastern portion of the Upper Fox River/Flint Creek watershed (Figure 2-2) near the Village of Wauconda. It is a small shallow slough with 60.6 surface acres. It is privately owned by the residents and developers (LCHD 2003). Maximum and mean water depths are 5.0 and 2.5 feet respectively (LCHD 2003). Lake Napa Suwe drains to the northwest via an outlet structure to Mutton Creek, which drains through Island Lake and eventually into the Fox River.

Lake Napa Suwe receives water from Drummond Lake, its watershed and the surrounding area (1069 acres). The watershed-to-lake area ratio is 18.1 suggesting that water quality in the lake is highly dependent on the quality of incoming water. The majority of the watershed area is residential (28%) or open space (26%). Fifteen percent of the watershed is impervious cover, a level at which impacts are expected.

Two locations within Lake Napa Suwe were sampled by the LMU in 2002 (LCHD 2003). The station located near the outfall was considered the most representative of in-lake conditions (Site 2). The LMU 2002 Summary Report of Lake Napa Suwe (LCHD 2003) notes that Lake Napa Suwe does not thermally stratify but DO concentrations are poor. DO concentrations were below the 5.0 mg/L WQS in June and July 2003, with a value as low as 3.4 mg/L just below the surface. DO concentrations in September were below the 3.5 mg/L WQS, with a value of 3.1 mg/L just below the surface. The DO concentration at 1' below the surface in September was only 2.1 mg/L. The suspected source of poor DO is severe planktonic algal blooms (LCHD 2003). These algal blooms consume oxygen during decomposition and respiration. In addition, this sampling location does not experience much wind mixing as it is more sheltered than the southern sampling station near the inlet. DO concentrations at the inlet station (Site 1) were above the WQS except near the bottom (3') in July (4.8 mg/L).

Lake Napa Suwe is listed as impaired due to excessive phosphorus concentrations (Appendix E). Water quality data for Lake Napa Suwe is limited to the 2002 study conducted by the LMU. Surface concentrations of TP ranged from 0.13 to 0.37 mg/L, with an average of 0.23 mg/L at the outlet station; concentrations at the inlet station were comparable (0.17 – 0.027 mg/L, average 0.20 mg/L) All samples collected contained concentrations above WQS.

The lake experiences severe summer algal blooms (LCHD 2003) and as a result, poor water clarity. The average Secchi disk transparency in 2002 was only 9.7 inches. Low clarity is related to high suspended solids and algal biomass. The average TSS concentration in 2002 was 60 mg/L and reached a high of 122 mg/L. Seventy one percent of the TSS is attributed to inorganic particles (soils/clays) while 29% is organic (algae) (LCHD 2003).

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Lake Napa Suwe is dominated by intense algal growth and therefore rooted aquatic plant growth is limited. Only 10% of the lake sediment surface contained plants. Of the plants that were present, the nuisance species Eurasian watermilfoil and coontail were the most abundant. The lack of light from algae and soil particles as well as unsuitable substrate is likely limiting rooted plant growth. The lake also supports an extensive carp population. Carp disturb bottom sediments during rooting and foraging which increases TSS and nutrients while decreasing water clarity as well as causing a direct disturbance.

Sources of phosphorus include internal recycling from sediments (resuspension) and decomposition of organic matter. Potential external sources of phosphorus include stormwater runoff from agricultural areas (6% of total land use), fertilizers, failing septic systems, geese feces, and erosion (LCHD 2003). Stormwater is suspected as the major external source of phosphorus, but peak in-lake concentrations of TP did not correlate with rainfall (LCHD 2003). Therefore internal sources are suspected to contribute the largest load during the summer. There are no NPDES dischargers located within the Lake Napa Suwe watershed.

6.4 Woodland Lake

Woodland Lake, also known as Highland Lake, is located in unincorporated Wauconda Township. This small lake (7.7 acres) is privately owned by 11 homeowners on the lake. The maximum and mean depth of Woodland Lake is estimated as 7.5 and 3.8 feet respectively (LCHD 2005). Woodlake drains to the northeast from the outlet at the southeast end of the lake via a small ditch. Water within the ditch enters Mutton Creek and passes through Island Lake prior to discharging into the Fox River.

Woodland Lake receives water from two inlets, two residential area culverts and a small creek draining a detention pond. The watershed area is 52 acres resulting in a watershed-to-lake area ratio of 7:1. The majority of the watershed is residential land use (71%). Twenty-five percent of the watershed is impervious, a level expected to result in water quality impairment. The majority of the shoreline is developed and consists of buffer (35%), lawn (25%) and rip rap (24%) (LCHD 2005).

Woodland Lake is listed as impaired due to low DO. Available DO data are limited to the 2004 LMU investigation. DO concentrations in 2004 were below the 3.5 mg/L WQS in August near the bottom (1.1 mg/L at 6'). All other values were above the WQS (Figure 5-3, Appendix E). The LMU 2004 Summary Report of Woodland Lake (LCHD 2005) states the Woodland Lake is polymictic (multiple stratification and mixing during the year) and that weak stratification was present in 2004. It is typical in lakes that undergo stratification to have low DO concentration near the sediment water interface due to sediment oxygen demand. It is likely that the sediment oxygen demand in Woodland Lake is high, especially during periods of low water circulation.

Total phosphorus concentrations in Woodland Lake are higher than the 0.05 mg/L WQS, but this WQS does not apply to Woodland Lake since it is less than 20 surface acres. TP in 2004 ranged from 0.08 to 0.13 mg/L and averaged 0.10 mg/L. It is likely that high sediment and water TP has resulted in increased primary productivity (algal and rooted plant biomass). Decomposition of organic material and respiration by plants reduces water column DO and is the likely source of the low DO observed in Woodland Lake.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. The LMU report indicated that aquatic plants reached excessive densities until recently, but the 2004 Woodland Lake survey encountered only three aquatic plant species (LCHD 2005). The invasive species, curly leaf pondweed was identified during the survey. The lake has shifted from a rooted plant dominated system to a planktonic algae dominated lake. It is suspected that stocking of carp initiated this shift. The lake also has low water clarity (1.7' on average) and high total suspended solids (21 mg/L), a majority of which is attributed to inorganic particles (78%). Woodland Lake is routinely treated with an algaecide to control algal blooms.

Sources of phosphorus include internal recycling from sediments (resuspension) and decomposition of organic matter. External sources of phosphorus include stormwater runoff from fertilized lawns (LCHD 2005). There are no NPDES dischargers located within the Woodland Lake watershed.

6.5 Island Lake

Island Lake is located in the central portion of the Upper Fox River/Flint Creek watershed (Figure 2-2) in the Village of Island Lake. It is a small shallow slough with 78.2 surface acres (83.8 acres according to LCHD 2004). The lake was artificially created by damming a former gravel pit. The lake is managed by the Village of Island Lake Management Committee (LCHD 2004). Maximum and mean water depths are 9.8 and 5.3 feet respectively (LCHD 2004). Island Lake drains to Cotton Creek to the southwest eventually draining into the Fox River.

Island Lake receives water from two other impaired lakes and their watersheds: Lake Napa Suwe and Drummond Lake. The total watershed area of Island Lake is 5,949 acres resulting in a watershed-to-lake area ratio of 76:1. The majority of the watershed area is used for row crops, grain or grazing (23%) with almost equal distribution of wetland (16%), open space (15%) and residential (15%) area. Twelve percent of the watershed is impervious cover, a level at which impacts are expected. In addition 99.6% of the shoreline is developed, with 60% comprised of seawall and 29% rip rap (LCHD 2004).

The LMU 2003 Summary Report of Island Lake (LCHD 2004) notes that this lake does not thermally stratify because of its shallow morphometry. Surface water concentrations of DO were above the WQS. However concentrations near the bottom (8') in June and July 2003 were below 2.0 mg/L (Appendix E).

Island Lake is listed as impaired due to excessive TP concentrations. Water quality data for Island Lake were collected in 1989, 1998 and 2003 (Appendix B). Surface water TP concentrations for this time period ranged from 0.05 to 0.16 mg/L, with an average of 0.11 mg/L (Table 5-2, Figure 5-6). All the averaged surface samples were above the 0.05 mg/L WQS. In 2003, the average surface concentration was 0.10 mg/L and ranged from 0.05 - 0.16 mg/L. The highest TP concentration occurred in September and corresponded to lower rainfall and decreased water level (LCHD 2004). Bottom concentrations were similar (average = 0.10 mg/L).

The lake experiences summer algal blooms and as a result, poor water clarity. The average Secchi disk transparency in 2003 was 3.0 feet, with a minimum value of 1.3 ft in September. Low clarity is related to high suspended solids and algal biomass. The average surface TSS concentration in 2003 was 16 mg/L. Sixty eight percent of the TSS is attributed to inorganic particles (soils/clays) while 32% is organic (algae) (LCHD 2004).

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. A quantitative survey of aquatic plants was not conducted within Island Lake, but it is expected that 36-90% of the lake area could support rooted plant growth based on light availability. However, given that the lake experiences severe algal blooms and extensive plant community is not expected. Of the few plants observed, sago pondweed (*Potamogeton pectinatus*) and Eurasian watermilfoil were dominant.

Sources of phosphorus include internal recycling from sediments (resuspension) and decomposition of organic matter. External sources of phosphorus include stormwater runoff, geese and poor water quality from Napa Suwe (LCHD 2004). Stormwater runoff potentially contributes phosphorus to surface waters via agriculture, including row crops, grain, and grazing (22% land use) and residential lawns (15% land use). There are no NPDES dischargers located within the Island Lake watershed.

6.6 Slocum

Slocum Lake is located in the central portion of the Upper Fox River/Flint Creek watershed (Figure 2-2) in the unincorporated Wauconda Township. It is a naturally formed glacial pothole slough with 211 surface acres. The lake is privately owned and access is restricted to ownership associations and homeowners on the lake. Maximum and mean water depths are 7.3 and 5.1 feet respectively (LCHD 2005). Slocum Lake drains to the south via an outlet structure eventually draining into the Fox River.

Slocum Lake receives water from Bangs Lake Drain to the east and the surrounding area (5310 acres). The watershed-to-lake area ratio is 25.1 suggesting that water quality in the lake is highly dependent on the quality of incoming water. The majority of the watershed area is open space (26%) and residential (25%). The majority of the shoreline is developed (67%) with 36% exhibiting some level of erosion. Seventeen percent of the watershed is impervious cover, a level at which impacts are expected.

The LMU 2005 Summary Report of Slocum Lake (LCHD 2005) notes that this lake does not thermally stratify because of its shallow morphometry. Slocum Lake is well oxygenated with DO concentrations above 5.0 mg/L at all depths in 2005, except at the bottom depth (6') in mid August when DO was 4.9 mg/L.

Slocum Lake is listed as impaired due to excessive TP concentrations. Total phosphorus data for Slocum Lake are available for 1973, 1995, 2001 and 2005 from Legacy Storet and Lake County. Surface water TP concentrations for this time period ranged from 0.11 to 1.33 mg/L, with an average of 0.29 mg/L (Table 5-2, Figure 5-6, Appendix E). All the averaged surface samples were above the 0.05 mg/L WQS. In 2005, the average surface concentration was 0.15 mg/L and ranged from 0.11 - 0.19 mg/L. These phosphorus concentrations are excessive, however severe algal blooms were not noted in the LMU 2005 report.

The lake experiences poor water clarity and suspected causes are algae and suspended sediment. The average Secchi disk transparency in 2005 was one foot. Low clarity is related to high suspended solids and algal biomass. However, severe blooms were not noted in the LMU 2005 report. The average TSS concentration in 2005 was 54 mg/L and reached a high of 77 mg/L. Much of the TSS and low clarity is attributed to resuspension of sediment by carp activity (LCHD 2005).

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Approximately 30% of the Slocum Lake surface area contains rooted aquatic plants. There were only three species observed in Slocum Lake. The nuisance species coontail and Eurasian watermilfoil were dominant. Sago pondweed was also present but in lower densities.

Sources of phosphorus include internal recycling from sediments (resuspension due to carp and wind/wave action) and decomposition of organic matter. Historically the Bangs Lake Drain received water from the Wauconda Wastewater Treatment Plant (WWTP) from the 1900's up until 1997 when the effluent was diverted to Fiddle Creek (LCHD 2005). For 10 years (1986 – 1996), and during excess flow conditions, raw sewage was discharged to the Bangs Lake Drain (LCHD 2002). This historic discharge from the Wauconda WWTP has resulted in phosphorus rich sediment that is often resuspended. This is likely the major source of phosphorus in Slocum Lake. External sources of phosphorus include stormwater runoff from agricultural (5% land use) and residential areas (25% land use) containing fertilizers and sediments (LCHD 2005), failing septic system, illicit connections to the storm sewer system and a nearby horse farm (LCHD 2002) are also potential sources. There are no NPDES dischargers located within the Slocum Lake watershed.

6.7 Timber Lake South

Timber Lake South is located near the Village of Barrington in the unincorporated Cuba and Wauconda Townships (Figure 2-2). Timber Lake South was created in 1949 by dredging a wetland and damming a creek. It has a surface area of approximately 33 acres with a maximum and mean depth of 14 and 7.6 feet respectively (LCHD 2001). The lake is privately owned by 26 residents and the Timber Lake Community Organization. Timber Lake South drains to the west via a creek to Tower Lake, eventually draining to the Fox River.

Timber Lake South receives water from an unnamed creek to the west and stormwater runoff from the surrounding area. The watershed is approximately 1228 acres resulting in a watershed-to-lake area ratio of 37:1 suggesting that water quality in the lake is highly dependent on the quality of incoming water. The majority of the watershed area is residential (49%) with row crop, grain and grazing comprising 13% of the area. The majority of the shoreline is also developed (97%) and is comprised primarily of buffer (48%) (LCHD 2007). Nineteen percent of the watershed is impervious cover, a level at which impacts are expected.

Timber Lake South was thermally stratified in 2007 from May through September. Epilimion DO concentrations were below 5.0 mg/L. Anoxic conditions (<1.0 mg/L) were recorded in May through September in 2007 (LCHD 2007) at water depth as shallow as nine feet. Although aerators are utilized in Timber Lake South, these systems are undersized for the lake. In addition, these aerators were not operating for a portion of 2007.

Timber Lake South is listed as impaired due to excessive TP concentrations. Water quality data for Timber Lake South were collected in 1989, 2000 and 2007 and are available from Legacy STORET and Lake County. Surface water TP concentrations for this time period ranged from 0.04 to 0.21 mg/L, with an average of 0.09 mg/L (Table 5-2, Figure 5-6, Appendix E). Sixty percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2007, the average surface concentration was 0.06 mg/L and ranged from 0.04 - 0.09 mg/L. Bottom concentrations in 2007 were higher and averaged 0.17 mg/L.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. The estimated aquatic plant density in 2007 was higher than in 2000. This increase in plant density also corresponded with an increase in water clarity and decreased TSS from 2000 (LCHD 2007). Two invasive species were identified, Eurasian watermilfoil and curly leaf pondweed.

Sources of phosphorus include internal recycling from sediments. Sediment sources include flux from nutrient rich sediment under anoxic conditions and resuspension due to carp, wind/wave action and aerators. External sources of phosphorus include stormwater runoff from the highly developed impervious surfaces such as residential and transportation areas (LCHD 2007). Although the watershed is likely a substantial contributor to the TP load, the major source of phosphorus is expected to be internal recycling (LCHD 2007). There are no NPDES dischargers located within the Timber Lake South watershed.

6.8 Lake Fairview

Lake Fairview is located in the Wauconda Townships (Figure 2-2). Lake Fairview is an artificial lake created in 1969 by damming a wetland. The lake is currently privately owned by residents along the lake. It has a surface area of approximately 20.5 acres with a maximum and mean depth of 10.5 and 5.3 feet respectively (LCHD 2001). Lake Fairview drains from the southeast corner via a culvert to Tower Lake, eventually draining to the Fox River.

There are no major creeks or tributaries draining to Lake Fairview. The watershed is small (30 acres) and therefore the watershed-to-lake area ratio is also small 2:1. The majority of the watershed area is residential (40%) with forest, grasslands and vegetation comprising 9% of the area. The majority of the shoreline is developed (75%) and is comprised primarily of buffer (69%) (LCHD 2001). Fifteen percent of the watershed is impervious cover, a level at which impacts are expected.

Lake Fairview did not thermally stratify in 2000 but was stratified in 2007 (LCHD 2001 & 2007). DO concentrations in 2007 fell below 5.0 mg/L in June and July below 4’ and in August below 6’. Anoxic conditions (<1.0 mg/L) were recorded in June, July and August 2007 as well. Depth to anoxia varied from 6 to 9' (LCHD 2007).

Lake Fairview is listed as impaired due to excessive TP concentrations. TP data are limited to the two surveys performed by LMU in 2000 and 2007. Surface water TP concentrations for this time period ranged from 0.02 to 0.09 mg/L, with an average of 0.07 mg/L (Table 5-2, Figure 5-6, Appendix E). Eighty nine percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2007, the average surface concentration was 0.06 mg/L and ranged from 0.02 - 0.09 mg/L. Bottom concentrations in 2007 were higher and averaged 0.15 mg/L.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Lake Fairview is not an algal dominated lake, it supports dense aquatic vegetation. Forty one percent of the bottom was covered by plants in 2007. Coontail and curly leaf pondweed dominated the community. It is likely that the dense rooted plant community outgrows algae for resources and is thereby reducing bloom intensity and frequency.

Sources of phosphorus include internal recycling from sediments. Sediment sources include flux from nutrient rich sediment under anoxic conditions and resuspension. External sources of phosphorus include stormwater runoff from the highly developed impervious residential areas. There are no NPDES dischargers located within the Lake Fairview watershed.

6.9 Tower Lake

Tower Lake is located in the southern portion of the Upper Fox River/Flint Creek watershed in the Village of Tower Lakes in Cuba Township (Figure 2-2). It is a small man-made lake with 68.8 surface acres. The lake was originally created in 1923 and further enlarged in 1927 and in the 1940's (LCHD 2002). The lake is privately owned by the Tower Lakes Improvement Association. Throughout its history, Tower Lake has experienced several challenges. The lake has suffered from fish kills and excessive aquatic vegetation, carp and turbidity. Recent issues include algal blooms, low aquatic plant growth and high bacteria concentrations. Much of the water quality problems in Tower Lake are related to its morphometry (LCHD 2002). The lake is shallow, with a maximum depth of 7.5' and a mean depth of 4.5'. Water flows from Tower Lake via a spillway located in the southwest portion of the lake to the Fox River.

The Tower Lake watershed is large (3,148 acres) relative to lake area (46:1). Water enters Tower Lake via the Timber Lake drain, small creeks and stormwater outfalls. The watershed is primarily residential (47%) and as a result has substantial impervious cover (21%). Water quality impacts are typically associated with IC values >10%.

The LMU 2007 Summary Report of Tower Lake (LCHD 2007) notes that Tower Lake does not thermally stratify due to its shallow morphometry and is subject to wind and wave mixing. Surface water DO concentrations remained above 5.0 mg/L for the summer (LCHD 2007). However, anoxia was observed in depths greater than 5' in August.

Tower Lake is listed as impaired due to excessive TP concentrations. Total phosphorus data for Tower Lake are available for 1988, 2001 and 2007 from Lake County. Surface water TP concentrations for this time period ranged from 0.02 to 0.16 mg/L, with an average of 0.07 mg/L (Table 5-2, Figure 5-6, Appendix E). Sixty four percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2007, the average surface concentration was 0.07 mg/L and ranged from 0.03 - 0.10 mg/L.

Historically, the lake suffered from excessive rooted plant densities, but today the lake suffers from algal blooms (LCHD 2007). Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. The shift from rooted plant dominance to algal dominance is suspected to have occurred around the 1970's shortly after the Davlin's pond dam was breached (2002). During this period, the lake experienced an increase in carp population, reduction in plant density, an increase in suspended sediment loading and increase in algal blooms. However, the lake still harbors nuisance aquatic species that are controlled using herbicides. Coontail was the most frequently encountered plant during the 2007 survey (LCHD 2007). Algal blooms have been noted after herbicide treatments following a decline in plant density (LCHD 2007). Algaecide treatments are also used in Tower Lake to control blooms.

Tower Lake is also listed as impaired due to excessive bacteria concentrations. Fecal coliform was measured in Tower Lake during 2001. Sixteen samples were collected from Tower Lake; two samples were collected on three occasions in May, two in June and July and once in August. Values in Tower Lake ranged from 10 to 820 cfu/100 ml (Figure 5-4). Five samples (31%) contained concentrations above the 200 cfu/100 ml WQS. Exceedences occurred in May and June.

E. coli, another pathogen indicator species, was also sampled within Tower Lake during May through August in 2002 through 2007 (Appendix B). Although Illinois does not have a numerical standard for *E. coli*, the US EPA document “Ambient Water Quality Criteria for Bacteria – 1986” states a freshwater bathing criteria of a geometric mean from five samples within a 30 day period not exceed 126 cfu/100 ml (US EPA 1986). During this period 98 samples were collected in Tower Lake. Samples were collected twice per day up to three times per month. Seven percent of the individual Tower Lake samples exceeded the *E. coli* level of 126 cfu/100 ml . These values, however, were individual exceedances and at no time was the geomean standard violated. *E. coli* data for these impaired segments are presented in Figure 5-5.

Sources of phosphorus entering Tower Lake, according to the LMU, include stormwater runoff carrying fertilizers and geese feces into the lake. Although not specifically mentioned in the LMU report, resuspension of nutrient rich sediment are also a potential source of phosphorus as well as pet feces and septic tanks. Sources of bacteria also include stormwater runoff and geese feces. There are no active NPDES discharges in the Tower Lake watershed.

6.10 Lake Barrington

Lake Barrington is located just south of Tower Lake in the unincorporated Cuba Township (Figure 2-2). Lake Barrington is a 91 acre man-made lake formed by damming a depressional area in 1925. Maximum and mean depths are 13.0 and 7.8 feet respectively. The lake is owned by the Lake Barrington Shores Homeowners Association and is used for viewing, non-motorized boating, fishing and golf course irrigation.

The Lake Barrington watershed is small (191 acres) relative to lake area (2:1) and as a result has a long retention time (6.2 years) (LCHD 2007). Lake Barrington receives water from an inlet on Forest Preserve Land and stormwater drainage outlets. The watershed is primarily residential (35%) and open space (20%). The shoreline is primarily developed (74%) and consists mainly of rip rap (73%). Impervious cover is relatively high (16%) above the level where water quality impairments are likely.

The LMU 2007 Summary Report of Lake Barrington (LCHD 2007) notes that Lake Barrington was slightly stratified in August 2007, but is generally well mixed. DO concentrations dropped below 5.0 mg/L in August (below 2’) and September (entire water column) 2007. Anoxia was observed in depths greater than 4’ in August.

Lake Barrington is listed as impaired due to excessive TP concentrations. Total phosphorus data for Lake Barrington are available for 1989, 2001 and 2007 from Lake County. Surface water TP concentrations for this time period ranged from 0.01 to 0.18 mg/L, with an average of 0.10 mg/L (Table 5-2, Figure 5-6, Appendix E). Sixty seven percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2007, the average surface concentration was 0.07 mg/L and ranged from <0.01 - 0.11 mg/L.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Lake Barrington, however, experiences both partly due to artificial manipulation. In the 1980's, curly leaf pondweed covered the entire bottom surface of Lake Barrington. Herbicide applications and mechanical harvesting began in an attempt to control this species and another invasive - Eurasian watermilfoil. Planting of natives occurred in the 1990's in an attempt to increase native plant density. In 2001, the control of plants using herbicides had left the lake with low plant densities and algal dominance and low water clarity resulted (LCHD 2002). Desiccation of plants and algae contribute to the lack of oxygen and high phosphorus concentrations within Lake Barrington.

Lake Barrington is also listed as impaired due to excessive bacteria concentrations. Figure 5-4 displays fecal coliform data within impaired segments during the WQS compliance period (May – October). Fecal coliform was measured in Barrington during 2001. Sixteen samples were collected in Lake Barrington; two samples were collected on three occasions in May, two in June and July and once in August. Values in Lake Barrington ranged from 10 to 890 cfu/100 ml. Four of the samples (25%) exceeded the 200 cfu/100 ml WQS. Exceedences occurred in May and June.

E. coli, another pathogen indicator species, was also sampled within Lake Barrington during May through August in 2002 – 2007 (Appendix B). During this period 102 samples were collected in Lake Barrington. Samples were collected twice per day up to three times per month. Eleven percent of individual Lake Barrington samples exceeded the *E. coli* 126 cfu/100 ml EPA criteria. *E. coli* data are presented in Figure 5-5.

Sources of phosphorus entering Lake Barrington include stormwater runoff. Internal sources appear to be the primary source, however. Internal phosphorus loading from nutrient rich sediment during periods of anoxia are highly likely. In addition, the decomposition of plant and algal material following management (herbicides, algaecides and harvesting) add to the internal phosphorus load. Potential sources of bacteria, according to the LMU, include stormwater runoff, geese and duck feces and wind/wave action stirring up beach sediments. Pet feces and malfunctioning septic systems are also suspected of contributing to pathogen impairments. There are no active NPDES discharges in the Lake Barrington watershed.

6.11 Fox River DT-22

The Fox River segment DT-22 is extends from the Colby Point to just upstream of the Flint Creek Fox River confluence (Figure 2-2). This segment is approximately 7.8 miles and drains 387 square miles within Illinois, including the Chain of Lakes watershed (267 sq mi). The Illinois portion of the drainage area to DT-22 is predominately used for row crop, grain and grazing (33%) and residential (20%). Impervious cover in this portion of the Fox River watershed is approximately 12%, a level where water quality impacts are expected.

This portion of the Fox River is impaired due to low DO, fecal coliform and high pH. Violation of the March – July instantaneous DO standard were recorded in April and June 2006 and June 2008 (Figure 5-2). Multiple fecal coliform samples were above the 200 cfu/100 mL WQS in this segment of the Fox River (Figure 5-4). pH values exceeded the 6.5 – 9.0 SU WQS on six occasions out of 657 measurements (<1%).

Potential sources of water quality impairment in this segment include flow and water level manipulation at the McHenry dam located upstream of this segment. According to the 2008 Integrated Report, urban runoff, storm sewers, recreational pollutant source and unknown sources may also contribute to the impairment
There are several NPDES discharges that contribute to the inorganic and organic load to the river that oxidize and consume oxygen which may contribute to low DO conditions (Figure 6-2, Appendix E). Two NPDES permittees discharge directly to the Fox River and have the potential for greater impact. These facilities include the Port Barrington Shores Sewage Treatment Plant and the Northern Moraine Wastewater Reclamation District WWTP. The six remaining facilities will likely have a lesser impact due to their distance from the Fox River. These facilities include:

- Mathews Company
- Crystal Lake WWTP #3
- Precision Twist Drill Corporation

- IAWC - Terra Cotta STP
- Snap-On Logistics Co. Crystal Lake DC
- Wauconda WWTP

Also included are all sources and NPDES dischargers identified in upstream impaired segments. These segments include:

- Upper Fox River/Chain of Lakes watershed
- Fox River DT-23
- Drummond Lake
- Lake Napa Suwe
- Woodland Lake
- Slocum Lake
- Timber Lake South
- Lake Fairview
- Tower Lake
- Barrington Lake

6.12 Echo Lake

Echo Lake is located in the southeastern portion of the Upper Fox River/Flint Creek watershed northeast of the Village of Lake Zurich (Figure 2-2). The lake is a natural slough that was enhanced by erecting a dam in the 1920's. The majority of the lake is owned by the Echo Lake Improvement Association. The Village of Lake Zurich and the Lake County owns the other two parcels. This 25 acre lake is shallow, with a maximum and mean depth of 10.5 and 5.3 feet respectively. The lake discharges from the north shore into a tributary of Grassy Lake and eventually to Flint Creek and the Fox River.

Water enters Echo Lake from the 1,229 acre watershed via two main inlets. One inlet drains residential areas and is located east of the Echo Lake Improvement Association beach. The second inlet drains from Lake Zurich and passes through other pond and wetland systems prior to entering Echo Lake. The watershed-to-lake area ratio is very high (49:1) and indicates water quality conditions within Echo Lake are highly dependent on incoming water quality. Watershed land use is primarily comprised of residential areas (24%) and water resources (22%). The majority of the shoreline is also developed (88%) and consists mostly of rip rap (24%) (LCHD 2001).

Echo Lake experienced summertime anoxia in 2000 at depths as shallow as 7'. DO concentrations below 5.0 mg/L were recorded at depths below 5'. Low bottom DO promotes the release of phosphorus from anoxic sediment.

Echo Lake is listed as impaired due to excessive TP concentrations. TP data for Echo Lake are available for 1995 and 2000 from Lake County. Surface water TP concentrations for this time period ranged from 0.04 to 0.15 mg/L, with an average of 0.09 mg/L (Table 5-2, Figure 5-6, Appendix E). Eighty percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2000, the average surface concentration was 0.08 mg/L and ranged from 0.05 - 0.13 mg/L. Bottom concentrations were slightly higher and averaged 0.13 mg/L.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Echo Lake, however, experiences both partly due to artificial manipulation. Curly leaf pondweed and coontail dominate the plant community in Echo Lake which covers 95% of the lake bottom. Herbicides are applied in an attempt to control these species. Algaecides are also applied to control nuisance algal growths (LCHD 2001). Desiccation of plants and algae contribute to the lack of oxygen and high phosphorus concentrations within Echo Lake.

Sources of phosphorus entering Echo Lake are stormwater runoff and surface water flow from the two main inlets. Internal sources include phosphorus loading from nutrient rich sediment during periods of anoxia, sediment resuspension and decomposition of plant and algal material following management activities (herbicide & algaecide applications). There are no active NPDES discharges in the Echo Lake watershed.

6.13 Honey Lake

Honey Lake is located in Cuba Township in the south central portion of the Upper Fox River/Flint Creek watershed (Figure 2-2). This 66 acre glacial lake is privately owned by the Biltmore Country Club and private land owners. The Country Club has a beach which is open to Biltmore Country Club members. Honey Lake has a maximum and mean depth of 18+ and 8.8 feet respectively (LCHD 2002). Water leaves Honey Lake via a spillway located on the west side of the lake to a tributary of Grassy Lake.

Honey Lake receives water from a wetland to the north and two main creeks on the east side. The watershed is approximately 1,111 acres which results in a watershed-to-lake area ratio of 17:1. Land use in the watershed is primarily residential (47%). About one half of the Honey Lake shoreline is developed (49%) and much of this area consists of buffer (49%). The relatively high percentage of residential area in the watershed results in a high percentage of IC (21%). This level of IC is just below the threshold where water quality impairments are expected (25%), but within the threshold where impacts are typical.

The LMU 2001 Summary Report of Honey Lake (LCHD 2002) notes that Honey Lake was thermally stratified in 2001. DO concentrations dropped below 5.0 mg/L below 10' in June, 8' in July and September and 12' in August 2001. Anoxia was observed in depths greater than 14' in July and August and 12' in September 2001.

Honey Lake is listed as impaired due to excessive TP concentrations. TP data for Honey Lake are available for 1988, 1998 and 2001 from Lake County. Surface water TP concentrations for this time period ranged from 0.03 to 0.20 mg/L, with an average of 0.06 mg/L (Table 5-2, Figure 5-6, Appendix E). Thirty percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2001, the average surface concentration was 0.07 mg/L and ranged from 0.03 - 0.20 mg/L. Bottom concentrations were much higher and averaged 0.26 mg/L with a range of 0.10 – 0.45 mg/L.

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Honey Lake is primarily rooted plant dominant but does experience periodic algal blooms which may be related to the instability of the thermocline. If the thermocline is disturbed, accumulated phosphorus in the hypolimnion becomes available in the photic zone (area available for photosynthetic activity) where it can be rapidly consumed by algae resulting in a bloom. The Biltmore Country Club treats the beach area with an algaecide during blooms. Rooted plant occupied 57% of the sediment surface area in Honey Lake and it is suspected that this high density of rooted growth is preventing more serious and frequent algal blooms from forming (LCHD 2001). *Chara*, a macro alga, is the dominant submerged plant in Honey Lake. The lake is treated with herbicides to control nuisance aquatic plant growth.

Honey Lake is also listed as impaired due to excessive bacteria concentrations. Figure 5-4 displays fecal coliform data within impaired segments during the WQS compliance period (May – October). Fecal coliform was measured in Honey Lake during 2001. Twenty two samples were collected in Honey Lake, two samples per day twice in May, June and July and five times in August. Values ranged from 10 to 1700 cfu/100 ml, with ten samples (45%) exceeding the 200 cfu/100 ml WQS. Exceedences occurred in July and August. The geometric mean of July and August samples was 441 cfu/100 ml, above the WQS.

E. coli, another pathogen indicator species, was also sampled within Honey Lake during May through August in 2002 – 2007 (Appendix B). During this period 108 samples were collected in Honey Lake. Samples were collected twice per day up to three times per month. Twenty four percent of individual Honey Lake samples exceeded the *E. coli* 126 cfu/100 ml EPA criteria. *E. coli* data are presented in Figure 5-5.

Potential sources of phosphorus entering Honey Lake include stormwater runoff, fertilizers, failing septic systems and erosion. Internal phosphorus loading from nutrient rich sediment during periods of anoxia are highly likely. In addition, the decomposition of plant and algal material following management (herbicides and algaecides) add to the internal phosphorus load. While the LMU only noted geese feces as the source of bacteria in Honey Lake, pet feces also serves as a likely source. There are no active NPDES discharges in the Honey Lake watershed.

6.14 Grassy Lake

Grassy Lake is a glacial slough located in the southern portion of the Upper Fox River/Flint Creek watershed in (Figure 2-2). It is a lake with 41 surface acres and a mean and maximum depth of 4.3 and 8.5 feet respectively. Water flows from Grassy Lake in the northwest portion of the lake to a tributary of Flint Creek eventually draining into the Fox River.

The Grassy Lake watershed is large (6,643 acres) relative to lake area (162:1). Grassy Lake receives water from two other impaired waterbodies within the watershed, Echo and Honey Lakes via a tributary located on the eastern portion of Grassy Lake. The watershed is primarily residential (40%) and as a result has substantial impervious cover (23%). Water quality impacts are typically associated with IC values >10%.

The LMU 2000 Summary Report of Grassy Lake (LCHD 2001) notes that Grassy Lake weakly stratifies for a short period due to its shallow morphometry and is subject to wind and wave mixing. DO concentrations remained above 5.0 mg/L for most of the summer, with values dropping below 5.0 mg/L at the bottom in May and below 5' in July. Anoxia was not observed at any depth in 2000 (LCHD 2001).

Grassy Lake is listed as impaired due to excessive TP concentrations. TP data for Grassy Lake are available for 1988 and 2000 from Lake County. Surface water TP concentrations for this time period ranged from 0.07 to 0.33 mg/L, with an average of 0.20 mg/L (Table 5-2, Figure 5-6, Appendix E). All averaged surface samples were above the 0.05 mg/L WQS. In 2000, the average surface concentration was 0.20 mg/L and ranged from 0.11 - 0.30 mg/L. The average bottom concentration was the same (0.20 mg/L).

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Grassy Lake has a poor aquatic plant community. The community consists of three species: coontail, curly leaf pondweed and duckweed (*Lemna minor*). In adequate light is the suspected cause of the poor community. Grassy Lake is very turbid from carp behavior and resuspension of sediment due to its shallow morphometry.

Sources of phosphorus entering Grassy Lake include the two other phosphorus impaired lakes and stormwater runoff. The LMU noted that resuspension of sediment due to carp and wind/wave action are likely a significant source (LCHD 2001). There are two active NPDES discharges in the Grassy Lake watershed. These include the North Barrington Elementary School sewer treatment plant and the Mount Saint Joseph Shelter Care Home Sewer Treatment Plant. Depending on the effluent TP load, these facilities have the potential to impact water quality in Grassy Lake.

6.15 Louise Lake

Louise Lake is the southern most impaired waterbody within the Upper Fox River/Flint Creek watershed (Figure 2-2). Louise Lake is a man-made lake created in 1967 during the development of the Fox Point Subdivision in the Village of Barrington. The lake is a 38 acre private lake owned by the Fox Point Homeowners Association. The maximum and mean depths are 10 and 5 feet respectively (LCHD 2004). Flint Creek is the main inlet and enters Louise Lake from the south. Water exits the lake, as Flint Creek, to the northwest draining to the Fox River.

The Louise Lake watershed is large (1582 acres), resulting in a watershed-to-area ratio of 42:1. Land use in the watershed is primarily residential (52%) and open space (24%). Impervious cover is high (20%) and at a level where water quality impacts are expected.

The lake is generally well mixed with no thermal stratification (LCHD 2004). During the 2003 study, the LMU measured surface DO concentrations at the surface above 5.0 mg/L. Anoxic conditions were observed once during this investigation and occurred in August below 5 feet.

Louise Lake is listed as impaired due to excessive TP concentrations. TP data for Louise Lake are available for 1988, 1998 and 2003 from Lake County. Surface water TP concentrations for this time period ranged from 0.04 to 0.31 mg/L, with an average of 0.15 mg/L (Table 5-2, Figure 5-6, Appendix E). Ninety two percent of the averaged surface samples were above the 0.05 mg/L WQS. In 2003, the average surface concentration at the inlet was 0.19 mg/L and ranged from 0.07 - 0.32 mg/L. The average outlet concentration was the same (0.19 mg/L).

Eutrophic lakes are typically algal or rooted plant dominated; rarely does co-dominance exist due to competition for resources. Louise Lake has a poor aquatic plant community and experience severe algal blooms. Although the current plant community is relatively scarce, an herbicide treatment was performed in 1998 when plants were thought to be a nuisance levels. This treatment is believed to have resulted in a shift from a plant dominated system to an algal dominated one (LCHD 2004). Algaecides are now applied several times a year to control algal growths.

Sources of phosphorus entering Louise Lake include surface waters from Flint Creek and stormwater runoff. The LMU noted that resuspension of sediment due to carp and wind/wave action are likely a significant source (LCHD 2001). There are no active NPDES discharges in the Louise Lake watershed.

7.0 TMDL Approach and Next Stages

This chapter discusses the methodology that may be used for the development of TMDLs for the Upper Fox River/Flint Creek watershed. While a detailed watershed modeling approach can be advantageous, a simpler approach is often able to efficiently meet the requirements of a TMDL and yet still support a TMDL-guided and site-specific implementation plan. The final selection of a methodology will be determined with consultation with the Illinois EPA based on following factors:

- Fundamental requirements of a defensible and approvable TMDL
- Data availability
- Fund availability
- Public acceptance
- Complexity of water body

A simpler approach shall be used as long as it adequately supports the development of a defensible TMDL. If it is deemed that this approach will not suffice, a more sophisticated modeling approach will be recommended for analysis to help better establish a scientific link between the pollutant sources and the water quality indicators for the attainment of designated uses. Methodology for estimating daily loads will depend on available data as well as the selected analysis.

7.1 Recommended Modeling Approach for Dissolved Oxygen and pH

Three segments within the Upper Fox River/Flint Creek watershed are targeted for DO TMDL development. These segments include two Fox River segments and Woodland Lake. Excessive nutrients often result in algal blooms and extensive rooted plant growths which can deplete oxygen and increase pH. The two main ways oxygen depletion occurs related to plant growth, both planktonic and rooted, include decomposition and respiration. Decomposition is the process of breaking down matter. During this process, aerobic bacteria utilize oxygen to convert organic matter into energy and release carbon dioxide. If the rate of decomposition is great enough, this process can result in deleterious oxygen depletion. Oxygen is also used during plant respiration for the conversion of stored sugars into energy. Excessive plant respiration can result in oxygen depletion. DO concentrations in lakes and ponds are typically at their lowest levels just before dawn after an evening of respiration without oxygen generation by photosynthesis.

Woodland Lake experienced excessive rooted plant densities historically, but recently the lake experiences severe algal blooms, either of these conditions can result in oxygen depletion. Given that Woodland Lake contains excessive TP concentrations which are likely related to low DO, a phosphorus TMDL should be prepared using available data (see discussion on TP approach). Additional sampling is not required in order to proceed with this TMDL.

Sources of the lack of DO and elevated pH in the Fox River segments DT-22 and DT-23 have been attributed to flow and water level manipulation at the McHenry dam located upstream of these segment, urban runoff, storm sewers, other recreational pollutant source and unknown causes. Other sources may include eutrophication, as mentioned above, and delete deleterious inputs.

For the Fox River segments, QUAL2K, a spreadsheet model that is based on the fundamental Streeter-Phelps DO sag equation, is recommended for DO TMDL development. QUAL2K is a one-dimensional, steady-state model that can accommodate point and non-point source loading and is capable of modeling DO and pH in streams and well-mixed lakes. QUAL2K is an updated version of QUAL2E and has been developed using a Microsoft Excel interface. QUAL2K allows for model segmentation, the use of two forms of carbonaceous BOD (both slow and rapid oxidizing forms), and is also capable of accommodating anoxia and sediment –

water interactions. While the model is simplistic in nature, it is capable of estimating critical BOD concentrations associated with in-stream DO concentrations of 5 mg/L and pH. In addition, denitrification is modeled as a first-order reaction that becomes pronounced at low oxygen concentrations. The model explicitly simulates attached bottom algae.

7.2 Recommended Modeling Approach for Fecal Coliform

Many states currently use load duration curves for fecal coliform TMDLs for its simplicity and effectiveness. Load duration curves use water quality criteria, ambient concentrations, and observed flows to estimate loading capacities for streams under various flow conditions. The load duration methodology is recommended for the impaired segment along the Fox River DT-22. There are three lake segments also targeted for bacteria TMDLs. These lakes include Tower, Barrington and Honey Lakes. An alternative approach for these lakes is discussed following the load duration methodology.

The first step in load duration process is to obtain an appropriate stream flow record. This is often difficult for streams not monitored by the USGS. There are methods, however, for developing stream flow statistics on ungaged streams. Regional curve numbers and regression equations are typical used in such instances. Alternatively, a gaged reference watershed can be used to obtain a stream flow record.

Flow duration curves are developed from stream flow records spanning multiple decades. The flow duration curve is based on flow frequency which provides a probability of meeting or exceeding a given flow. The duration curve is broken into hydrologic categories where high flows represent a duration interval of 0-10%, moist conditions represent 10-40%, mid-range flows 40-60%, dry conditions 60-90% and low flows 90-100%.

Once the flow duration curve is established, a load duration curve can be generated by multiplying stream flow with the numerical water quality standard and a conversion factor to obtain the load per day for a given stream flow. Individual measurements can be plotted against the load duration curve to evaluate patterns of impairment. Values that fall above the load duration line indicate an exceedance of the daily load and hence, water quality standard. These data can aid in determining whether impairment occurs more frequently in one of the hydrologic categories (wet, moist, mid-range, dry or low).

The MOS for duration curves can be implicit or explicit. Implicit MOS are derived from the inherent assumptions in establishing the water quality target. Explicit MOS include setting the water quality target lower than the WQS or not allocating a portion of the allowable load. For the Fox River DT-35 and potentially Deep Lake TMDL, WLAs will be based on permit levels or percent reductions required to meet the target load. The MOS will be determined during modeling and will be further explained in the Stage 3 report. Design discharge flow, permit limits and TMDL targets will be used to calculate a daily load and serve as the WLA. WLAs for NPDES-permitted stormwater discharges, including current and future MS4s, "Urbanized" areas, construction and industrial discharges and SSOs that do not have numerical effluent limitations will be expressed as a percent reduction instead of a numerical target. The NPDES Phase II Stormwater Regulations require all areas defined as "Urbanized" by the US Census obtain a permit for the discharge of stormwater. A map of these MS4 dischargers will be provided in the Stage 3 report. Stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern, whichever is less restrictive. The load allocation (LA) for all non-regulated sources, including non-point sources, will also be expressed as a reduction of the actual load. Sanitary Sewer Overflows (SSOs) will not receive an allocation as they are deemed illicit discharges.

Potential sources of bacteria in Tower, Barrington and Honey Lakes are waterfowl (mainly geese), runoff, and potentially failing septic systems. The Simple Method is the proposed for the development of a pathogen indicator (either fecal coliform or *E. coli*) TMDL. The Simple Method estimates loads based on runoff volume and pollutant concentrations on an areal basis. Impacts associated with direct loadings (failing septic systems and waterfowl) will be made in a similar way. Literature derived loadings per bird and/septic system will be used to generate direct loads. The MOS, WLA and LA will be determined in a similar manner as with the load duration curve (described above). The critical condition will be defined as the bathing season (May – October). Selection of this critical period will also address seasonality.

7.3 Recommended Modeling Approach for Total Phosphorus

For the 12 segments listed for TMDL development due to excessive phosphorus concentrations an export coefficient model linked to empirical in-lake response models will be used to determine existing loading and load reductions required to these segments into compliance with current WQS. In addition to these segments, a TP TMDL is also recommended Woodland Lake with the objective to bring DO into compliance with WQS.

A listing of phosphorus impaired lakes targeted for TP TMDLs are provided below. For these lakes the ENSR-LRM is proposed.

Barrington	Lake Napa Suwe
Drummond	Louise
Echo	Slocum
Grassy	Timber Lake South
Honey	Tower
Island	Woodland
Lake Fairview	

7.3.1 LLRM

The suggested model, LLRM (lake response model), was developed by AECOM (formerly ENSR) and has been used for more than 35 lake TMDLs. LLRM uses export coefficients for runoff, groundwater and nutrients to estimate loading as a function of land use. Yields will be assigned to each defined parcel (sub-watershed) in the lake watershed. Loading estimates will be adjusted based on proximity to the lake, soils and major Best Management Practices (BMPs) in place. Model yields will be compared to measured data, where available. Export coefficients and attenuation factors will be adjusted such that model loading accurately reflects actual loading based on sample data and measured in-lake concentrations.

Watershed and sub-watershed boundaries have been delineated and watershed land use has been determined using publically available data layers as part of this Stage 1 investigation. LLRM will be set-up on a sub-watershed level using available land use and average annual precipitation. The spreadsheet-based export coefficient model allows the user to select watershed yield coefficients and attenuation factors from a range appropriate in the region. The model also includes direct inputs for atmospheric deposition, septic systems, point sources, waterfowl and internal loading from lake sediments.

The generated load to the lake is processed through five empirical models: Kirchner & Dillon 1975, Vollenweider 1975, Larsen & Mercier 1976, Jones & Bachmann 1976 and Reckhow 1977. These empirical models predict in-lake phosphorus concentrations based on loading and lake characteristics such as mean water depth, volume, inflow, flushing and settling rates. Predicted in-lake phosphorus is compared to measured data. An acceptable agreement between measured and predicted concentrations indicates loading estimates are appropriate for use in the preparation of a TMDL. Adjustments to the loading portion of the model are made when necessary based on best professional judgment to ensure acceptable agreement between measured and predicted concentrations. These empirical models also predict chlorophyll *a* concentrations and water clarity (Secchi disk transparency). LLRM also includes a statistical evaluation of algal bloom probability.

Once the model has been calibrated to existing conditions, adjustments to the model can be made to determine the load reductions necessary to meet WQS. Different scenarios can be modeled to determine the appropriate BMPs during the implementation plan stage. In some instances, waterbodies are naturally eutrophic and may not achieve numerical WQS LLRM is most effective when calibrated with water quality data for the target system, but can be used with limited data. While it is a spreadsheet model with inherent limitations on applied algorithms and resultant reliability of predictions, it provides a rational means to link actual water quality data and empirical models in an approach that addresses the whole watershed and lake. LLRM is an easy and efficient method of estimating current loads to lakes as well as providing predictions on lake response under countless loading scenarios.

LLRM, like most simplified lake models, predicts phosphorus concentrations and estimates loading on an average annual basis. As required by the EPA, the TMDL must be expressed on a daily basis. However, there is some flexibility in how the daily loads may be expressed. Several of these options are presented in "Options for Expressing Daily Loads in TMDLs" (US EPA, 2007). For TMDLs based on watershed load and in-lake response models providing predictions on an annual basis, the EPA offers a method for calculating the maximum daily limit based on long-term average and variability. This statistical approach is preferred since long periods of continuous simulation data and extensive flow and loading data are not available. The following expression assumes that loading data are log-normal distributed and is based on a long term average load calculated by the empirical model and an estimation of the variability in loading.

$$MDL = LTA * e^{[z\sigma - 0.5\sigma^2]}$$

Where:
MDL = maximum daily limit
LTA = long-term average
Z = z-statistic of the probability of occurrence
$\sigma^2 = \ln(CV^2 + 1)$
CV= coefficient of variation

Data from similar lakes will be used in situations where there are not enough data to determine probability of occurrence or coefficient of variation for the impaired waterbody. The water quality data points from the entire watershed will be used in a statistic analysis to determine z-score and CV.

MOS for phosphorus using this method is implicit. There is substantial uncertainty when introducing concentration inputs to the models that results from the timing of sampling and analytical methods. Similarly, the empirical equations used to predict in-lake phosphorus concentrations, mean and maximum chlorophyll *a*, Secchi disk transparency, and bloom probability also introduce variability into the predictions.

WLA will be determined based on NPDES permit effluent limitations and design flows. WLAs for NPDES-permitted stormwater discharges, including current and future MS4s, "Urbanized" areas, construction and industrial discharges that do not have numerical effluent limitations will be expressed as a reduction. Stormwater discharges are required to meet the existing instream standard for the pollutant of concern. LAs will also be expressed as a load reduction.

Critical conditions for lakes typically occur during the summertime, when the potential (both occurrence and frequency) for nuisance algal blooms are greatest. The loading capacity for total phosphorus is set to achieve desired water quality standards during this critical time period and also provide adequate protection for designated uses throughout the year. The target goal is based on average annual values, which is typically higher than summer time values. Therefore a load allocation based on average concentrations will be sufficiently low to protect designated uses in the critical summer period.

The LLRM derived TMDL takes into account seasonal variations because the allowable annual load is developed to be protective of the most sensitive (i.e., biologically responsive) time of year (summer), when conditions most favor the growth of algae. Maximum annual loads are calculated based on an overall annual average concentration. Summer epilimnetic concentrations are typically lower than the average annual concentration, so it is assumed that loads calculated in this manner will be protective of designated uses in the summer season, It is possible that concentrations of phosphorus will be higher than the annual average during other seasons, most notably in the spring, but higher phosphorus levels at that time does not compromise uses. The proposed TMDL is expected to protect all designated uses of the impaired waterbody.

7.4 Stages 2 & 3

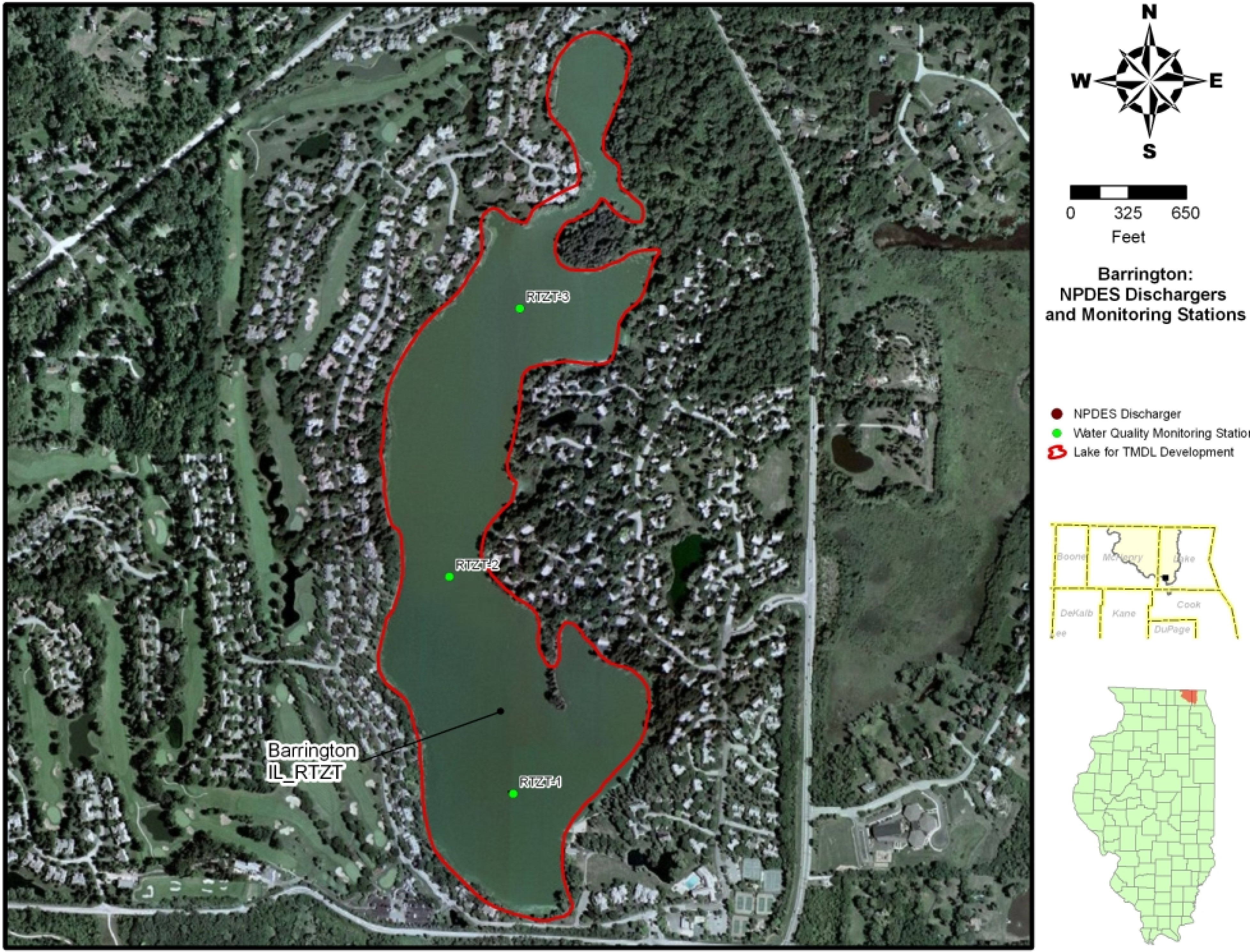
Effective TMDL development heavily relies on site-specific data. Sufficient flow and water quality data are required for the evaluation of water conditions and for model calibration. In fact, data availability often dictates the modeling approach used for various watersheds. Five types of data are crucial for the Upper Fox River/Flint Creek watershed TMDL development:

- Flow data
- Meteorological data
- Water quality data
- Watershed and water body physical parameters
- Source characteristics data

In general, if a water body was sampled in 2005 or later at multiple times, the data is considered adequate to characterize current conditions and support TMDL development. IL EPA and Lake County sampled in 4 lakes in 2008, including Echo, Grassy, Honey and Louise. Additional data will be gathered from Island Lake by the Illinois EPA in 2009. These collected data will be used for Stage 3 TMDL development. In addition, IL EPA stream monitoring unit will collect two sets of five-samples in 30 days for fecal coliform test at Fox River segment DT-22 ambient station in 2009. These data will be used to compare against fecal standards and verify the impairment.

Appendix A

Waterbody and Sub-Watershed Maps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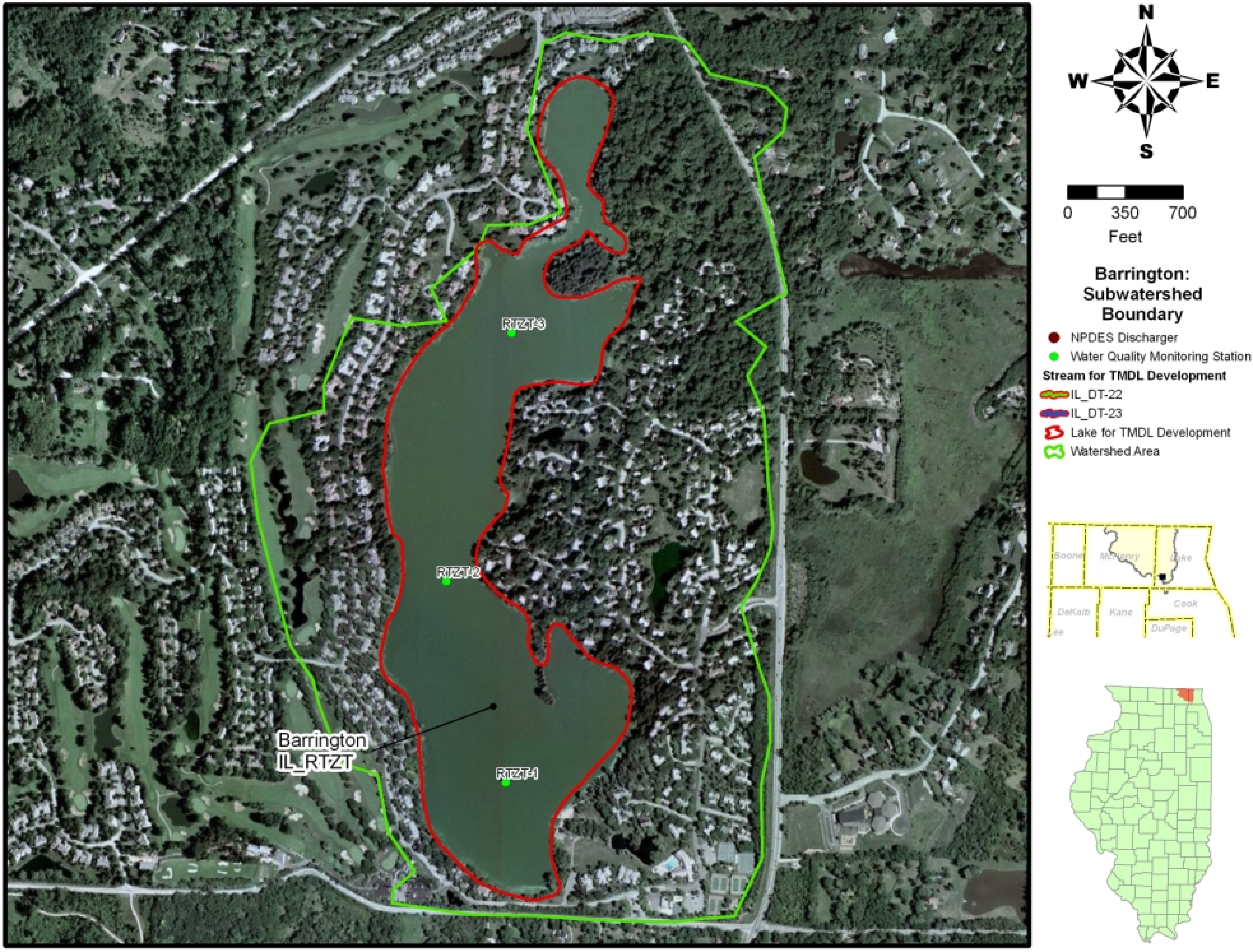

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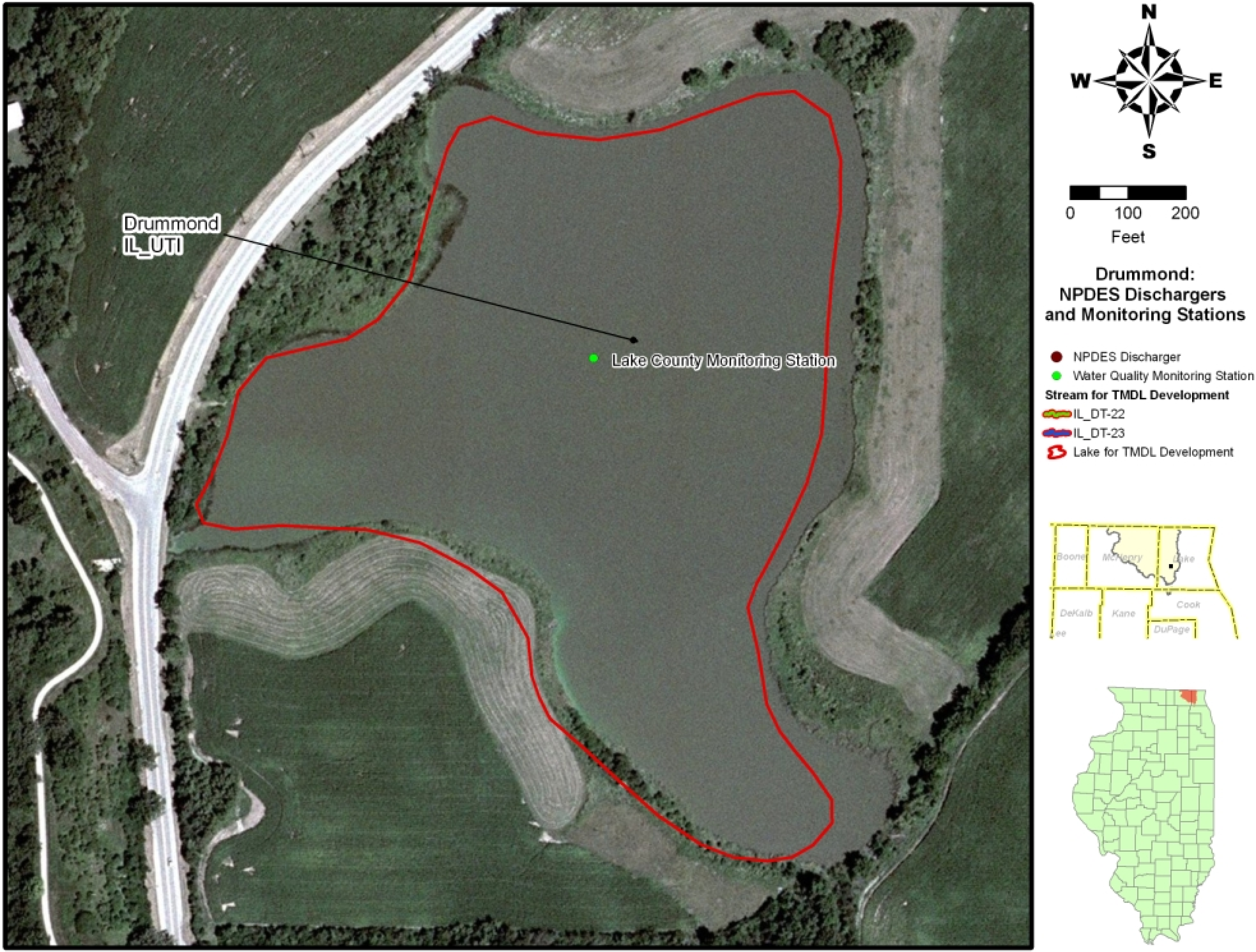
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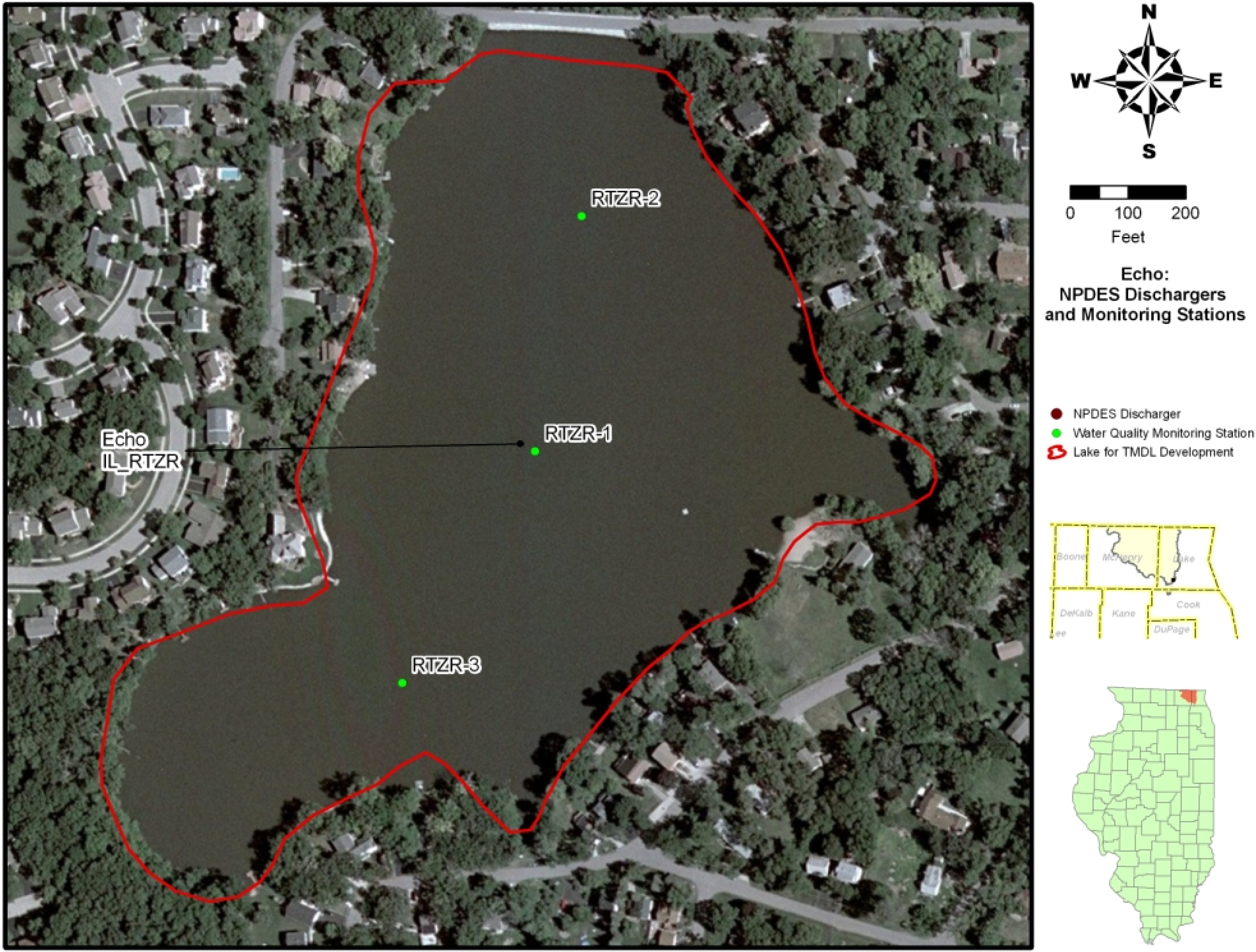

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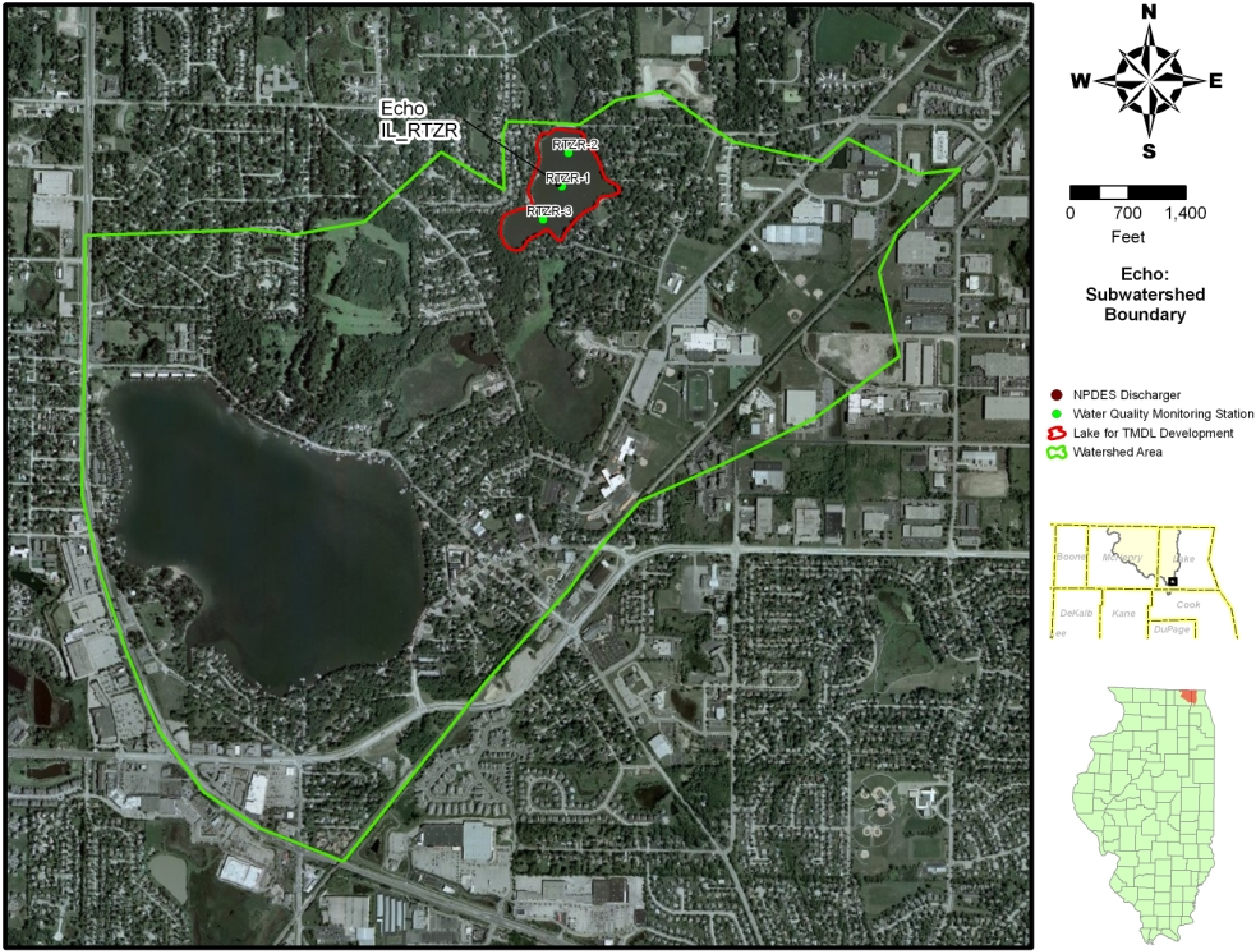

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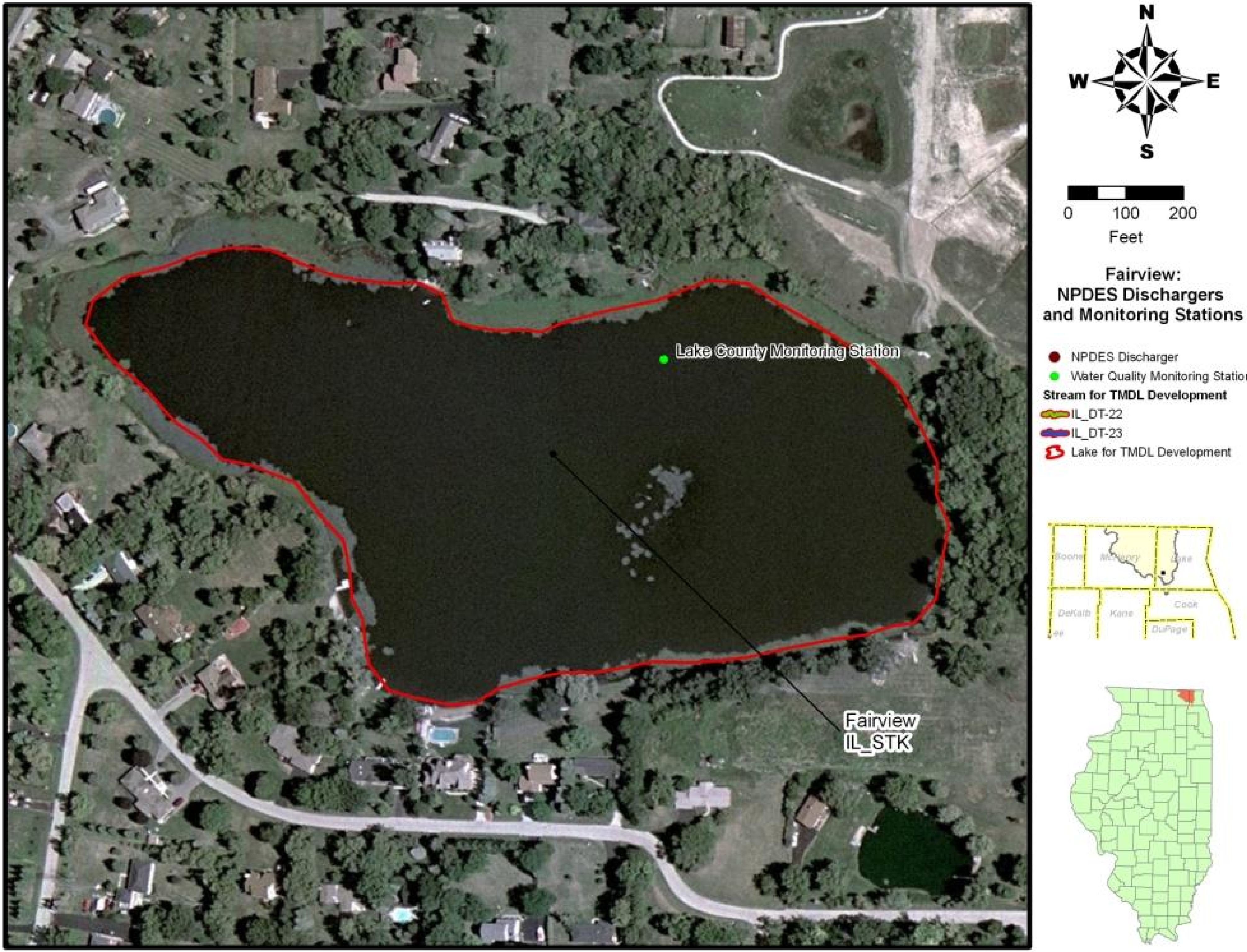
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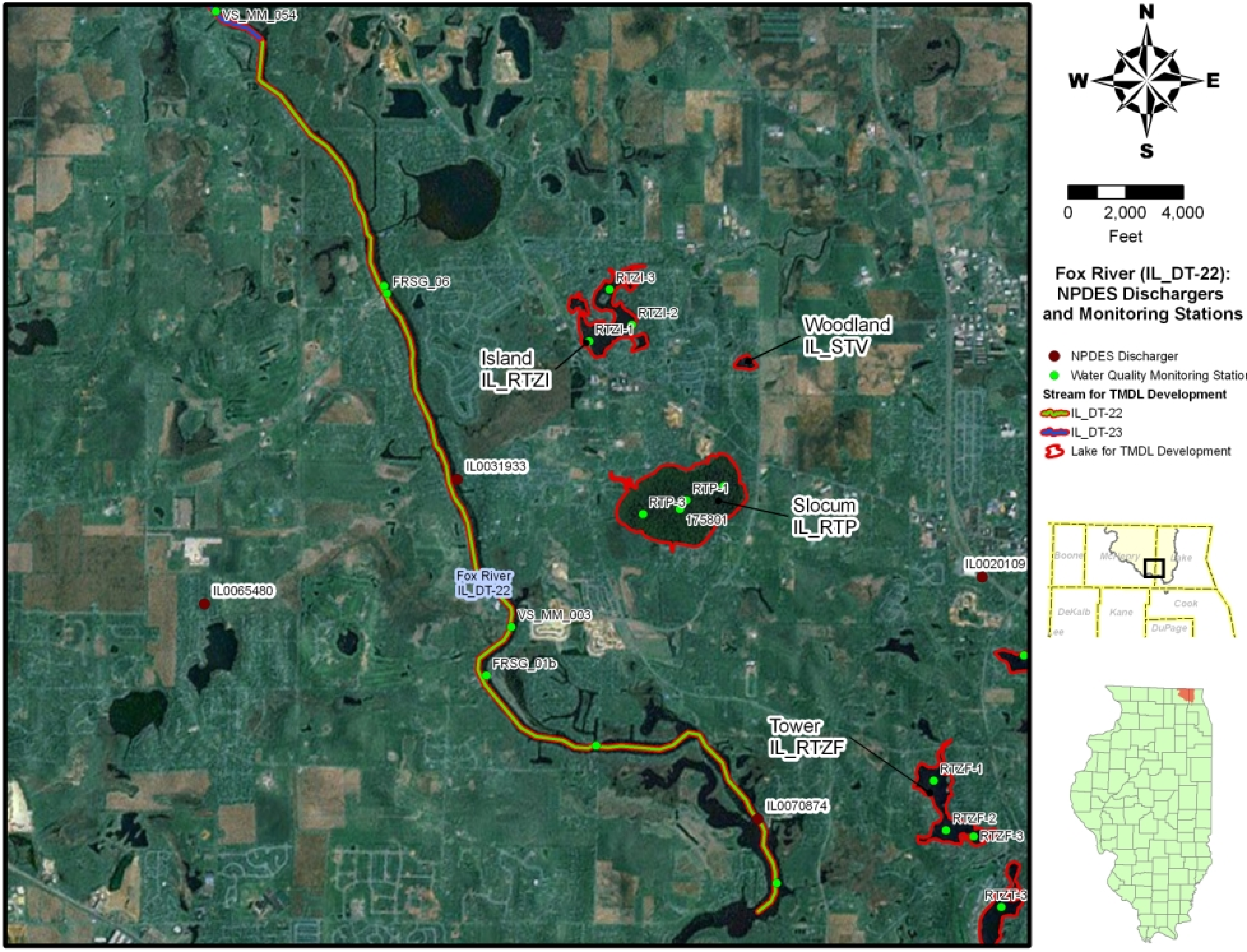
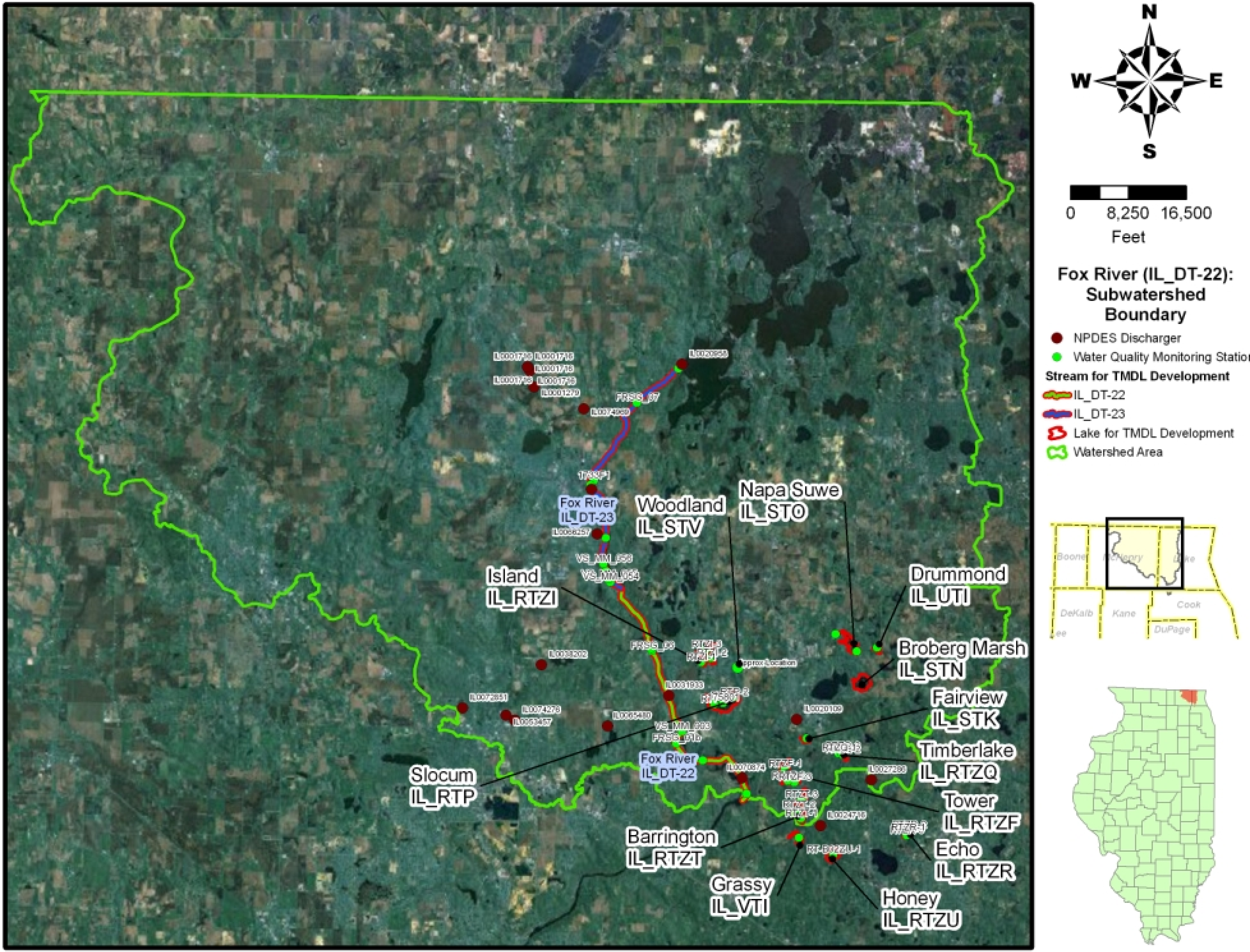
DuPage
Lee



N
W
E
S
0
2,000
4,000
Feet
Fox River (IL_DT-22):
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
VS_MM_054
FRSG_06
RTZI-3
RTZI-2
RTZI-1
Island
IL_RTZI
Woodland
IL_STV
IL0031933
RTP-1
RTP-3
175801
Slocum
IL_RTP
Fox River
IL_DT-22
IL0065480
VS_MM_003
FRSG_01b
IL0020109
Tower
IL_RTZF
RTZF-1
RTZF-2
RTZF-3
IL0070874
RTZF-3
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee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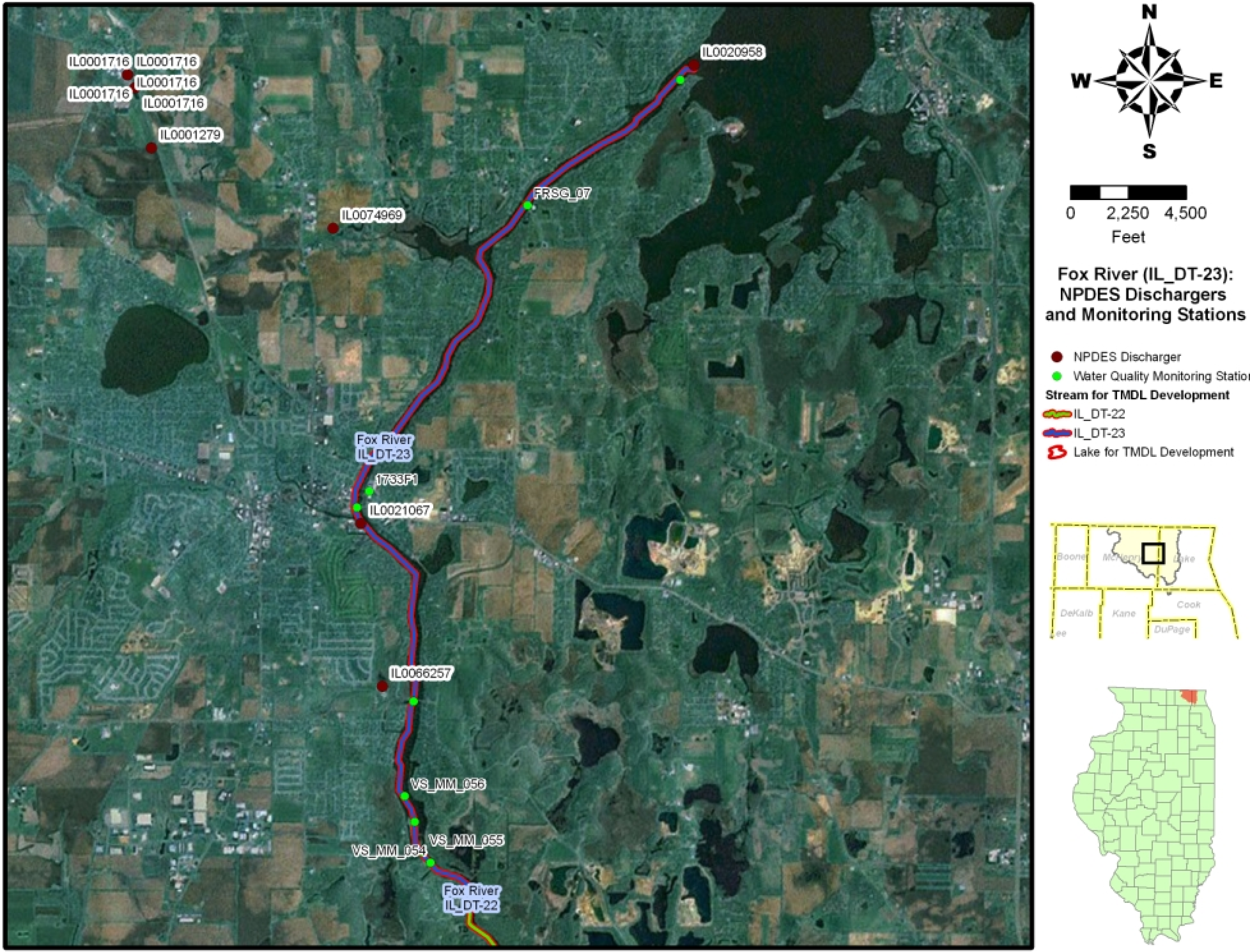
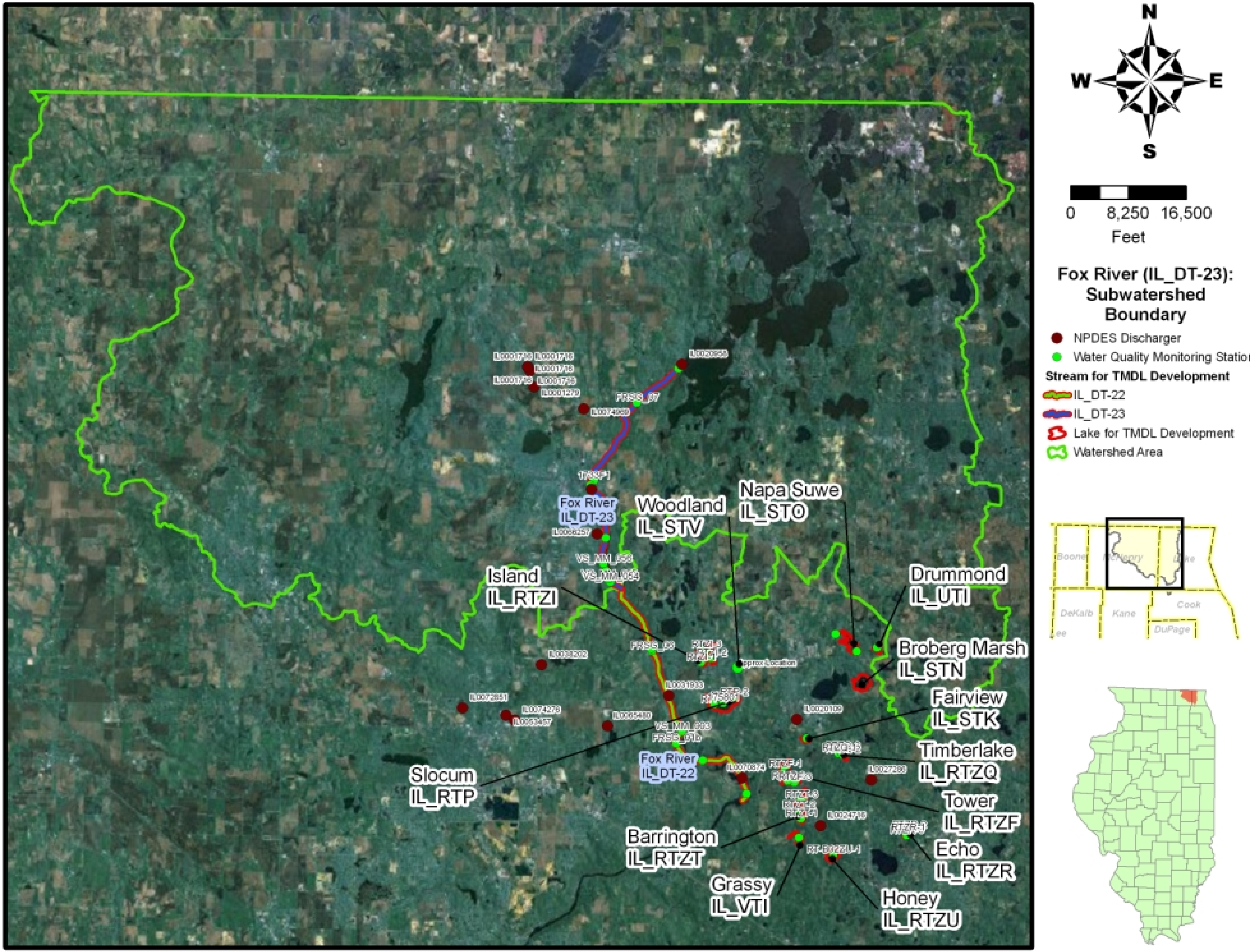
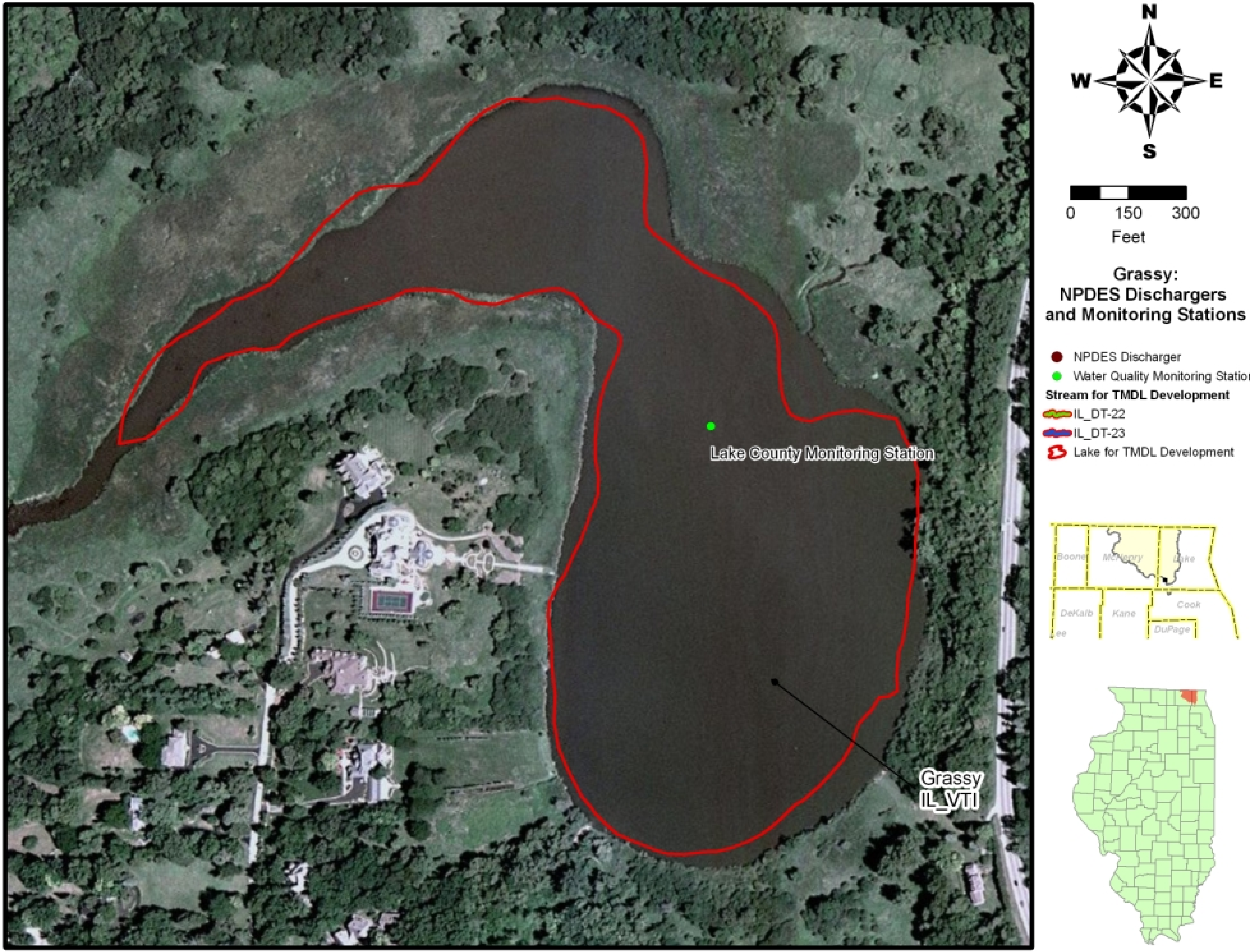
W
E
S
0
8,250
16,500
Feet
Fox River (IL_DT-22): Subwatershed Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Fox River IL_DT-23
Fox River IL_DT-22
Woodland IL_STV
Napa Suwe IL_STO
Island IL_RTZI
Drummond IL_UTI
Broberg Marsh IL_STN
Fairview IL_STK
Timberlake IL_RTZQ
Slocum IL_RTP
Tower IL_RTZF
Barrington IL_RTZT
Echo IL_RTZR
Grassy IL_VTI
Honey IL_RTZU
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

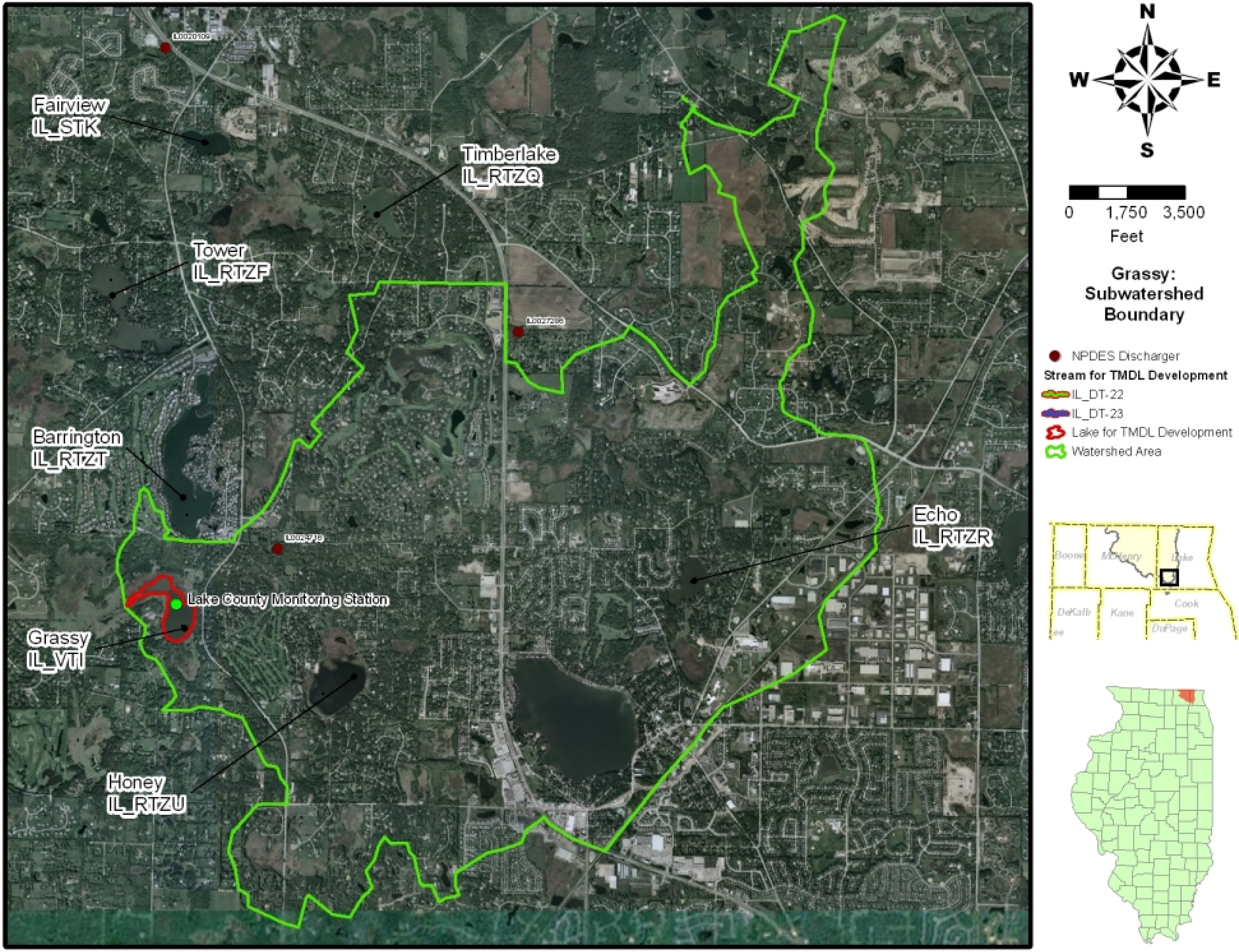

IL0001716
IL0001716
IL0001716
IL0001716
IL0001716
IL0001279
IL0020958
FRSG_07
IL0074969
Fox River
IL_DT-23
1733F1
IL0021067
IL0066257
VS_MM_056
VS_MM_055
VS_MM_054
Fox River
IL_DT-22
N
W
E
S
0
2,250
4,500
Feet
Fox River (IL_DT-23):
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee



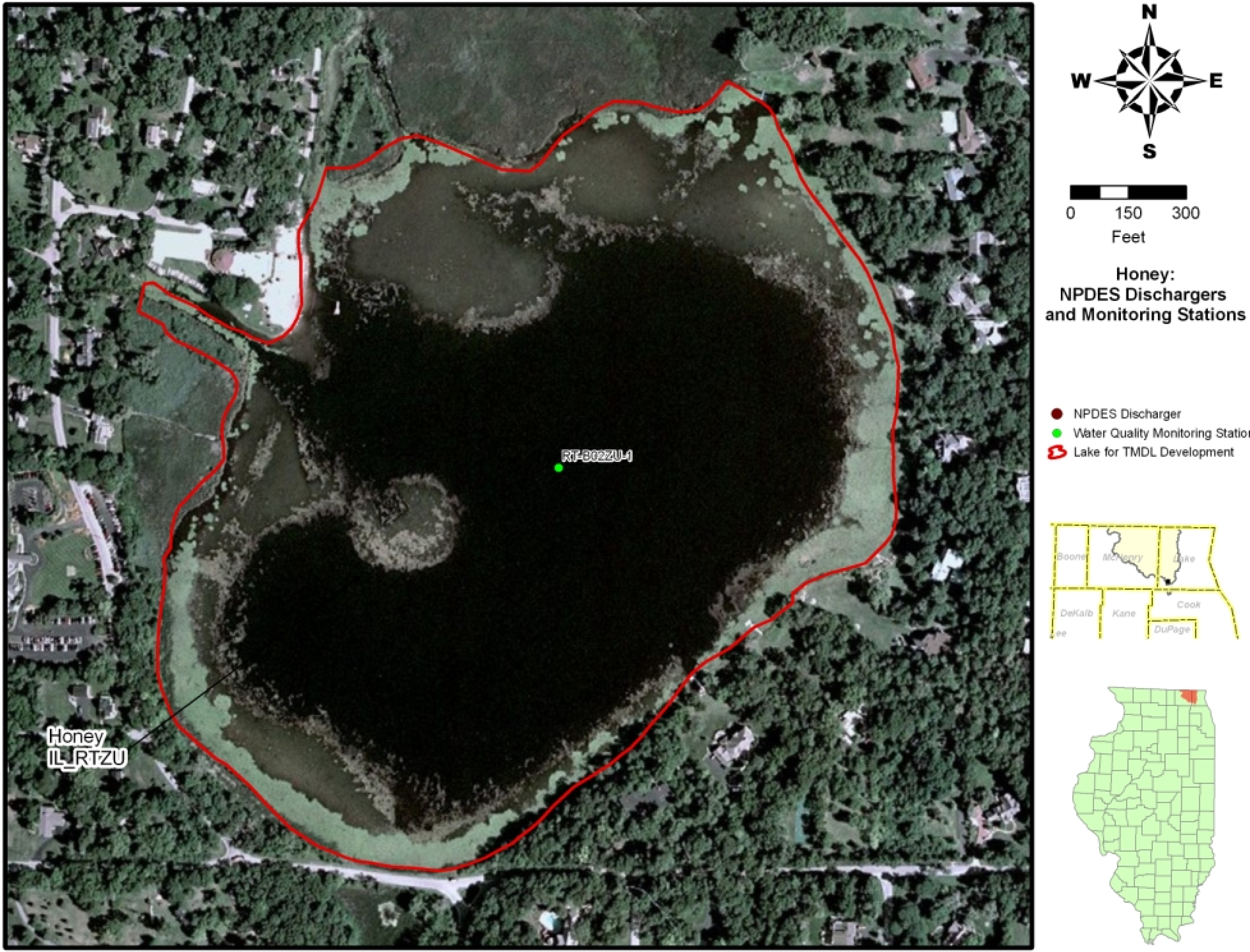
N
W
E
S
0
8,250
16,500
Feet
Fox River (IL_DT-23): Subwatershed Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee
Fox River IL_DT-23
Fox River IL_DT-22
Woodland IL_STV
Napa Suwe IL_STO
Island IL_RTZI
Drummond IL_UTI
Broberg Marsh IL_STN
Fairview IL_STK
Timberlake IL_RTZQ
Tower IL_RTZF
Echo IL_RTZR
Honey IL_RTZU
Grassy IL_VTI
Barrington IL_RTZT
Slocum IL_RTP
FRSG_07
FRSG_06
VS_MM_056
VS_MM_054
VS_MM_003
Approx Location



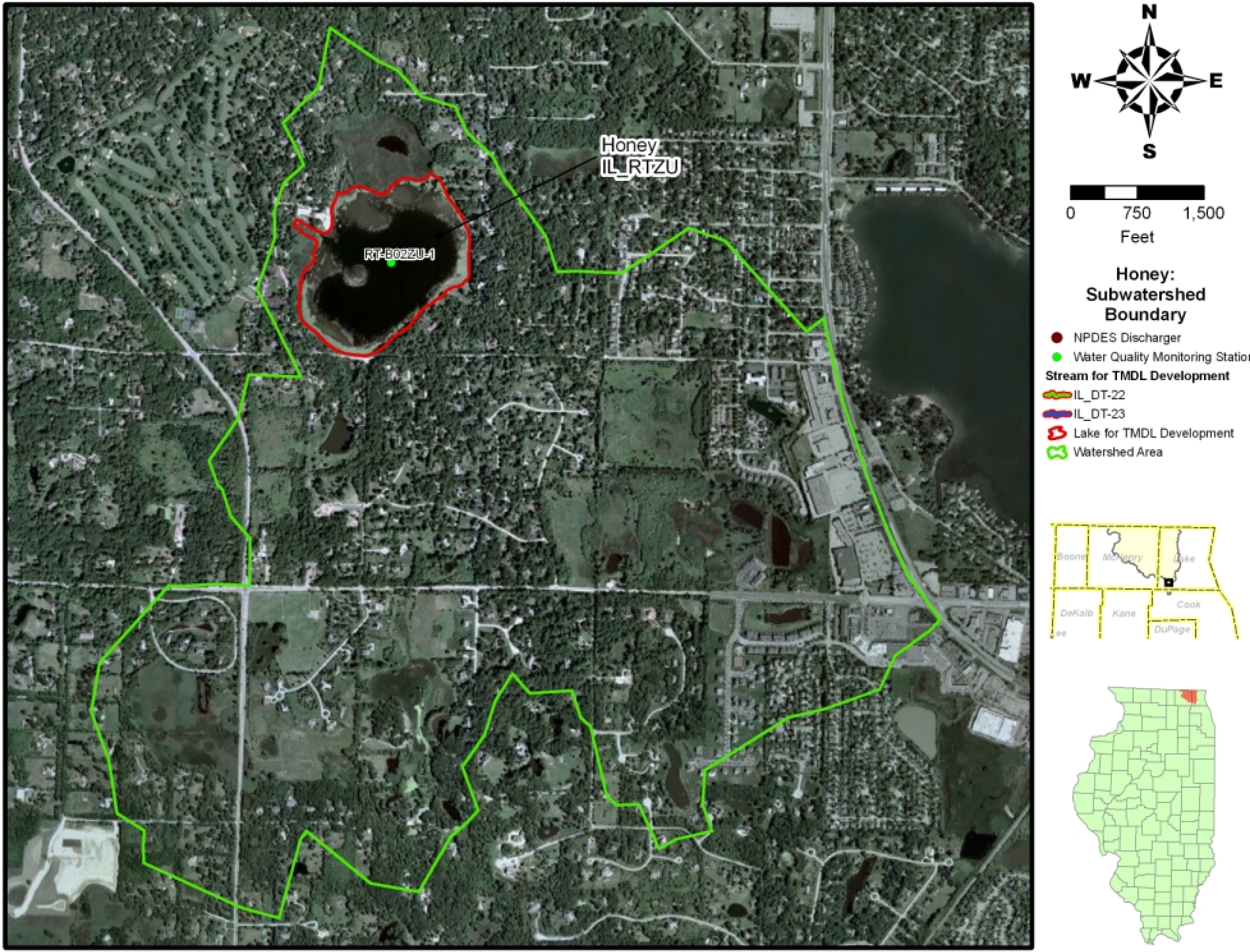
N
W
E
S
0
150
300
Feet
Grassy:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Lake County Monitoring Station
Grassy
IL_VTI
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

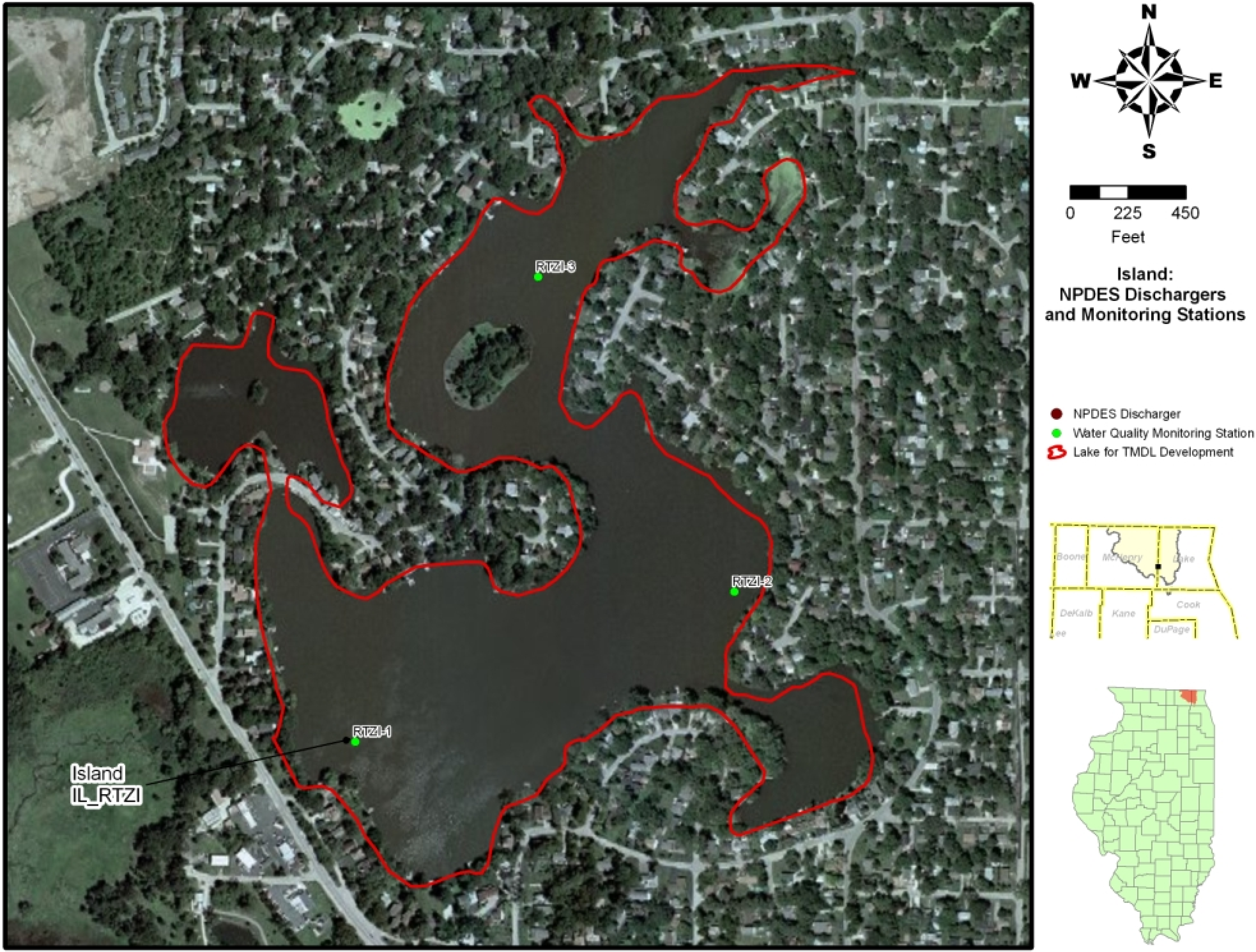


Fairview
IL_STK
Timberlake
IL_RTZQ
Tower
IL_RTZF
Barrington
IL_RTZT
Lake County Monitoring Station
Grassy
IL_VTI
Honey
IL_RTZU
Echo
IL_RTZR
N
W
E
S
0
1,750
3,500
Feet
Grassy:
Subwatershed
Boundary
NPDES Discharger
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

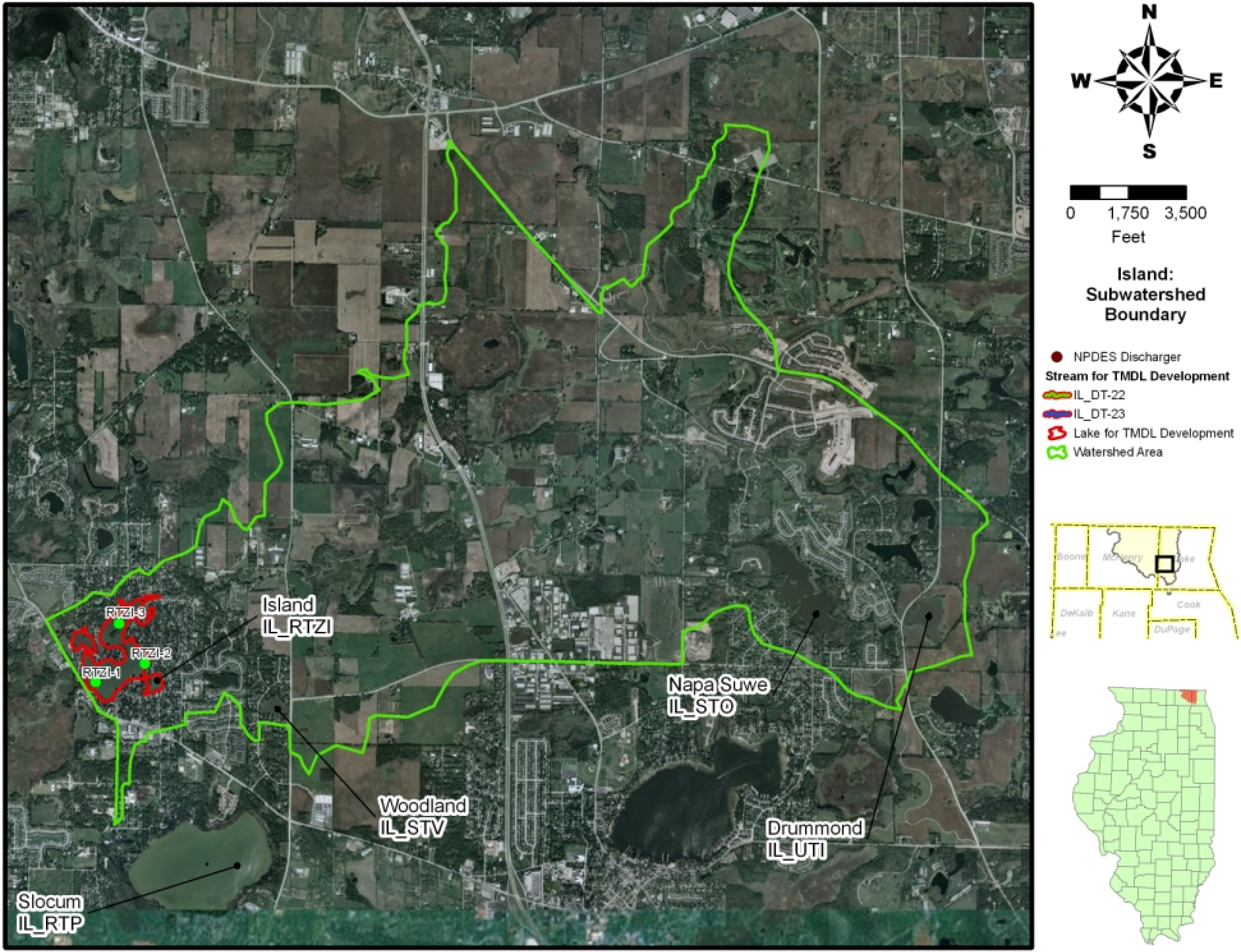


N
W
E
S
0
150
300
Feet
Honey: NPDES Dischargers and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
RT-B02ZU-1
Honey
IL_RTZU
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

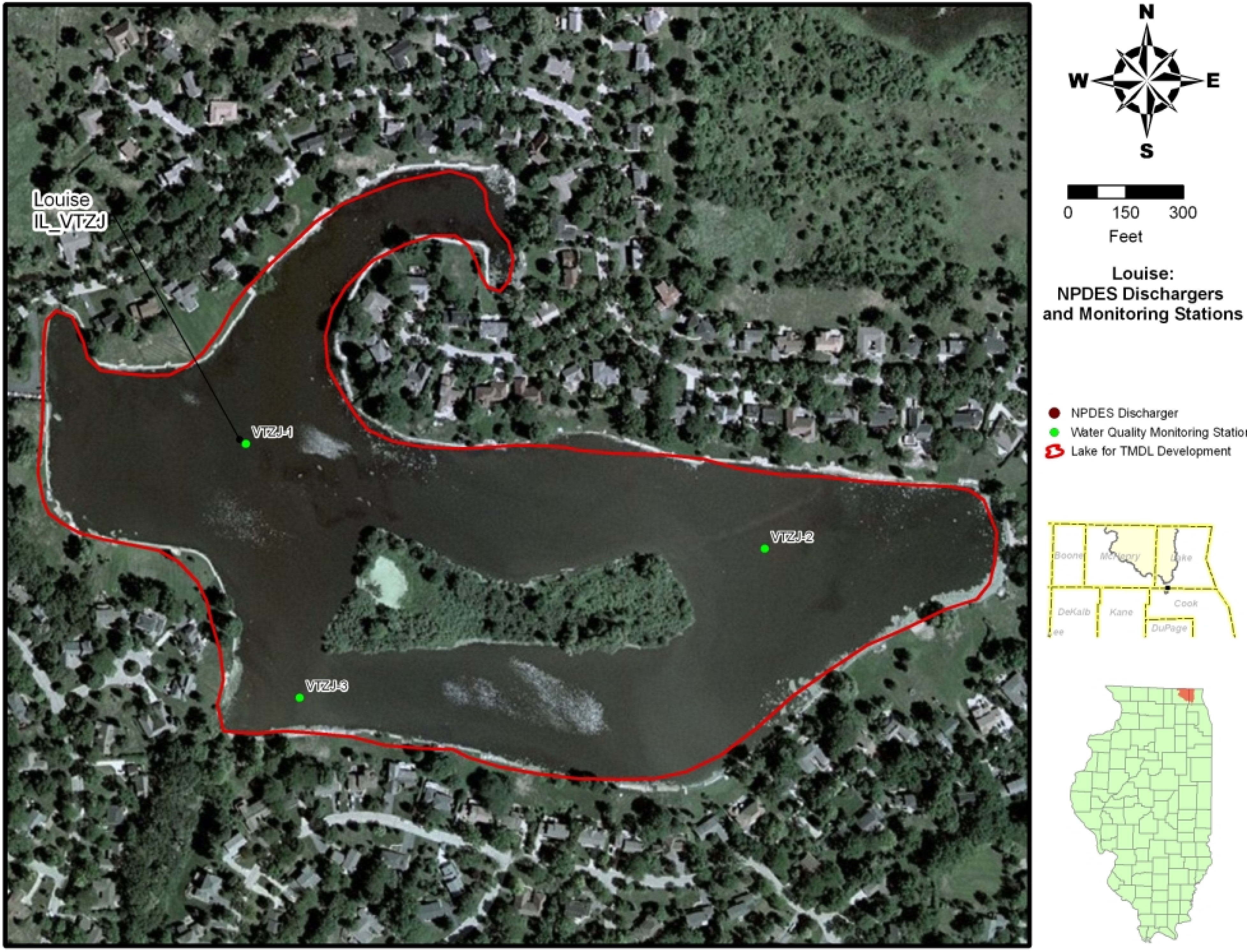

Honey
IL_RTZU
RT-B02ZU-1
N
W
E
S
0
750
1,500
Feet
Honey:
Subwatershed
Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee



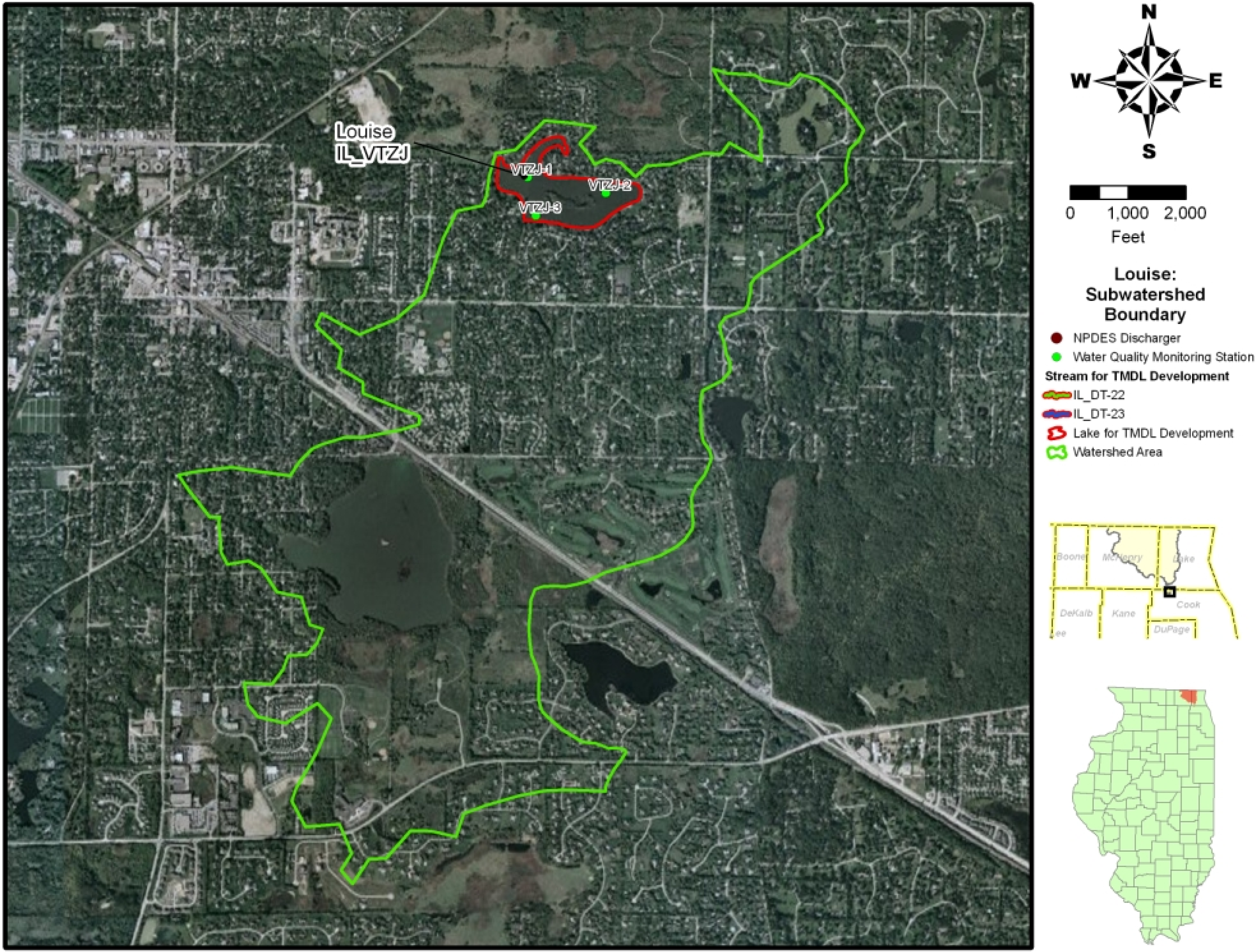
N
W
E
S
0
225
450
Feet
Island:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
RTZI-3
RTZI-2
RTZI-1
Island
IL_RTZI
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage



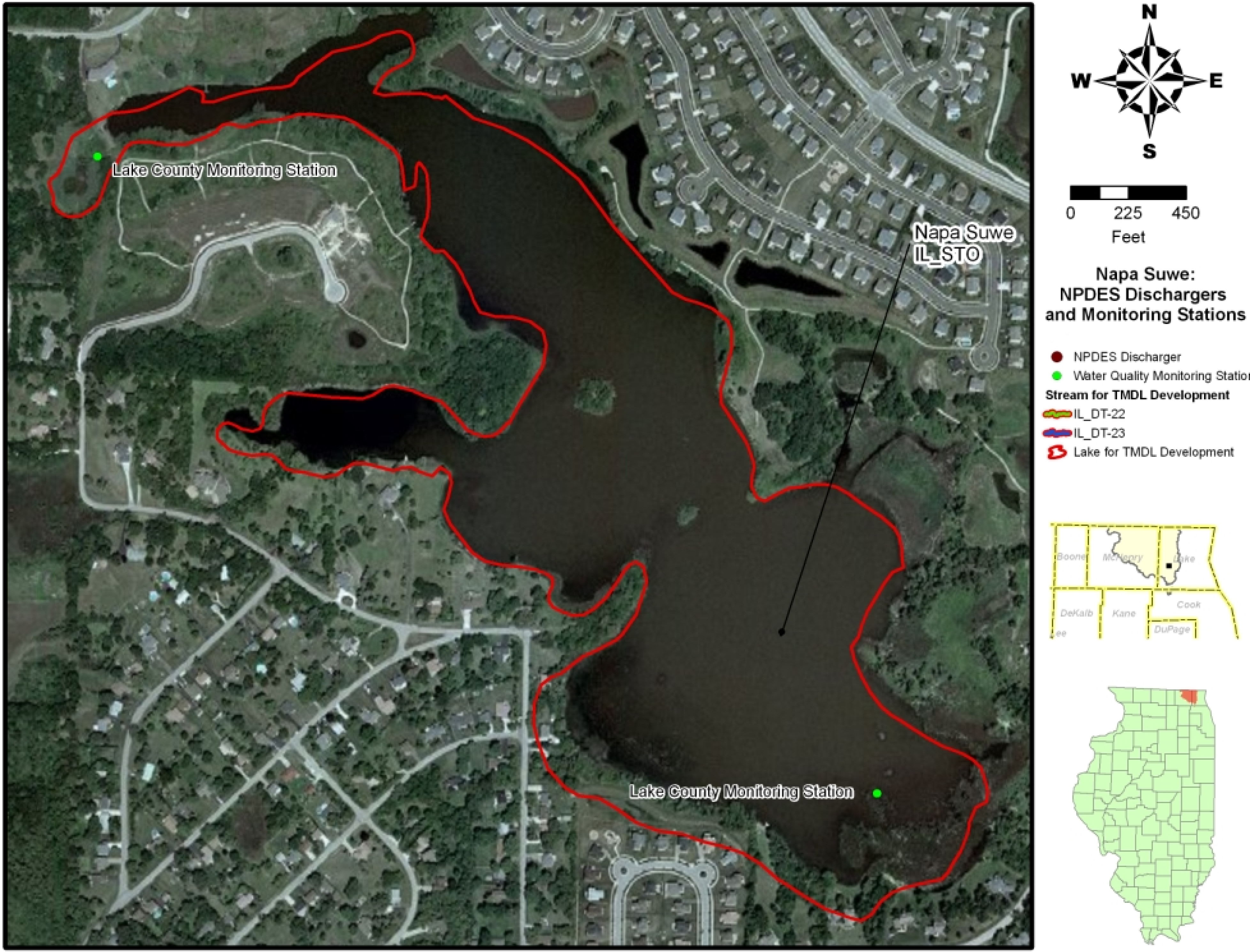
N
W
E
S
0
1,750
3,500
Feet
Island:
Subwatershed
Boundary
NPDES Discharger
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee
RTZI-3
RTZI-2
RTZI-1
Island
IL_RTZI
Napa Suwe
IL_STO
Woodland
IL_STV
Drummond
IL_UTI
Slocum
IL_RTP



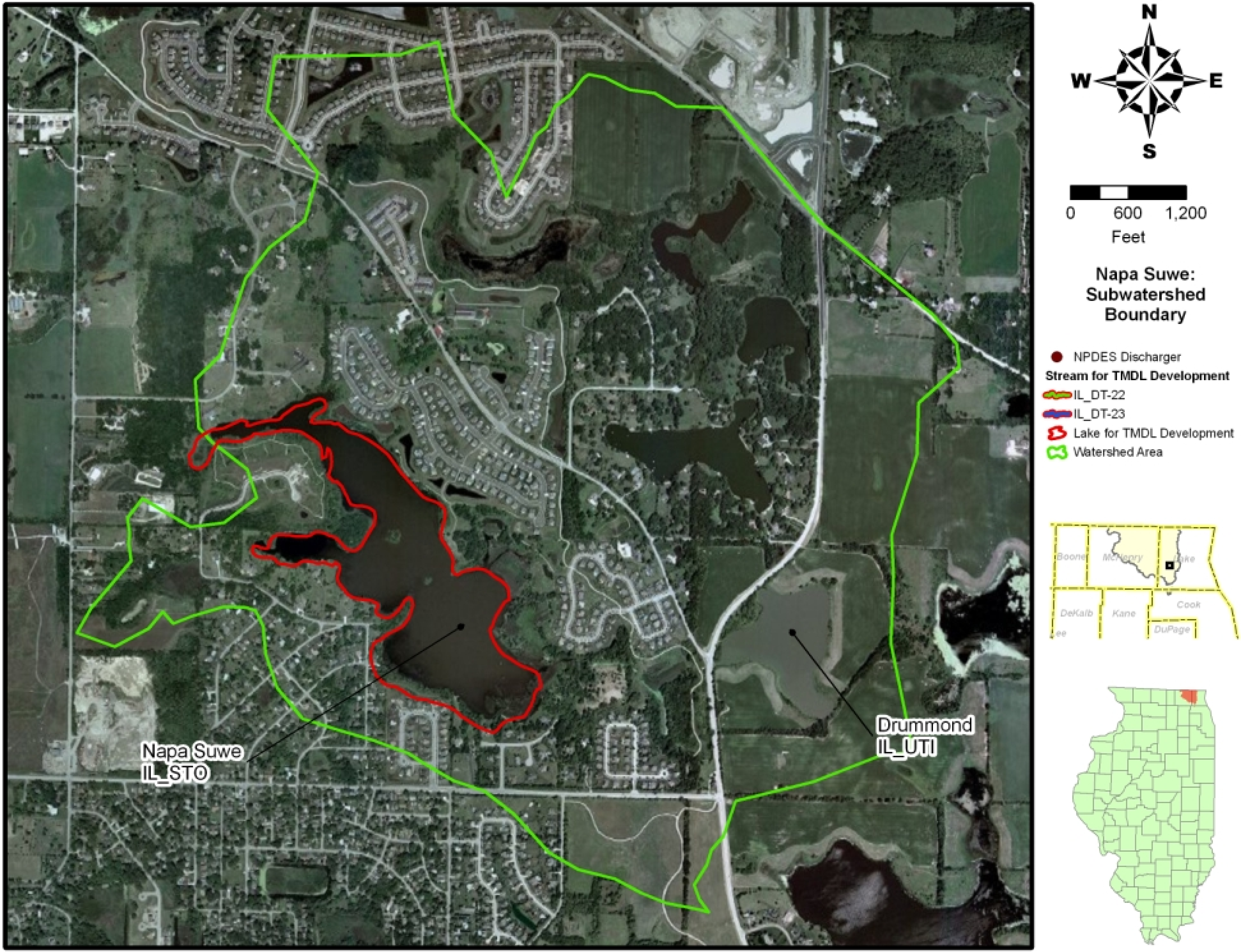
N
W
E
S
0
150
300
Feet
Louise:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
Louise
IL_VTZJ
VTZJ-1
VTZJ-2
VTZJ-3
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

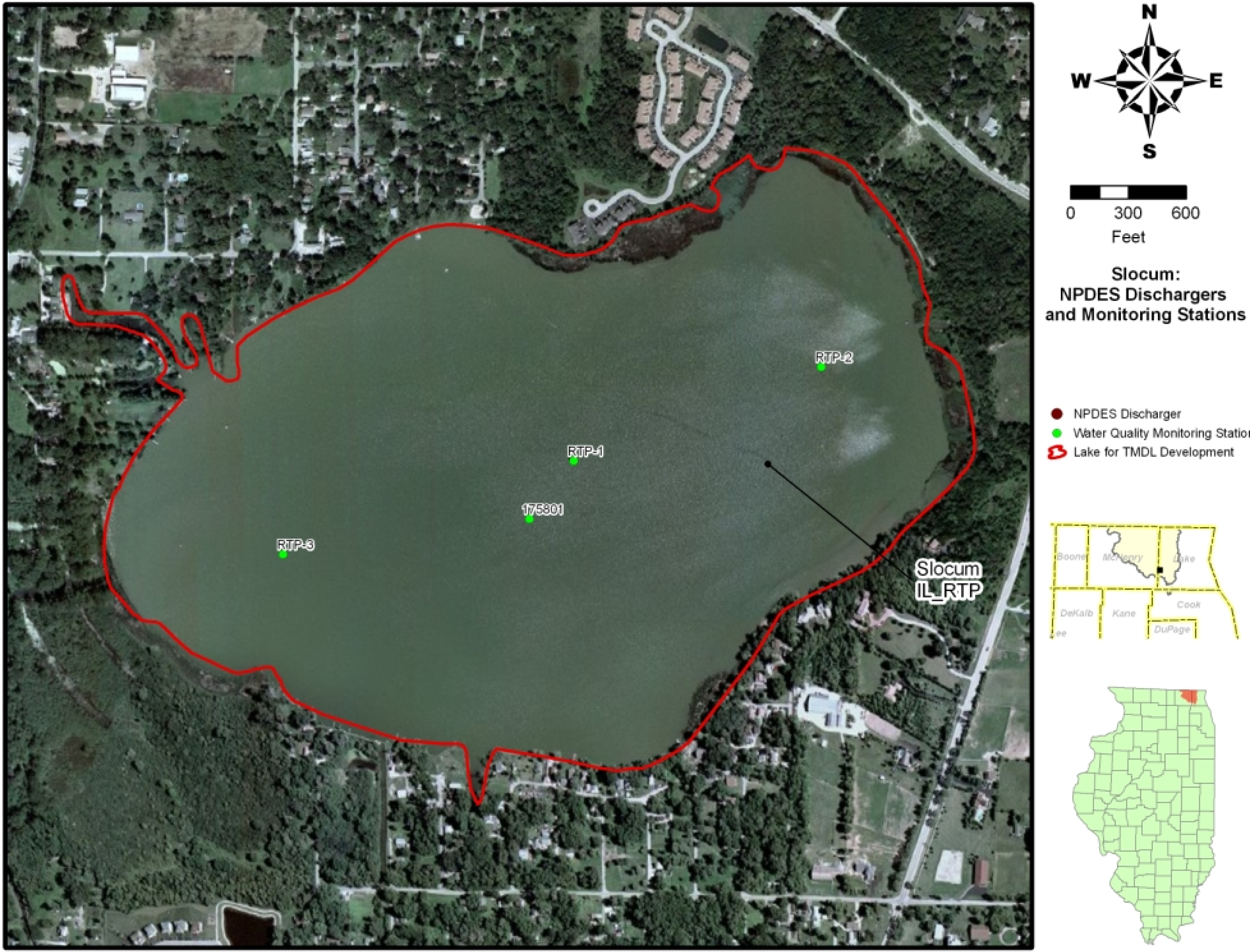


Louise
IL_VTZJ
VTZJ-1
VTZJ-2
VTZJ-3
N
W
E
S
0
1,000
2,000
Feet
Louise:
Subwatershed
Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

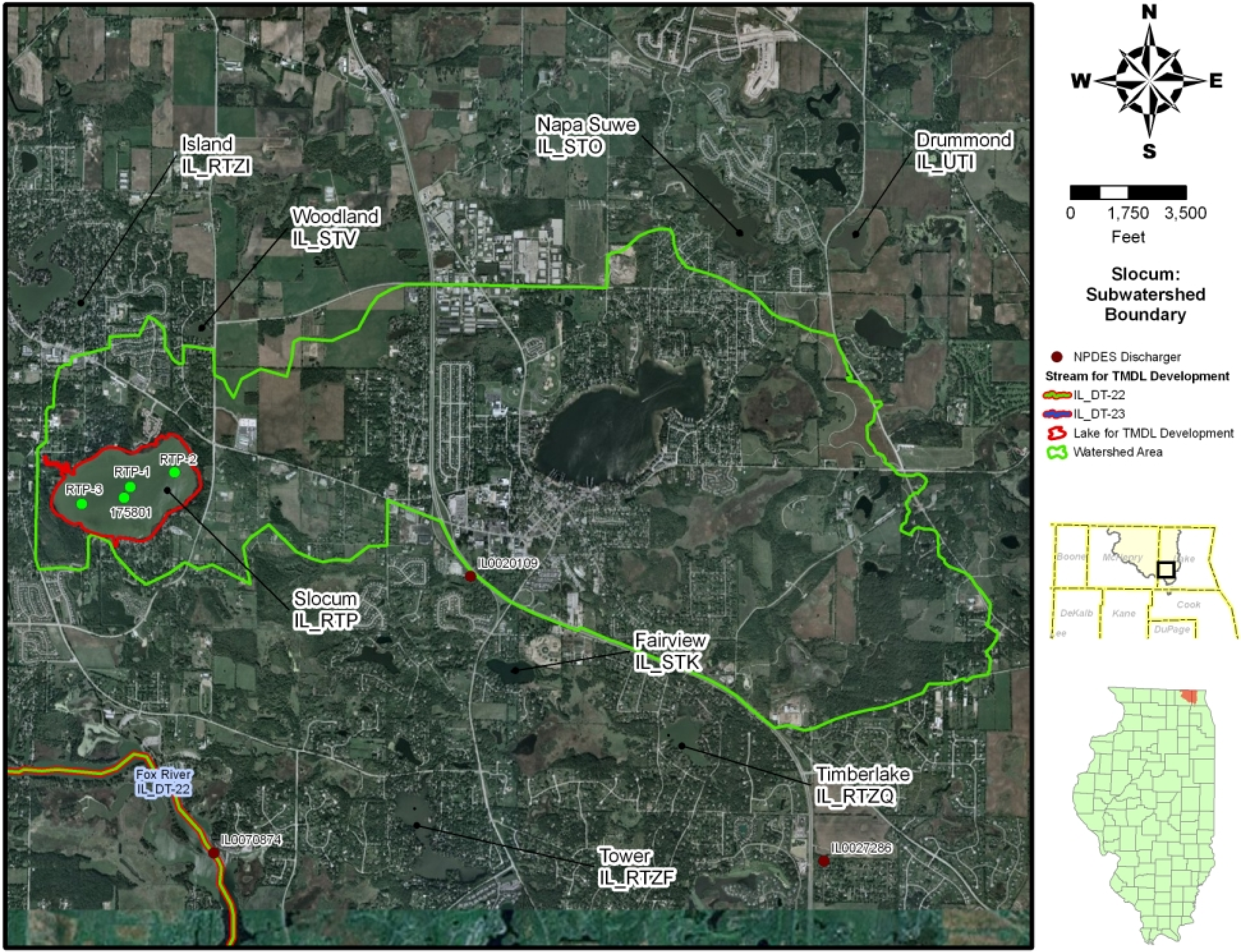


Lake County Monitoring Station
Napa Suwe
IL_STO
Lake County Monitoring Station
N
W
E
S
0
225
450
Feet
Napa Suwe:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage

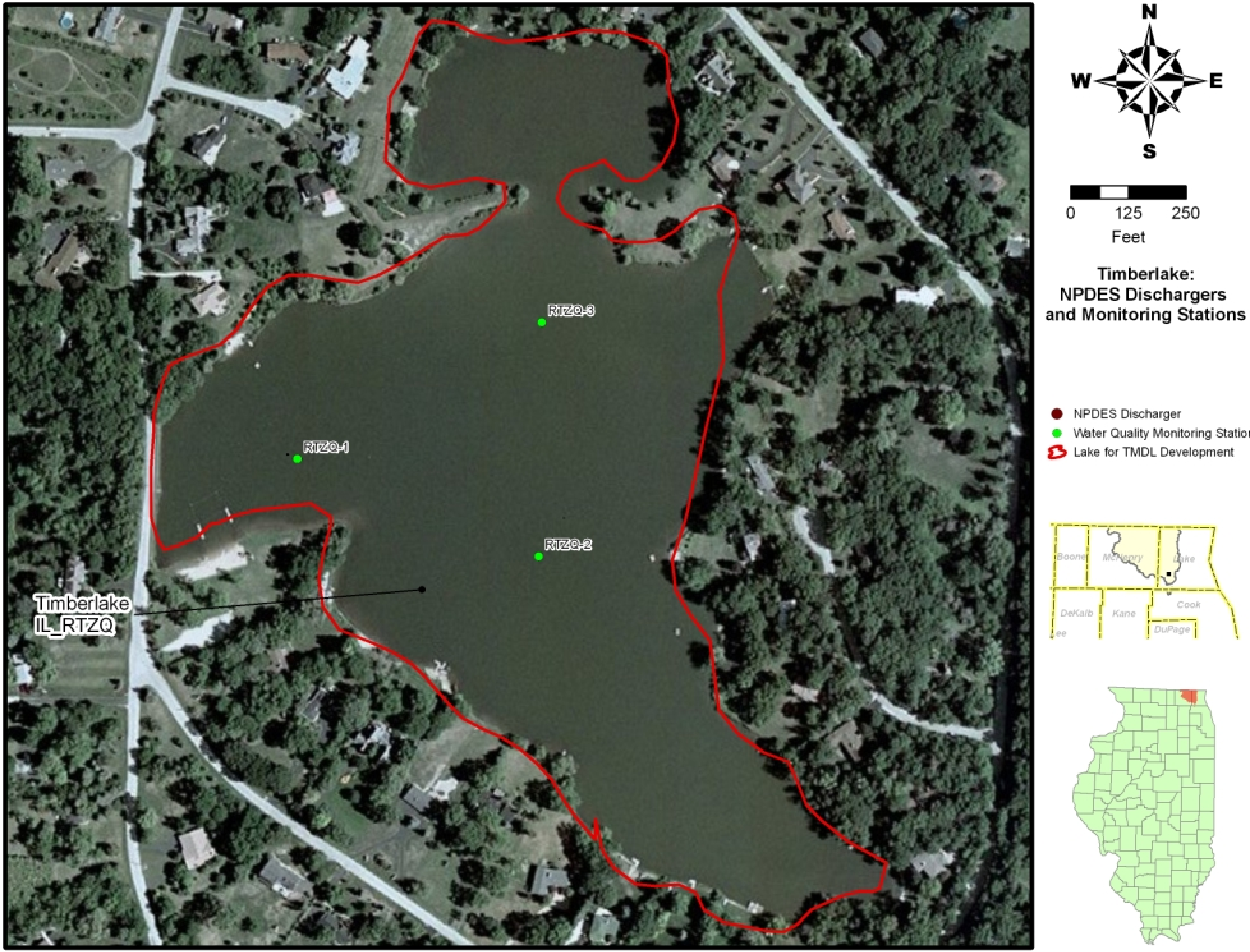

N
W
E
S
0
600
1,200
Feet
Napa Suwe:
Subwatershed
Boundary
NPDES Discharger
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee
Napa Suwe
IL_STO
Drummond
IL_UTI



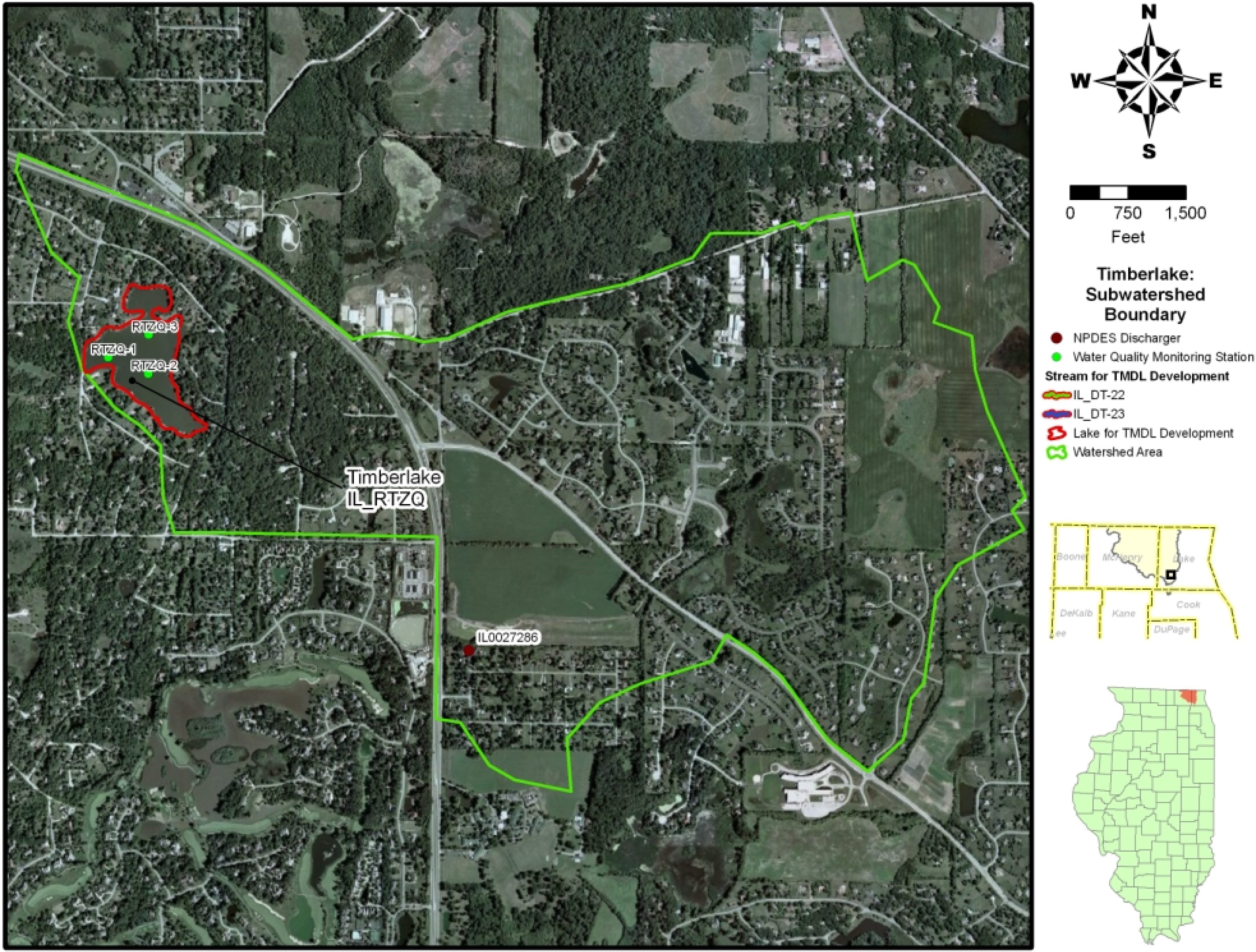
N
W
E
S
0
300
600
Feet
Slocum:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
RTP-2
RTP-1
175801
RTP-3
Slocum
IL_RTP
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

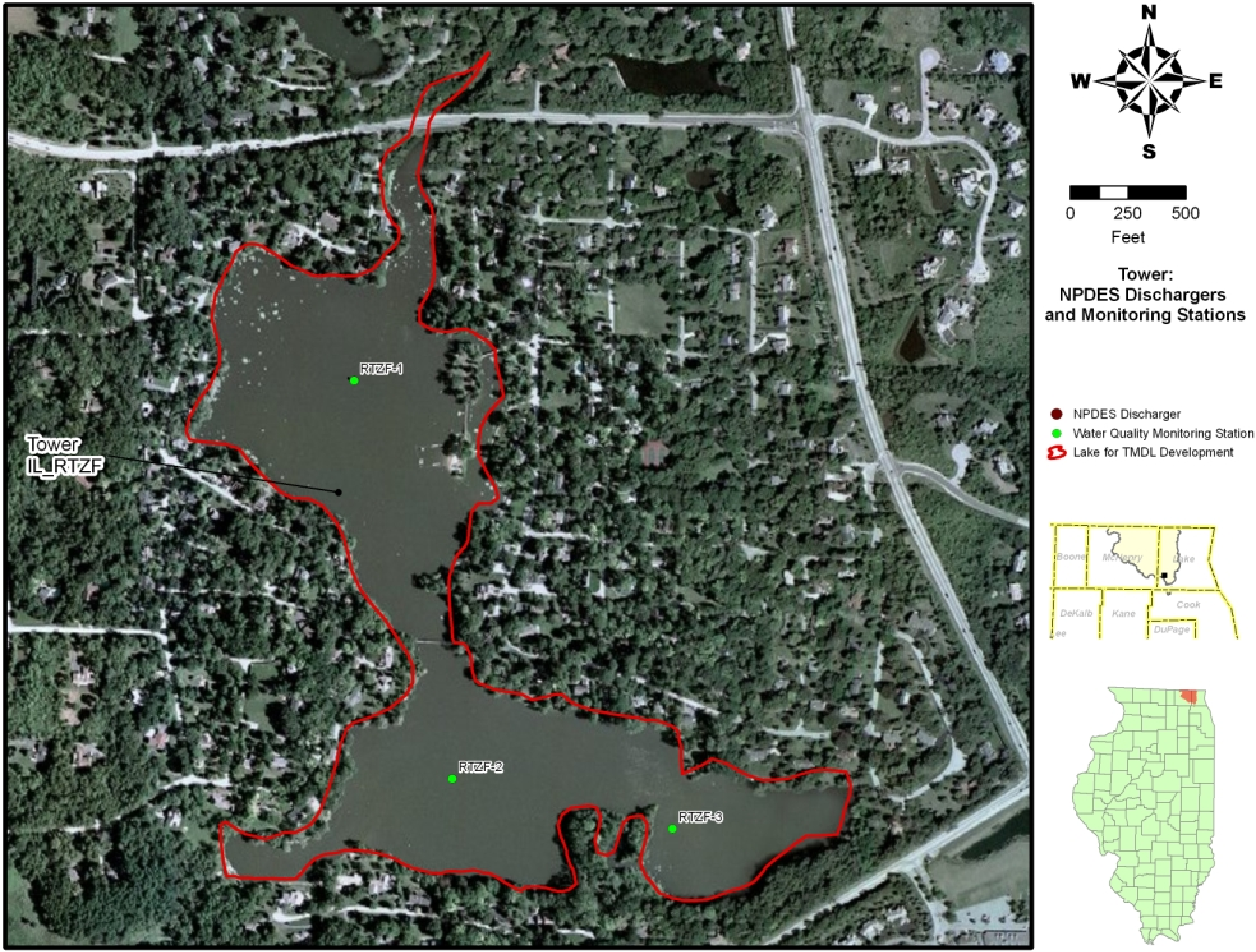


N
W
E
S
0
1,750
3,500
Feet
Slocum: Subwatershed Boundary
NPDES Discharger
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Island IL_RTZI
Woodland IL_STV
Napa Suwe IL_STO
Drummond IL_UTI
RTP-2
RTP-1
RTP-3
175801
Slocum IL_RTP
IL0020109
Fairview IL_STK
Fox River IL_DT-22
IL0070874
Timberlake IL_RTZQ
Tower IL_RTZF
IL0027286
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

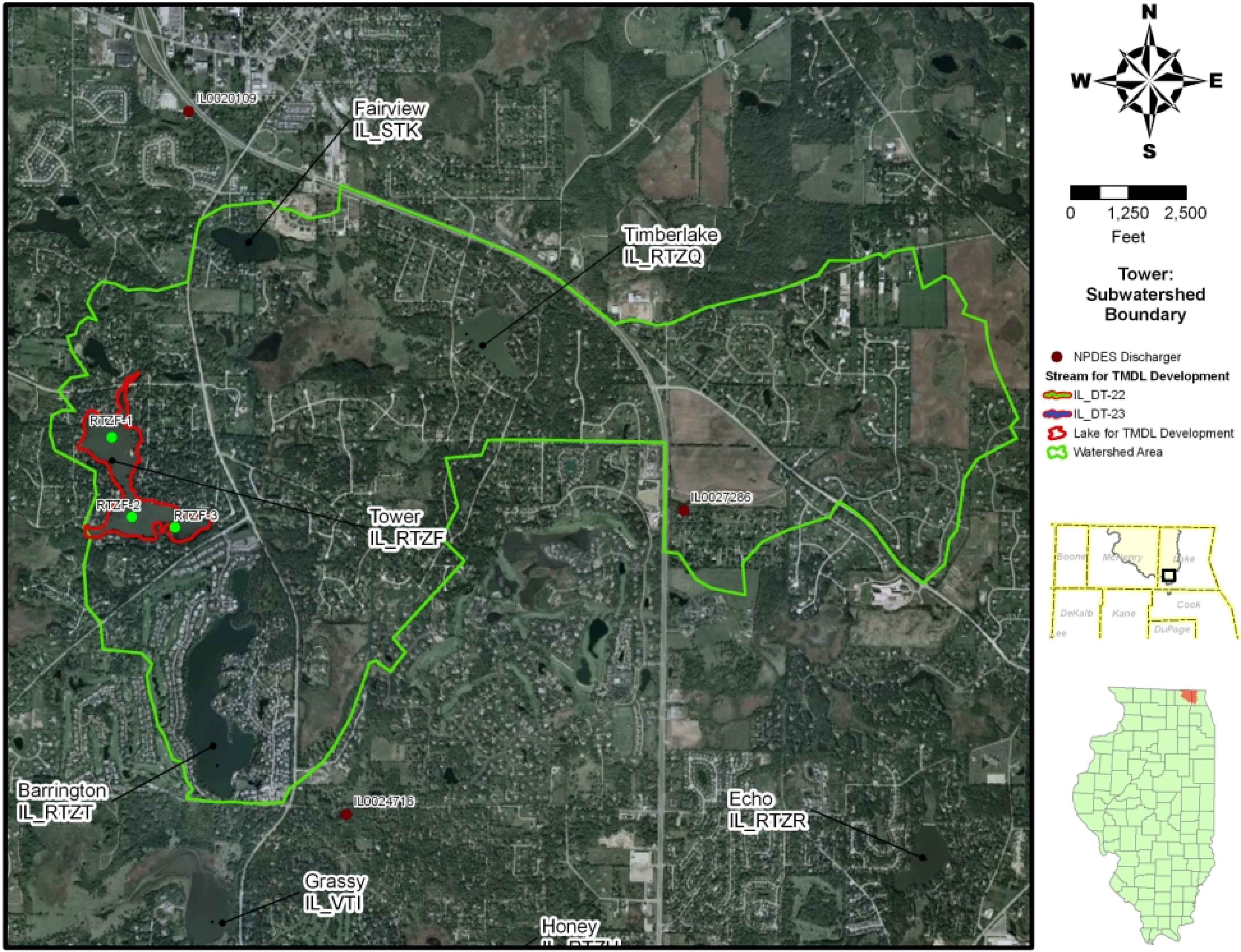


N
W
E
S
0
125
250
Feet
Timberlake:
NPDES Dischargers
and Monitoring Stations
RTZQ-3
RTZQ-1
RTZQ-2
Timberlake
IL_RTZQ
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

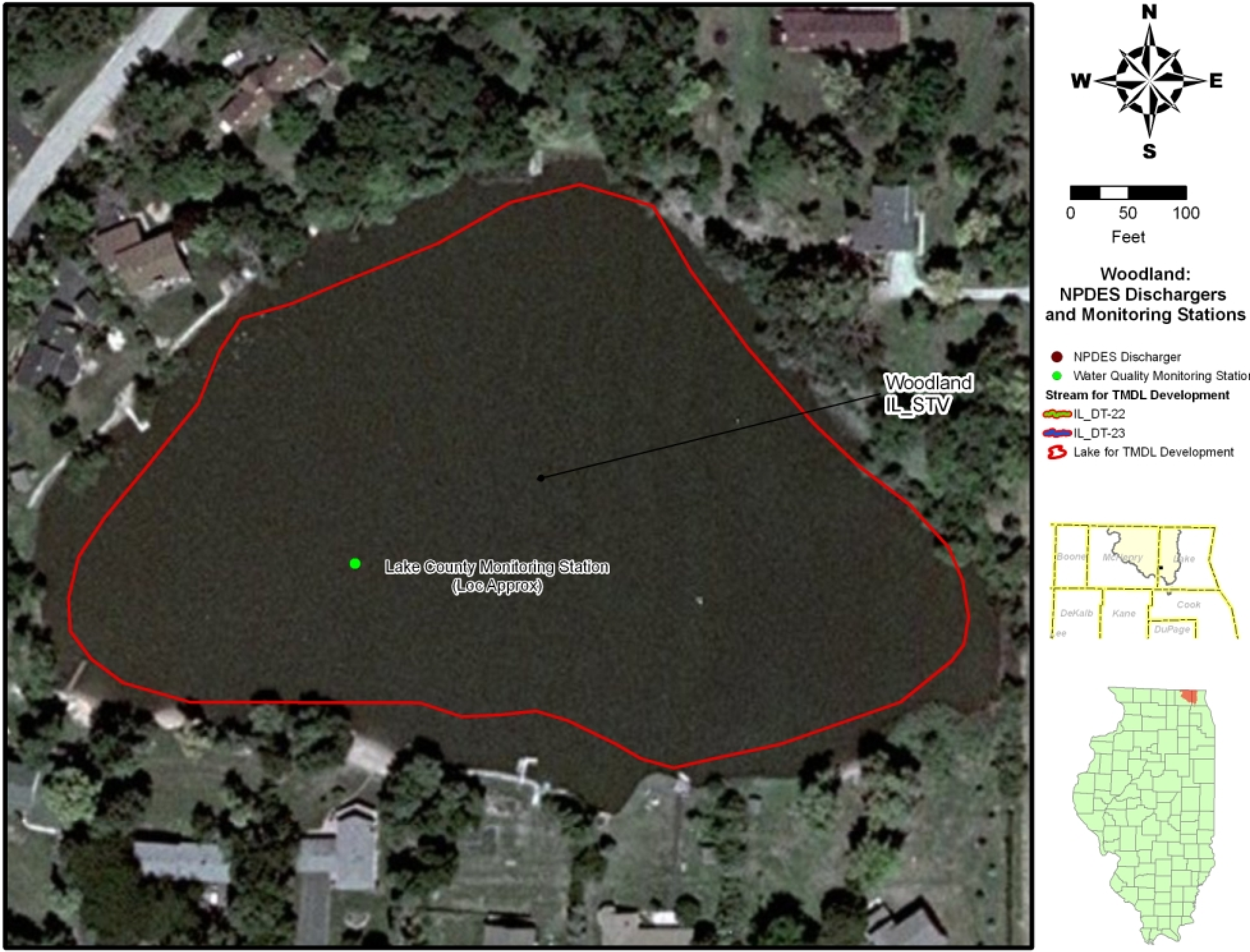

N
W
E
S
0
750
1,500
Feet
Timberlake:
Subwatershed
Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
RTZQ-3
RTZQ-1
RTZQ-2
Timberlake
IL_RTZQ
IL0027286
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee



N
W
E
S
0
250
500
Feet
Tower:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Lake for TMDL Development
Tower
IL_RTZF
RTZF-1
RTZF-2
RTZF-3
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee



N
W
E
S
0
1,250
2,500
Feet
Tower:
Subwatershed
Boundary
NPDES Discharger
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee
IL0020109
Fairview
IL_STK
Timberlake
IL_RTZQ
RTZF-1
RTZF-2
RTZF-3
Tower
IL_RTZF
IL0027286
Barrington
IL_RTZT
IL0024716
Echo
IL_RTZR
Grassy
IL_VTI
Honey


Woodland
IL_STV
Lake County Monitoring Station
(Loc Approx)
N
W
E
S
0
50
100
Feet
Woodland:
NPDES Dischargers
and Monitoring Stations
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

N
W
E
S
0
150
300
Feet
Woodland: Subwatershed Boundary
NPDES Discharger
Water Quality Monitoring Station
Stream for TMDL Development
IL_DT-22
IL_DT-23
Lake for TMDL Development
Watershed Area
Woodland
IL_STV
Lake County Monitoring Station
(Loc Approx)
Boone
McHenry
Lake
DeKalb
Kane
Cook
DuPage
Lee

Appendix B

Water Quality Data

(Available on a Supplemental CD)

Appendix C

Land Use Tables

Land Use Summary for All Watersheds Within the Fox River Watershed (Acres)

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland	Grand Total
Barrington		4.91	0.07			93.72		56.88			99.02			27.75			***282.35***
Drummond			0.02			20.94		64.21						2.15			***87.32***
Echo		47.66	86.34	39.03	101.10	276.73	1.49	181.09	5.86		305.27			157.02	9.55	43.09	***1,254.23***
Fairview	0.45		4.69			20.32				0.54	19.64			1.95	1.86		***49.46***
Fox R DT-22	951.26	3,307.68	24,319.03	4,386.05	2,847.29	15,154.78	4,124.49	29,516.98	210.77	554.56	49,932.46	1,888.18	82,428.96	7,577.29	1,910.48	18,728.96	***247,866.18***
Fox R DT-23	696.06	2,699.35	19,831.99	3,294.00	2,342.94	12,985.55	3,546.20	20,876.54	92.93	342.73	37,038.33	1,221.53	76,499.83	5,777.34	1,493.92	14,542.33	***203,308.55***
Grassy	28.88	142.31	578.68	47.68	230.40	581.58	11.36	795.99	5.86	34.80	2,693.00	7.98	223.60	732.45	130.15	439.35	***6,684.06***
Honey	13.03	54.07	116.75		1.81	96.10		69.49		19.33	547.86			113.39	0.90	144.63	***1,177.37***
Island	114.44	37.72	378.63	211.82	28.69	351.78	64.97	931.00	84.94	113.04	903.62	24.23	1,215.19	439.21	148.62	979.24	***6,027.16***
Louise		25.62	56.58		33.42	190.12		386.49			844.41	0.30		59.65	11.28	12.31	***1,620.19***
McHenry	256.71	1,925.86	16,116.67	2,926.33	1,478.42	3,518.21	3,308.87	13,427.00	19.16	0.04	32,802.40	960.32	72,814.17	404.71	651.72	10,963.89	***161,580.30***
Napa Suwe	10.96	0.50	50.46			167.67		294.11	0.12	1.05	313.57	3.06	56.48	89.49	51.93	90.80	***1,130.19***
Slocum	51.90	123.65	438.23	133.83	102.35	635.16	14.28	1,456.93	28.82	66.51	1,393.61	7.21	235.15	502.24	12.84	318.23	***5,520.95***
Timber	27.91	3.34	88.47		0.02	47.57		58.40	3.78	12.65	611.98		164.48	148.26		94.23	***1,261.08***
Tower	28.45	11.17	289.67		2.04	275.25	16.95	232.70	3.97	13.30	1,483.25	1.57	164.66	363.70	14.81	315.73	***3,217.21***
Woodland						8.15		0.21			42.48			8.97			***59.81***
Grand Total	***2,180.05***	***8,383.84***	***62,356.28***	***11,038.74***	***7,168.48***	***34,423.63***	***11,088.61***	***68,348.02***	***456.20***	***1,158.56***	***129,030.89***	***4,114.38***	***233,802.52***	***16,405.59***	***4,438.05***	***46,672.79***	***641,126.40***

Land Use Summary for All Watersheds Within the Fox River Watershed (Percent)

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland
Barrington	<1%	2%	<1%	<1%	<1%	33%	<1%	20%	<1%	<1%	35%	<1%	<1%	10%	<1%	<1%
Drummond	<1%	<1%	<1%	<1%	<1%	24%	<1%	74%	<1%	<1%	<1%	<1%	<1%	2%	<1%	<1%
Echo	<1%	4%	7%	3%	8%	22%	<1%	14%	<1%	<1%	24%	<1%	<1%	13%	1%	3%
Fairview	1%	<1%	9%	<1%	<1%	41%	<1%	<1%	<1%	1%	40%	<1%	<1%	4%	4%	<1%
Fox R DT-22	<1%	1%	10%	2%	1%	6%	2%	12%	<1%	<1%	20%	1%	33%	3%	1%	8%
Fox R DT-23	<1%	1%	10%	2%	1%	6%	2%	10%	<1%	<1%	18%	1%	38%	3%	1%	7%
Grassy	<1%	2%	9%	1%	3%	9%	<1%	12%	<1%	1%	40%	<1%	3%	11%	2%	7%
Honey	1%	5%	10%	<1%	<1%	8%	<1%	6%	<1%	2%	47%	<1%	<1%	10%	<1%	12%
Island	2%	1%	6%	4%	<1%	6%	1%	15%	1%	2%	15%	<1%	20%	7%	2%	16%
Louise	<1%	2%	3%	<1%	2%	12%	<1%	24%	<1%	<1%	52%	<1%	<1%	4%	1%	1%
McHenry	<1%	1%	10%	2%	1%	2%	2%	8%	<1%	<1%	20%	1%	45%	<1%	<1%	7%
Napa Suwe	1%	<1%	4%	<1%	<1%	15%	<1%	26%	<1%	<1%	28%	<1%	5%	8%	5%	8%
Slocum	1%	2%	8%	2%	2%	12%	<1%	26%	1%	1%	25%	<1%	4%	9%	<1%	6%
Timber	2%	<1%	7%	<1%	<1%	4%	<1%	5%	<1%	1%	49%	<1%	13%	12%	<1%	7%
Tower	1%	<1%	9%	<1%	<1%	9%	1%	7%	<1%	<1%	46%	<1%	5%	11%	<1%	10%
Woodland	<1%	<1%	<1%	<1%	<1%	14%	<1%	<1%	<1%	<1%	71%	<1%	<1%	15%	<1%	<1%
Grand Total	***<1%***	***1%***	***10%***	***2%***	***1%***	***5%***	***2%***	***11%***	***<1%***	***<1%***	***20%***	***1%***	***37%***	***2%***	***1%***	***7%***

Sub-Watershed and Total Watershed Land Use Areas (Acres) for Hydrologically Connected Waterbodies

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Lake Napa Suwe

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland	Grand Total
Napa Suwe	10.96	0.50	50.46			167.67		294.11	0.12	1.05	313.57	3.06	56.48	89.49	51.93	90.80	***1,130.19***
Contributing Watersheds (Drummond)			0.02			20.94		64.21						2.15			***87.32***
Total	10.96	0.50	50.48	0.00	0.00	188.61	0.00	358.31	0.12	1.05	313.57	3.06	56.48	91.64	51.93	90.80	1,217.51

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Island Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland	Grand Total
Island	114.44	37.72	378.63	211.82	28.69	351.78	64.97	931.00	84.94	113.04	903.62	24.23	1,215.19	439.21	148.62	979.24	***6,027.16***
Contributing Watersheds (Napa Suwe, Woodland, Drummond)	10.96	0.50	50.48	0.00	0.00	196.76	0.00	358.53	0.12	1.05	356.04	3.06	56.48	100.61	51.93	90.80	1,277.32
Total	125.39	38.22	429.12	211.82	28.69	548.54	64.97	1,289.53	85.06	114.10	1,259.66	27.29	1,271.67	539.83	200.55	1,070.04	7,304.48

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Tower Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland	Grand Total
Tower	28.45	11.17	289.67		2.04	275.25	16.95	232.70	3.97	13.30	1,483.25	1.57	164.66	363.70	14.81	315.73	***3,217.21***
Contributing Watersheds (Timber, Fairview)	28.36	3.34	93.15	0.00	0.02	67.89	0.00	58.40	3.78	13.19	631.62	0.00	164.48	150.22	1.86	94.23	1,310.54
Total	56.81	14.51	382.82	0.00	2.06	343.14	16.95	291.10	7.75	26.49	2,114.87	1.57	329.14	513.92	16.67	409.96	4,527.76

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Grassy Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland	Grand Total
Grassy	28.88	142.31	578.68	47.68	230.40	581.58	11.36	795.99	5.86	34.80	2,693.00	7.98	223.60	732.45	130.15	439.35	***6,684.06***
Contributing Watersheds (Echo, Honey)	13.03	101.73	203.09	39.03	102.91	372.83	1.49	250.58	5.86	19.33	853.13	0.00	0.00	270.42	10.45	187.72	2,431.60
Total	41.91	244.04	781.77	86.71	333.32	954.41	12.85	1,046.57	11.71	54.13	3,546.13	7.98	223.60	1,002.87	140.60	627.07	9,115.66

Sub-Watershed and Total Watershed Land Use Areas (Percent) for Hydrologically Connected Waterbodies

Sub-Watershed and Total Watershed Land Use Areas (Percent) For Lake Napa Suwe

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland
Napa Suwe	1%	<1%	4%	<1%	<1%	15%	<1%	26%	<1%	<1%	28%	<1%	5%	8%	5%	8%
Contributing Watersheds (Drummond)	<1%	<1%	<1%	<1%	<1%	24%	<1%	74%	<1%	<1%	<1%	<1%	<1%	2%	<1%	<1%
Total	1%	<1%	4%	<1%	<1%	15%	<1%	29%	<1%	<1%	26%	<1%	5%	8%	4%	7%

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Island Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland
Island	2%	1%	6%	4%	<1%	6%	1%	15%	1%	2%	15%	<1%	20%	7%	2%	16%
Contributing Watersheds (Napa Suwe, Woodland)	1%	<1%	4%	<1%	<1%	15%	<1%	25%	<1%	<1%	30%	<1%	5%	8%	4%	8%
Total	2%	1%	6%	3%	<1%	7%	1%	17%	1%	2%	17%	<1%	18%	7%	3%	15%

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Tower Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland
Tower	1%	<1%	9%	<1%	<1%	9%	1%	7%	<1%	<1%	46%	<1%	5%	11%	<1%	10%
Contributing Watersheds (Timber, Fairview)	2%	<1%	7%	<1%	<1%	5%	<1%	4%	<1%	1%	48%	<1%	13%	11%	<1%	7%
Total	1%	<1%	8%	<1%	<1%	8%	<1%	6%	<1%	1%	47%	<1%	7%	11%	<1%	9%

Sub-Watershed and Total Watershed Land Use Areas (Acres) For Grassy Lake

Name	Agriculture, Other	Commercial and Services	Forested, Grasslands, Vegetation	Industrial, Warehousing, Wholesale Trade	Institutional	Lakes, Reservoirs, Lagoons	Nurseries, Greenhouses, Orchards, Tree Farms	Open Space	Other Vacant Land	Pastureland	Residential	Rivers, Streams, Canals	Row Crop, Grain, Grazing	Transportation, Communication, and Utilities	Under Construction	Wetland
Grassy	<1%	2%	9%	1%	3%	9%	<1%	12%	<1%	1%	40%	<1%	3%	11%	2%	7%
Contributing Watersheds (Echo, Honey)	1%	4%	8%	2%	4%	15%	<1%	10%	<1%	1%	35%	<1%	<1%	11%	<1%	8%
Total	<1%	3%	9%	1%	4%	10%	<1%	11%	<1%	1%	39%	<1%	2%	11%	2%	7%

Appendix D

NPDES Detailed Information

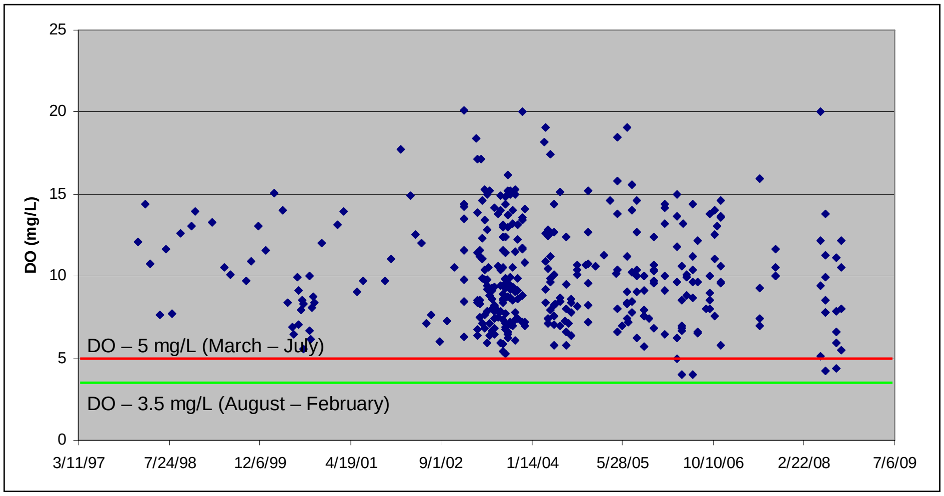
Permit Name	NPDES Number	Name of TMDL	Outfall	Outfall description	DAF (MGD)	DMF (MGD)	Receiving Water	TMDL Segment ID
CITY OF CRYSTAL LAKE	IL0053457	Upper Fox/Flint Creek	001	STP	1.7	5.0	Unnamed tributary of Sleepy Hollow Creek	Fox River DT-22
VILLAGE OF FOX LAKE- NW REGIONAL WRF	IL0020958	Upper Fox/Flint Creek	001	STP	9.0	22.5	Fox River	Fox River DT-23
IL AMERICAN WATER COMPANY	IL0038202	Upper Fox/Flint Creek	001	STP	0.1	0.25	Sleepy Hollow Creek	Fox River DT-22
VILLAGE OF JOHNSBURG	IL0074969	Upper Fox/Flint Creek	001	STP	0.5	1.62	Dutch Creek	Fox River DT-23
MATHEWS COMPANY-CRYSTAL LAKE	IL0072851	Upper Fox/Flint Creek	001	non-contact cooling water	0.0039	NA	Fox River	Fox River DT-22
CITY OF MCHENRY-CENTRAL WWTP	IL0021067	Upper Fox/Flint Creek	001	STP	3.0	7.5	Fox River	Fox River DT-23
CITY OF MCHENRY-SOUTH WWTP	IL0066257	Upper Fox/Flint Creek	001	STP	1.5	4.2	Fox River	Fox River DT-23
MODINE MANUFACTURING	IL0001279	Upper Fox/Flint Creek	001	Inactive	NA	NA	NA	NA
MODINE MANUFACTURING	IL0001279	Upper Fox/Flint Creek	002	non-contact cooling water, Reverse Osmosis water generation, and Storm Water	NA	NA	Unnamed Tributary to Dutch Creek	Fox River DT-23
MODINE MANUFACTURING	IL0001279	Upper Fox/Flint Creek	003	Storm Water	NA	NA	Unnamed Tributary to Dutch Creek	Fox River DT-23
MOUNT SAINT JOSEPH SHELTER CARE	IL0027286	Upper Fox/Flint Creek	001	STP	0.0125	0.025	Unnamed tributary of Flint Creek	Flint Creek DTZS-01; Fox River DT-06
NORTH BARRINGTON ELEMENTARY SCHOOL	IL0024716	Upper Fox/Flint Creek	001	STP	0.005	0.0125	Unnamed Tributary to Flint Creek	Flint Creek DTZS-01; Fox River DT-06
NORTHERN MORAINE WW REC DIST	IL0031933	Upper Fox/Flint Creek	001	STP	2.0 (Existing Plant) 3.0 (Proposed Plant)	5.0 (Existing Plant) 6.0 (Proposed Plant)	Fox River	Fox River DT-22
PORT BARRINGTON SHORES	IL0070874	Upper Fox/Flint Creek	001	STP	0.012	0.0504	Fox River	Fox River DT-22
PRECISION TWIST DRILL CORP	IL0074276	Upper Fox/Flint Creek	001	Contaminated Groundwater remediation	0.17	NA	Northwest drainage ditch to Squaw Creek	Fox River DT-22
PRECISION TWIST DRILL CORP	IL0074276	Upper Fox/Flint Creek	002	Non-contact cooling water	0.00125	NA	Northwest drainage ditch to Squaw Creek	Fox River DT-22

Permit Name	NPDES Number	Name of TMDL	Outfall	Outfall description	DAF (MGD)	DMF (MGD)	Receiving Water	TMDL Segment ID
ROHM AND HAAS CHEMICAL LLC	IL0001716	Upper Fox/Flint Creek	001	Non-contact cooling water, Deionizer Backwash, boiler blowdown, water softener regenerate, fire protection stystem test water, infiltration, storwater runoff, discharge from A01	2.002 (includes A01)	NA	Dutch Creek tributary to Fox River	Fox River DT-23
ROHM AND HAAS CHEMICAL LLC	IL0001716	Upper Fox/Flint Creek	002	Stormwater Runoff	NA	NA	Dutch Creek tributary to Fox River	Fox River DT-23
ROHM AND HAAS CHEMICAL LLC	IL0001716	Upper Fox/Flint Creek	A01	Treated polymer washwater, treated contaminated groundwater	0.353	NA	Internal Outfall	Fox River DT-23
SNAP-ON TOOLS-CRYSTAL LAKE	IL0065480	Upper Fox/Flint Creek	001	Treated Sanitary Waste and Stormwater	Intermittent	NA	Unnamed tributary of Fox River	Fox River DT-22
SNAP-ON TOOLS-CRYSTAL LAKE	IL0065480	Upper Fox/Flint Creek	A01	Treated Sanitary Waste	Intermittent	NA	Unnamed tributary of Fox River	Fox River DT-22
VILLAGE OF WAUCONDA	IL0020109	Upper Fox/Flint Creek	001	STP	1.9 (Existing Plant) 2.4 (Phase 2 Expansion)	5.963 (Existing Plant) 7.93 (Phase 2 Expansion)	Fiddle Creek	Slocum Lake RTP
VILLAGE OF WAUCONDA	IL0020109	Upper Fox/Flint Creek	A01	Excess Flow	NA	NA	Fiddle Creek	Slocum Lake RTP

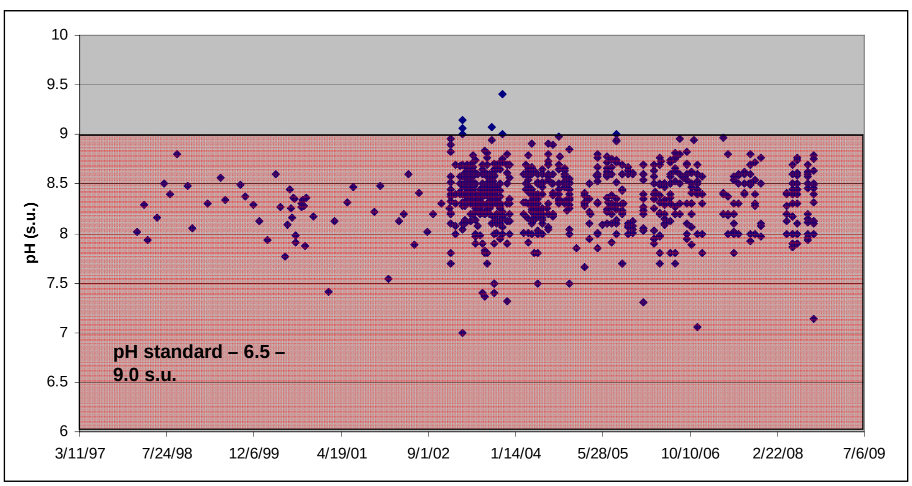
Appendix E

Time-Series Plots

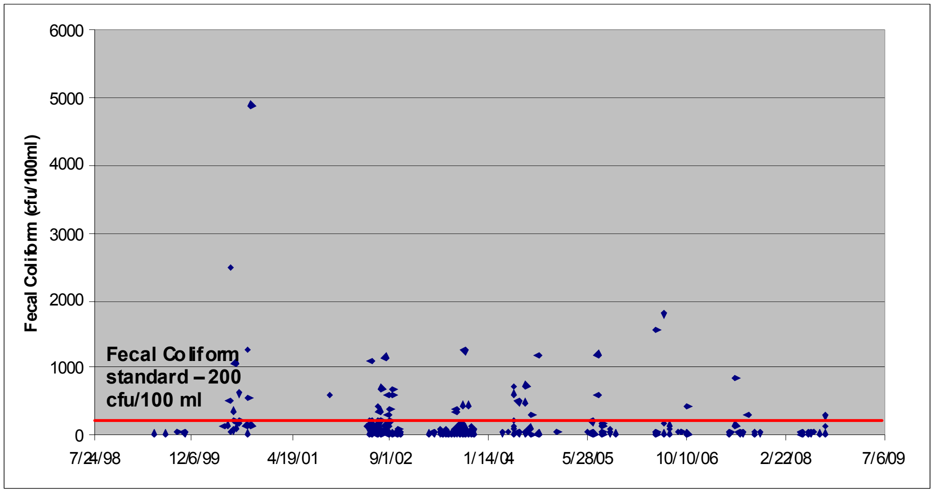
Fox River (DT-22) – Dissolved Oxygen Time Series 1998 - present



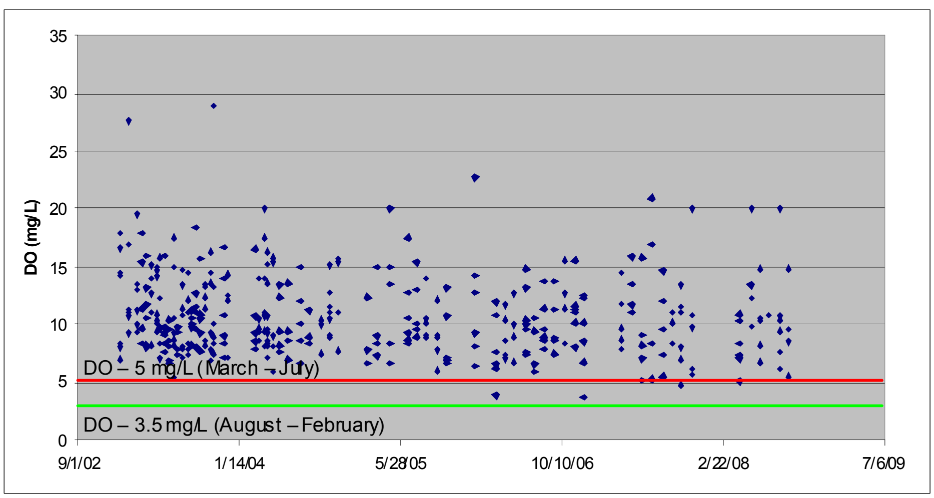
Fox River (DT-22) – pH Time Series 1998 - present



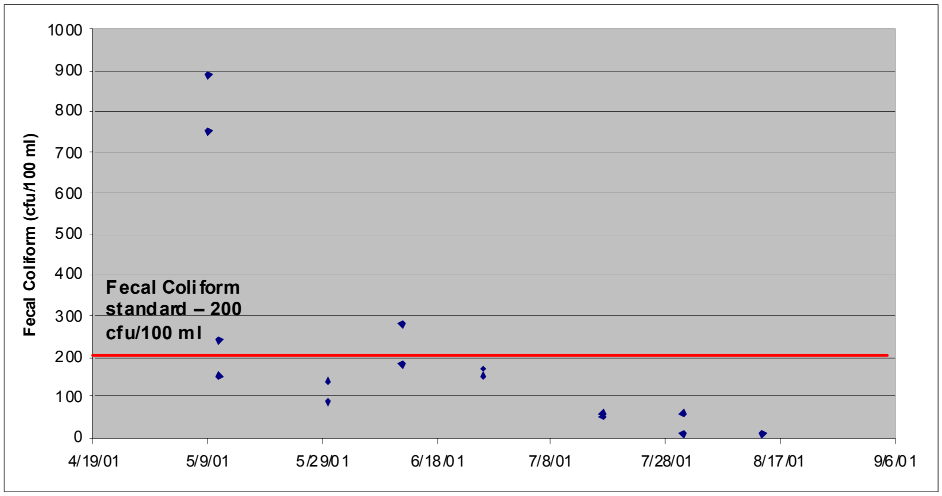
Fox River (DT-22) – Fecal Coliform Time Series 1998 - present



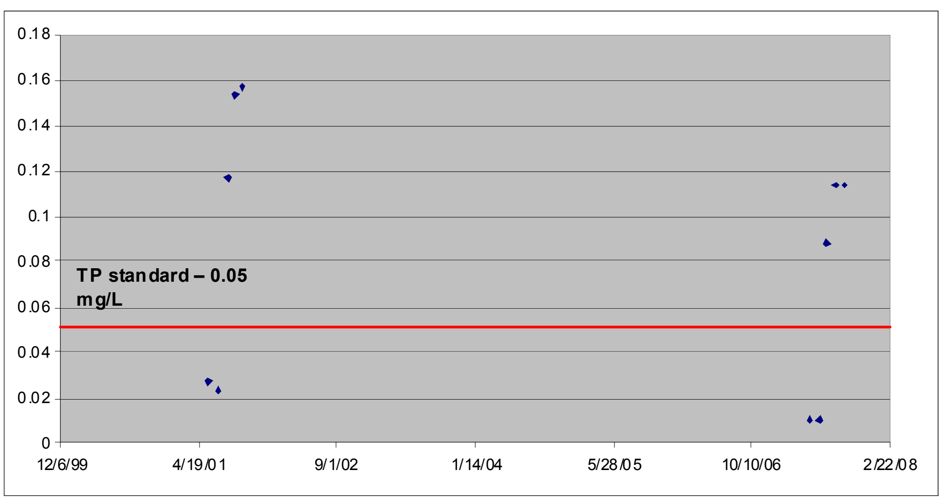
Fox River (DT-23) – Dissolved Oxygen Time Series 1998 - present



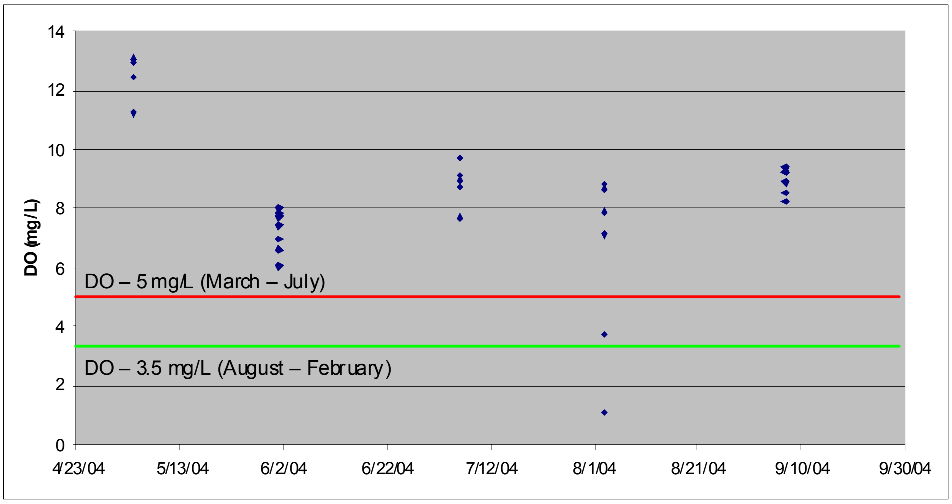
Barrington – Fecal Coliform Time Series 1998 - present



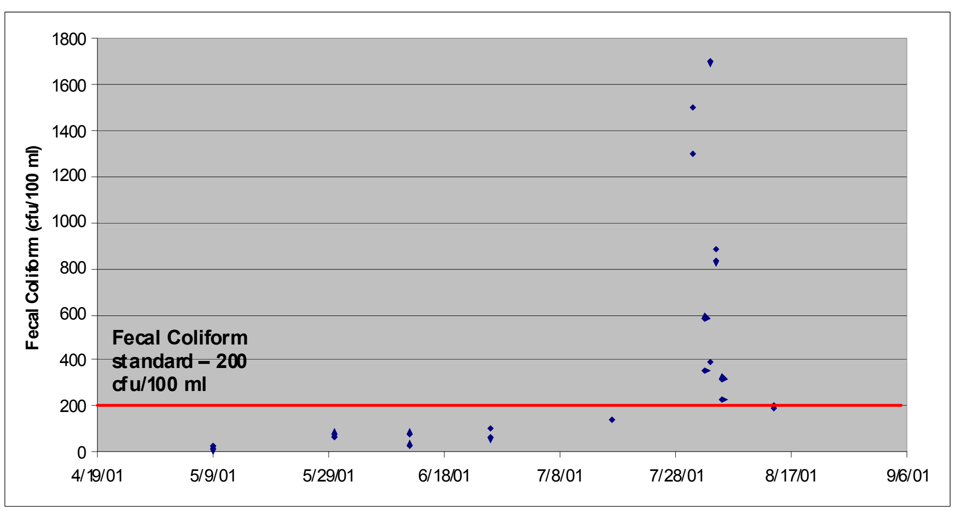
Barrington – Total Phosphorus Time Series 1998 - present



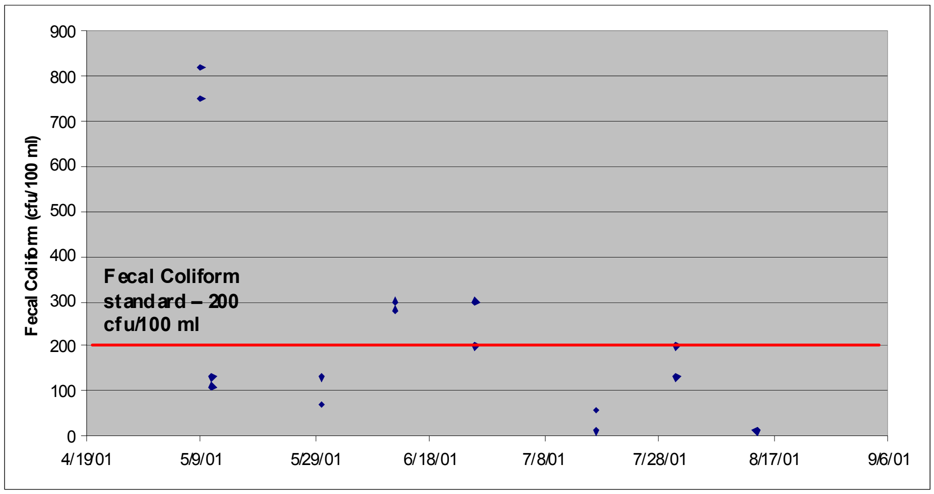
Woodland – Dissolved Oxygen Time Series
1998 - present



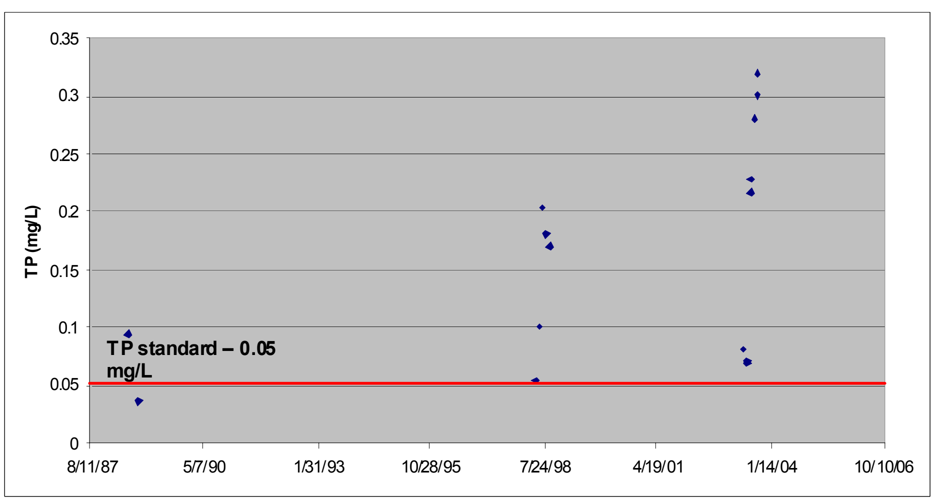
Honey – Fecal Coliform Time Series
1998 - present



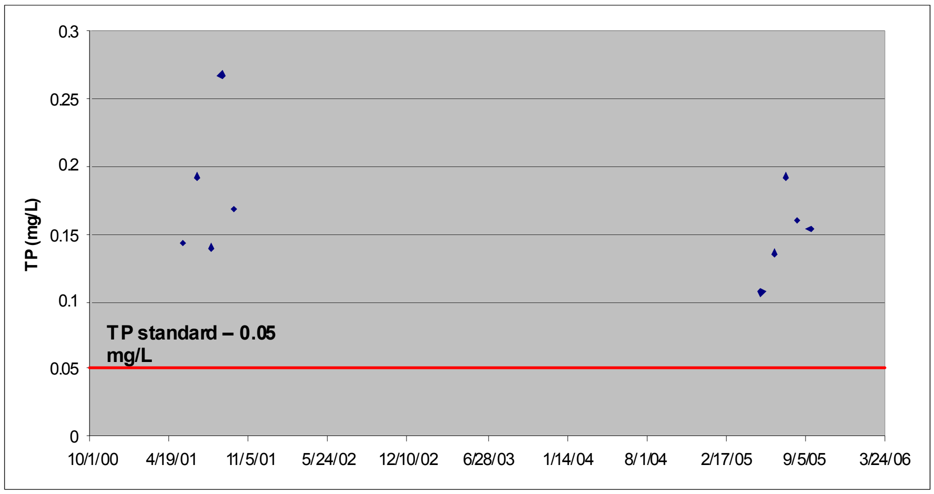
Tower – Fecal Coliform Time Series 1998 - present



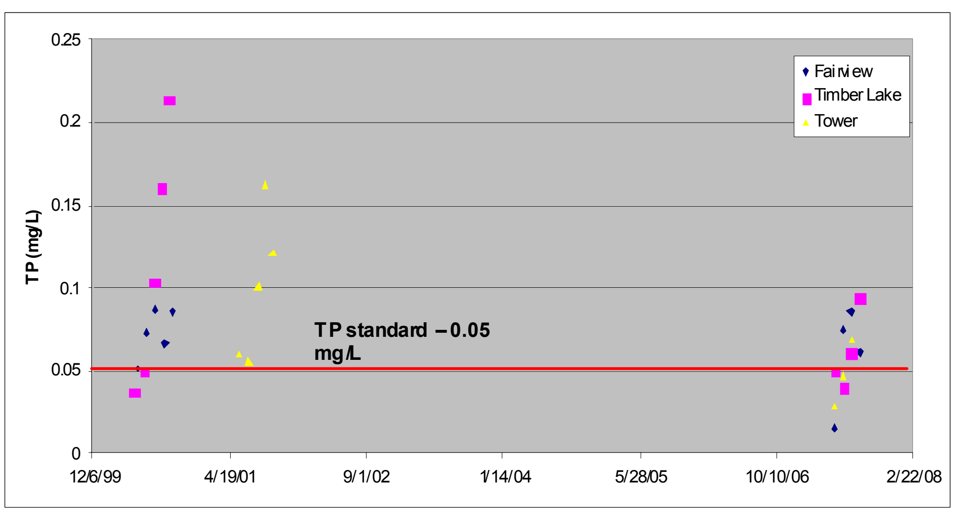
Louise – Total Phosphorus Time Series 1998 - present



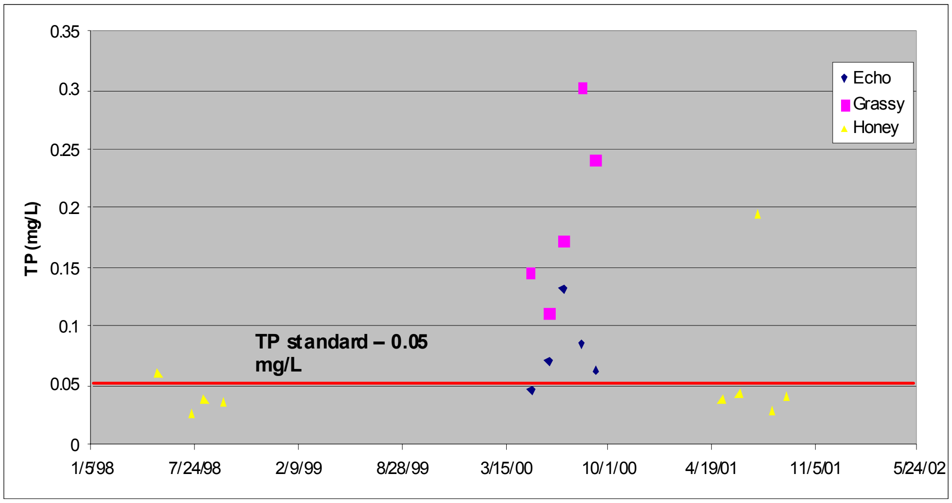
Slocum – Total Phosphorus Time Series
1998 - present



Timber, Tower, Fairview – Total Phosphorus Time Series
1998 - present



Grassy, Honey, Echo – Total Phosphorus Time Series 1998 - present



Napa Suwe, Island, Drummond – TP Time Series 1998 - present