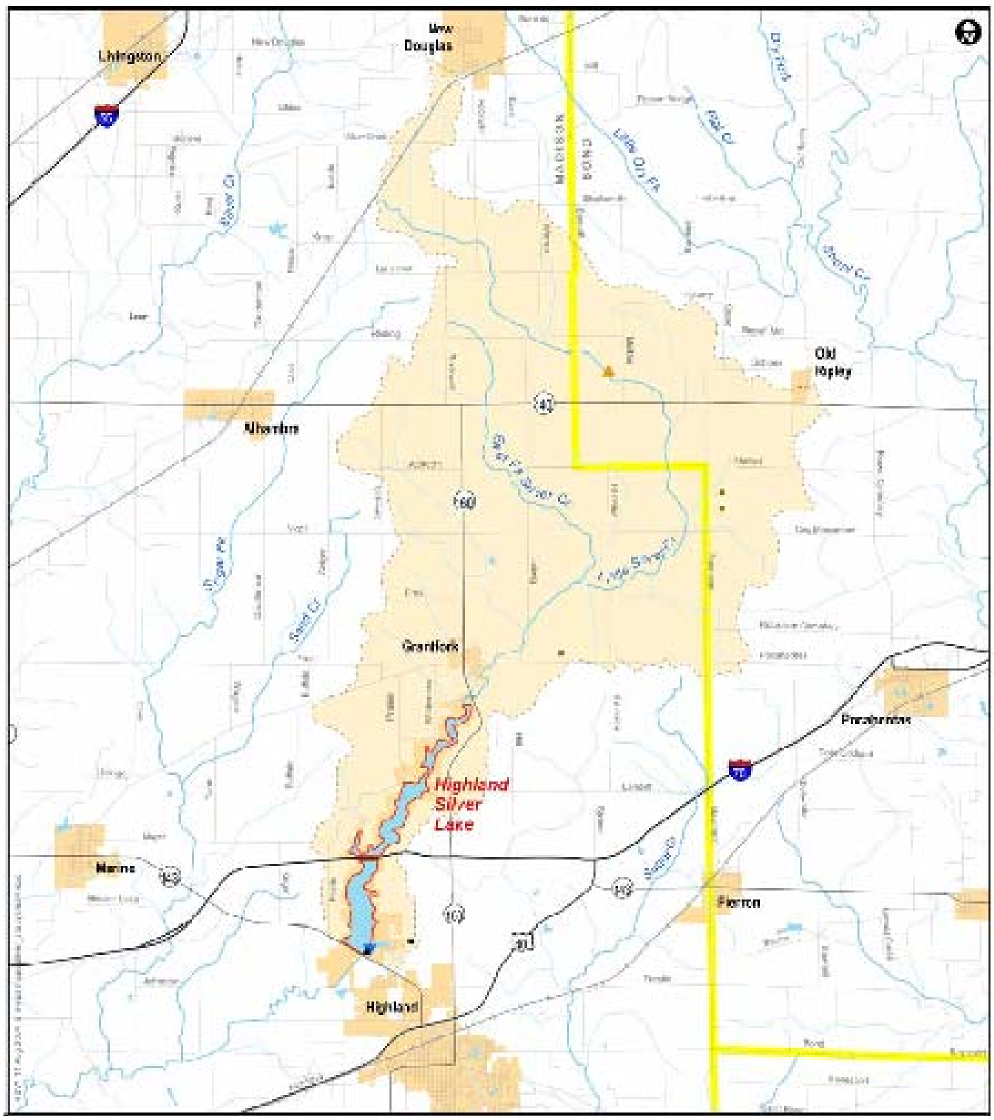
Illinois
Environmental
Protection Agency

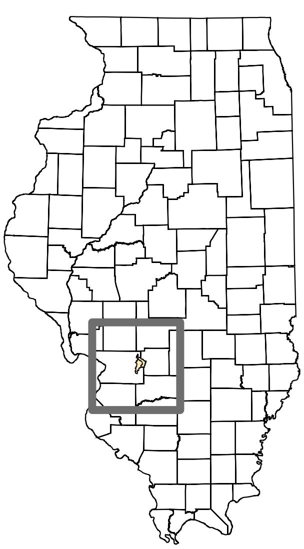
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

October 2006

IEPA/BOW/07-004

HIGHLAND SILVER LAKE WATERSHED TMDL REPORT





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

REPLY TO THE ATTENTION OF:

WW-16J

SEP 30 2005

Marcia Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has conducted a complete review of the final Total Maximum Daily Load (TMDL) submittal, including supporting documentation and information, for Highland Silver Lake Watershed TMDL, which is located in Madison and Bond Counties, Illinois. Based on this review, U.S. EPA has determined that Illinois's Highland Silver Lake Watershed TMDL meets the requirements of Section 303(d) of the Clean Water Act (CWA), 33 U.S.C. § 1313(d), and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, by this letter, U.S. EPA hereby approves three TMDLs for phosphorous, aldrin, and chlordane. The statutory and regulatory requirements, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We appreciate your hard work in this area and the submittal of the TMDL as required. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

for Jo Lynn Traub
Director, Water Division

Enclosure

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Final Stage 1 Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Highland Silver Lake Watershed (ROZA)

Limno-Tech, Inc.
www.limno.com

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First Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

August 2004

Highland Silver Lake Watershed (ROZA)

Limno-Tech, Inc.
www.limno.com

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EXECUTIVE SUMMARY

This is the first in a series of quarterly status reports documenting work completed on the Highland Silver Lake project watershed (also referred to locally as Silver Lake). The objective of this report is to provide a summary work completed to date that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a TMDL be completed for each pollutant listed for an impaired waterbody. A TMDL is a report that is submitted by the States to the EPA. In the TMDL report, a determination is made of the greatest amount of a given pollutant that a waterbody can receive without violating water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Methods

The effort completed in the first quarter included: 1) a site visit and collection of information to complete a detailed watershed characterization; 2) development of a water quality database and data analyses; and 3) synthesis of the watershed characterization information and the data analysis results to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list of impaired waterbodies.

Results

The listing of Highland Silver Lake on the Illinois 303(d) list for impairment for due to dissolved oxygen, total phosphorus, manganese, aldrin and chlordane has been confirmed based on a review of the data.

Potential sources contributing to the listing of Highland Silver Lake include: runoff from cropland, pastureland animal feeding operations and lawns; lakeshore and streambank erosion; lake bottom sediments; failing septic systems; brine pumped from oil wells; and natural background sources.

It should be noted that the manganese criterion for the public water supply use may be difficult to attain. This is due to the fact that the manganese is ubiquitous in the watershed due to naturally occurring manganese in the soils. Furthermore, it is worth noting that according to the Highland Public Works Director (personal communication, 2004), there have been no citizen complaints about clothing or dish staining (manganese can be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures).

Similarly, it is suspected that both aldrin and chlordane are widespread throughout the watershed, due to historical application of these pesticides to cropland. The control of these chemicals may be difficult due to their persistent nature and widespread use.

INTRODUCTION

This Stage 1 report describes initial activities related to the development of TMDLs for Highland Silver Lake watershed. Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed. This section provides some background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments in Highland Silver Lake are also described.

TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA 2004a), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Illinois Assessment and Listing Procedures

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of five generic designated use categories: public water supply, aquatic life, primary contact (swimming), secondary contact (recreation), and fish consumption (IEPA, 2004). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of three possible "use-support" levels:

- Fully supporting (the water body attains the designated use);
- Partially supporting (the water body attains the designated use at a reduced level); or
- Not supporting (the water body does not attain the designated use).

All water bodies assessed as having partial or nonsupport attainment for any designated use are identified as "impaired." Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the 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 (IEPA, 2004).

Identified Watershed Impairment

The impaired waterbody segment included in the project watershed is listed in Table 1 below, along with the cause of the listing. These impairments were identified in the draft 2004 303(d) list (IEPA, 2004). Only those identified causes which have numerical water quality standards are included in Table 1. TMDLs are currently only being developed for pollutants that have numerical water quality standards. Sources that are listed for pollutants that exceed statistical guidelines are not subject to TMDL development at this time (IEPA, 2004).

On this draft 303(d) list, Highland Silver Lake was identified as being in partial support of the following designated uses: overall use, aquatic life, fish consumption, primary contact (swimming) and public water supply. Additionally, this lake is non-supportive of the secondary contact (recreation) designated use.

The listing of Highland Silver Lake as non-supportive of secondary contact (recreation), but partially supportive of primary contact (swimming) is somewhat counter-intuitive. This listing was verified with IEPA and it should be noted that IEPA is working on their assessment approach to make the assessment of these two uses more consistent in future report cycles.

Table 1. Impaired waterbody in the project watershed

Waterbody segment	Waterbody Name	Size (acres)	Year Listed	Listed for[1]
ROZA	Highland Silver Lake	550	1994	**Manganese, total phosphorus, dissolved oxygen, aldrin, chlordane,** sedimentation/siltation, total suspended solids, excess algal growth, and total phosphorus (statistical guideline)

[1] Bold font indicates those parameters that are addressed in this report. The other parameters will not be included because they do not have a numeric water quality standard.
Source: IEPA, 2004

The remaining sections of this report include:

- Watershed characterization: *discussion of methods for information compilation and a detailed characterization of the watershed*
- Database development and data analysis: *discussion of data sources and methods of data analysis*
- Confirmation of causes and sources of impairment: *assessment of sufficiency of data to support the listing and identification of potential sources contributing to the impairment*
- Conclusions

WATERSHED CHARACTERIZATION

The purpose of watershed characterization was to obtain information describing the watershed to support the identification of sources contributing to manganese, total phosphorus, low dissolved oxygen, aldrin and chlordane impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including soils and topography, climate, land cover, urbanization and growth and point sources and water withdrawals. Active watershed organizations were also identified. The methods used to characterize the watershed, and the findings are described below.

Methods

Watershed characterization was conducted by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, numerous calls were placed to local agencies to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. Additionally, on December 11, 2003 a meeting was held with Regional and State-level

EPA staff and a site visit was conducted later the same day. The GIS data obtained, calls placed, meeting and site visit are described below.

The first step in watershed characterization was to delineate the watershed boundary for Highland Silver Lake in GIS using topographic and stream network (hydrography) information. Information obtained and processed for mapping and analysis purposes included:

- current land cover;
- current cropland;
- State and Federal lands;
- soils;
- point source dischargers;
- public water supply intakes;
- roads;
- railroads;
- state, county and municipal boundaries;
- landfills;
- oil wells;
- coal mines;
- dams;
- data collection locations; and
- the location of 303(d) listed lake.

To better describe the watershed and obtain information related to active local watershed groups, data collection efforts, agricultural practices, and septic systems, numerous calls were placed to county-level officials, including those listed below:

- Madison and Bond County Natural Resources Conservation District (NRCS);
- University of Illinois Agricultural Extension Office, Edwardsville Center;
- University of Illinois Agricultural Extension Office, Carbondale Center;
- Madison County Planning and Development;
- Madison and Bond County Health Departments; and
- Madison and Bond County Soil and Water Conservation Districts.

Calls were also placed to the Public Works Department for the City of Highland, the Silver Lake Advisory Commission and Heartland Ecosystem Services, Inc. Finally, calls were placed to the State Water Quality Specialist with the NRCS, the Illinois Department of Public Health, University of Illinois Extension and the USEPA Office of Pesticide Programs to obtain information on manganese sources, the fish consumption advisory and chlordane and aldrin use. A site visit was completed on December 11, 2003 to familiarize the project team with the lake and watershed, and gain a better understanding of land uses and potential sources in the watershed. Lists of data sources and calls made are included in Appendix A. Some photos of the lake are included in Appendix B.

Other information compiled for this task related to climate, population growth and urbanization. These data were obtained from State and Federal sources, including the Illinois State Climatologist, the U.S. Census Bureau and the State of Illinois. A summary of the Highland Silver Lake watershed follows.

Highland Silver Lake Watershed Characterization

The Highland Silver Lake watershed is located in western Illinois, approximately 35 miles east of St. Louis. This project study area is part of the larger, Lower Kaskaskia River Watershed. This lake is an impoundment of East Fork Silver Creek and was constructed in the 1960-1962 time period to provide a reliable water source to the City of

Highland. Also contained in this watershed is Little Silver Creek, which drains the northernmost and northeast portions of the watershed. When completed, Highland Silver Lake replaced a much smaller impoundment, which is just east of the large dam.

The lake itself is 550 acres in size (IEPA, 2004a) and has a maximum depth of approximately 20 feet. In general, it is a shallow lake and is used both for public water supply and recreation (Silver Lake Park is located on North Route 143). The watershed draining to Highland Silver Lake is approximately 48 square miles in size and includes portions of Madison and Bond Counties. A protective buffer strip and conservation areas surround the lake and are maintained by the Highland Parks and Recreation Department. The primary road traversing the watershed is Interstate 70.

Figure 1 shows a map of the watershed, and includes some key features such as waterways, Highland Silver Lake, the public water intake, roads and other key features. The map also shows the location of the Highland water treatment plant (WTP) and Munie Trucking Company discharges.

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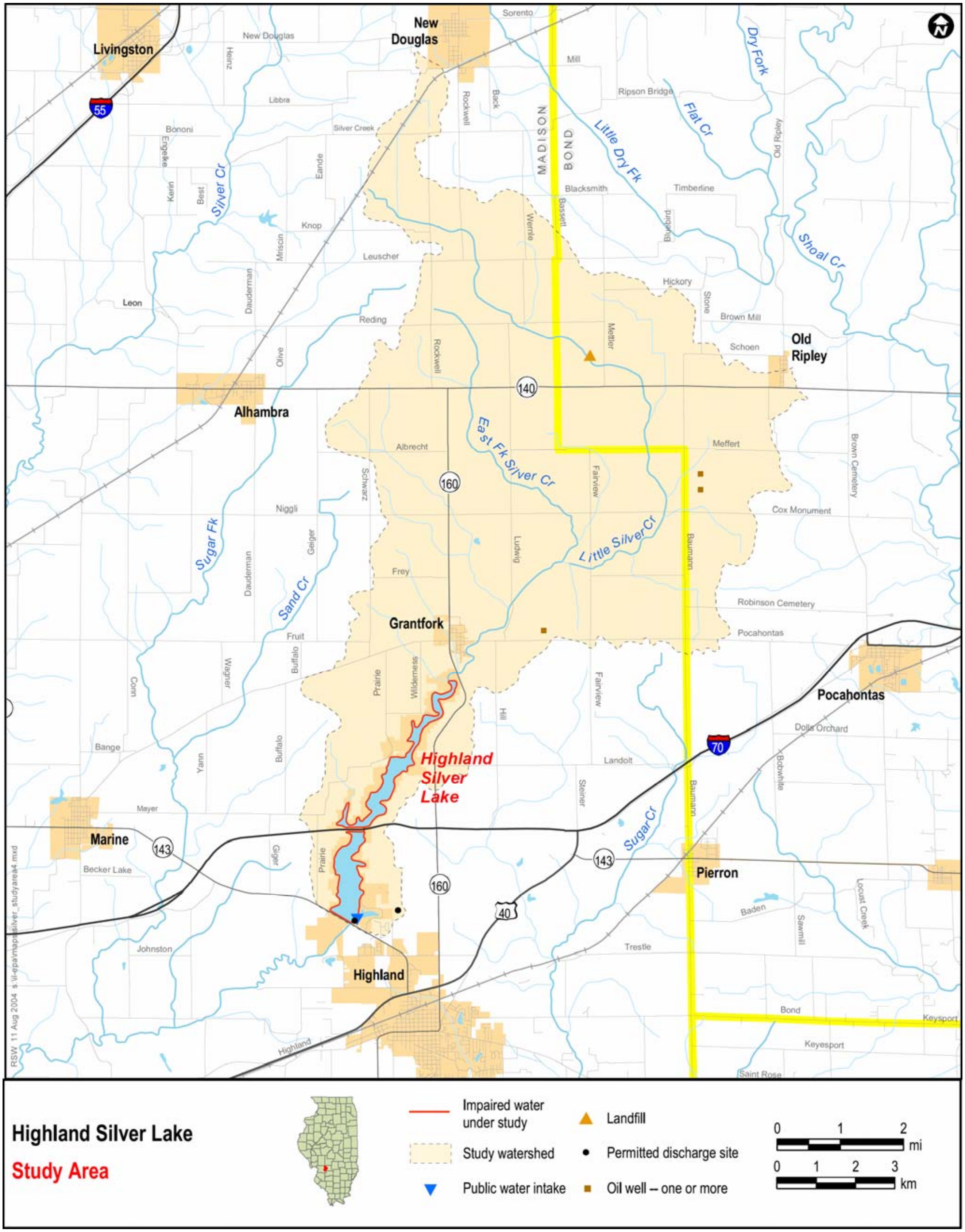

Figure 1. Study area map

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The following sections provide a broad overview of the characteristics of the Highland Silver Lake watershed.

Soils and topography

Information on soils and topography was compiled in order to understand whether the soils are a potential source of manganese and phosphorus. County soil information was available for Madison County in electronic format (SSURGO and STATSGO) and for Bond County in printed and electronic format (USDA, 1983; STATSGO). Soils for the Highland Silver Lake watershed are shown in Figure 2 and summarized in Table 2. A revised soils survey for Madison County has recently been completed but printed copies are not yet available. The soil discussion that follows is based on the Bond County soil survey (USDA, 1983) and Madison County STATSGO soils. As discussed below, many of the soils in the Highland Silver Lake watershed contain manganese and iron oxide concretions or accumulations and are also acidic. This could result in manganese and iron moving into solution and being transported in base flow and/or runoff.

The portion of the watershed in Bond County is primarily underlain by the Piasa-Cowden association of soils. This association is comprised of nearly level (0-2% slopes), poorly drained soils that have a very slowly permeable or slowly permeable subsoil and formed in loess; on uplands. The Piasa series is not described as containing iron or manganese oxides, however, the upper six soil horizons (0 to 33 inches) of the Cowden series do contain concretions comprised of iron and manganese oxide and these horizons are described as being slightly to strongly acid.

A lesser portion of the Highland Silver watershed soils in Bond County are described by the Oconee-Darmstadt association. These are nearly level or gently sloping (0 – 5% slopes), somewhat poorly drained soils that have a slowly permeable or very slowly permeable subsoil and formed in loess; on uplands. The upper six soil horizons (0 to 54 inches) of the Oconee series contain common fine irregular accumulations of iron and manganese oxide and are described as being slightly to medium acid. Six of the upper seven soil horizons (0 – 45 inches) of the Darmstadt series have few to many fine rounded concretions or accumulations of iron and manganese oxide.

The portion of the Highland Silver Lake watershed in Madison County is underlain primarily by three soil associations: Cowden-Oconee-Darmstadt; Herrick-Virden-Piasa; and Rozetta-Keomah-Hickory. In comparing the STATSGO soils and the Bond County soil survey, it is noted that the Madison County Cowden-Oconee-Darmstadt association appears to be contiguous with the Oconee-Darmstadt series in Bond County and the Herrick-Virden-Piasa association is contiguous with the Piasa-Cowden association and the previous descriptions of these associations should apply to the Madison County portion of the watershed. The Rozetta-Keomah-Hickory association primarily is located near Highland Silver Lake. As described in the Bond County soil survey (USDA, 1983), the Hickory series consists of well drained moderately permeable soils on side slopes along drainage ways in the uplands. These soils were formed in glacial till. Slope ranges from 15 to 30 percent. At depths of 46 to 60 inches, few small black concretions of iron and manganese oxide are noted. These soils are very strongly acid. There are no descriptions of the Rozetta or Keomah associations in the Bond County soil survey.

Because the Madison County soil survey is out of print and the newer version is not yet available, these two associations are not described here.

Natural soil phosphorus levels vary between normal (Bond County SWCD, 2004) and high (Madison County SWCD, 2004 and University of Illinois Extension, 2004).

Table 2. Watershed soils distribution for Highland Silver Lake watershed

Soil Map Units (MUID)	Acres	Percentage
Herrick-Virden-Piasa (IL004)	7,511	24.5%
Cowden-Oconee-Darmstadt (IL005)	16,350	53.3%
Rozetta-Keomah-Hickory (IL036)	6,840	22.3%

Source: STATSGO

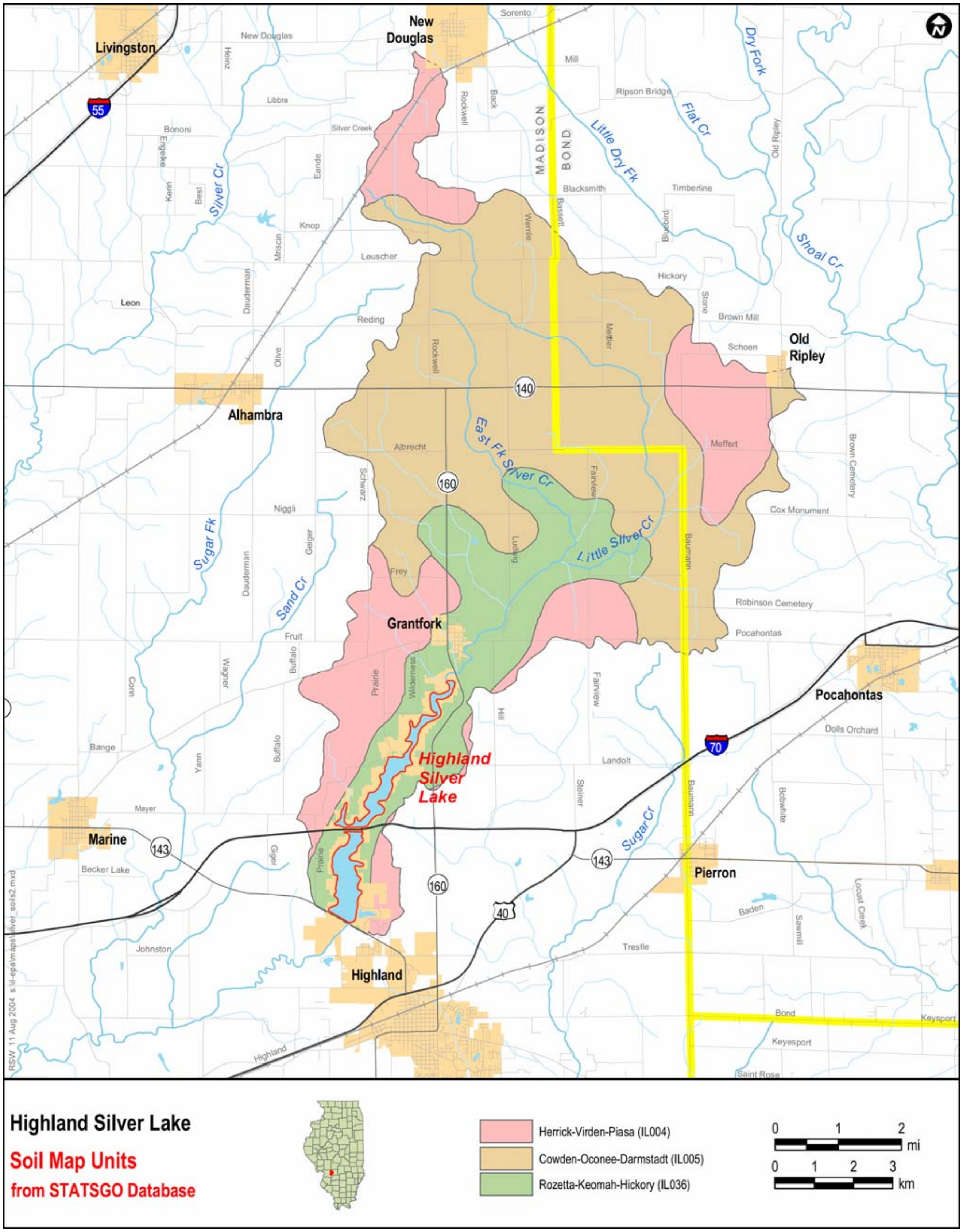

Figure 2. Highland Silver Lake watershed soil map

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Climate

Climate information was obtained and summarized to support the watershed characterization and gain an understanding of runoff characteristics for this study area. Climate summaries were available on the web page of the Illinois State Climatologist Office, Illinois State Water Survey. Climate data were obtained for a station in Greenville (precipitation and snowfall) and at Carlyle Lake (air temperature). These two sites belong to the National Weather Service (NWS) Cooperative Observer Program (COOP).

The Highland Silver watershed has a temperate climate with cold, snowy winters and hot summers. The average long-term precipitation recorded at Greenville 1 E (Station 113693) is approximately 40 inches. The maximum annual precipitation is 54.66 inches (1946) and the minimum annual precipitation is 24.11 inches (1953). On average there are 98 days with precipitation of at least 0.01 inches and 10 days with precipitation greater than 1 inch. Average snowfall is approximately 18.3 inches per year.

Average minimum and maximum temperatures recorded at Carlyle Reservoir (Station 111290) are 18.8 ^{o}F and 36.3 ^{o}F, in January and 66.6 ^{o}F and 87.7 ^{o}F in July. This is based on measurements collected between 1971 and 2000. The average temperature recorded in January is 27.6 ^{o}F and the average temperature recorded in July is 77.2 ^{o}F.

Land Cover

Runoff from the land surface contributes pollutants to nearby receiving waters. In order to understand sources contributing to the lake impairments, it was necessary to characterize land cover in the watershed. Land cover in the watershed is shown in Figure 3, and listed in Table 3. Land cover is described in more detail in the sections that follow.

Agriculture

The predominant land cover in the watershed is agriculture, comprising 83% of the watershed. Using the 1999-2000 land cover information obtained from the Illinois Department of Agriculture, the agricultural land cover can be more specifically described as being dominated by corn (46%) and soybeans (38%), with lesser amount of winter wheat and other small grains. Due to rotations, the percent of land with these crops varies year to year, but the primary crops (corn, soybeans and wheat) remain the same from year to year. This is consistent with information obtained from calling the Madison and Bond County NRCS offices (personal communication, 2004), who added that the crops are rotated in a standard rotation and that most land is tilled in a conventional manner (0 – 10% residue left on the fields) because of the flat topography.

In Bond County, no till agriculture is used, but only in highly erodable areas, of which there isn’t much in the Bond County portion of the watershed. It is thought that there is very little land in the Conservation Reserve Program (personal communication, Madison County NRCS District Conservationist). A summary of tillage information for Madison and Bond Counties (Illinois Department of Agriculture, 2002) is presented in Tables 4 and 5 below. This information is consistent with the tillage information obtained through conversations with the County NRCS offices. The majority of the corn and soybean croplands are tilled using conventional tillage methods that leave little or no residue on the surface. Much of the small grain (wheat) cropland, however, is planted without any tillage prior to planting (Bond County) or is planted using reduced till (Madison County). These tillage systems can reduce soil loss from cropland.

Tile drains are not common (estimated at < 5%) due to the tight clay soils, and farms use surface ditches to carry runoff since the soil is too tight for tile drains to be used (Personal communication, University of Illinois Extension and Madison County SWCD).

BMPs

As part of a pilot study in the 1970s, the USDA spend several hundred thousand dollars to implement BMPs to reduce soil loading to Highland Silver Lake. Water and sediment control systems were installed in streams upstream of Highland Silver Lake, terrace systems were installed in the more sloping farm fields, and grassed ditches were developed to remove pollutants. Sediment basins were also placed within the creeks themselves (personal communication, Madison County SWCD Resource Conservationist).

Through the United States Department of Agriculture, a rural clean water program was started in 1985 to reduce erosion. By voluntarily changing tillage practices, farmers qualified for cost sharing for construction of permanent structural measures such as terraces and water and sediment basins. All of these structural measures still exist in the watershed (personal communication, Madison County SWCD Resource Conservationist). Currently, there are not a lot of filter strips within the watershed and farm fields usually extend right up to ditches and roads (personal communication, Madison County NRCS District Conservationist).

A different view was provided by the University of Illinois Extension Natural Resources Management Educator, who stated that conventional tilling has largely been replaced by low-till and no-till methods and vegetation is being reestablished at field edges and along streams (personal communication, University of Illinois Extension Natural Resources Management Educator).

Fertilizer and pesticide use

Commercial fertilizers (primarily anhydrous ammonia) are used primarily, with supplements from manure applications, when manure needs to be disposed of. There is not a lot of available manure to use on farm fields. It is estimated that 80-90 percent of farmers use soil testing to determine the amount and type of fertilizer to apply to the soil. Anhydrous ammonia is usually applied in the spring, with phosphorus and potash applied in the fall (Personal communication, Bond and Madison County NRCS).

According to the University of Illinois Extension Office, Edwardsville Center, fertilizers used in the watershed consist of phosphorus, potassium and nitrogen (anhydrous ammonia) and vary by crop. Cropland runoff of phosphorus may contribute to the listing of Highland Silver Lake for phosphorus and runoff of ammonia and phosphorus may contribute to the listing of the lake for low dissolved oxygen.

When used, pesticides are applied to the whole field on an as-needed basis, an estimated once or twice a year. Most soybeans are Roundup Ready. Most applications are ground-based applications, with only ~2 percent crop dusting. Highland Silver Lake is not on the 303(d) list for any currently used pesticides, however, it is listed for the historically used (but now banned) pesticides, aldrin and chlordane.

The use of aldrin and chlordane in the watershed was difficult to assess, but through a review of documents and discussions with several people knowledgeable about aldrin and chlordane, it is thought that these chemicals were historically used in the watershed. A discussion of aldrin and chlordane follows.

From the 1950s until 1970, aldrin was a widely used pesticide for crops, such as corn. Because of concern about damage to the environment and potentially to human health, USEPA banned all uses of aldrin in 1974, except to control termites. In 1987, USEPA banned all uses of aldrin (ATSDR, 2002).

Chlordane is a manufactured chemical that was used as a pesticide in the United States from 1948 to 1988. Because of concern about damage to the environment and harm to human health, the USEPA banned all uses of chlordane in 1983, except to control termites. In 1988, USEPA banned all uses of chlordane (ATSDR, 1995).

The USEPA Office of Pesticide Programs, the University of Illinois Department of Crop Sciences and the University of Illinois Extension were contacted to obtain information on historical aldrin and chlordane usage. According to the USEPA Office of Pesticide Programs, no county level use information exists for these pesticides for the 1950-1990 period. According to a University of Illinois Extension Field Crops Entomologist, the cyclodienes (e.g., chlordane, aldrin/dieldrin, etc.) were used extensively for corn rootworm control in much of the Corn Belt during the 1950s and 1960s. According to the University of Illinois Extension Natural Resources Management Educator (personal communication with Mike Plumer), these pesticides were used all around the farm operations, especially in dairy barns. By the early 1970s, the USEPA banned the use of chlorinated hydrocarbons. Corn rootworms developed resistance to these products in the 1960s. Resistance began in south central Nebraska and this resistant strain quickly spread across Iowa and Illinois. The cyclodiene soil insecticides also were widely used across Illinois for secondary insect pests such as wireworms and white grubs. The typical rate used was 1.0 lb active ingredient per acre. Many of the applications were broadcast in nature.

Although the counties of Bond and Madison were not "hot spots" for corn rootworms, the University of Illinois Extension Field Crops Entomologist stated that he suspects the cyclodienes were used for the secondary insect pests.

During the time that aldrin and chlordane were being used, the area was dominated by intensive row crop production, with open ditches and active removal of vegetation from stream banks. Conventional till farming led to high erosion rates transporting pesticides to the lake (personal communication, Univ. of IL Natural Resources Management Educator).

Animal feeding operations

The yellow areas on Figure 3, indicating agricultural land cover, include livestock operations. Information on the few animal operations in the watershed was obtained through conversations with the Madison and Bond County NRCS and the University of Illinois Extension Natural Resources Management Educator. According to the University of Illinois Extension Educator, the Highland Silver Lake watershed previously had a very large number of small dairies, with nearly every farm having several head. The number of dairies in the watershed has been drastically reduced as farming economies and family practices have changed. Only one dairy operation with 50-60 head of cattle was identified currently, with some farmers having individual cows as well. Within the watershed, there is also a small beef operation with 15 head of cattle. It is thought that these cattle have access to the streams. It is thought that these animals are not usually put out to pasture, but that if they were let out, they would not be excluded from streams. There is one farm with beef cattle (number of head has not been verified) that have direct access to the lake just north of Interstate-70. Manure produced is most likely spread on fields. A large hog operation (~ 800 head) is located on the northern edge of the watershed, west of New Douglas. At most, only 25% of this operation is estimated to be within the watershed. The hogs are confined in structures and manure is mostly disposed of on fields by injecting it into the soil.

Forest and urban areas

The green areas on Figure 3 show forested lands (approximately 6% of the watershed), which are both upland and partial canopy/Savannah upland. Also shown on the map (in red) are areas of low/medium and high density development. These areas indicate the locations of the towns and residential communities in the watershed and comprise only two percent of the total land area within the watershed. Highland is the major urban area in the vicinity of the watershed, however, it is primarily located outside of this project study area. Other developed areas within the Highland Silver Lake watershed include Grantfork, and portions of New Douglas and Old Ripley.

Based on calls to local agencies, it is believed that only the city of Highland has municipal sewer service and that the rest of the watershed is served by septic systems. For septic systems that are inspected, it is estimated that 50% are failing. However, not many complaints are received. When a septic system was failing, often leaching to the ground surface was occurring or there might be an aerobic discharge unit without any parts inside (Madison County Planning and Development, 2004).

Table 3. Land cover distribution within the Highland Silver Watershed

Land cover type	Area (acres)	Percent of total
Agriculture[1]	25,345	83
Forest	1,987	6
Grassland	1,535	5
Urban	623	2
Wetland	597	2
Water	585	2
Barren	16	0

Source: Illinois Department of Agriculture, 1999-2000 land cover
[1] Agriculture is primarily comprised of corn (46%) and soybeans (38%), with lesser amount of winter wheat and other small grains.

Table 4. Percent of fields, by crop, with indicated tillage system – Madison County

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	79	16	3	2
Soybean	45	30	13	13
Small grain	8	92	0	0

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

Table 5. Percent of fields, by crop, with indicated tillage system – Bond County

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	91	0	0	9
Soybean	56	4	0	40
Small grain	27	3	0	69

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

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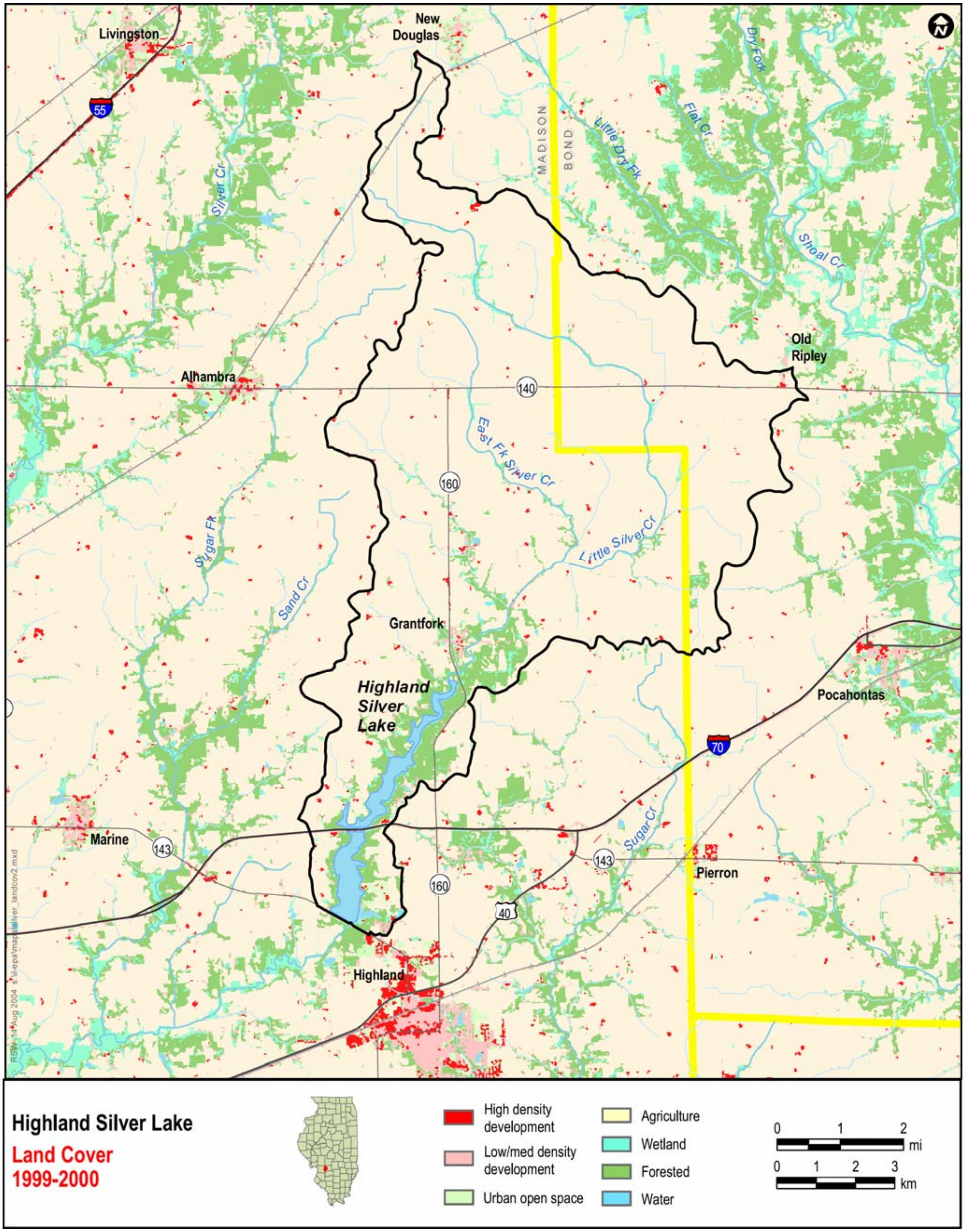

Figure 3. Current land cover in the project watershed

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Urbanization and growth

Urbanization and growth are two factors that can affect the amount and quality of runoff from land surfaces and which also affect the demand on water and sewage treatment facilities. The Highland Silver Lake watershed encompasses portions of two rural counties and four small communities. 77% of the watershed is located in Madison County and 23% is located in Bond County. The four communities are Highland, Grantfork, New Douglas and Old Ripley. The City of Highland is the largest urbanized area in the watershed, with a population of 8,500 residents (City of Highland website). This city is only partially contained in the Highland Silver watershed.

Table 6 indicates that population growth in Madison County has been slow (3%) between 1990-2000, while it has been more rapid in Bond County (~18%). Anecdotal information from area residents suggest that there is a significant amount of new residential development near the upper part of the lake that are serviced by septic systems. Population projections available in a State of Illinois (1997) report project Bond County to decrease in population by 2020 and for Madison County to increase by 5% between 2000 and 2010 and by another 5% between 2010 and 2020 (Table 5). Based on the growth observed from the U.S. Census data for Bond County (~18% between 1990-2000), it appears that the population projections for 2010 and 2020 are no longer valid.

Table 6. Bond and Madison County population

County	1990[1]	2000[1]	2010[2]	2020[2]
Bond	14,991	17,633	16,917	16,908
Madison	249,238	258,941	271,091	285,126

[1]U.S. Census Bureau
[2]State of Illinois, 1997

Point sources and water withdrawal

Point sources and water withdrawals may affect water quantity and quality in Highland Silver Lake. Two NPDES-permitted dischargers are located within the Highland Silver Lake watershed. One is the Highland Water Treatment Plant, which has a permit (IL0001112) to discharge treated filter backwash and settling lagoon overflow to Highland Silver Lake. The other is the Munie Trucking Company, which has an expired permit (IL0068861) for pit pumpage and stormwater. There are also three locations in the watershed where there are one or more oil wells. One landfill (Bertha Davis, ID 50200001) was also identified within the watershed. The locations of the water treatment plant, Munie Trucking Company, the oil wells and the landfill are shown on Figure 1.

The Highland Water Treatment Plant mentioned previously, also has a permit to withdraw and treat surface water from Highland Silver Lake (Facility No. IL1190550). This water is supplied to Highland, St. Jacob, Grantfork and Pierron. The average daily process produces 1.2 million gallons per day (MGD) with a total design capacity of 4.2 MGD (City of Highland Water Treatment Plant website, http://www.ci.highland.il.us/Public_Documents/HighlandIL_Treatment/index).

Watershed organizations

Active watershed organizations are good sources of watershed and lake information and will be important teaming partners for community outreach and implementation of this TMDL. One active organization was identified within the watershed. This is the Silver Lake Advisory Commission (Commission), which is a city-appointed commission that makes efforts to protect water quality in the lake. This Commission is lead by Mark Rosen, who is also the head of the Highland Parks and Recreation Department. Highland Parks and Recreation maintains the grounds and lakeshore around the lake.

The City of Highland and the Commission are looking to establish a positive, working relationship with farm producers and land owners in the watershed upstream of the lake. They are hoping to see BMPs established in the watershed, as few are currently being used.

The Commission is developing a Comprehensive Plan for Silver Lake and Silver Lake Park (Rosen, 2003). The immediate plan of the Commission is to designate a variety of six (6) zones around the lake to improve and maintain water quality and recreational opportunities.

- **Conservation Zone**: This is designed to promote the growth of wildlife and native plant species.
- **Nature Preserve Zone**: This is similar to the Conservation Zone, but it is designed to promote the growth of species in as close to their natural state as possible.
- **Silver Lake Park Zone**: This is designed to provide a pleasant setting for picnicking, fishing, hiking and family activities.
- **Restricted Zone**: This includes areas along roadways or elsewhere, to restrict access for the safety of people.
- **Wetland Zone**: This is designed to improve the water quality of the lake and provide habitat for native wetland wildlife and plant species in a natural setting.
- **Private Use Buffer Zone**: This is designed for contiguous landowners to apply for a permit to alter the natural state of the buffer area between landowners and the Lake’s property.

Future recommendations for managing the lake and the land area around it were also noted in Rosen (2003). Those which relate to water quality improvement are highlighted below in bold.

- Developing a canoe launch at the head of the Lake on the west and north side of Illinois Route 160 near Grantfork.
- Develop a camp ground in the northern part of the Lake on the west side near Decks Prairie Road.
- **Install shoreline erosion protection throughout portions of the Lake.**
- **Assist in acquiring monies for repairing the Low Level Outlet to aid in implementing strategies to improve water quality and shoreline protection.**
- Survey and sign City Property around the entire Lake.

The Commission is currently working with Heartland Ecosystem Services, Inc. in Greenville, Illinois to collect monitoring data. A year's worth of data have been collected at three or four stations in the lake plus one upstream tributary. Parameters analyzed included: dissolved oxygen, alkalinity, nitrate, nitrite, ammonia, phosphorus, ortho-phosphorus, total suspended solids, total Kjeldahl nitrogen, and chlorophyll. The results are expected to be published before the end of August 2004. This document should be available from Mark Rosen at the City of Highland.

The intent of the data collection effort was to use the data to support a grant application for a Clean Lakes Study. The Illinois Clean Lake Program, which funds the Clean Lakes Studies, is described on the Illinois EPA website (see below).

> The Illinois Clean Lakes Program (ICLP) is a financial assistance grant program that supports lake owners' interest and commitment to long-term, comprehensive lake management and ultimately results in improved water quality and enhanced lake use. Detailed "Phase I" diagnostic/feasibility studies scientifically document the causes, sources, and magnitude of lake impairment. Data generated from these monitoring studies are used to recommend lake protection/restoration practices for future implementation. "Phase II" implementation project grants can then be awarded to lake owners to implement Phase I report recommendations (http://www.epa.state.il.us/water/conservation-2000/iclp.html).

The City has now been awarded that grant by the Illinois EPA for a Clean Lakes Study, so this effort will be going on at the same time as the TMDL work (personal communication, Heartland Ecosystem Services). There is a need for collaboration between these two efforts (TMDL and Clean Lakes Study) to maximize resources and reduce redundancy.

With the new Clean Lakes Study, a new round of data collection will commence in October 2004. Monitoring will last another year from then. The Illinois EPA lab in Champaign will analyze samples. Once the Clean Lakes Study is completed, Section 319 grants will be pursued (Personal communication, Heartland Ecosystem Services).

DATABASE DEVELOPMENT AND DATA ANALYSIS

The purpose of this effort was to identify and compile all relevant water quality, sediment and fish data into a project database to facilitate data analysis to: 1) determine the sufficiency of the data for supporting waterbody listing on the 303(d) list of impaired waters and 2) support identification of potential sources contributing to waterbody impairment.

All readily available water quality and NPDES effluent data were obtained from Illinois EPA and the USEPA STORET database and compiled into a Microsoft Access database. Those data that were provided in printed format were entered into the database to facilitate analysis. Information on water quality criteria was also obtained for comparison to the collected data.

Once database development was completed, the data were analyzed. Analysis methods included computing summary statistics, evaluating trends and correlations and using graphical analysis, including profile plots, to discern relationships in the data.

Data sources

All readily available data to describe water quality in Highland Silver Lake and its watershed were obtained. All data identified were collected from the lake; no tributary monitoring data were identified. Sources contacted for data include the Illinois Environmental Protection Agency (State and Regional offices) and the United States Geologic Survey (USGS). No USGS data were identified for the project watershed. All readily available data describing effluent quality for the Highland WTP were obtained from the Illinois EPA and permit limits were obtained from the USEPA PCS database. No monitoring data were available for the Munie Trucking facility discharge. All available and relevant data were compiled in electronic format along with sample location and collection information, in a project database. A list of data sources is included in Appendix A.

A summary of readily available water quality, sediment and fish data for the lake is presented in Table 7. Sampling station locations for the data analyzed for this report are shown in Figure 4. The fish sampling station (ROZA) indicates the fish were caught in the lake. A specific location where the fish were caught was not available.

Table 7. Water quality data summary for Highland Silver Lake[1]

Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
Manganese (ug/l)	ROZA-1	4/2002-10/2002 (5 samples)	72	220	135
Total phosphorus (mg/l)	ROZA-1	3/1990-10/2002 (76 samples)	0.057	0.874	0.267
	ROZA-2	3/1990-10/2002 (35 samples))	0.098	0.835	0.320
	ROZA-3	3/1990-10/2002 (36 samples)	0.139	1.55	0.503
	ROZA-4	3/1990-11/1990 (9 samples)	0.077	0.896	0.336
	ROZA-5	3/1990-11/1990 (9 samples)	0.104	4.32	0.740
	ROZA-6	3/1990-11/1990 (9 samples)	0.105	0.673	0.339
	ROZA-9	3/1990-11/1990 (9 samples)	0.137	1.47	0.538
Dissolved oxygen (mg/l)	ROZA-1	3/1990-10/1996 (233 samples)	0	12.1	5.0
	ROZA-2	3/1990-10/1996 (101 samples)	0	11.4	5.8
	ROZA-3	3/1990-10/1996 (45 samples)	0.3	17.3	7.9
	ROZA-4	3/1990-11/1990 (87 samples)	0	10.5	5.5
	ROZA-5	3/1990-11/1990 (65 samples)	0	11.6	5.8
	ROZA-6	3/1990-11/1990 (54 samples)	0	13.6	6.0
	ROZA-9	3/1990-11/1990 (20 samples)	2	14.6	7.0
Aldrin (ug/l in water; ug/kg in sediment)	ROZA-1	4/2002-10/2002 (5 samples)	Non-detect DL= 0.01 ug/l	Non-detect DL= 0.01 ug/l	Non-detect DL=0.01 ug/l
	ROZA-1 (sediment)	8/2002 (1 sample)	1.9	1.9	1.9
	ROZA-3 (sediment)	8/2002 (1 sample)	1.4	1.4	1.4
Chlordane (ug/l in water; ug/kg in sediment; and mg/kg in fish)	ROZA-1	4/2002-10/2002 (5 samples)	Non-detect DL= 0.01	Non-detect DL= 0.01	Non-detect DL=0.01
	ROZA-1 (sediment)	8/2002 (1 sample)	Non-detect DL=5	Non-detect DL=5	Non-detect DL=5
	ROZA-3 (sediment)	8/2002 (1 sample)	Non-detect DL=5	Non-detect DL=5	Non-detect DL=5
	ROZA (fish)[2]	10/1991-9/1998 (19 samples)	0.018	0.726	0.185

[1]Media is water, unless otherwise noted
[2] Fish include channel catfish, largemouth bass and carp

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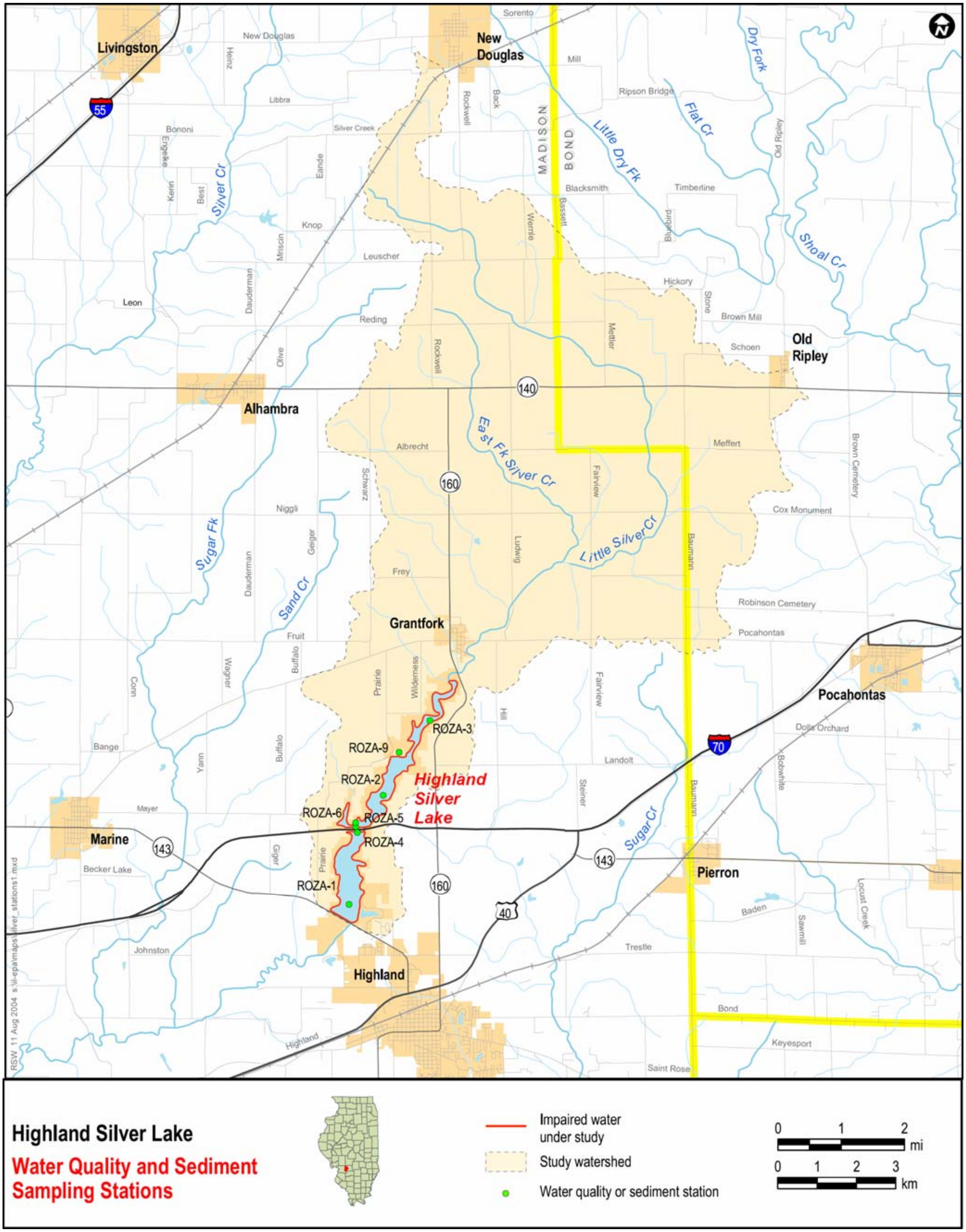

Figure 4. Sampling station locations in the Highland Silver Lake watershed

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Methods of data analysis

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, were assessed to confirm the sufficiency of the data to support the listing decision and the sources of impairment that are included on the draft 2004 303(d) list.

Analysis methods including computing summary statistics, comparing the data to water quality criteria, evaluating trends and correlations, and using graphical analysis to discern relationships in the data.

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

This section presents an assessment of the sufficiency of the data to support the 303(d) listings and identifies suspected or known sources.

Sufficiency of data to support listing

Highland Silver Lake appears on the draft 2004 303(d) list for manganese, total phosphorus, low dissolved oxygen, aldrin and chlordane. The sufficiency of data to support these listings was assessed through a review of the available data, including the number of sampling locations, the period of data collection, the number of samples collected, and the frequency and amount by which the water quality criteria were exceeded. Comparisons of the data to water quality criteria are shown in Table 8.

Through an analysis of available data and information it was determined that the listing of Highland Silver Lake for manganese, total phosphorus, dissolved oxygen, aldrin and chlordane is warranted. Although all of the aldrin water column samples were less than the detection limit, aldrin was measured at levels in the lake sediments that are considered to be highly elevated (Short, 1997) at two locations (2 samples). All of the chlordane water column samples were also less than the detection limit, however, the Illinois Department of Public Health has issued a “restricted consumption” fish advisory for catfish from Highland Silver Lake which are larger than 25 inches long, supporting the listing of this lake for chlordane. It was noted that fish tissue concentrations appear to be decreasing and more recent data should be collected to assess whether the fish consumption advisory for catfish is still appropriate. Additional discussion related to this assessment of the data follows.

Table 8. Water quality impairments and endpoints for Highland Silver Lake

Sample location/cause of impairment	Applicable Illinois Nonspecific Use Designations	Criterion	Number of Samples Exceeding Criterion
Manganese	Public water supply	150 ug/l	2 out of 5 samples > criterion
	General use	1000 ug/l	0 out of 5 samples > criterion
Total phosphorus	General use	0.05 mg/l	154 of 154 surface samples > criterion
Dissolved oxygen	General use	5 mg/l minimum	27 of 91 samples collected at one foot below lake surface < criterion
Aldrin	Public water supply	1 ug/l	0 of 5 samples > criterion
	Aquatic life (medium =sediment)	≥ 1 ug/kg[1]	2 of 2 samples > criterion
Chlordane	Public water supply	3 ug/l	0 of 5 samples > criterion
	Aquatic life (medium =sediment)	≥ 23 ug/kg[1]	0 of 2 samples > criterion
	Fish consumption (medium = fish)	Fish advisory issued	"Restricted consumption" fish advisory issued by IDPH for catfish based on at least two consecutive sampling events

[1]Any priority organic compound at highly elevated concentrations (Short, 1997)

Manganese

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in lakes state that the aquatic life use is not supported if there is at least one exceedance of applicable standard. The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available. Five manganese samples were collected in 2002 at a single station in the lake that is located near the dam. Of these five samples, two (40%) exceeded the public water supply use manganese criterion and none exceeded the general use criterion. The two samples that exceeded the public water supply criterion were 170 ug/l and 220 ug/l compared to the 150 ug/l criterion. The available data support the listing of Highland Silver Lake for manganese.

It should be noted, that according to the City of Highland Director of Public Works, there have been no citizen complaints about clothing or dish staining, which is the primary detriment associated with high manganese in water supplies.

Total phosphorus

The IEPA guidelines (IEPA, 2004a) for identifying total phosphorus as a cause in lakes (for lakes ≥ 20 acres) state that the aquatic life use and the secondary contact use are not supported if the surface phosphorus concentration exceeds the applicable standard (0.05 mg/l) in at least one sample during the monitoring year. Over the period March 1990-October 2002, total phosphorus was analyzed at three locations in the lake (near the inlet, near the middle and near the dam). Total phosphorus data were also available for the March 1990-November 1990 for four other lake stations. 154 of the 183 total phosphorus samples available for analysis were collected at the surface of the lake and were analyzed over the March 1990-October 2002 period. 100% of the 154 surface samples exceeded the total phosphorus criterion of 0.05 mg/l, with concentrations ranging from 0.057 mg/l – 4.315 mg/l. It should be noted that 100% of all samples also exceeded the 0.05 mg/l criterion.

Although the total phosphorus levels in the lake are higher than the total phosphorus criterion, neither the Director of Public Works or the Director of Parks and Recreation are aware of any excess algae problems in the lake.

Figure 5 shows the total phosphorus data plotted over time. From this figure, it appears that the maximum total phosphorus concentrations at the lake surface may be decreasing, although the General Use criterion is still being exceeded. A review of total phosphorus profiles showed higher total phosphorus concentrations at depth during the summer, indicating that sediment phosphorus release is occurring (Figure 6).

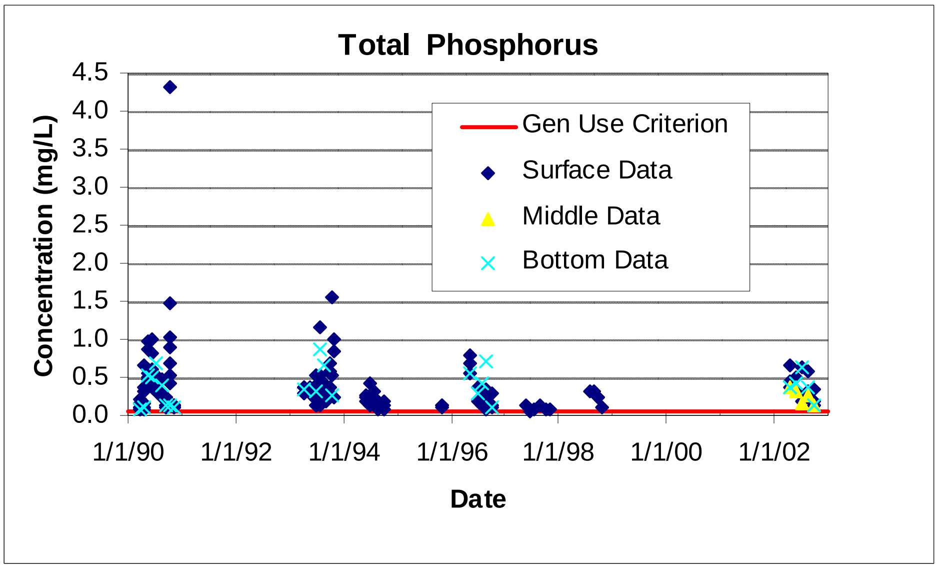

Figure 5. Historical distribution of Highland Silver Lake total phosphorus concentrations

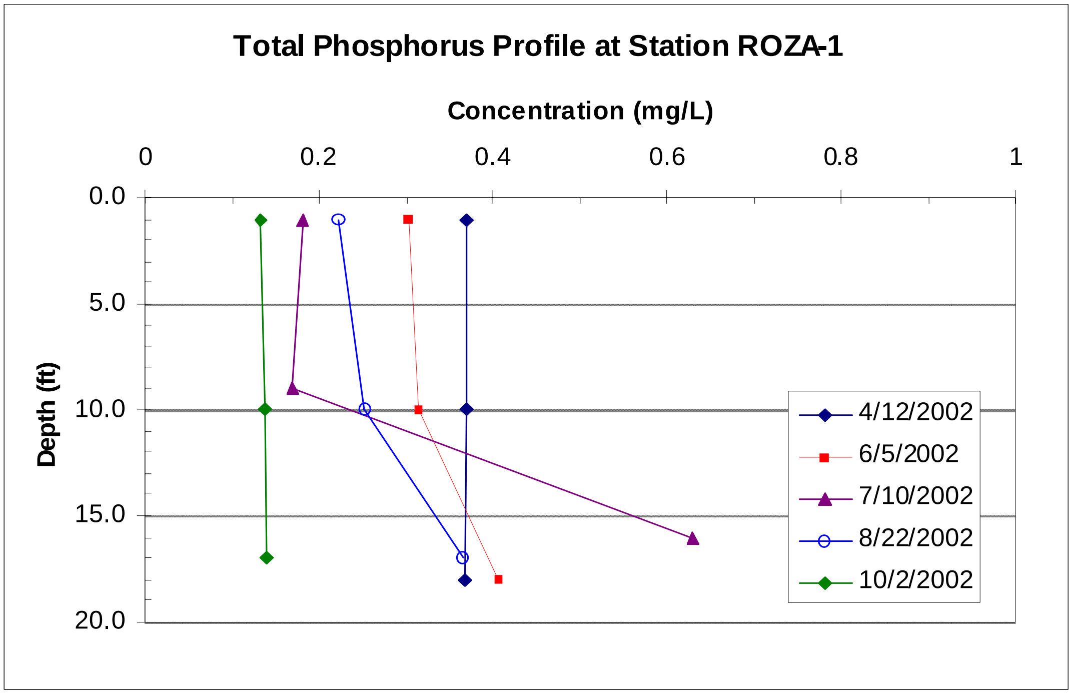

Figure 6. Seasonal distribution of 2002 total phosphorus depth profiles near the Highland Silver dam

Dissolved oxygen

The IEPA guidelines (IEPA, 2004a) for identifying dissolved oxygen as a cause in lakes state that the aquatic life use is not supported if there is at least one violation of the applicable standard (5.0 mg/l) at one foot depth below the lake surface; or a known fish kill resulting from dissolved oxygen depletion. Over the period March 1990-October 1996, dissolved oxygen concentrations were measured at three locations in the lake (near the inlet, near the middle and near the dam). Dissolved oxygen was also measured at four other lake stations between March and November 1990. A total of 605 measurements were taken over the March 1990-October 1996 period at depths ranging from 0 to 23.5 feet. Of these, 91 samples were collected at one foot below the surface and 27 of these (30%) were less than the dissolved oxygen criterion of 5 mg/l. Looking at the data year by year, some temporal differences were noted, with fewer violations observed in 1996 than in previous years. In 1990, between 22% and 44% of the samples were below the 5 mg/l dissolved oxygen criterion at one foot depth at all seven stations. In 1993, between 20% and 50% of the dissolved oxygen measurements were less than the 5 mg/l criterion at three monitoring stations. In 1996, 40% of the dissolved oxygen measurements taken at one foot depth were less than the 5 mg/l criterion at ROZA-3 (near the inlet), but no measurement were less than the criterion at one-foot depth near the middle of the lake or the Highland Silver Lake dam. Significantly more measurements were less than 5 mg/l at greater depths, with a total of 41% of the samples (considering measurement taken at all stations, years and depths) observed below the 5 mg/l dissolved oxygen criterion. A review of dissolved oxygen profiles shows that the lake goes anoxic near the bottom during the summer months (Figure 7).

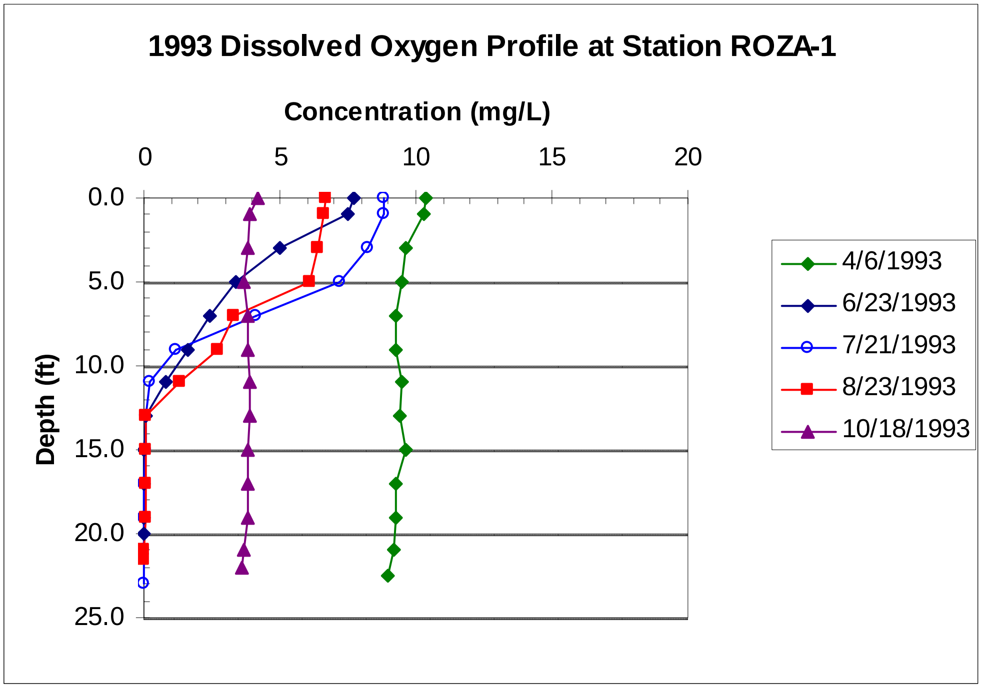

Figure 7. Seasonal distribution of 1996 dissolved oxygen profiles at ROZA-1

Because the dissolved oxygen data were not collected very recently (1996), other parameters collected were examined to determine if there is reason to believe the dissolved oxygen levels have improved in recent years. Total phosphorus concentrations continue to remain high and exceed the general use total phosphorus criterion. Recent data show sediment phosphorus release may be occurring in the summer (Figure 6). Because sediment phosphorus release occurs under anoxic conditions, it is reflective of continuing low dissolved oxygen levels at least in the deeper portions of the lake. The available dissolved oxygen data support the listing of Highland Silver Lake for low dissolved oxygen; however, because these data are more than five years old, it is recommended that either additional dissolved oxygen measurements be taken or that the IEPA coordinates with Heartland Ecosystems to review their dissolved oxygen data (collected in 2003), to confirm whether the listing is still appropriate. It is recommended that any plans for additional data collection be coordinated with the Clean Lakes Study work being conducted by Heartland Ecosystems.

Aldrin

The IEPA guidelines (IEPA, 2004a) for identifying aldrin as a cause in lakes state that the fish consumption use is not supported if there is a fish consumption advisory or commercial fishing ban in effect, attributable to any applicable parameter (e.g., aldrin). Furthermore, the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard for water samples collected in 1999 or later and for which results are readily available. Five water column aldrin samples were collected between April and October 2002. These samples were all collected at the same location in the lake, near the dam. The aldrin concentration was less than detection in all five samples (DL = 0.01 ug/l). Because the detection level is lower than the public water supply criterion for aldrin (1 ug/l), the public water supply use was supported, with no exceedances of the criterion noted.

Two sediment aldrin samples were collected in October 2002. These samples were collected near the dam and near the inlet of the lake. Aldrin was detected in both sediment samples at levels that are classified as being highly elevated following Short (1997). Although there are only two sediment aldrin samples available for analysis, the fact that they were both classified as highly elevated supports the listing of Highland Silver Lake for aldrin.

Chlordane

The IEPA guidelines (IEPA, 2004a) for identifying chlordane as a cause in lakes state that the fish consumption use is not supported if there is a fish consumption advisory or commercial fishing ban in effect, attributable to any applicable parameter (e.g., chlordane). Furthermore, the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard for water samples collected in 1999 or later and for which results are readily available.

Five water column chlordane samples were collected between April and October 2002. These samples were all collected at the same location in the lake, near the dam. The chlordane concentration was less than detection in all five samples (DL = 0.01 ug/l) and the detection level was less than the chlordane criterion (3 ug/l). The drinking water supply use criterion was supported, with no exceedances of this criterion noted.

Two sediment chlordane samples were collected in October 2002. These samples were collected near the dam and near the inlet of the lake. Chlordane was not detected in either sample (DL = 5 ug/kg).

The Illinois Department of Public Health (IDPH) has issued a fish advisory for Highland Silver Lake for channel catfish due to chlordane. There is unlimited consumption allowed for fish less than 25 inches in length, but for those catfish larger than 25 inches, the Public Health Department recommends only one meal per week because of chlordane (Illinois Department of Public Health website). This “restricted consumption” fish consumption advisory maps to the Illinois EPA guideline for listing a waterbody as partially supportive of the fish consumption use (IEPA, 2004a).

According to the Illinois Department of Public Health, catfish samples taken in 1997-1998 showed high enough chlordane values for the fish consumption advisory to be issued. Based on an analysis of data in the project database, channel catfish data collected in 1997 and 1998 had chlordane concentrations of 0.24 mg/kg and 0.31 mg/kg, respectively. A review of all channel catfish data (9 samples) collected between 1991 and 1998 showed a decreasing trend in fish tissue chlordane concentrations.

According to IDPH, samples taken in 2000-2002 exhibited decreasing chlordane concentrations. Two consecutive sampling events were below the state criterion. However, only small catfish were sampled in the 2002 event. All of the fish were below the 25-inch threshold on which the consumption advisory is based. So the advisory remains in place.

More sampling is planned for 2004 or soon after. Those doing the sampling have explicit instructions to try to obtain larger catfish. The results of this sampling will determine whether the fish advisory will remain for Highland Silver Lake.

Potential sources

The Illinois EPA (IEPA, 2004) defines potential sources as known or suspected activities, facilities or conditions that may be contributing to impairment of a designated use. The potential sources identified for Highland Silver Lake (IEPA, 2004) are presented in Table 9. These potential sources were supplemented with data reflecting the point source discharge in the watershed, nonpoint pollution sources, data collection efforts and interviews and professional judgment (Table 10).

The Illinois EPA identified agriculture; crop-related sources; non-irrigated crop production; grazing-related sources; pastureland; contaminated sediments; source unknown. Additional sources identified through this investigation include failing septic systems, lakeshore and streambank erosion, natural background sources, brine from oil wells, and runoff from lawns.

Table 9. Waterbody impairment causes and sources (from IEPA, 2004)

Cause of impairment	Potential Sources (IEPA, 2004)
Manganese	Agriculture; Crop-related sources; Non-irrigated crop production; Grazing-related sources; Pastureland; Contaminated sediments; Source unknown
Total phosphorus	
Dissolved oxygen	
Aldrin	
Chlordane	

Table 10. Sources of impairment determined through this study

Cause of impairment	Potential Source(s)
Manganese	Naturally elevated concentrations in groundwater; streambank and lakeshore erosion of soils naturally enriched with manganese; release from lake bottom sediments during anoxic conditions; brine from oil wells
Total phosphorus	Crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; lake bottom sediments during anoxic conditions; failing septic systems; lakeshore and streambank erosion; runoff from fertilized lawns
Dissolved oxygen	Lake bottom sediment oxygen demand; algal respiration; crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; runoff from fertilized lawns; lakeshore and streambank erosion
Aldrin	Cropland runoff; lake bottom sediments
Chlordane	Cropland runoff; runoff from lawns; lake bottom sediments

Within the Highland Silver Lake watershed, there are two NPDES permitted dischargers. These are the Highland WTP, which has a permit to discharge flow, pH and total suspended solids (TSS) and Munie Trucking Company, which has an expired permit to discharge flow, pH and TSS (Table 11). Based on a review of these permit limits, these facilities are not thought to contribute to the causes of impairment in Highland Silver Lake.

Table 11. NPDES permit information

Facility Name	NPDES ID	Pipe Description	Average Design Flow (MGD)	Permitted to Discharge	Permit expiration date
Highland WTP	IL0001112	Treated filter backwash and settling lagoon overflow	0.063	Flow, pH, TSS	11/30/04
Munie Trucking Co.	IL0068861	Pit pumpage and stormwater	--	Flow, pH, TSS	6/30/01

Manganese

Manganese is a naturally occurring element that is a component of over 100 minerals. Of the heavy metals, it is surpassed in abundance only by iron (Agency for Toxic Substances and Disease Registry (ATSDR), 1997). Because of the natural release of manganese into the environment by the weathering of manganese-rich rocks and sediments, manganese occurs ubiquitously at low levels in soil, water, air, and food (USEPA, 2003).

As discussed previously, many of the soils in the Highland Silver Lake watershed contain naturally-occurring manganese concretions or accumulations and are also acidic. The low pH could result in the manganese moving into solution and being transported through baseflow and/or runoff (personal communication, State Water Quality Specialist).

Streambank and lakeshore erosion of manganese-containing soils is also a likely source of manganese in the lake. Finally, a potential minor source of manganese may be brine water pumped during oil drilling. Brine from oil drilling operations used to be routinely dumped in lagoons and allowed to evaporate or drain to surface waters. However, that was in the 1920s through 1950s. Now the oil producers realize that they shouldn't mix drilled water with fresh water from near the surface and the brine can be reinjected to help push oil to the pump (Personal communication, Marion County SWCD). Therefore, while manganese from brine water may have accumulated on the surface and may have contributed to surface water concentrations of manganese in the past this is not expected to be a continuing source.

There were no manganese profiles available for analysis, however, in other lakes being studied, manganese has been observed to be released from lake bottom sediments under anoxic conditions. Due to the age of the reservoir, documented sedimentation problems and the listing of Highland Silver Lake for low dissolved oxygen, it is likely that manganese is being released from lake bottom sediments under anoxic conditions.

The observed levels of manganese are likely due to the natural geochemical environment and most likely reflect natural background conditions. For this reason, the general use criterion may be unattainable. Manganese does not present any human health hazards, but may be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures.

Total phosphorus

Several potential total phosphorus sources were identified through this investigation. Based on a review of lake water quality data, sediment phosphorus release appears to be occurring under anoxic conditions. In addition to lake bottom sediments, total phosphorus is also originating in the watershed. Potential watershed sources of total phosphorus include runoff and erosion from cropland treated with commercial fertilizers or manure, runoff from agricultural lands with animal operations, animals with direct access to the lake, failing septic systems, and erosion of streambanks and the lakeshore. Recall that soil phosphorus levels vary between normal (Bond County SWCD, 2004) and high (Madison County SWCD, 2004). Finally, runoff from fertilized lawns, especially those adjacent to the lake is a potential source of total phosphorus.

Dissolved oxygen

A review of dissolved oxygen and ammonia data show that low dissolved oxygen appears to be related to elevated total ammonia levels. This indicates that nitrogeneous oxygen demand (via nitrification) may be a mechanism contributing to low dissolved oxygen. Sources of ammonia include runoff from cropland (anhydrous ammonia is applied to corn in the spring), runoff from lawns, and runoff from animal feedlots and pastureland.

Maximum chlorophyll a levels in the lake around 150 ug/l have been observed between 1990 and 1996. These levels are considered to be elevated and indicative of eutrophic conditions. Algal respiration is another potential source contributing to low dissolved oxygen.

Because total phosphorus is often the limiting nutrient controlling algae growth, phosphorus sources identified previously can all be considered potential sources contributing to low dissolved oxygen.

Aldrin and chlordane

Because the history of use and the sources of aldrin and chlordane are similar, these two pollutants are discussed together. As discussed below, sources of aldrin are runoff and erosion from agricultural land where aldrin was historically applied (primarily corn crops and dairy barns) and lake bottom sediments, where aldrin-enriched sediment has accumulated. Sources of chlordane are runoff and erosion from agricultural land (primarily corn crops and dairy barns), lawn runoff and erosion (due to historical chlordane application and accumulation in the soil) and lake bottom sediments, where chlordane-enriched sediment has accumulated.

As discussed in the previous section on fertilizer and pesticide use, both aldrin and chlordane are suspected to have been used on agricultural land (on corn and in dairy barns) and to control termites between the 1950s and late 1980s in the Highland Silver watershed. In the late 1980s, the USEPA banned all uses of aldrin and chlordane (ATSDR, 1995 and 2002).

Both chlordane and aldrin bind tightly to soil particles. Chlordane is not likely to enter groundwater, can stay in the soil for over 20 years, breaks down very slowly and doesn't dissolve easily in water (ATSDR, 1995). Sunlight and bacteria change aldrin to dieldrin (ATSDR, 2002). A review of lake sediment data for Highland Silver Lake found levels of dieldrin that are considered elevated (per Short, 1997) in one of the two sediment samples collected in 2002; dieldrin was not detected in the other sample.

Because the use of aldrin has been banned since 1987 and chlordane since 1988, there are no new sources of aldrin or chlordane suspected in the watershed. Instead, both of these chemicals are legacy pollutants. Because they bind tightly to soil, potential sources include watershed sediment erosion from agricultural land (aldrin and chlordane) and residential lands (chlordane) and lake bottom sediments (aldrin has been detected in lake sediments).

Highland Silver Lake is listed on the 2004 draft 303(d) list for sedimentation. This was identified as a problem for the lake by the Highland Director of Public Works, who also noted that sediment build-up is clearly visible at the north end of the lake where the East Fork Silver Creek empties into the impoundment (Personal communication, Highland Director of Public Works). The erosion of sediment in the watershed and deposition in the lake is thought to be the primary mechanism by which aldrin and chlordane have accumulated in the lake sediments.

CONCLUSIONS

The listing of Highland Silver Lake on the Illinois 303(d) list for dissolved oxygen, total phosphorus, manganese, aldrin and chlordane has been confirmed based on a review of the data.

Potential sources contributing to the listing of Highland Silver Lake include: runoff from cropland, pastureland, animal feeding operations and lawns; lakeshore and streambank erosion; lake bottom sediments; failing septic systems; brine pumped from oils wells; and natural background sources.

It should be noted that the manganese criterion for the public water supply use may be difficult to attain. This is due to the fact that the manganese is ubiquitous in the watershed due to naturally occurring manganese in the soils. Furthermore, it is worth noting that according to the Highland Public Works Director (personal communication, 2004), there have been no citizen complaints about clothing or dish staining (manganese can be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures).

Similarly, it is suspected that both aldrin and chlordane are widespread throughout the watershed, due to historical application of these pesticides to cropland and their use to control termites. The control of these chemicals may be difficult due to their persistent nature and widespread use.

NEXT STEPS

In the upcoming quarter, methods, procedures and models that will be used to develop TMDLs for the project watershed will be identified and described. This description will include documentation of any important assumptions underlying the recommended approach (methods, procedures and models) and a discussion of data needed to support the development of a credible TMDL.

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APPENDIX A. DATA SOURCES AND LOCAL CONTACTS

Table A-1. Data sources

Data description	Agency	Source
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
NPDES permit limits	United States Environmental Protection Agency	http://www.epa.gov/enviro/html/pcs/pcs_query.html
Aerial photography	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/webdocs/doqs/graphic.html
Coal mines: active and abandoned - polygons part 1	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned - polygons part 2	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned – points	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mine permit boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
County boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Cropland	United States Department of Agriculture, National Agricultural Statistics Service, via Illinois Department of Agriculture	http://www.agr.state.il.us/gis/pass/nassdata/
Dams	National Inventory of Dams (NID)	http://crunch.tec.army.mil/nid/webpages/nid.cfm
Elevation	United States Geological Survey	http://seamless.usgs.gov/viewer.htm
Federally-owned lands	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrologic cataloging units	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrography	United States Geological Survey	http://nhd.usgs.gov/
Impaired lakes	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Impaired streams	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Land cover	Illinois Department of Agriculture	http://www.agr.state.il.us/gis/
Landfills	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Municipal boundaries	U.S. Census Bureau	
Municipal boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
National Pollutant Discharge Elimination System (NPDES) permitted sites	United States Environmental Protection Agency	
Nature preserves	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Oil wells	United States Geological Survey	http://energy.cr.usgs.gov/oilgas/noga/
Railroads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/

Data description	Agency	Source
Roads – state highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads – U.S. highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads- detailed road network	U.S. Census Bureau	http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html
Survey-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/ssurgo.html
State-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/statsgo_inf.html - statsgo8
State boundary	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State conservation areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State forests	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State fish and wildlife areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State parks	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangle index	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangles	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
USGS stream gages	Illinois State Water Survey	
Watersheds	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Water supply – Public water supply intakes	Illinois State Water Survey	
Water column and sediment data for Highland Silver Lake	Illinois EPA	Provided to LTI via e-mail
Fish, land use, water column, sediment, macroinvertebrate and habitat data for Highland Silver Lake	Illinois EPA Southern Regional Office	Provided on CD by Dave Muir
Water quality and sediment data	USEPA STORET	http://www.epa.gov/storet/dbtop.html
DMR data and information on NPDES permitted facilities	IEPA Springfield Regional office	Provided by e-mail from Tim Kelly

Table A-2. Local and state contacts

Contact	Agency/ Organization	Contact Means	Phone #	Subject
Joe Gillespie	City of Highland	Telephone	618-654-7511	Water quality, mgmt, and history of Highland Silver Lake
Thomas Hawkins	Madison County Planning and Development	Telephone	618-692-7040 x 4663	Septic systems
Daniel Mueller	Bond County NRCS	Telephone	618-664-0555 x 3	Agricultural practices and pesticides
Dan Steinmann	Madison County NRCS	Telephone	618-656-4710 x 3	Agricultural practices and pesticides
Dan Feldmann	Bond County SWCD	Telephone	618-526-7919 x 3	Pesticide application
Robert Bellm	University of Illinois Extension, Edwardsville Center	Telephone	618-650-7050	Pollutant loading, BMPs and pesticides
Rick Macho	Madison County SWCD	Telephone	618-656-4710 x 3	Agricultural practices and pesticides
Mark Rosen	City of Highland	Telephone	618-651-1386	Water quality, mgmt, and history of Highland Silver Lake
David Patrick	Heartland Ecosystem Services, Inc.	Telephone	618-664-9749	On-going study for the City of Highland, upcoming Clean Lakes Study
Jeff ?	Heartland Ecosystem Services, Inc.	Telephone	618-664-9749	Parameters sampled in Highland Silver Lake
Ken Runkle	Illinois Department of Public Health	Telephone	217-785-3121	Fish consumption advisory for Highland Silver Lake.
Tom Hornshaw (through Ken Runkle)	Illinois Environmental Protection Agency, Toxicity Assessment Unit	Telephone	217-785-0832	Fish consumption advisory for Highland Silver Lake.
Tom Melvin	Bond County Health Department	Telephone	618-664-1442	Septic systems
Mara DeYoung	Madison County Health Department	Telephone	618-692-8954	Redirected to Tom Hawkins
Mike Plumer	U of I Extension, Carbondale Center	Telephone	618-453-5563	Changing farming practices
Burke Davies	Marion Co. SWCD	Telephone	618-548-1337 x3	Manganese and iron
Bruce Paulsrud (contacted Mike Gray for LTI)	U of I Dept of Crop Sciences Mike Gray is with University of Illinois Extension – Field Crops Entomologist	Telephone	217-244-9646	Aldrin and chlordane use in Illinois
??	Bureau of Environmental Programs	Telephone	217-755-2427	Pesticide use in Illinois - referred to Bruce Paulsrud
Michael Clark	Illinois Agricultural Statistics Service	Telephone	271-492-4295	Pesticide use in Madison and Bond Counties. Referred to Bureau of Environmental Programs
Cynthia Doucoure	USEPA Office of Pesticide Programs	Telephone	Doucoure.Cynthia @epa.gov	Pesticide use in Illinois

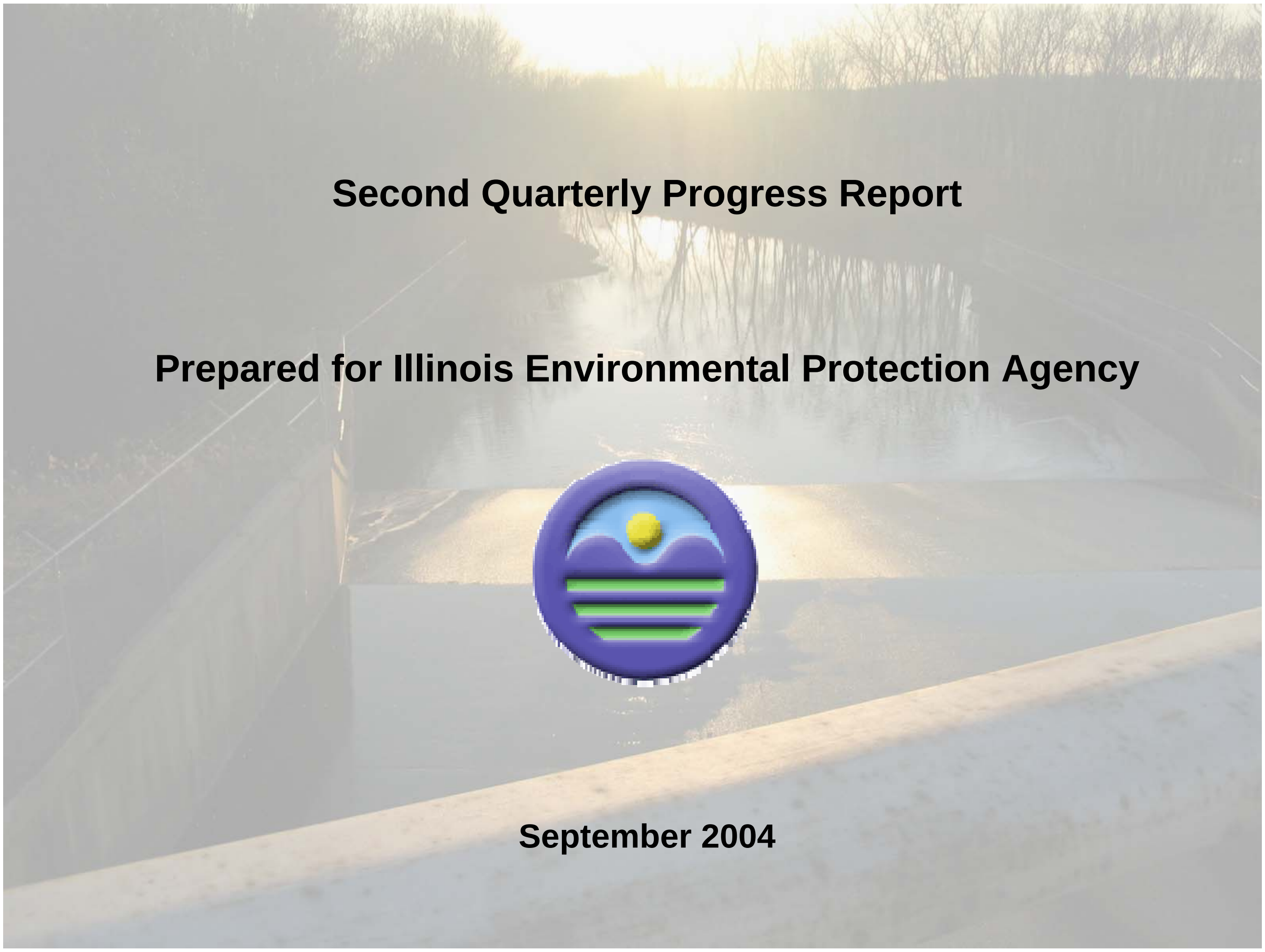
Contact	Agency/ Organization	Contact Means	Phone #	Subject
Arthur Grube, Ph.D.	USEPA Office of Pesticide Programs	e-mail	Grube.Arthur@epamail.epa.gov	Pesticide use in Illinois
Rich Nickels	Illinois Department of Agriculture	Telephone	217-782-6297	Requested Cropland Transect Survey
Sue Ebetsch	Illinois State Data Center	Telephone	217-782-1381	Requested Population projection report
Laura Biewick	U.S. Geological Survey	Telephone	303-236-7773	GIS data for oil & gas wells
Kathy Brown	Illinois State Water Survey	Telephone	217-333-6778	USGS gage locations; water supply intakes
Sharie Heller	SW Illinois GIS resource Center	Telephone	618-566-9493	Discussed CRP maps
Steve Sobaski	Illinois Department of National Resources	e-mail	ssobaski@dnrmail.state.il.us	Formal request for conservation related GIS files
Don Pitts	United States Department of Agriculture Natural Resources Conservation Service	Telephone	217-353-6642	Potential sources of iron and manganese in south-central Illinois surface waters.
Tony Meneghetti	IEPA	Telephone and e-mail	217-782-3362 Anthony.Meneghetti@epa.state.il.us	Lake data and SWAPs
Dave Muir	IEPA Marion Regional office	Personal visit	618-993-7200	Assessment data used in 303(d) and 305(b) reports
Tim Kelly	IEPA Springfield Regional office	Telephone and e-mail	217/-786-6892 Tim.Kelly@epa.state.il.us	NPDES DMR data
Jeff Mitzelfelt	IEPA	e-mail	jeff.mitzelfelt@epa.state.il.us	Websites for GIS information

APPENDIX B. PHOTOS

Looking downstream of dam at Highland Silver Lake outlet

Water treatment plant near outlet of Highland Silver Lake (looking up to the lake inlet)

Looking up Highland Silver Lake towards inlet (not visible)



Second Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

September 2004

Highland Silver Lake Watershed (ROZA)

Limno-Tech, Inc.
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EXECUTIVE SUMMARY

This is the second in a series of quarterly status reports documenting work completed on the Highland Silver Lake project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

The intent of this second quarterly status report is to:

- Identify and briefly describe the methodologies/procedures/models to be used in the development of TMDLs
- Document important assumptions underlying the recommended methodologies
- Identify the data needs for the methodologies to be used in TMDL development, including an assessment of whether additional data are needed to develop credible TMDLs

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the second quarter included: 1) summarizing potentially applicable model frameworks for TMDL development, 2) Recommending specific model frameworks for application to the Highland Silver Lake watershed, and 3) Making a determination whether sufficient data exist to allow development of a credible TMDL. Selection of specific model frameworks was based upon consideration of three separate factors, consistent with the guidance of DePinto et al (2004):

- **Site-specific characteristics:** The characteristics define the nature of the watershed and water bodies. For Highland Silver Lake, the relevant site-specific characteristics include a watershed with predominantly agricultural land use, and a lake impaired by manganese, total phosphorus, low dissolved oxygen, aldrin and chlordane.

- **Management objectives:** These objectives consist of the specific questions to be addressed by the model. For this application, the management objective is to define a credible TMDL.
- **Available resources:** This corresponds to the amount and time and data available to support TMDL development. Water quality data currently exist for Highland Silver Lake. One aspect of this work is to define whether or not the existing data are sufficient to allow development of a credible TMDL.

Results

Several modeling frameworks potentially applicable for developing TMDLs were identified, spanning a range of detail from simple to complex. Selection of a specific modeling framework is complicated by the fact that the definition of a "credible" TMDL depends upon the level of detail to be contained in the implementation plan. If the goal of the TMDL implementation plan is to define the primary sources of impairment and quickly identify the general level of reduction required, relatively simple models can be used to develop a credible TMDL. If the goal of the TMDL implementation plan is to explicitly define the specific levels of controls required, more detailed models (and additional data) are required to develop a credible TMDL. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

The recommended approach consists of using the GWLF and BATHTUB models to address total phosphorus, dissolved oxygen, and manganese problems in Highland Silver Lake. Specifically, GWLF will be applied to calculate phosphorus loads to Highland Silver Lake over a time scale consistent with the nutrient residence time of Highland Silver Lake. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus and dissolved oxygen concentrations. This relationship will be used to define the dominant sources of phosphorus to the lake, and the extent to which they must be controlled to attain water quality standards. Simple empirical spreadsheet methods would be used to define the expected system response time to attain aldrin and chlordane standards. Application of these models will require no additional data collection.

Two alternative approaches are also provided. The first alternative approach would not include any watershed modeling for phosphorus, but would focus only on determining the pollutant loading capacity of the lake. This approach would be used to determine existing loading sources, prioritize restoration alternatives and support development of a voluntary implementation plan that includes both accountability and the potential for adaptive management. Other alternative model frameworks are also provided in the event that more detailed implementation plans are desired. These frameworks have significantly greater data requirements, and their use would require additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Highland Silver Lake watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed.

The remaining sections of this report include:

- **Identification of potentially applicable methodologies to be used in TMDL development:** This section describes the range of potentially applicable watershed loading and water quality methodologies that could be used to conduct the TMDL, and identifies their strengths and weaknesses.
- **Model selection process:** This section describes how management objectives, available resources and site-specific conditions in the Highland Silver Lake watershed affect the recommendation of specific methodologies.
- **Selection of specific methodologies and future data requirements:** This section provides specific recommendation of methodologies for the Highland Silver Lake watershed, along with the data needed to support application of the methodologies.

IDENTIFICATION OF POTENTIALLY APPLICABLE MODELS AND PROCEDURES TO BE USED IN TMDL DEVELOPMENT

Development of TMDLs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream (or in-lake) concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the methodologies that are potentially applicable for the Highland Silver Lake watershed, and is divided into separate discussions of watershed methodologies and receiving water quality model frameworks.

Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL development. These include:

- Empirical Approaches
- Unit Area Loads/Export Coefficients
- Universal Soil Loss Equation
- Watershed Characterization System (WCS) Sediment Tool
- Generalized Watershed Loading Functions (GWLF) Model
- Agricultural Nonpoint Source Pollution Model (AGNPS)
- Hydrologic Simulation Program - Fortran (HSPF)
- Better Assessment Science Integrating point and Nonpoint Sources (BASINS)/ Nonpoint Source Model (NPSM)
- Storm Water Management Model (SWMM)

- Soil & Water Assessment Tool (SWAT)

This section describes each of the model frameworks and their suitability for characterizing watershed loads for TMDL development. Table 1 summarizes some important characteristics of each of the models relative to TMDL application.

Table 1 Summary of Potentially Applicable Models for Estimating Watershed Loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
WCS Sediment Tool	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
GWLF	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

Empirical Approaches

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model describing specific cause-effect relationships. Time series information is required on both stream flow and pollutant concentration.

The advantage to empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. Statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. The EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimating watershed loads.

Unit Area Loads/Export Coefficients

Unit area loads (also called export coefficients) are routinely used to develop estimates of pollutant loads in a watershed. An export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit areal loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward; different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach permits estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, which can estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al., (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

Watershed Characterization System (WCS) Sediment Tool

The Watershed Characterization System (WCS) Sediment Tool was developed by EPA Region 4. The Watershed Characterization System is an ArcView-based application used to display and analyze GIS data including land use, soil type, ground slope, road networks, point source discharges, and watershed characteristics. WCS has an extension called the Sediment Tool that is specifically designed for sediment TMDLs. For each grid cell within the watershed, the WCS Sediment Tool calculates potential erosion using the USLE based on the specific cell characteristics. The model then calculates the potential sediment delivery to the stream grid network. Sediment delivery can be calculated using one of the four available sediment delivery equations: a distance-based equation, a distance slope-based equation, an area-based equation, or a WEPP-based regression equation.

The applicability of WCS for estimating sediment loads for TMDLs is similar to that of the USLE in terms of data requirements and model results; i.e., it is relatively simple to apply but has the potential to be inaccurate. It provides three primary enhancements over the USLE: 1) Model inputs are automatically incorporated into the model through GIS coverages; 2) Topographic factors are calculated in the model based on digital elevation data; and 3) The model calculates the fraction of eroded sediment that is delivered to the surface water. It is only applicable to sediment TMDLs whose target represents long-term loading conditions. Because its predictions represent average annual conditions, it is not suitable for predicting loads associated with specific storm events. Like the USLE, it is does not lend itself to model calibration unless data are available to define annual loading rates.

Generalized Watershed Loading Functions Model (GWLF)

The Generalized Watershed Loading Functions Model (GWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment results are provided on a monthly basis. GWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio that is present in the WCS sediment tool. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE or the WCS sediment tool.

Agricultural Nonpoint Source Pollution Model (AGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. The sheet and rill erosion model internal to AGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources.

AGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – Fortran (HSPF)

The Hydrologic Simulation Program – Fortran (HSPF) uses continuous rainfall and other meteorologic records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. HSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM)

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT)

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software.

SWAT is a continuous time model, i.e., a long-term yield model. The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas.

Water Quality Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL development. These include:

- Spreadsheet Approaches
- EUTROMOD
- BATHTUB
- WASP5
- CE-QUAL-RIV1
- CE-QUAL-W2
- EFDC

This section describes each of the methodologies and their suitability for defining water quality for TMDL development. Table 2 summarizes some important characteristics of each of the models relative to TMDL application.

Table 2. Summary of Potentially Applicable Models for Estimating Water Quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL
Spreadsheet approaches	Steady State	River or lake	0- or 1-D	Low	DO, nutrients, algae, pH, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E	Steady State	River	1-D	Moderate	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP5	Dynamic	River or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics
CE-QUAL-RIV1	Dynamic	River	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	River or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	River or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

Spreadsheet Approaches

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

EUTROMOD

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al., (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker, 1986). It was developed, and is distributed, by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constitutent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, and chlorophyll concentrations, and Secchi depth (transparency). Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E

QUAL2E is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. QUAL2E also includes components that allow implementation of uncertainty analyses using sensitivity analysis, first-order error analysis, or Monte Carlo simulation. QUAL2E has been used for wasteload allocation purposes throughout the United States. QUAL2E is also linked into EPA's BASINS modeling system.

The primary advantages of using QUAL2E include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP5

WASP5 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP5 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP5 can also accept user-specified advective and dispersive flows. WASP5 provides separate submodels for conventional and toxic pollutants. The EUTRO5 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI5 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP5 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it is designed to read hydrodynamic results only from the one-dimensional RIVMOD-H and DYNHYD5 models. Coupling of WASP5 with multi-dimensional hydrodynamic model results will require extensive site-specific linkage efforts.

CE-QUAL-RIV1

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and non-point source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al, 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e. dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA’s BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In un-stratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, it includes a near field mixing zone model that is fully coupled with a far field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

MODEL SELECTION

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs for the Highland Silver watershed. This chapter presents the general guidelines used in model selection process, and then applies these guidelines to make specific recommendations. In summary, three alternative approaches are recommended for the Highland Silver watershed, with final selection dependent upon the level of implementation to be immediately conducted for the TMDLs.

General Guidelines

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs. This section provides the guidelines to be followed for the model selection process, based upon work summarized in (DePinto et al, 2004). Three factors will be considered when selecting an appropriate model for TMDL development:

- **Management objectives:** Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- **Available resources:** The resources available to support the modeling effort include data, time, and level of effort of modeling effort
- **Site-specific characteristics:** Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained. There are no simple answers to these questions, and the decisions are often made using best professional judgment.

The required level of reliability for this modeling effort is one able to "support development of a credible TMDL". The amount of reliability required to develop a credible TMDL depends, however, on the degree of implementation to be included in the TMDL. TMDL implementation plans that require complete and immediate implementation of strict controls will require much more model reliability than an implementation plan based upon adaptive management which allows incremental controls to be implemented and includes follow-up monitoring of system response to dictate the need for additional control efforts.

The approach to be taken here regarding model selection is to provide recommendations which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date. Alternative methodologies are also provided that will support the development of differing levels of TMDL implementation plans. For each approach, the degree of implementation that can be supported to produce a credible TMDL will be provided. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Model Selection for Highland Silver Watershed

Tables 1 and 2 summarized the characteristics of the various watershed and water quality methodologies with potential applicability to TMDL development. This section reviews the relevant site-specific characteristics of the systems, summarizes the data available, and provides recommended approaches. Data needs, assumptions, and level of TMDL implementation support are provided for each of the recommended approaches.

Site Characteristics

Watershed characterization for the Highland Silver watershed was provided in the first quarterly status report (LTI, 2004). In summary, the Highland Silver watershed is located in western Illinois, approximately 35 miles east of St. Louis. This project study area is part of the larger, Lower Kaskaskia River Watershed. This lake is an impoundment of East Fork Silver Creek. The lake itself is 550 acres in size (IEPA, 2004) and has a maximum depth of approximately 20 feet. In general, it is a shallow lake and is used both for public water supply and recreation. The watershed draining to Highland Silver Lake is approximately 48 square miles in size and includes portions of Madison and Bond Counties. Agricultural land uses comprise 83% of the watershed, with forest, grassland, wetlands, and urban land uses each comprising 6% or less of the watershed area. A protective buffer strip and conservation areas surround the lake and are maintained by the Highland Parks and Recreation Department. The listing of Highland Silver Lake on the Illinois 303(d) list for impairment for due to dissolved oxygen, total phosphorus, manganese, aldrin and chlordane has been confirmed based on a review of the data.

Potential sources contributing to the listing of Highland Silver Lake include: runoff from cropland, pastureland animal feeding operations and lawns; lakeshore and streambank erosion; lake bottom sediments; failing septic systems; brine pumped from oil wells; and natural background sources.

Data Available

Table 3 provides a summary of available water quality data from the first quarterly status report (LTI, 2004). This amount of data is sufficient to confirm the presence of water quality impairment, but not sufficient to support development of a rigorous watershed or water quality model. Specific items lacking in this data set include tributary loading data for all pollutants of concern, data describing the distribution of aldrin and chlordane throughout the watershed, and chlorophyll a data to better define the processes controlling dissolved oxygen throughout the lake. It should be noted that Heartland Ecosystems recently completed an approximately 1-year monitoring program for three or four lake stations and one upstream tributary. Parameters analyzed included: dissolved oxygen, alkalinity, nitrate, nitrite, ammonia, phosphorus, ortho-phosphorus, total suspended solids, total Kjeldahl nitrogen, and chlorophyll. Furthermore, using funding through Illinois' Clean Lakes Study Program, a new round of data collection will commence in October 2004 and continue for a year. It is recommended that these data be obtained when they become available, as they will be valuable to support model development and calibration.

Table 3. Water Quality Data Summary for Highland Silver Lake[1]

Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
Manganese (ug/l)	ROZA-1	4/2002-10/2002 (5 samples)	72	220	135
Total phosphorus (mg/l)	ROZA-1	3/1990-10/2002 (76 samples)	0.057	0.874	0.267
	ROZA-2	3/1990-10/2002 (35 samples))	0.098	0.835	0.320
	ROZA-3	3/1990-10/2002 (36 samples)	0.139	1.55	0.503
	ROZA-4	3/1990-11/1990 (9 samples)	0.077	0.896	0.336
	ROZA-5	3/1990-11/1990 (9 samples)	0.104	4.32	0.740
	ROZA-6	3/1990-11/1990 (9 samples)	0.105	0.673	0.339
	ROZA-9	3/1990-11/1990 (9 samples)	0.137	1.47	0.538
Dissolved oxygen (mg/l)	ROZA-1	3/1990-10/1996 (233 samples)	0	12.1	5.0
	ROZA-2	3/1990-10/1996 (101 samples)	0	11.4	5.8
	ROZA-3	3/1990-10/1996 (45 samples)	0.3	17.3	7.9
	ROZA-4	3/1990-11/1990 (87 samples)	0	10.5	5.5
	ROZA-5	3/1990-11/1990 (65 samples)	0	11.6	5.8
	ROZA-6	3/1990-11/1990 (54 samples)	0	13.6	6.0
	ROZA-9	3/1990-11/1990 (20 samples)	2	14.6	7.0
Aldrin (ug/l in water; ug/kg in sediment)	ROZA-1	4/2002-10/2002 (5 samples)	Non-detect DL= 0.01 ug/l	Non-detect DL= 0.01 ug/l	Non-detect DL=0.01 ug/l
	ROZA-1 (sediment)	8/2002 (1 sample)	1.9	1.9	1.9
	ROZA-3 (sediment)	8/2002 (1 sample)	1.4	1.4	1.4
Chlordane (ug/l in water; ug/kg in sediment; and mg/kg in fish[2])	ROZA-1	4/2002-10/2002 (5 samples)	Non-detect DL= 0.01	Non-detect DL= 0.01	Non-detect DL=0.01
	ROZA-1 (sediment)	8/2002 (1 sample)	Non-detect DL=5	Non-detect DL=5	Non-detect DL=5
	ROZA-3 (sediment)	8/2002 (1 sample)	Non-detect DL=5	Non-detect DL=5	Non-detect DL=5
	ROZA (fish)[2]	10/1991-9/1998 (19 samples)	0.018	0.726	0.185

[1]Media is water, unless otherwise noted
[2] Fish include channel catfish, largemouth bass and carp

Recommended Approaches

This section provides recommendations for specific modeling approaches to be applied for the Highland Silver watershed TMDLs. Three alternative sets of approaches are provided in Table 4, with each approach having unique data needs and resulting degree of detail.

Table 4. Recommended Modeling Approaches for Highland Silver Lake

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	TP, DO, Mn	GWLF	BATHTUB	None	Identify primary sources to be controlled; and approximate level of control needed
	Aldrin, chlordane	Spreadsheet approach	Spreadsheet approach	None	Verify appropriateness of natural attenuation
Alternative 1					
	TP, DO, Mn	None	BATHTUB	None	Identify approximate level of control needed
	Aldrin, chlordane	Spreadsheet approach	Spreadsheet approach	None	Verify appropriateness of natural attenuation
Alternative 2					
	TP, DO, Mn	SWAT	CE-QUAL-W2	Tributary flow and concentrations	Define detailed control strategies
	Aldrin, chlordane	SWAT	CE-QUAL-W2, WASP	Tributary flow and concentrations; soils data	Define remediation strategies

The recommended approach consists of using the GWLF and BATHTUB models to address total phosphorus, dissolved oxygen, and manganese problems in Highland Silver Lake. Specifically, GWLF will be applied to calculate phosphorus loads to Highland Silver Lake for each land-use category. The BATHTUB model will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus and dissolved oxygen concentrations. This relationship will be used to define the dominant sources of phosphorus to the lake, and the extent to which they must be controlled to attain water quality standards. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed Highland Lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data. Simple empirical spreadsheet methods defining sediment response times, linked to biota-sediment accumulation factors (BSAFs) to define fish tissue response, would be used to define the expected system response time to attain aldrin and chlordane standards. These empirical methods were chosen over more detailed models because active remediation of aldrin and chlordane are not planned at this time.

The first alternative approach would not include any watershed modeling for phosphorus, but would focus only on determining the pollutant loading capacity of the lake. Determination of existing loading sources and prioritization of restoration alternatives would be conducted by local experts as part of the implementation process. Based upon their recommendations, a voluntary implementation plan would be developed that includes both accountability and the potential for adaptive management.

The second alternative would consist of applying the SWAT watershed model to define watershed loads for all pollutants, coupled with application of the reservoir models CE-QUAL-W2 and WASP to describe in-lake water quality response. CE-QUAL-W2 would be applied to define hydrodynamics and eutrophication processes. WASP would be used to define aldrin and chlordane concentrations in Highland Silver Lake water column and sediments. This alternative approach would be capable of defining with some detail the specific action strategies necessary to attain water quality standards.

Assumptions Underlying the Recommended Methodologies

The recommended approach is based upon the following assumptions:

- Nutrient enrichment is the primary cause of dissolved oxygen problems, such that dissolved oxygen problems can be addressed via attainment of the total phosphorus standard.
- The only controllable source of manganese to the lake is that which enters from lake sediments during periods of low dissolved oxygen; this source can be (partially) controlled by reducing phosphorus loads and increasing hypolimnetic dissolved oxygen concentrations.
- No active remediation strategies are planned to address chlordane and aldrin
- A credible TMDL implementation plan can be developed based upon relatively simple models

LTI believes that these assumptions are appropriate. Phosphorus concentrations, which contribute to dissolved oxygen and manganese problems, currently exceed the water quality standard by a factor of six. This indicates that phosphorus loads will need to be reduced by more than 80% to attain water quality standards. The dominant land use in the watershed is agriculture. This level of load reduction is likely not attainable in the near future, if at all. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The recommended approach, which requires no additional data collection, will expedite these implementation efforts.

DATA NEEDS FOR THE METHODOLOGIES TO BE USED

The recommended modeling approach and the first alternative approach can be applied without collection of any additional data. Follow-up monitoring is strongly recommended after controls are implemented, to verify their effectiveness in reducing loads and documenting the lake response.

Should the second alternative approach be selected, extensive data collection efforts would be required in order to calibrate the watershed and water quality models. The purpose of the detailed data collection is as follows:

1) define the distribution of specific loading sources throughout the watershed,
2) define the extent to which these loads are being delivered to the lake, and
2) define important reaction processes in Highland Silver Lake

To satisfy objective one, sediment sampling of aldrin and chlordane, and wet weather event sampling of phosphorus and manganese at multiple tributary locations in the watershed will be needed. To satisfy objective two, routine monitoring of loads to the lake will be needed. This would involve collection of continuous flows where East Fork Silver Creek enters the lake in addition to water quality analyses for several wet and dry weather events for: total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen, chlorophyll a, aldrin, and chlordane. To satisfy the third objective, routine in-lake monitoring will be needed. In Highland Silver Lake, bi-monthly sampling would need to be conducted for water temperature, in addition to total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen, chlorophyll a, aldrin, and chlordane.

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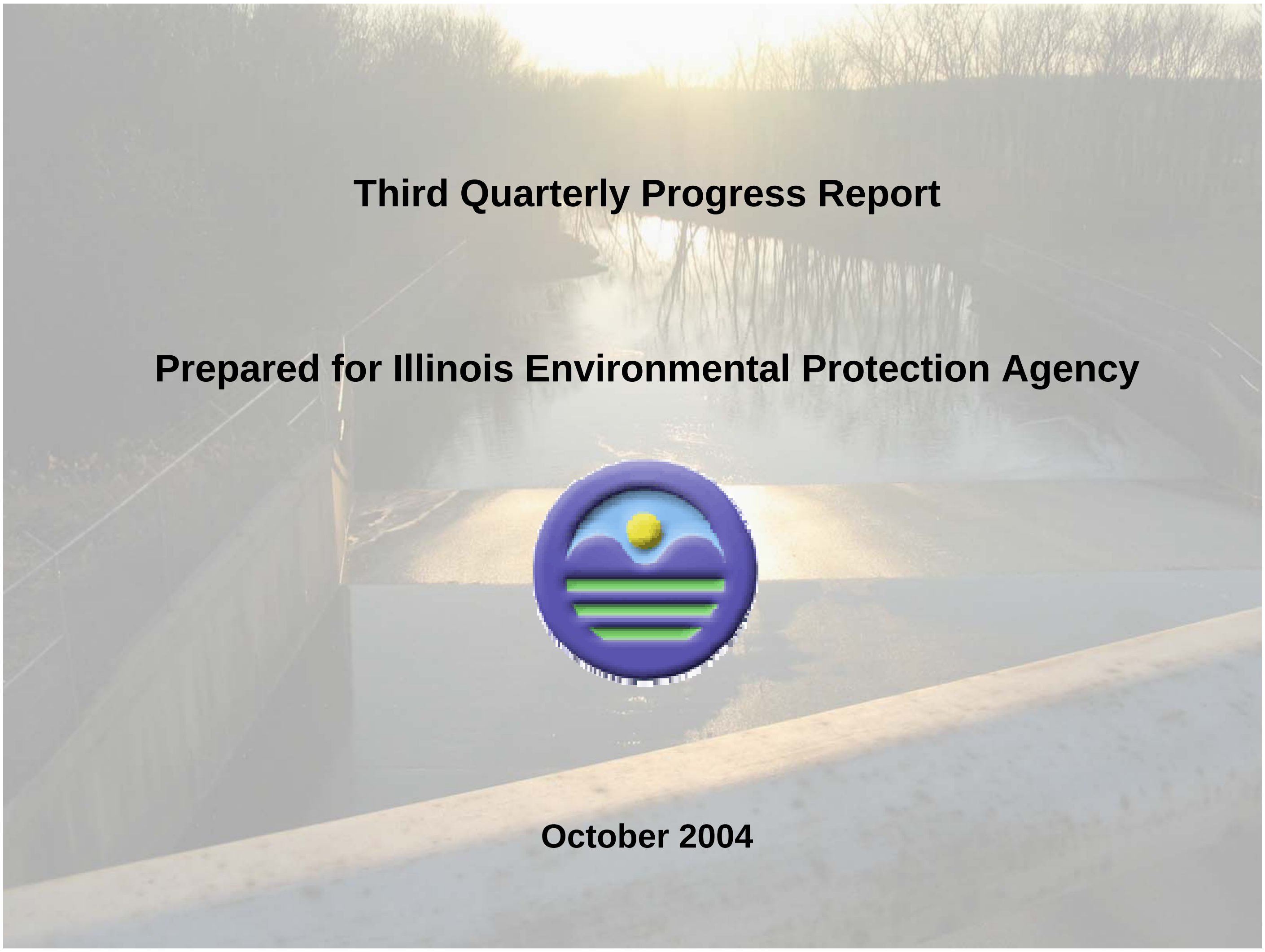

Third Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Highland Silver Lake Watershed (ROZA)

Limno-Tech, Inc.
www.limno.com

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EXECUTIVE SUMMARY

This is the third in a series of quarterly status reports documenting work completed on the Highland Silver Lake project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

In a second quarterly status report, the methodologies/procedures/models to be used in the development of TMDLs were identified and described and models were recommended for application to the project watershed.

The intent of this third quarterly status report is to:

- Identify the amount of data needed to support the modeling (if additional data collection is recommended);
- Provide a general data collection plan; and
- Identify, to the extent possible, the responsible parties for additional data collection.

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the third quarter included summarizing additional data needs to support the recommended methodologies/procedures/models to be used in the development of TMDLs, and where needed, providing general information related to the data collection.

Results

The recommended approach for the Highland Silver watershed consists of using the GWLF and BATHTUB models to address total phosphorus, dissolved oxygen, and manganese problems in Highland Silver Lake. Simple empirical spreadsheet methods would be used to define the expected system response time to attain aldrin and chlordane standards. As noted in the second quarterly status report, application of these models will require no additional data collection.

Because no additional data collection is required to support development of the recommended models, a data collection plan is not needed.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Highland Silver Lake watershed. Previous Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed, and the recommendation of models to support TMDL development.

The remaining sections of this report address:

- **Description of additional data collection, if any, to support modeling:** This section describes the amount (temporal and spatial) of data, if any, to be collected and also includes a general description of a data collection plan. Potential parties that may be responsible for additional data collection are also identified.
- **Next steps**

DESCRIPTION OF ADDITIONAL DATA COLLECTION TO SUPPORT MODELING

In the second quarterly progress report for the Highland Silver Watershed (LTI, 2004), modeling approaches were recommended. The recommended approach for the Highland Silver watershed consists of using the GWLF and BATHTUB models to address total phosphorus, dissolved oxygen, and manganese problems in Highland Silver Lake. Simple empirical spreadsheet methods would be used to define the expected system response time to attain aldrin and chlordane standards. As noted in the second quarterly status report, the recommended modeling approach described above can be applied without collection of any additional data.

Data Collection Plan

Because no additional data collection is needed to support development and application of the recommended models, a data collection plan is not included as part of this third quarterly status report.

NEXT STEPS

In the upcoming month, the IEPA will confer with the Scientific Advisory Committee to discuss the work presented in the first three quarterly status reports. A public meeting will also be scheduled in the watershed to present the conclusions and recommendations of Stage 1 to local stakeholders and to obtain feedback on the work completed to date.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. Second Quarterly Status Report Highland Silver Lake Watershed (ROZA). September 2004.

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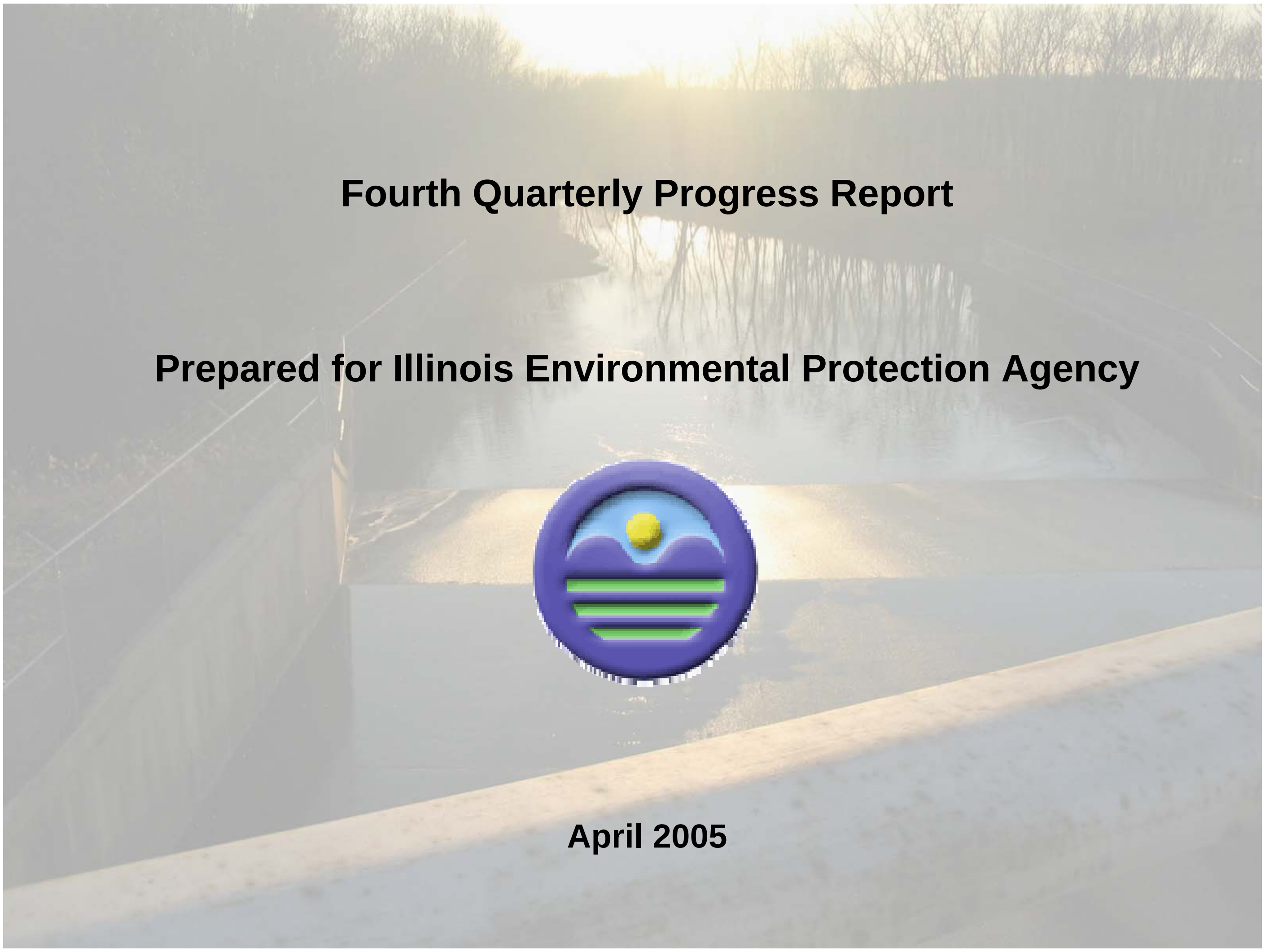

Fourth Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Highland Silver Lake Watershed (ROZA)

Limno-Tech, Inc.
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PUBLIC PARTICIPATION

Stage One included opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in June 2004 to initiate Stage One. As quarterly progress reports were produced, the Agency posted them to their website. The draft Stage One Report for this watershed was available to the public for review beginning in December 2004.

In February 2005, a public meeting was announced for presentation of the Stage One findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Tuesday, March 15, 2005 in Highland, Illinois at the Highland City Hall. In addition to the meeting's sponsors, approximately 30 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage One findings by Limno-Tech, Inc. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public at least through April 16, 2005. While there were several general questions, comments were focused on potential sources of phosphorus, including septic systems for new residential developments around the upper portion of the lake and livestock that have direct access to the lake. Additional information on soils with “hot spots” of high phosphorus may be available for several farms that have done extensive soil testing in their fields. Further comment was offered that these “hot spots” are the legacy of livestock practices in the 1930s and 1940s. There was some skepticism expressed regarding the value of conducting a TMDL for manganese, given its natural occurrence and prevalence in the soils in the watershed. Similar skepticism was expressed for the legacy pollutants of aldrin and chlordane TMDLs since there are no active sources in the watershed and there were no detectable concentrations for either constituent in the most recent water samples collected by IEPA.

This is the fourth in a series of quarterly status reports documenting work completed on the Skillet Fork project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. Draft Stage 1 Report Highland Silver Lake Watershed (ROZA). December 2004.

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FINAL APPROVED TMDL

Highland Silver Lake Watershed (ROZA)

Prepared for Illinois Environmental Protection Agency

September 2005

Highland Silver Lake
Manganese, Total Phosphorus, Dissolved Oxygen,
Aldrin, and Chlordane

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EXECUTIVE SUMMARY

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The Illinois Environmental Protection Agency's (IEPA) 2004 303(d) list is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (EPA, 1991).

Highland Silver Lake is listed on the 2004 Illinois Section 303(d) List of Impaired Waters (IEPA, 2004a) as a water body that is not meeting its designated uses. As such, the lake has been targeted as a high priority water body for TMDL development. This document presents the TMDLs designed to allow Highland Silver Lake to fully support its designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

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1 PROBLEM IDENTIFICATION

The impairments of Highland Silver Lake addressed in this TMDL are summarized below, with the parameters (causes) that Highland Silver Lake is listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2004a). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Those causes that are the focus of this report are shown in bold font.

As noted above, TMDLs are currently only being developed for pollutants that have numerical water quality standards; however, it is important to note that any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) are also expected to help reduce TSS, sedimentation and algal growth in the lake. Watershed phosphorus controls would serve to reduce not only phosphorus, but also sediment loads to the lake, as phosphorus BMPs are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging, is expected to work towards reducing algal growth, as the algae are phosphorus-limited.

Highland Silver Lake	
Waterbody Segment	ROZA
Size (Acres)	550
Listed For	**Manganese, total phosphorus, dissolved oxygen, aldrin, chlordane,** sedimentation/siltation, total suspended solids, excess algal growth, and total phosphorus (statistical guideline)
Use Support[1]	Overall use (P), Aquatic life (P), Fish consumption (P), Public water supply (P), Primary contact (P), Secondary contact (N)

[1]F=full support, P=partial support, N=nonsupport

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2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain the following specific components. Each of those components is summarized here.

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Highland Silver Lake, HUC 0714020404. The pollutants of concern addressed in this TMDL are manganese, total phosphorus, low dissolved oxygen, aldrin and chlordane. Potential sources contributing to the listing of Highland Silver Lake include: runoff from cropland, pastureland, animal feeding operations, and lawns; lakeshore and streambank erosion; lake bottom sediments; failing septic systems; brine pumped from oil wells; and natural background sources. Highland Silver Lake is ranked high priority on the 2004 Illinois EPA 303(d) list.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **phosphorus** to protect aquatic life and secondary contact uses in Illinois lakes is 0.05 mg/l. For Highland Silver Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.050 mg-P/l.

   The water quality standard for **dissolved oxygen** is a minimum of 5.0 mg/l and an average of 6.0 mg/l. Violation of the dissolved oxygen standard is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in attainment of the dissolved oxygen standard. The TMDL target for dissolved oxygen is therefore a total phosphorus concentration of 0.050 mg-P/l.

   The applicable water quality standard for **manganese** is 150 ug/l. For this TMDL, the manganese target is maintenance of hypolimnetic dissolved oxygen concentrations above zero, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target is for manganese is therefore set as a total phosphorus concentration of 0.050 mg-P/l.

   Numeric water quality standards do not exist for chlordane and aldrin in Illinois. The TMDL targets for these pollutants were based on Federal water quality criteria. These criteria correspond to 0.00014 ug/l for aldrin and 0.0008 ug/l for chlordane (http://www.epa.gov/waterscience/criteria/wqcriteria.html).

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 5.13 kg/day between April –and August, with the total load not to exceed 784 kg over this period. The loading capacities for chlordane and aldrin were based upon calculations of a simple mass-balance model. The loading capacity for aldrin is 0.009 g/d with the annual average load not to exceed 3.3 g/year.The loading capacity for chlordane is 0.051 g/d, with the annual average load not to exceed 18.6 g/year.

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

   Total phosphorus: 4.512 kg/day for the period April-August

   Chlordane: 0.051 g/day over a year

   Aldrin: 0.009 g/day over a year

5. **Wasteload Allocations (WLA):** The Highland Water Treatment Plant is the sole NPDES permitted point source discharge in the watershed. The WLA for this facility was set at estimated existing loading conditions of 0.10 kg phosphorus/day. This plant is not expected to cause or contribute to the aldrin and chlordane contamination, and does not require a WLA for these pollutants.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, dissolved oxygen, and manganese, corresponding to 0.513 kg/day. This value was set to reflect the uncertainty in the BATHTUB model predictions. The chlordane and aldrin TMDLs have an implicit margin of safety, based on the use of conservative assumptions in the water quality model.

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus, dissolved oxygen, and manganese TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The April-August duration for the seasonal loading was determined based on a calculation of a two-week to two-month phosphorus residence time in Highland Silver Lake.

   The chlordane and aldrin TMDLs are based on annual loading, consistent with the long-term duration associated with water quality criteria for carcinogenic pollutants.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA has the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permit for the only point source discharger in the watershed (Highland WTP) will be

modified if necessary to ensure it is consistent with the applicable wasteload allocation.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 report (refer to First Quarterly Progress Report, Watershed Characterization).

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.

10. **Transmittal Letter:** A letter was included with the transmittal of this TMDL to US EPA Region V.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (Provided in Stage 1 report; see First Quarterly Progress Report, Appendix A). Two public meetings were conducted in Highland, Illinois and one additional public meeting will be held to present the implementation plan. A responsiveness summary is included in Attachment 2.

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3 WATERSHED CHARACTERIZATION

The Stage 1 report, presented previously discusses information describing the Highland Silver Lake watershed to support the identification of sources contributing to the listed impairments as applicable. The Stage 1 report is divided into four sections, called Quarterly Progress Reports. The watershed characterization is discussed in the First Quarterly Progress Report. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The Highland Silver Lake watershed is located in western Illinois, approximately 35 miles east of St. Louis. This project study area is part of the larger, Lower Kaskaskia River Watershed. This lake is an impoundment of East Fork Silver Creek and was constructed in the 1960-1962 time period to provide a reliable water source to the City of Highland. Also contained in this watershed is Little Silver Creek, which drains the northernmost and northeast portions of the watershed. When completed, Highland Silver Lake replaced a much smaller impoundment, which is just east of the large dam.

The lake itself is 550 acres in size (IEPA, 2004a) and has a maximum depth of approximately 20 feet. In general, it is a shallow lake and is used both for public water supply and recreation (Silver Lake Park is located on North Route 143). The watershed draining to Highland Silver Lake is approximately 48 square miles in size and includes portions of Madison and Bond Counties. A protective buffer strip and conservation areas surround the lake and are maintained by the Highland Parks and Recreation Department. The primary road traversing the watershed is Interstate 70.

Figure 3.1 shows a map of the watershed, and includes some key features such as waterways, Highland Silver Lake, the public water intake, roads and other key features.

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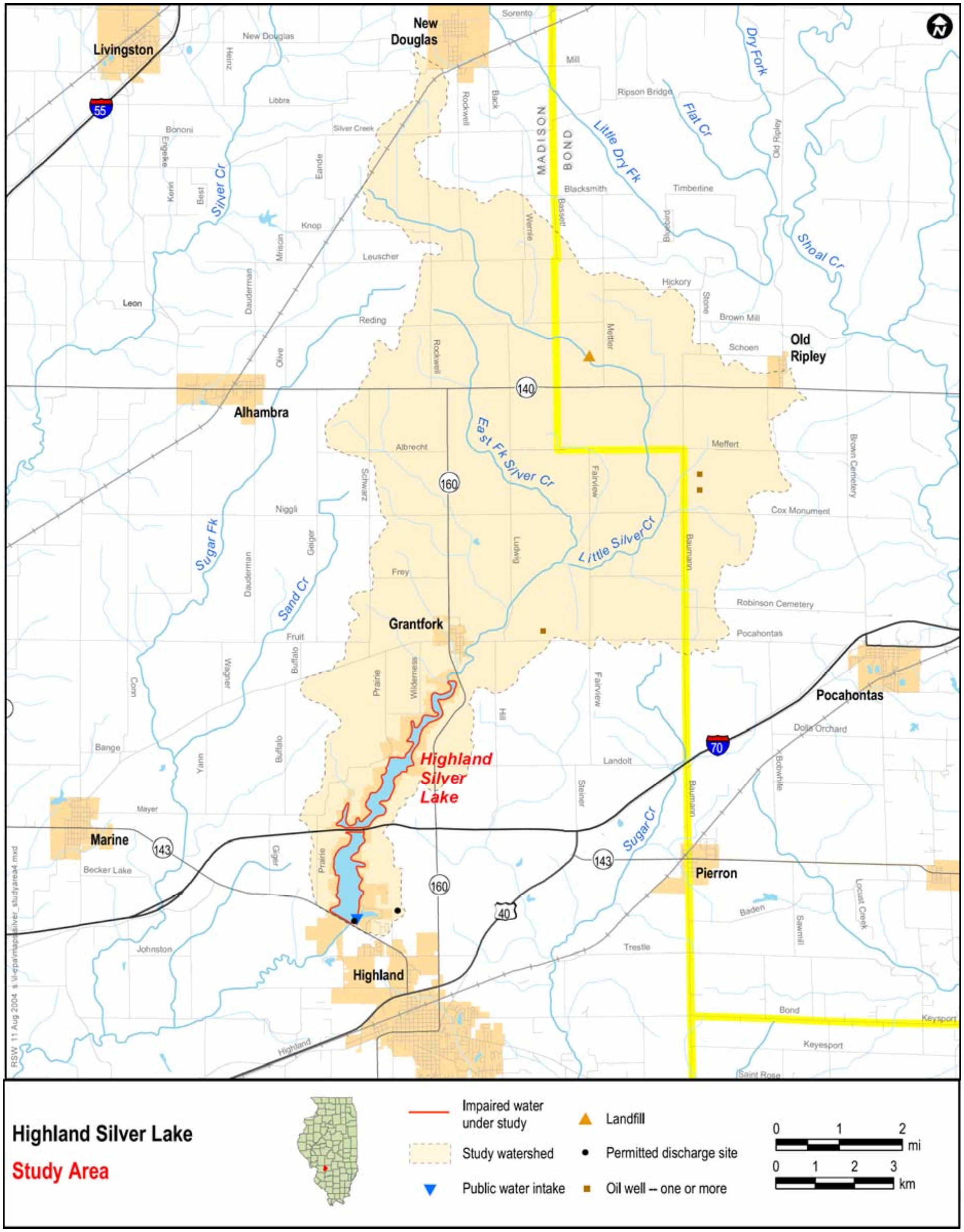

Figure 3.1 Base Map of Highland Silver Lake Watershed

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4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. This section discusses the applicable designated uses, use support, and criteria for Highland Silver Lake.

4.1 Designated Uses and Use Support

Illinois EPA conducts its assessment of water bodies using a set of five generic designated use categories: public water supply, aquatic life, primary contact (swimming), secondary contact (recreation), and fish consumption (IEPA, 2004b). Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of three possible "use-support" levels:

- Fully supporting (the water body attains the designated use);
- Partially supporting (the water body attains the designated use at a reduced level); or
- Not supporting (the water body does not attain the designated use).

All water bodies assessed as partial or nonsupport attainment for any designated use are identified as "impaired." Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the 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 (IEPA, 2004a).

4.2 Water Quality Criteria

Illinois has established water quality criteria and guidelines for allowable concentrations of manganese, total phosphorus, dissolved oxygen, aldrin (in sediment), and chlordane (in fish tissue) under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria was previously provided in the Stage 1 Report; First Quarterly Status Report.

4.2.1 Manganese

The water quality standard for manganese in Illinois waters designated as public water supply is 150 ug/l, and the general use standard is 1000 ug/l. The IEPA guidelines (IEPA, 2004b) for identifying manganese as a cause of impairment in lakes state that the aquatic life use is not supported if there is at least one exceedance of the applicable standard.

The guidelines also state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available. The available data confirm that the listing of Highland Silver Lake for manganese is appropriate based on IEPA's guidelines.

4.2.2 Total Phosphorus

The IEPA guidelines (IEPA, 2004b) for identifying total phosphorus as a cause in lakes (for lakes ≥ 20 acres) state that the aquatic life use and the secondary contact use are not supported if the surface phosphorus concentration exceeds the applicable standard (0.05 mg/l) in at least one sample during the monitoring year. The available data support the listing of phosphorus as a cause of impairment in Highland Silver Lake.

4.2.3 Dissolved oxygen

The IEPA guidelines (IEPA, 2004b) for identifying dissolved oxygen as a cause in lakes state that the aquatic life use is not supported if there is at least one violation of the applicable standard (5.0 mg/l minimum; 6.0 mg/l average) at one foot depth below the lake surface; or a known fish kill resulting from dissolved oxygen depletion. The available data support the listing of dissolved oxygen as a cause of impairment in Highland Silver Lake.

4.2.4 Aldrin

The IEPA guidelines (IEPA, 2004b) for identifying aldrin as a cause in lakes state that the fish consumption use is not supported if there is a fish consumption advisory or commercial fishing ban in effect, attributable to any applicable parameter (e.g., aldrin). Furthermore, the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard for water samples collected in 1999 or later and for which results are readily available. Finally, the aquatic life use in inland lakes is not supported if aldrin in the sediment is found at highly elevated concentrations. The available data confirm that the listing of Highland Silver Lake for aldrin is appropriate based on IEPA's guidelines.

4.2.5 Chlordane

The IEPA guidelines (IEPA, 2004b) for identifying chlordane as a cause in lakes state that the fish consumption use is not supported if there is a fish consumption advisory or commercial fishing ban in effect, attributable to any applicable parameter (e.g., chlordane). Furthermore, the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard for water samples collected in 1999 or later and for which results are readily available. The available data confirm that the listing of Highland Silver Lake for chlordane is appropriate based on IEPA's guidelines.

4.3 Development of TMDL Targets

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

As discussed below, a surrogate parameter (total phosphorus concentration) is selected as the TMDL target for dissolved oxygen and manganese. The linkage between the TMDL target (total phosphorus) and the other impairments is explained as follows. First, phosphorus loadings to lakes can stimulate excess algal growth. When the algae die and decompose, they then settle to the lake bottom where they contribute to low dissolved oxygen levels and anoxic conditions at depth. Under anoxic conditions, manganese is released from the lake sediments.

For the Highland Silver Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.050 mg-P/l.

For the Highland Silver Lake manganese TMDL, the target is maintenance of hypolimnetic dissolved oxygen concentrations above zero. The primary sources of manganese are naturally elevated concentrations in groundwater; streambank and lakeshore erosion of soils naturally enriched with manganese; and release from lake bottom sediments during anoxic conditions. Thus, the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore also set as a total phosphorus concentration of 0.050 mg-P/l.

Violation of the dissolved oxygen standard is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in attainment of the dissolved oxygen standard. The TMDL target for dissolved oxygen is therefore a total phosphorus concentration of 0.050 mg-P/l.

Numeric water quality standards do not exist for chlordane and aldrin in Illinois. The TMDL targets for these pollutants were based on Federal water quality criteria. These criteria correspond to 0.00014 ug/l for aldrin and 0.0008 ug/l for chlordane (http://www.epa.gov/waterscience/criteria/wqcriteria.html).

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5 DEVELOPMENT OF WATER QUALITY MODEL

Two distinct models were used to define maximum allowable loads to Highland Silver Lake. The BATHTUB water quality model was used to define the relationship between external phosphorus loads and the resulting concentrations of total phosphorus, dissolved oxygen, and manganese in the lake. A simple spreadsheet mass-balance model was used to define the maximum allowable chlordane and aldrin loads. The development of these models is described in the following sections covering:

- Model selection;
- Modeling approach;
- BATHTUB model inputs; and
- BATHTUB calibration.

5.1 Model Selection

A detailed discussion of the model selection process for the Highland Silver Lake watersheds was previously provided in the Stage 1 Report; Second Quarterly Progress Report.

5.1.1 Phosphorus, Oxygen, and Manganese

Of the models discussed previously, the BATHTUB model (Walker, 1985) was selected to address phosphorus, dissolved oxygen, and manganese impairments to Highland Silver Lake. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

The BATHTUB model does not directly model manganese concentrations, but it is still appropriate for TMDL application. The only controllable source of manganese to Highland Silver Lake is that which enters from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. This source of manganese can be controlled by reducing phosphorus loads to the lake, which will reduce algal growth and increase hypolimnetic dissolved oxygen concentrations.

The model was used to predict the relationship between phosphorus load and resulting in-lake phosphorus, as well as the resulting potential for oxygen depletion and manganese release from sediments.

5.1.2 Chlordane and Aldrin

A relatively simple spreadsheet mass-balance model was selected for chlordane and aldrin. This approach was chosen over the use of a more detailed model because active remediation of aldrin and chlordane is not planned at this time. This simple approach is consistent with that used in other chlordane and aldrin TMDLs (e.g., Georgia DNR, 2005; U.S. EPA, 2000).

5.2 Modeling Approach

5.2.1 Phosphorus, Oxygen, and Manganese

This approach to be taken for the manganese, phosphorus, and dissolved oxygen TMDLs is based upon discussions with IEPA and the Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the lake, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach corresponds to Alternative 1 in the detailed discussion of the model selection process provided in the Stage 1 Report. This approach was taken because phosphorus concentrations, which contribute to dissolved oxygen and manganese problems, currently exceed the water quality standard by a factor of six. Assuming that there is a linear correlation between phosphorus concentrations observed in the lake and phosphorus loads to the lake from the watershed, phosphorus loads will need to be reduced by 5/6, or more than 80% to attain water quality standards. The dominant land use in the watershed is agriculture. This level of load reduction is likely not attainable in the near future, if at all. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection and can be conducted immediately, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives will be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan will be developed that includes both accountability and the potential for adaptive management.

5.2.2 Chlordane and Aldrin

Aldrin and chlordane concentrations in Highland Silver Lake are described through the use of a simple mass-balance model that predicts the change in pollutant concentration over time as a function of external pollutant load, flushing, and pollutant decay. This model can be expressed as:

$$VdC/dt = W - QC - VkC \qquad (1)$$

where

V = Lake volume (L^3)

dC/dt = rate of change in pollutant concentration ($M/L^3/T$)

W = external loading rate of pollutant to lake (M/T)

Q = flow of water out of the lake (L^3/T)

k = first-order pollutant decay rate (1/T)

C = Pollutant concentration (M/L^3)

Equation 1 can be solved mathematically to predict the maximum allowable loading rate that will result in long-term compliance with the applicable water quality target:

$$W_{LC} = C_{Target} \times (Q + Vk) \tag{2}$$

Where

W_{LC} = maximum allowable load, i.e. "loading capacity" (M/T)

C_{Target} = Target pollutant concentration (M/L^3)

For purposes of TMDL development, the pollutant decay rate will be set to zero for both chlordane and aldrin. This conservative assumption will serve as the implicit margin of safety for the TMDL.

5.3 BATHTUB Model Inputs

This section gives an overview of the model inputs required for BATHTUB application, and how they were derived. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

5.3.1 Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 5-1, with the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The second order available phosphorus option was selected for phosphorus, as it is the default option for BATHTUB. Nitrogen was not simulated, because phosphorus is the nutrient of concern.

Chlorophyll a and transparency were simulated for Highland Silver Lake. This is because prediction of chlorophyll levels is a required component for determining hypolimnetic oxygen demand and the potential for manganese release from lake sediments. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required, and estimated concentrations were used to generate mass balance tables.

Table 5-1. BATHTUB Model Options for Highland Silver Lake

MODEL	MODEL OPTION
Conservative substance	Not computed
Total phosphorus	2nd order, available phosphorus
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Not computed
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

5.3.2 Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of the length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon what is called the nutrient residence time, i.e. the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes with a nutrient residence time on the order of weeks to a few months, a seasonal (e.g. spring-summer) averaging period is recommended. The nutrient residence time for Highland Silver Lake was calculated as ranging from two weeks to two months. Therefore, the averaging period used for this analysis was set to the seasonal period April-August.

Precipitation inputs were taken from the observed long-term annual average precipitation data and scaled for the April-August simulation period. This resulted in a precipitation value of 16.7 inches. Evaporation was set equal to precipitation and there was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

5.3.3 Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of the reservoir. The segmentation scheme selected for Highland Silver Lake was designed to provide one segment for each of the primary lake sampling stations. The lake was divided into five segments as shown in Figure 5.1. The areas of segments and watersheds for each segment were determined by Geographic Information System (GIS).

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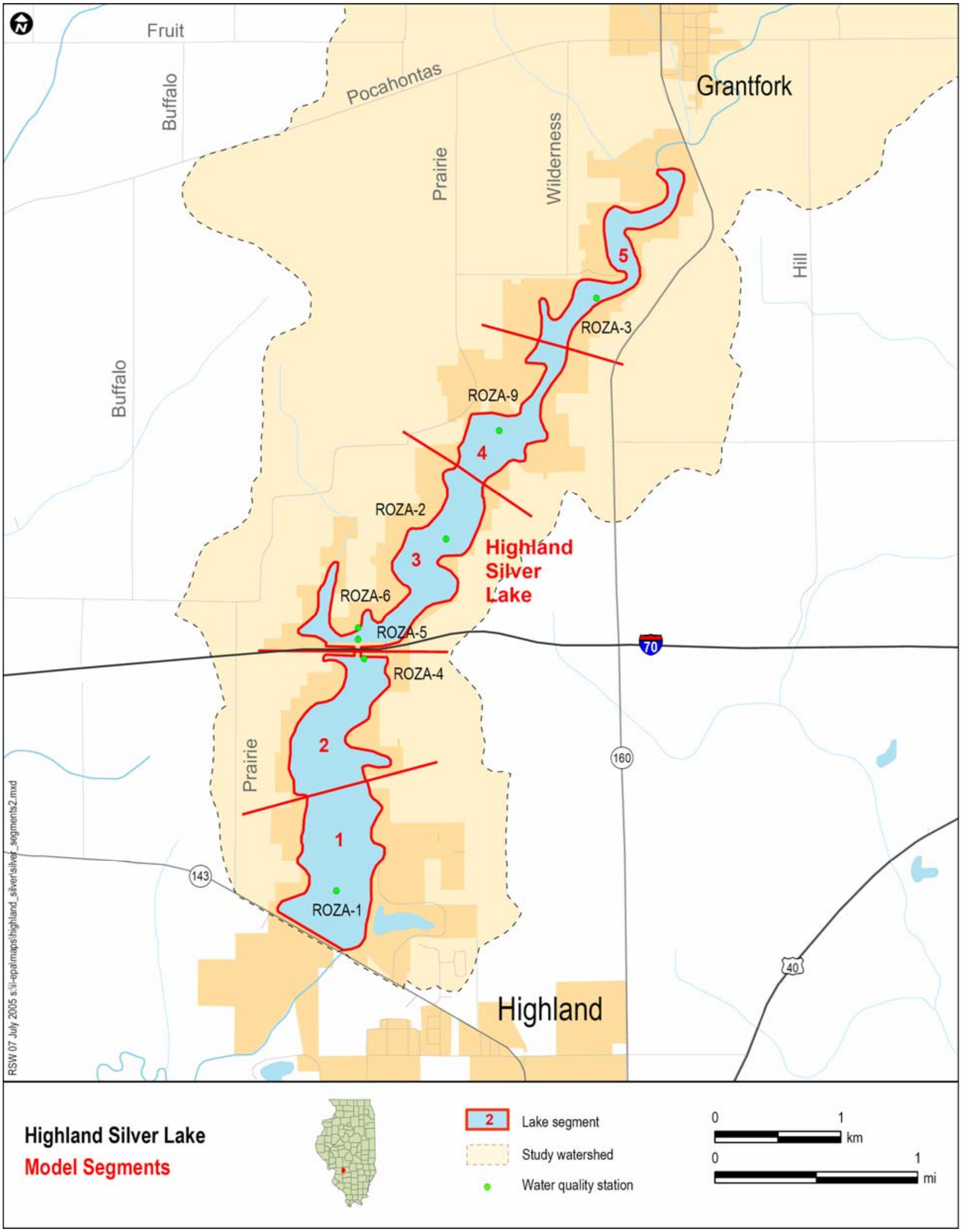

Figure 5.1 Highland Silver Lake Segmentation Used in BATHTUB

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BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths were calculated from the lake monitoring data, while segment lengths and surface areas were calculated via GIS. A complete listing of all segment-specific inputs is provided in Attachment 1.

5.3.4 Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Flows to each segment were estimated using observed flows at the USGS gaging station at East Fork Shoal Creek (05593900), adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to model segment}}{\text{Drainage area of watershed contributing to USGS gage}}$$

Segment-specific drainage area ratios were calculated via GIS information.

Total phosphorus concentrations for each major lake tributary were based upon springtime measurements taken near the headwaters of the lake. Concentrations for small tributaries were set equal to the assumed concentration for the major tributary. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 1.

5.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 1990 were used for calibration purposes, as this year provided the most robust data set. The August data were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. The default calibration coefficients in BATHTUB provided an acceptable fit to the observed data in segments 1 and 2 (nearest the dam), and no additional calibration activities were required. Model results in segments 3 through 5 (mid-lake and upper lake) initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling – sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected via the addition of an internal phosphorus load of 30 mg/m^2/day in segment 3, 100 mg/m^2/day in segment 4, and 200 mg/m^2/day in segment 5. The resulting predicted lake average total phosphorus concentration was 312 ug/l, compared to an observed average of 310 ug/l. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily load for Highland Silver Lake. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

6.1.1 Phosphorus, Oxygen, and Manganese

The loading capacity was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of water quality objectives. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the lake's loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Highland Silver Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for all future scenarios where tributary phosphorus loads averaged 100 ug/l or less. The resulting tributary phosphorus load that led to compliance with water quality standards was 5.13 kg phosphorus/day between April and August, with the total load for this period not to exceed 784 kg. This allowable load corresponds to an approximately 90% reduction from existing loads (estimated as 7,651 kg phosphorus over the April to August period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Highland Silver Lake ranges from two weeks to two months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.2 Chlordane and Aldrin

The loading capacity for chlordane and aldrin were both calculated following equation 2. The harmonic mean flow through Highland Silver Lake was calculated as 26 cubic feet per second. This results in a loading capacity of 0.009 g/day for aldrin and 0.051 g/d for chlordane.

6.2 Allocation

The Highland Water Treatment Plant is the sole NPDES permitted point source discharge in the watershed. The WLA for this facility was set at estimated existing loading conditions of 0.10 kg phosphorus/day. The existing load for this facility was estimated using its permitted flow rate (0.063 MGD) and the average estimated phosphate concentration in the finished water (0.42 mg/l) (personal communication with the Highland WTP supervisor), which is used to backwash the filters. The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 5.13 kg/day, a WLA of 0.10 kg/day, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Highland Silver Lake of 4.512 kg/day.

The Highland Water Treatment Plant is not expected to cause or contribute to the aldrin and chlordane contamination, and does not require a WLA for these pollutants. Because of the implicit margin of safety described below, the load allocations are the loading capacities of 0.009 g/day for aldrin and 0.051 g/day for chlordane.

6.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon a seasonal period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

6.4 Seasonality

These TMDLs were conducted with an explicit consideration of seasonal variation. The BATHTUB model used for these TMDLs is designed to evaluate loads over a seasonal to annual averaging period. Model results indicate that the phosphorus residence time in Highland Silver Lake ranges from two weeks to two months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.5 Margin of Safety

The phosphorus TMDL for the protection of phosphorus, dissolved oxygen, and manganese contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit phosphorus load allocated to the margin of safety is 0.513 kg/day.

The chlordane and aldrin TMDLs have an implicit margin of safety, attained through the use of conservative assumptions in the application of the mass balance model. The conservative assumption of zero pollutant decay provides an absolute lower bound estimate for the TMDL.

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7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (Stage 1 Report, see Appendix A to the First Quarterly Progress Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review. A public meeting was conducted in Highland, Illinois on March 15, 2005 to present the results of Stage 1 work. A second meeting was conducted in the same location on August 4, 2005, to present TMDL results. A third meeting will be held at a later date to discuss the implementation planning.

7.1 Summary of March 15, 2005 Public Meeting

In February 2005, a public meeting was announced for presentation of the Stage One findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Tuesday, March 15, 2005 in Highland, Illinois at the Highland City Hall. In addition to the meeting's sponsors, approximately 30 individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage One findings by Limno-Tech, Inc. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public at least through April 16, 2005. While there were several general questions, comments were focused on potential sources of phosphorus, including septic systems for new residential developments around the upper portion of the lake and livestock that have direct access to the lake. Additional information on soils with “hot spots” of high phosphorus may be available for several farms that have done extensive soil testing in their fields. Further comment was offered that these “hot spots” are the legacy of livestock practices in the 1930s and 1940s. There was some skepticism expressed regarding the value of conducting a TMDL for manganese, given its natural occurrence and prevalence in the soils in the watershed. Similar skepticism was expressed for the legacy pollutants of aldrin and chlordane TMDLs since there are no active sources in the watershed and there were no detectable concentrations for either constituent in the most recent water samples collected by IEPA.

7.2 Summary of August 4, 2005 Public Meeting

In July 2005, a public meeting was announced for presentation of the development of the draft Total Maximum Daily Loads for Highland-Silver Lake. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Thursday, August 4, 2005 in Highland, Illinois at the Highland City Hall. In addition to the meeting's sponsors, approximately 20 individuals attended the meeting. Attendees registered and listened to a presentation on the draft TMDLs developed by Limno-Tech, Inc. for phosphorus, dissolved oxygen, manganese, chlordane and aldrin. This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public through midnight on August 19, 2005. While there were several general questions, comments were focused on several potential strategies for implementing the TMDLs. These included agitators to increase reaeration, using the upper portion of the lake as a sedimentation basin, and dredging. Additional discussion regarding health risks and effects of the TMDL constituents on the water treatment process were also part of the question and answer period. A responsiveness summary is included in Attachment 2. This responsiveness summary addresses substantive questions and comments received during the public comment period.

8 ADAPTIVE IMPLEMENTATION PROCESS

This approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Convene local experts to prioritize pollutant sources and identify restoration alternatives.
5. Based upon the results of step 4, develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management will be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 have been completed, as described in Section 5 of this document. Upon receipt of public comments and approval of the TMDL, Illinois EPA will conduct steps 4 and 5.

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Attachment 1

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Highland Silver

Water Balance Terms (hm3/yr) **Averaging Period =** **0.42** **Years**

Seg	Name	External	Inflows Precip	Advect	Storage Increase	Outflows------> Advect	Disch.	Downstr Exchange	Evap
1	Segment 1	1	1	32	0	32	0	0	1
2	Segment 2	1	1	31	0	32	0	100	1
3	Segment 3	1	1	30	0	31	0	51	1
4	Segment 4	2	0	28	0	30	0	152	0
5	Segment 5	28	0	0	0	28	0	23	0
Net		32	3	0	0	32	0	0	3

Mass Balance Terms (kg/yr) Based Upon **Predicted** **Reservoir & Outflow Concentrations** **Component: TOTAL P**

Seg	Name	Inflows--> External	Atmos	Advect	Storage Increase	Outflows-----> Advect	Disch.	Net Exchange	Net Retention
1	Segment 1	418	21	9587	0	11235	0	4427	-5637
2	Segment 2	315	16	8189	0	9587	0	-2414	1346
3	Segment 3	679	19	8334	0	8189	0	-4379	5222
4	Segment 4	939	10	10266	0	8334	0	442	2439
5	Segment 5	15903	10	0	0	10266	0	1924	3723
Net		18253	76	0	0	11235	0	0	7094

Highland Silver

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
5	1	Segment 1 Direct Drainage	0.7	2.2%	417.8	0.7%	566
PRECIPITATION			0.7	2.1%	20.9	0.0%	30
INTERNAL LOAD			0.0	0.0%	50769.8	83.5%	
TRIBUTARY INFLOW			0.7	2.2%	417.8	0.7%	566
ADVECTIVE INFLOW			31.5	95.6%	9586.7	15.8%	304
***TOTAL INFLOW			33.0	100.0%	60795.0	100.0%	1845
ADVECTIVE OUTFLOW			32.2	97.9%	11235.2	18.5%	348
NET DIFFUSIVE OUTFLOW			0.0	0.0%	4426.7	7.3%	
***TOTAL OUTFLOW			32.2	97.9%	15662.0	25.8%	486
***EVAPORATION			0.7	2.1%	0.0	0.0%	
***RETENTION			0.0	0.0%	45133.1	74.2%	

Hyd. Residence Time = 0.1386 yrs
Overflow Rate = 46.4 m/yr
Mean Depth = 6.4 m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
4	1	Segment 2 Direct Drainage	0.6	1.7%	314.6	1.1%	566
PRECIPITATION			0.5	1.6%	15.5	0.1%	30
INTERNAL LOAD			0.0	0.0%	18920.0	63.4%	
TRIBUTARY INFLOW			0.6	1.7%	314.6	1.1%	566
ADVECTIVE INFLOW			31.0	96.6%	8188.6	27.4%	265
NET DIFFUSIVE INFLOW			0.0	0.0%	2414.4	8.1%	
***TOTAL INFLOW			32.0	100.0%	29853.0	100.0%	932
ADVECTIVE OUTFLOW			31.5	98.4%	9586.7	32.1%	304
***TOTAL OUTFLOW			31.5	98.4%	9586.7	32.1%	304
***EVAPORATION			0.5	1.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	20266.3	67.9%	

Hyd. Residence Time = 0.0835 yrs
Overflow Rate = 60.8 m/yr
Mean Depth = 5.1 m

Component:	TOTAL P			Segment:	3	Segment 3	
			Flow	Flow	Load	Load	Conc
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 3 Direct Drainage	1.2	3.8%	678.8	3.3%	566
PRECIPITATION			0.6	2.0%	18.8	0.1%	30
INTERNAL LOAD			0.0	0.0%	6881.3	33.9%	
TRIBUTARY INFLOW			1.2	3.8%	678.8	3.3%	566
ADVECTIVE INFLOW			29.8	94.2%	8334.4	41.1%	280
NET DIFFUSIVE INFLOW			0.0	0.0%	4378.5	21.6%	
***TOTAL INFLOW			31.6	100.0%	20291.8	100.0%	642
ADVECTIVE OUTFLOW			31.0	98.0%	8188.6	40.4%	265
***TOTAL OUTFLOW			31.0	98.0%	8188.6	40.4%	265
***EVAPORATION			0.6	2.0%	0.0	0.0%	
***RETENTION			0.0	0.0%	12103.3	59.6%	

Hyd. Residence Time = 0.0671 yrs
Overflow Rate = 49.3 m/yr
Mean Depth = 3.3 m

Component:	TOTAL P			Segment:	4	Segment 4	
			Flow	Flow	Load	Load	Conc
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 4 Direct Drainage	1.7	5.5%	939.4	8.4%	566
PRECIPITATION			0.4	1.2%	10.4	0.1%	30
TRIBUTARY INFLOW			1.7	5.5%	939.4	8.4%	566
ADVECTIVE INFLOW			28.1	93.3%	10265.6	91.5%	365
***TOTAL INFLOW			30.1	100.0%	11215.4	100.0%	373
ADVECTIVE OUTFLOW			29.8	98.8%	8334.4	74.3%	280
NET DIFFUSIVE OUTFLOW			0.0	0.0%	441.8	3.9%	
***TOTAL OUTFLOW			29.8	98.8%	8776.1	78.3%	295
***EVAPORATION			0.4	1.2%	0.0	0.0%	
***RETENTION			0.0	0.0%	2439.3	21.7%	

Hyd. Residence Time = 0.0126 yrs
Overflow Rate = 86.0 m/yr
Mean Depth = 1.1 m

Component:	TOTAL P			Segment:	5	Segment 5	
			Flow	Flow	Load	Load	Conc
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	28.1	98.8%	15902.7	99.9%	566
PRECIPITATION			0.3	1.2%	10.3	0.1%	30
TRIBUTARY INFLOW			28.1	98.8%	15902.7	99.9%	566
***TOTAL INFLOW			28.4	100.0%	15913.0	100.0%	559
ADVECTIVE OUTFLOW			28.1	98.8%	10265.6	64.5%	365
NET DIFFUSIVE OUTFLOW			0.0	0.0%	1924.4	12.1%	
***TOTAL OUTFLOW			28.1	98.8%	12190.0	76.6%	434
***EVAPORATION			0.3	1.2%	0.0	0.0%	
***RETENTION			0.0	0.0%	3723.0	23.4%	

Hyd. Residence Time = 0.0119 yrs
Overflow Rate = 82.2 m/yr
Mean Depth = 1.0 m

Highland Silver
Overall Water & Nutrient Balances

Overall Water Balance | **Averaging Period = 0.42 years**

Trb	**Type**	**Seg**	**Name**	**Area** km^2	**Flow** hm^3/yr	**Variance** $(hm3/yr)^2$	**CV** -	**Runoff** m/yr
1	1	5	Inlet Tributary	108.2	28.1	0.00E+00	0.00	0.26
2	1	4	Segment 4 Direct Drainage	6.4	1.7	0.00E+00	0.00	0.26
3	1	3	Segment 3 Direct Drainage	4.6	1.2	0.00E+00	0.00	0.26
4	1	2	Segment 2 Direct Drainage	2.1	0.6	0.00E+00	0.00	0.26
5	1	1	Segment 1 Direct Drainage	2.8	0.7	0.00E+00	0.00	0.26
PRECIPITATION				2.5	2.6	0.00E+00	0.00	1.02
TRIBUTARY INFLOW				124.2	32.2	0.00E+00	0.00	0.26
***TOTAL INFLOW				126.8	34.8	0.00E+00	0.00	0.27
ADVECTIVE OUTFLOW				126.8	32.2	0.00E+00	0.00	0.25
***TOTAL OUTFLOW				126.8	32.2	0.00E+00	0.00	0.25
***EVAPORATION					2.6	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**
Component: **TOTAL P**

Trb	**Type**	**Seg**	**Name**	**Load** kg/yr	**%Total**	**Load Variance** $(kg/yr)^2$	**%Total**	**CV**	**Conc** mg/m^3	**Export** $kg/km^2/yr$
1	1	5	Inlet Tributary	15902.7	16.8%	0.00E+00		0.00	566.0	146.9
2	1	4	Segment 4 Direct Drainage	939.4	1.0%	0.00E+00		0.00	566.0	147.0
3	1	3	Segment 3 Direct Drainage	678.8	0.7%	0.00E+00		0.00	566.0	146.9
4	1	2	Segment 2 Direct Drainage	314.6	0.3%	0.00E+00		0.00	566.0	147.0
5	1	1	Segment 1 Direct Drainage	417.8	0.4%	0.00E+00		0.00	566.0	147.1
PRECIPITATION				75.9	0.1%	0.00E+00		0.00	29.5	30.0
INTERNAL LOAD				76571.0	80.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				18253.3	19.2%	0.00E+00		0.00	566.0	146.9
***TOTAL INFLOW				94900.2	100.0%	0.00E+00		0.00	2725.5	748.7
ADVECTIVE OUTFLOW				11235.2	11.8%	0.00E+00		0.00	348.4	88.6
***TOTAL OUTFLOW				11235.2	11.8%	0.00E+00		0.00	348.4	88.6
***RETENTION				83665.0	88.2%	0.00E+00		0.00		

Overflow Rate (m/yr)	12.8	Nutrient Resid. Time (yrs)	0.0325
Hydraulic Resid. Time (yrs)	0.3066	Turnover Ratio	12.8
Reservoir Conc (mg/m3)	311	Retention Coef.	0.882

Highland Silver

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	32.2	0.1386	46.4	9.2	57.5	5.8	0.0
2	Segment 2	1	31.5	0.0835	60.8	14.7	66.7	9.1	100.3
3	Segment 3	2	31.0	0.0671	49.3	28.1	113.7	26.6	50.7
4	Segment 4	3	29.8	0.0126	86.0	100.3	709.2	63.2	152.1
5	Segment 5	4	28.1	0.0119	82.2	175.2	477.2	183.1	22.6

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.7	6.4	5.5	1.3	4.5	0.5	2.3
2	Segment 2	0.5	5.1	4.6	1.2	2.6	0.4	2.9
3	Segment 3	0.6	3.3	3.3	1.9	2.1	0.3	5.7
4	Segment 4	0.3	1.1	1.0	1.3	0.4	0.3	4.6
5	Segment 5	0.3	1.0	0.9	2.1	0.3	0.2	12.8
Totals		2.5	3.9			9.9		

Highland Silver

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	5	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	4	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	3	Segment 3 Direct Drainage	Type:	Monitored Inflow
--------Segment:	4	Segment 4		
Outflow Segment:	3	Segment 3		
Tributary:	2	Segment 4 Direct Drainage	Type:	Monitored Inflow
--------Segment:	5	Segment 5		
Outflow Segment:	4	Segment 4		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Highland Silver
Description:
Single reservoir
5 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.4167	0.0
Precipitation (m)	0.4234	0.0
Evaporation (m)	0.4234	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	1	DECAY RATES
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.695	6.43	1.27	5.5	0.12	2.81	0	3.39	0	0	0	200	0	0	0
2	Segment 2	1	1	0.518	5.08	1.23	4.63	0.12	1.74	0	3.78	0	0	0	100	0	0	0
3	Segment 3	2	1	0.628	3.31	1.89	3.31	0	1.32	0	4.43	0	0	0	30	0	0	0
4	Segment 4	3	1	0.346	1.08	1.26	0.97	0	0	0	9	0	0	0	0	0	0	0
5	Segment 5	4	1	0.342	0.98	2.09	0.85	0	0	0	11	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	336	0	0	0	11	0	0.273	0	0	0	0	0	0	0	0	0
2	0	0	289	0	0	0	16	0	0.239	0	0	0	0	0	0	0	0	0
3	0	0	256	0	0	0	21	0	0.202	0	0	0	0	0	0	0	0	0
4	0	0	296	0	0	0	41	0	0.169	0	0	0	0	0	0	0	0	0
5	0	0	400	0	0	0	56	0	0.141	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
4	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	5	1	108.24	28.0967	0	0	0	566	0	0	0	0	0	0	0
2	Segment 4 Direct Drainage	4	1	6.39	1.6598	0	0	0	566	0	0	0	0	0	0	0
3	Segment 3 Direct Drainage	3	1	4.62	1.1993	0	0	0	566	0	0	0	0	0	0	0
4	Segment 2 Direct Drainage	2	1	2.14	0.5558	0	0	0	566	0	0	0	0	0	0	0
5	Segment 1 Direct Drainage	1	1	2.84	0.7381	0	0	0	566	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Inlet Tributary	94.38	5.54	4.78	1.57	1.72	0.26	0	0
2	Segment 4 Direct Drainage	4.07	0.28	1.4	0.14	0.19	0.31	0	0
3	Segment 3 Direct Drainage	2.6	0.25	0.67	0.33	0.23	0.55	0	0
4	Segment 2 Direct Drainage	0.83	0.07	0.59	0.08	0.12	0.46	0	0
5	Segment 1 Direct Drainage	0.8	0.11	0.59	0.4	0.16	0.79	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.2596	0	0	0	566	0	0	0	0	0	0	0
2	Grassland	0.2596	0	0	0	566	0	0	0	0	0	0	0
3	Forest	0.2596	0	0	0	566	0	0	0	0	0	0	0
4	Urban	0.2596	0	0	0	566	0	0	0	0	0	0	0
5	Wetland	0.2596	0	0	0	566	0	0	0	0	0	0	0
6	Other	0.2596	0	0	0	566	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Highland Silver

Variable = TOTAL P MG/M3 **R^2 = 0.86**
Global Calibration Factor = 1.00 **CV = 0.45**

Seg	Group	Name	Calibration Factor Mean	Calibration Factor CV	Predicted Mean	Predicted CV	Observed Mean	Observed CV	Log (Obs/Pred) Mean	Log (Obs/Pred) SE	t
1	1	Segment 1	1.00	0.00	348.4	0.00	336.0	0.00	-0.04	0.00	0.00
2	1	Segment 2	1.00	0.00	304.2	0.00	289.0	0.00	-0.05	0.00	0.00
3	1	Segment 3	1.00	0.00	264.5	0.00	256.0	0.00	-0.03	0.00	0.00
4	1	Segment 4	1.00	0.00	280.1	0.00	296.0	0.00	0.06	0.00	0.00
5	1	Segment 5	1.00	0.00	365.4	0.00	400.0	0.00	0.09	0.00	0.00
6	1	Area-Wtd Mean			311.5	0.00	309.7	0.00	-0.01	0.00	0.00

Highland Silver

T Statistics Compare Observed and Predicted Means Using the Following Error Terms:
1 = Observed Water Quality Error Only
2 = Error Typical of Model Development Dataset
3 = Observed & Predicted Error

Segment: **Area-Wtd Mean**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	309.7	0.00	311.5	0.00	0.99		-0.02	

Segment: **1** **Segment 1**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	336.0	0.00	348.4	0.00	0.96		-0.13	

Segment: **2** **Segment 2**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	289.0	0.00	304.2	0.00	0.95		-0.19	

Segment: **3** **Segment 3**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	256.0	0.00	264.5	0.00	0.97		-0.12	

Segment: **4** **Segment 4**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	296.0	0.00	280.1	0.00	1.06		0.21	

Segment: **5** **Segment 5**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	400.0	0.00	365.4	0.00	1.09		0.34	

Highland Silver

Segment	Name
1	Segment 1
2	Segment 2
3	Segment 3
4	Segment 4
5	Segment 5
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	4	5	Mean
TOTAL P MG/M3	348.4	304.2	264.5	280.1	365.4	311.5
TURBIDITY 1/M	3.4	3.8	4.4	9.0	11.0	5.5
ZMIX * TURBIDITY	18.6	17.5	14.7	8.7	9.4	14.8
CARLSON TSI-P	88.6	86.6	84.6	85.4	89.2	86.8

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	4	5	Mean
TOTAL P MG/M3	336.0	289.0	256.0	296.0	400.0	309.7
CHL-A MG/M3	11.0	16.0	21.0	41.0	56.0	24.7
SECCHI M	0.3	0.2	0.2	0.2	0.1	0.2
ANTILOG PC-1	972.4	1570.8	2378.3	5299.2	8433.9	3045.1
ANTILOG PC-2	2.5	2.9	3.0	4.1	4.4	3.2
TURBIDITY 1/M	3.4	3.8	4.4	9.0	11.0	5.5
ZMIX * TURBIDITY	18.6	17.5	14.7	8.7	9.4	14.8
ZMIX / SECCHI	20.1	19.4	16.4	5.7	6.0	15.2
CHL-A * SECCHI	3.0	3.8	4.2	6.9	7.9	4.7
CHL-A / TOTAL P	0.0	0.1	0.1	0.1	0.1	0.1
FREQ(CHL-a>10) %	43.8	67.3	81.2	97.5	99.3	72.8
FREQ(CHL-a>20) %	10.1	25.1	40.8	80.2	91.2	41.4
FREQ(CHL-a>30) %	2.7	9.3	18.8	57.7	75.7	25.4
FREQ(CHL-a>40) %	0.8	3.7	8.9	39.3	59.2	16.6
FREQ(CHL-a>50) %	0.3	1.6	4.4	26.4	44.9	11.2
FREQ(CHL-a>60) %	0.1	0.7	2.3	17.8	33.7	7.7
CARLSON TSI-P	88.0	85.9	84.1	86.2	90.5	86.7
CARLSON TSI-CHLA	54.1	57.8	60.5	67.0	70.1	60.4
CARLSON TSI-SEC	78.7	80.6	83.0	85.6	88.2	82.4

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	4	5	Mean
TOTAL P MG/M3	1.0	0.9	1.0	1.1	1.1	1.0
TURBIDITY 1/M	1.0	1.0	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0	1.0	1.0
CARLSON TSI-P	1.0	1.0	1.0	1.0	1.0	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	4	5	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	4	5	Mean

Highland Silver

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 6 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	311.5		98.1%	309.7		98.1%
CHL-A MG/M3				24.7		89.5%
SECCHI M				0.2		1.7%
ANTILOG PC-1				3045.1		97.3%
ANTILOG PC-2				3.2		9.2%
TURBIDITY 1/M	5.5		99.4%	5.5		99.4%
ZMIX * TURBIDITY	14.8		97.7%	14.8		97.7%
ZMIX / SECCHI				15.2		97.7%
CHL-A * SECCHI				4.7		13.5%
CHL-A / TOTAL P				0.1		7.5%
FREQ(CHL-a>10) %				72.8		89.5%
FREQ(CHL-a>20) %				41.4		89.5%
FREQ(CHL-a>30) %				25.4		89.5%
FREQ(CHL-a>40) %				16.6		89.5%
FREQ(CHL-a>50) %				11.2		89.5%
FREQ(CHL-a>60) %				7.7		89.5%
CARLSON TSI-P	86.8		98.1%	86.7		98.1%
CARLSON TSI-CHLA				60.4		89.5%
CARLSON TSI-SEC				82.4		98.3%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	348.4		98.6%	336.0		98.5%
CHL-A MG/M3				11.0		58.1%
SECCHI M				0.3		3.5%
ANTILOG PC-1				972.4		85.4%
ANTILOG PC-2				2.5		3.5%
TURBIDITY 1/M	3.4		97.4%	3.4		97.4%
ZMIX * TURBIDITY	18.6		98.9%	18.6		98.9%
ZMIX / SECCHI				20.1		99.3%
CHL-A * SECCHI				3.0		4.2%
CHL-A / TOTAL P				0.0		0.2%
FREQ(CHL-a>10) %				43.8		58.1%
FREQ(CHL-a>20) %				10.1		58.1%
FREQ(CHL-a>30) %				2.7		58.1%
FREQ(CHL-a>40) %				0.8		58.1%
FREQ(CHL-a>50) %				0.3		58.1%
FREQ(CHL-a>60) %				0.1		58.1%
CARLSON TSI-P	88.6		98.6%	88.0		98.5%
CARLSON TSI-CHLA				54.1		58.1%
CARLSON TSI-SEC				78.7		96.5%

Segment:	2	Segment 2				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	304.2		98.0%	289.0		97.7%
CHL-A MG/M3				16.0		75.6%
SECCHI M				0.2		2.4%
ANTILOG PC-1				1570.8		92.2%
ANTILOG PC-2				2.9		6.4%
TURBIDITY 1/M	3.8		98.1%	3.8		98.1%
ZMIX * TURBIDITY	17.5		98.6%	17.5		98.6%
ZMIX / SECCHI				19.4		99.2%
CHL-A * SECCHI				3.8		8.3%
CHL-A / TOTAL P				0.1		2.3%
FREQ(CHL-a>10) %				67.3		75.6%
FREQ(CHL-a>20) %				25.1		75.6%
FREQ(CHL-a>30) %				9.3		75.6%
FREQ(CHL-a>40) %				3.7		75.6%
FREQ(CHL-a>50) %				1.6		75.6%
FREQ(CHL-a>60) %				0.7		75.6%
CARLSON TSI-P	86.6		98.0%	85.9		97.7%
CARLSON TSI-CHLA				57.8		75.6%
CARLSON TSI-SEC				80.6		97.6%

Segment:	3	Segment 3				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	264.5		97.1%	256.0		96.9%
CHL-A MG/M3				21.0		85.2%
SECCHI M				0.2		1.4%
ANTILOG PC-1				2378.3		95.9%
ANTILOG PC-2				3.0		7.7%
TURBIDITY 1/M	4.4		98.8%	4.4		98.8%
ZMIX * TURBIDITY	14.7		97.6%	14.7		97.6%
ZMIX / SECCHI				16.4		98.3%
CHL-A * SECCHI				4.2		10.8%
CHL-A / TOTAL P				0.1		8.5%
FREQ(CHL-a>10) %				81.2		85.2%
FREQ(CHL-a>20) %				40.8		85.2%
FREQ(CHL-a>30) %				18.8		85.2%
FREQ(CHL-a>40) %				8.9		85.2%
FREQ(CHL-a>50) %				4.4		85.2%
FREQ(CHL-a>60) %				2.3		85.2%
CARLSON TSI-P	84.6		97.1%	84.1		96.9%
CARLSON TSI-CHLA				60.5		85.2%
CARLSON TSI-SEC				83.0		98.6%

Segment:	4	Segment 4				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	280.1		97.5%	296.0		97.8%
CHL-A MG/M3				41.0		97.2%
SECCHI M				0.2		0.7%
ANTILOG PC-1				5299.2		99.1%
ANTILOG PC-2				4.1		20.2%
TURBIDITY 1/M	9.0		99.9%	9.0		99.9%
ZMIX * TURBIDITY	8.7		90.6%	8.7		90.6%
ZMIX / SECCHI				5.7		62.5%
CHL-A * SECCHI				6.9		29.2%
CHL-A / TOTAL P				0.1		29.3%
FREQ(CHL-a>10) %				97.5		97.2%
FREQ(CHL-a>20) %				80.2		97.2%
FREQ(CHL-a>30) %				57.7		97.2%
FREQ(CHL-a>40) %				39.3		97.2%
FREQ(CHL-a>50) %				26.4		97.2%
FREQ(CHL-a>60) %				17.8		97.2%
CARLSON TSI-P	85.4		97.5%	86.2		97.8%
CARLSON TSI-CHLA				67.0		97.2%
CARLSON TSI-SEC				85.6		99.3%

Segment:	5	Segment 5				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	365.4		98.8%	400.0		99.1%
CHL-A MG/M3				56.0		99.0%
SECCHI M				0.1		0.4%
ANTILOG PC-1				8433.9		99.7%
ANTILOG PC-2				4.4		24.1%
TURBIDITY 1/M	11.0		99.9%	11.0		99.9%
ZMIX * TURBIDITY	9.4		92.0%	9.4		92.0%
ZMIX / SECCHI				6.0		65.6%
CHL-A * SECCHI				7.9		35.9%
CHL-A / TOTAL P				0.1		29.8%
FREQ(CHL-a>10) %				99.3		99.0%
FREQ(CHL-a>20) %				91.2		99.0%
FREQ(CHL-a>30) %				75.7		99.0%
FREQ(CHL-a>40) %				59.2		99.0%
FREQ(CHL-a>50) %				44.9		99.0%
FREQ(CHL-a>60) %				33.7		99.0%
CARLSON TSI-P	89.2		98.8%	90.5		99.1%
CARLSON TSI-CHLA				70.1		99.0%
CARLSON TSI-SEC				88.2		99.6%

Attachment 2

Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from July 25, 2005 through August 19, 2005 postmarked, including those from the August 4, 2005 public meeting discussed below.

What is a TMDL?

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

Background

The 550 acre Highland Silver Lake is located in western Illinois approximately 35 miles east of St. Louis. It is a water source to the City of Highland and is also used for recreation. Highland Silver Lake is listed as impaired for manganese, total phosphorus, dissolved oxygen, aldrin, chlordane, sedimentation/siltation, total suspended solids, and excess algal growth. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Therefore, TMDLs were developed for manganese, total phosphorus, dissolved oxygen, aldrin, and chlordane. The Illinois EPA contracted with Limno-Tech, Inc. (LTI) to prepare a TMDL report for Highland Silver Lake.

Public Meetings

Public meetings were held in the city of Highland on March 15, 2005 and August 4, 2005. The Illinois EPA provided public notice for the meetings by placing display ads in the "Highland News Leader" and the "Belleville News Democrat" on February 7, 2005 and July 25, 2005. The notices gave the date, time, location, and purpose of the meetings. The notices also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Illinois EPA also sent the public notice for the August 4 meeting, by first class mail, to approximately 55 individuals and organizations. The draft TMDL Report was available for review at the Highland City Hall offices and also on the Agency's web page at http://www.epa.state.il.us/water/tmdl .

The final public meeting started at 6:30 p.m. on Thursday, August 4, 2005. It was attended by approximately twenty people and concluded at 8:00 p.m. with the meeting record remaining open until midnight, August 19, 2005.

Questions and Comments

1. In regards to manganese, is there any reason to do anything?

Response: The Public Water Supply Water Quality Standard for manganese is 150 mg/L based on taste and staining of clothes. High levels of manganese can increase drinking water treatment costs.

2. What is the application deadline for the 319 grant?

Response: Applications are accepted June 1 through August 1.

3. What are the risks to citizens?

Response: From manganese there is low risk to human health. Low dissolved oxygen and elevated phosphorus levels, however, can be a threat to the health of aquatic life in the lake. This can reduce the health of aquatic communities in the lake.

4. Would reaeration or de-stratification help dissolved oxygen? The city could install a solar agitator or at least do a study on this.

Response: It is out of the scope of this TMDL to investigate any implementation measures in detail. The implementation plan for this TMDL will likely be a list of recommendations that the City can use as a guide in improving the water quality of the lake. Some form of aeration could be a component of the restoration plan.

5. Is the real underlying problem suspended solids? Could dredging solve the problem?

Response: We believe there is considerable internal cycling occurring in the lake from the sediment. Dredging in parts of the lake could be part of a restoration plan. Other options include construction of retention basins and use of BMPs in the upper watershed.

6. Where are the highest concentrations of phosphorus? That is, where should we concentrate our efforts?

Response: The Stage 1 report details the water quality data available on phosphorus and the locations of the lake monitoring stations.

7. How does this relate to what is coming out of the tap?

Response: The Highland Water Treatment Plant indicates that treatment costs for the water treatment plant do go up in the summer when the algae levels are high; more activated carbon is used. Accordingly, there is a notable difference in the taste of the water in the summer months.

8. There is a lot of spring water supplying the lake. Has water from the springs been tested/monitored for manganese and phosphorus?

Response: LTI did look at groundwater data for the state, but they didn't have data specific to Madison County. The groundwater data they have show that manganese levels are high in some areas. Phosphorus measurements for groundwater were not available; however, we do not expect the groundwater to be a significant source of phosphorus to the lake. We believe the amount coming in from runoff of agricultural fields is much greater.

9. The Lake Commission has discussed putting in a sediment retention basin in the upper part of the lake. Would that help with these impairments? The I-70 bridge acts as a natural retention dam. It can be seen on aerial photos.

Response: A sediment retention dam could be part of the overall restoration plan. This would address sediment/siltation issues and, over time, aid in reducing the amount of internal cycling of manganese and phosphorus. A separate feasibility study would be required to explore this further.

10. When will the third meeting be held?

Response: The tentative schedule for the meeting on the implementation plan is mid to late November.

11. What is the Agency's strategy for control and clean-up of aldrin and chlordane? What does the Agency propose as milestones for measuring success of the TMDL? Specifically, what milestones will you incorporate to measure success at implementing management measures in your implementation plan? What milestones will you incorporate for measuring water quality improvement?

Response: This is a matter that will be taken up in the implementation phase. Both of the substances are no longer used. During the implementation phase, among the milestones we will look at are sediment quality and fish tissue quality improvements/reductions.

12. What will the Illinois Environmental Protection Agency do to encourage more filter strips and more no-till or low-till agriculture practices, beyond the "voluntary" program that exists now?

Response: Implementation will be handled in the next phase. During that phase, we will encourage these and other practices through Section 319 funding and existing NRCS conservation programs. In past implementation strategies, we have relied heavily on 319 funding and existing NRCS conservation programs. Voluntary programs are the extent of our capability to address nonpoint sources at this time.

13. What is the Agency requiring the farmers to do to improve the water quality?

Response: Implementation will be handled in the next phase. The Agency cannot currently require farmers to implement BMPs, however, we will encourage the use of existing voluntary programs such as Section 319 and NRCS conservation programs.

14. What is the Agency's plan to rectify the septic system issues described on page 48 of the draft Highland Silver Lake TMDL report? Specifically, what milestones will the Agency incorporate to measure success at implementing management and enforcement measures in the TMDL implementation plan?

Response: These issues will be addressed in the implementation phase. Based on our past practices in implementation, we will work with the county health department, using 319 funds, to promote septic system investigation and repair work, if necessary. Milestones will be developed during the implementation phase and will likely include our ongoing ambient monitoring program.

15. Two NPDES-permitted dischargers are located within the Highland Silver Lake watershed; one is the Munie Trucking Company, which has an expired permit for pit pumpage and stormwater. Is the Munie Trucking Company currently dumping or pumping? Are they attempting to get their permit renewed? What will the Agency's recommendation be for such a request?

Response: Munie Trucking Company is not currently discharging and requested termination of the permit. They may continue to mine, but are no longer discharging. They are currently operating under an administratively continued NPDES permit.

16. The draft report states that "The Commission [the Silver Lake Advisory Commission] is developing a Comprehensive Plan for Silver Lake and Silver Lake Park (Rosen, 2003) in efforts to protect water quality in the Lake. While we commend that action, we want to know what the Agency is setting as their plan of protection.

Response: During the implementation phase, we hope that the Commission will review the implementation plan and interact with us on the joint priorities.

17. What are the Agency's long-range plans to reduce phosphorus loads and increase hypolimnetic dissolved oxygen concentrations?

Response: Our plan is to investigate individual sources, identify and prioritize the sources, and identify Best Management Practices to reduce the load.

TMDL Implementation Plan

Highland Silver Lake Watershed (ROZA)

Prepared for Illinois Environmental Protection Agency

October 2006

Highland Silver Lake

Manganese, Total Phosphorus, Dissolved Oxygen,
Aldrin, and Chlordane

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SUMMARY

Total Maximum Daily Loads (TMDLs) were developed and submitted to the U.S. EPA in August 2005 for Highland Silver Lake in western Illinois, to address water quality impairments due to manganese, total phosphorus, low dissolved oxygen, aldrin, and chlordane. These TMDLs, which determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives, have been approved by the U.S. EPA. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. This document identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation; these are summarized in the table below.

Summary of Implementation Alternatives

Alternative	Estimated Cost[1]	Notes
Restrict Livestock Access	Fencing: $3,500 to $4,000 per mile Pipeline watering: $0.32 - $2.60 per foot Watering tanks and troughs: $291 - $1,625 each	
Conservation Buffers	$200 - $360/acre	• Common around the lake; rare within the watershed
Shoreline Enhancement & Protection	$5/linear foot for plantings $67-$73/ton for rip-rap	
Streambank Stabilization	$629,750 for 109 incised locations on East Fork Silver Creek Other streambank stabilization projects at priority sites, cost varies depending on nature and size of site	• Recommended by IL Dept. of Agriculture • Additional study required to identify priority sites
Sediment Control Basins	$1,200 to $229,000 per basin, depending on size	• Some basins already in the watershed
Nutrient Management Plans	$6 to $20/acre	• May lead to cost savings
Conservation Tillage	$12 to $83/acre	
Grassed Waterways	$1,800/acre	
Aeration/Destratification	$65,000 - $72,000	
Septic System Inspection & Maintenance	Variable	• Cost would be low if existing staff could accomplish
Dredging	$6 - $20/cubic yard removed	• Only in concert with watershed reductions
Phosphorus Inactivation	$550,000 - $715,000 for whole lake	• Only in concert with watershed reductions

[1] Costs expressed in 2006 dollars

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define waters that are not meeting designated uses under technology-based controls and identify them on a list of impaired waters, which is referred to as the 303(d) list. The Illinois Environmental Protection Agency's (IEPA) 2004 303(d) list is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for these impaired water bodies. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and conditions in the water body. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA, 1991).

Highland Silver Lake is listed on the 2004 Illinois Section 303(d) List of Impaired Waters (IEPA, 2004a) as a water body that is not meeting its designated uses. As such, this lake was targeted as a high priority water for TMDL development. TMDLs for Highland Silver Lake have been developed (LTI, 2005) and approved by the U.S. EPA. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a "perfect" solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL's goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This document presents the implementation plan for the Highland Silver Lake watershed TMDLs. It is divided into sections describing the watershed, summarizing the allowable loads and needed reductions identified in the TMDL, describing the implementation strategy, discussing alternatives to reduce the existing loadings of the pollutants of concern, describing reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

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WATERSHED DESCRIPTION

The Highland Silver Lake watershed is located in western Illinois, approximately 35 miles east of St. Louis. This project study area is part of the larger, Lower Kaskaskia River Watershed. This lake is an impoundment of East Fork Silver Creek and was constructed in the 1960-1962 time period to provide a reliable water source to the City of Highland. When completed, Highland Silver Lake replaced a much smaller impoundment, which is just east of the large dam. The lake itself is 550 acres in size (IEPA, 2004a) and has a maximum depth of approximately 20 feet. In general, it is a shallow lake and is used both for public water supply and recreation (Silver Lake Park is located on North Route 143). The watershed draining to Highland Silver Lake is approximately 48 square miles in size and includes portions of Madison and Bond Counties. A protective buffer strip and conservation areas surround the lake and are maintained by the Highland Parks and Recreation Department. The primary road traversing the watershed is Interstate 70.

Figure 1 shows a map of the watershed, and includes waterways, Highland Silver Lake, the public water supply intake, roads and other key features.

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TMDL SUMMARY

Highland Silver Lake is listed on the Illinois 303(d) list for impairment for due to dissolved oxygen, total phosphorus, manganese, aldrin, and chlordane (Table 1). Potential sources contributing to the listing of Highland Silver Lake are summarized in Table 2.

Table 1. Summary of Impairments

Highland Silver Lake	
Waterbody Segment	ROZA
Size (Acres)	550
Listed For	**Manganese, total phosphorus, dissolved oxygen, aldrin, chlordane,** sedimentation/siltation, total suspended solids, excess algal growth, and total phosphorus (statistical guideline)
Use Support[1]	Overall use (P), Aquatic life (P), Fish consumption (P), Public water supply (P), Primary contact (P), Secondary contact (N)

[1]F=full support, P=partial support, N=nonsupport

Table 2. Sources of Impairment for Highland Silver Lake

Cause of Impairment	Potential Source(s)
Manganese	Streambank and lakeshore erosion of soils naturally enriched with manganese; release from lake bottom sediments during anoxic conditions
Total phosphorus	Crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; lake bottom sediments during anoxic conditions; failing septic systems; lakeshore and streambank erosion; runoff from fertilized lawns
Dissolved oxygen	Lake bottom sediment oxygen demand; algal respiration; crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; runoff from fertilized lawns; lakeshore and streambank erosion
Aldrin	Cropland runoff; lake bottom sediments
Chlordane	Cropland runoff; runoff from lawns; lake bottom sediments

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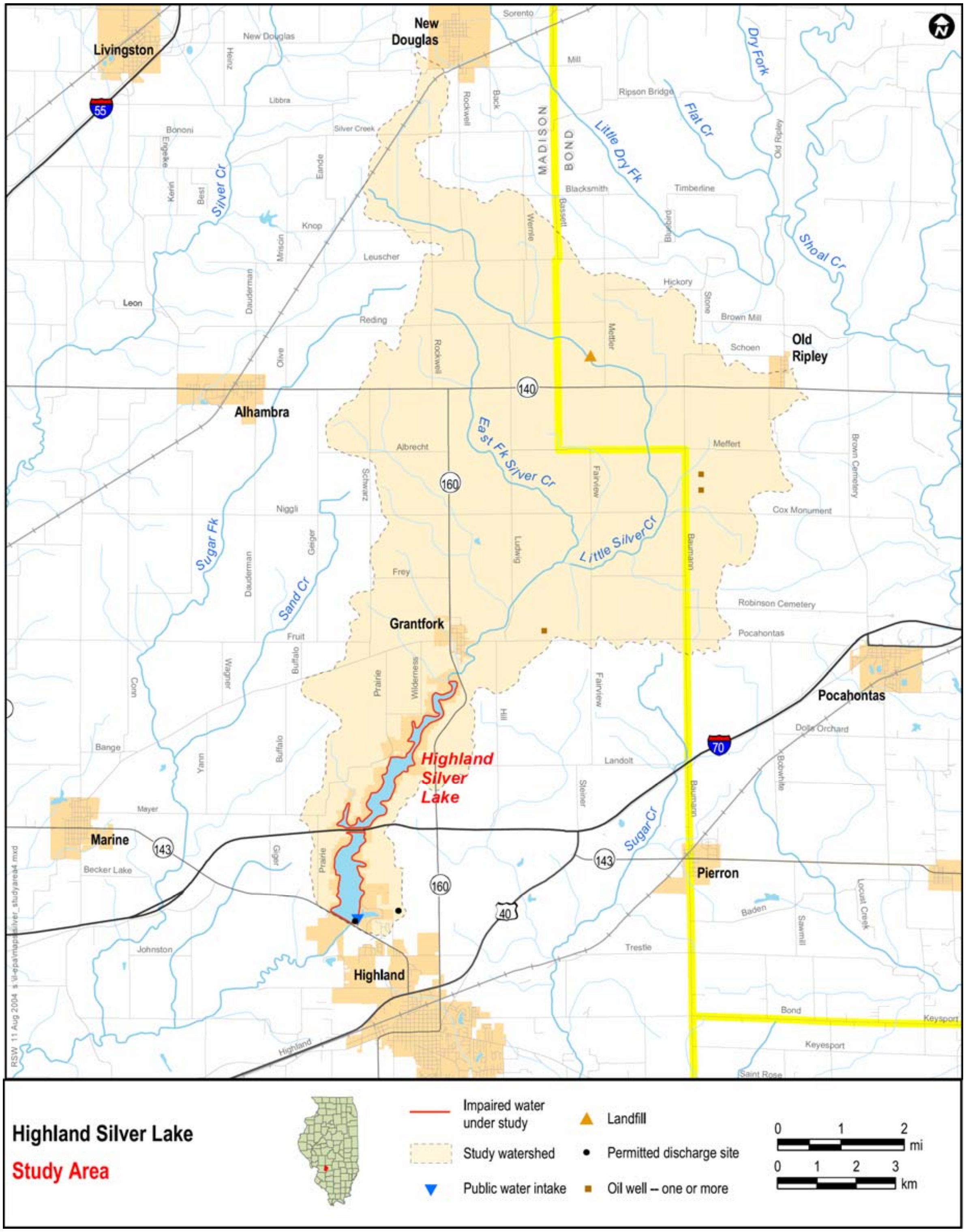

Figure 1. Base Map of Highland Silver Lake Watershed

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TMDLs require targets, numeric endpoints specified to represent the level of acceptable water quality to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist or are not practical for TMDL implementation, surrogate parameters must be selected to represent the designated use. TMDL targets were developed to represent each pollutant addressed in these TMDLs.

The water quality standard for phosphorus to protect aquatic life and secondary contact uses in Illinois lakes is 0.05 mg-P/l. The water quality standard for dissolved oxygen is a minimum of 5.0 mg/l and an average of 6.0 mg/l. Violation of the dissolved oxygen standard is presumed to be primarily due to the effects of nutrient enrichment, as there are no point source discharges to the lake, nor were other significant sources of oxygen demanding materials identified in the watershed characterization (LTI, 2004). For this reason, attainment of the total phosphorus standard is expected to result in attainment of the dissolved oxygen standard. The TMDL target for dissolved oxygen is therefore a total phosphorus concentration of 0.05 mg-P/l.

The applicable water quality standard for manganese is 150 ug/l. For this TMDL, the target is maintenance of hypolimnetic dissolved oxygen concentrations above zero, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

Numeric water quality standards do not exist for chlordane and aldrin in Illinois. The TMDL targets for these pollutants were based on Federal water quality criteria for these chemicals. These criteria correspond to 0.00014 ug/l for aldrin and 0.0008 ug/l for chlordane (http://www.epa.gov/waterscience/criteria/wqcriteria.html).

The TMDL determined the total allowable load for each pollutant, as well as the level of reduction needed to achieve the TMDL targets for Highland Silver Lake. Table 3 summarizes the existing loads for each pollutant, the total loading capacity, the waste load allocations for point sources, the load allocations given to non-point sources, the explicit margin of safety incorporated in the TMDLs, and the amount of reduction of exiting load that would be needed to attain the water quality objective.

Table 3. Summary of Highland Silver TMDLs

Pollutant	Existing Load[1]	Allowable Load [1]	Waste Load Allocation	Load Allocation	Margin of Safety	Percent Reduction Needed
Phosphorus (kg)	18,253	1,871	37	1,647	187	90%
Chlordane (g)	<232[2]	18.6	0	18.6	Implicit	N/A[3]
Aldrin (g)	<232[2]	3.3	0	3.29	Implicit	N/A[3]

[1] Phosphorus loads are for April-August (critical period); chlordane and aldrin loads are expressed on an annual basis.
[2]All recent measurements are below detection at 0.01 ug/L. Therefore, the existing load can only be estimated as an upper bound using the detection limit.
[3]Percent reduction cannot be calculated directly due to the uncertainty in the existing loads. However, the data from the water column, sediments and fish tissue suggest that the lake is improving with respect to these chemicals.

IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts, using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies. The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps One through Three described above have been completed, as described in the TMDL report (LTI, 2005). This plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

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IMPLEMENTATION ALTERNATIVES

Based on the objectives for the TMDLs, information obtained at the public meetings, the Silver Lake Commission Comprehensive Plan (Rosen, 2003) and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. It should be noted that a number of BMPs, including water and sediment control systems, terracing, and reduced tillage, were implemented in this watershed in the 1980s as part of the USDA Rural Clean Water Program (NRCS, 2004). Results of the most recent Illinois State Water Survey sedimentation survey (ISWS, 2001) suggest that these efforts may have had some effect, as sedimentation rates were considerably lower for the period 1984-1999 than for 1962-1984.

Chlordane and aldrin are no longer in use in the watershed, having been banned in the late 1980s (LTI, 2004). The available data from the water column, sediments and fish tissue suggest that the lake is improving with respect to these chemicals, and is likely to recover on its own. Several of the reduction strategies described below for phosphorus will reduce soil delivery to the lake, and could therefore have the added benefit of reducing watershed loads of chlordane and aldrin delivered to the lake.

Implementation alternatives are focused on those sources suspected of contributing phosphorus loads to the lake (agricultural sources, release from existing lake bottom sediments under anoxic conditions, streambank and shoreline erosion, and failing private sewage disposal systems.) The alternatives include:

- Restricting Livestock Access
- Conservation Buffers
- Shoreline Enhancement and Protection
- Streambank Stabilization
- Sediment Control Structures
- Nutrient Management Plans
- Conservation Tillage
- Grassed Waterways
- In-lake Control Structures
- Aeration/Destratification
- Septic System Inspection and Maintenance Program
- Dredging
- Phosphorus Inactivation

Each of these alternatives is described briefly below, including information about their costs and effectiveness in reducing phosphorus inputs.

RESTRICT LIVESTOCK ACCESS TO LAKE AND TRIBUTARIES

It has been noted that livestock within this watershed have access both to the tributaries and the lake itself (LTI, 2004). Livestock are a source of nutrients and oxygen-demanding substances that are the focus of this TMDL.

One potential component of TMDL implementation would be to restrict livestock access to both the lake and the stream. This could be accomplished by fencing and installation of alternative systems for livestock watering. Livestock exclusion and other grazing management measures have been shown to reduce phosphorus loads on the order of 49%, (EPA, 2003). The principal direct costs of providing grazing practices vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA, 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA, 2003).

CONSERVATION BUFFERS

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999). Currently, there are few filter strips within the watershed and farm fields usually extend right up to ditches and roads (NRCS, 2004). Around the lake, however, buffer strips are more common (Rosen, 2004).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006).

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

SHORELINE ENHANCEMENT AND PROTECTION

Shoreline erosion has been a problem in this watershed. Sediment derived from shoreline erosion not only increases solids in the lakes and decreases lake volume, but also can increase nutrient loads to the lakes. Shoreline erosion protection has been recommended as part of the Silver Lake Comprehensive Plan (Rosen, 2003). Shoreline enhancement efforts, such as planting deep-rooted vegetation or installing rip-rap in the unprotected shoreline areas, will provide protection against erosion and the associated increased pollutant loads. Estimates for rip-rapping are approximately $67-$73/ton (NRCS, 2005), while estimates for plantings at another Illinois lake suggest a cost of approximately $5/linear foot (CMT, 2004).

STREAMBANK STABILIZATION

Erosion of the banks and beds of tributary streams is recognized as a significant source of sediment to Highland Silver Lake. This sediment load not only leads to sedimentation in the lake, but also contributes to phosphorus loading. Streambank stabilization (including grade stabilization to reduce erosive velocities and shear stresses) is a key measure in reducing loads.

A recent aerial assessment report identified streambank incision and erosion as prevalent upstream of Highland Silver Lake (IDOA, 2005). This study recommends rock riffle grade control and stone toe protection to stabilize banks of East Fork Silver Creek. Using costs presented in the report, the estimated cost to stabilize East Fork Silver Creek upstream of the lake is $629,750.

In addition to the sites recommended in the IDOA report, other sites for streambank stabilization likely exist in the Highland Silver Lake watershed. For example, discussions with local stakeholders have identified what is perceived as a significant site of bank erosion at the crossing of Silver Creek by Route 160 near Grantfork, just upstream of the lake. Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observation of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

SEDIMENT CONTROL BASINS

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (EPA, 2003). A number of basins were constructed in the Highland Silver watershed during the 1970s and 1980s to reduce erosion and sedimentation (NRCS, 2004). Additional basins could be installed throughout the watershed, in areas selected to minimize disruption to existing croplands. In addition to controlling sediment, these basins would reduce phosphorus loads to the lakes. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%. As an alternative to siting smaller sedimentation basins throughout the watershed, a larger sedimentation basin may be sited near the inlet to Highland Silver Lake. This type of regional sedimentation basin would be similar to the one recently constructed on Otter Lake. The cost of the Otter Lake sedimentation basin is estimated at $750,000, but project costs will depend on basin size and land acquisition costs.

It has been observed that some of the suspended sediment entering Highland Silver Lake does not readily settle and contributes to turbidity in the lake. This finer portion of the suspended sediment load may not be easily treated by sedimentation basins, but may be treatable through the use of constructed wetlands. Implementation of storm water wetlands at various locations in the watershed may be feasible where hydric soils exist, but where wetlands, forest or development does not currently exist. This is discussed in more detail in the section "Identifying Priority Areas for Control." These wetlands would trap sediments and nutrients; a study prepared for another Illinois watershed provides an estimated phosphorus removal rate of 45% (Zahniser Institute, undated). Wetlands generally have low to moderate effectiveness at reducing particulate phosphorus, and low to negative effectiveness at reducing dissolved phosphorus (NRCS, 2006).

NUTRIENT MANAGEMENT

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. Because agriculture is the most common land use in the watershed, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lakes. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff (vs. leaching through the soil, as occurs for nitrogen), mostly in particulate form attached to eroded soil particles. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.
- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.

- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

Local NRCS staff have indicated that the vast majority (on the order of 90%) of farmers in the area are using soil testing to determine the amount and type of fertilizer to apply to the soil. This suggests that some nutrient management is already occurring in the watershed. A U.S. Department of Agriculture study reported that average annual phosphorus application rates were reduced by 36 lb/acre when nutrient management practices were adopted (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality.

Costs of developing nutrient management plans have been estimated at $6 to $20/acre (EPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed improved nutrient management on cornfields led to a savings of about $3.60/acre (EPA, 2003).

CONSERVATION TILLAGE

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of phosphorus lost from the land and delivered to the lake. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognize as cost-effective means of significantly reducing soil erosion and maintaining productivity. Currently, most landowners in the watershed use conventional tillage (NRCS, 2004). The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that, countywide, 92% of land under soybean production and 94% of the land in small grain production in Madison County is farmed using reduced till, mulch till, or no-till, while 68% of cornfields are farmed with conventional methods. In Bond County, 94% of cornfields, 67% of soybeans, and 77% of small grains are farmed with conventional methods (IDOA, 2004). Note that the Transect Survey values include the entire county in each case, and are not specific to the Highland Silver watershed. Discussions with local NRCS staff were specific to this watershed, and indicated that most landowners are using conventional methods (NRCS, 2004). Expanding conservation tillage measures should be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre (1998 dollars) in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois

Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

GRASSED WATERWAYS

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006b).

AERATION/DESTRATIFICATION

As noted in the TMDL report (LTI, 2005), the existing sediments are a significant source of both phosphorus and manganese, as well as aldrin and chlordane. When dissolved oxygen is absent in the hypolimnion (deep layer) of the lake, phosphorus and manganese are released from the sediments. Control of this internal load requires either removing phosphorus (and manganese) from the lake bottom (such as through dredging), or preventing oxygen-deficient conditions from occurring. Aeration of portions of the lake might be considered as an alternative to increase mixing and improve oxygen levels. Destratifiers have also been installed in other Illinois lakes to prevent thermal stratification, and thus increase oxygen concentrations in the deeper lake waters. Studies have indicated that such systems can significantly improve water quality (Raman et. al, 1998). A destratification system installed in Lake Evergreen in McLean County, a lake somewhat larger than Highland Silver Lake (754 acres, vs. 550 acres for Highland Silver) was effective in improving dissolved oxygen levels throughout the lake, up to the depth of its operation (Raman et al, 1998). The destratifier used on Lake Evergreen cost approximately $72,000 (Raman et al, 1998). The cost of a destratifier or an aeration system has been estimated for a smaller Illinois lake at $65,000 (CMT, 2004).

SEPTIC SYSTEM INSPECTION AND MAINTENANCE PROGRAM

Most of the watershed, with the exception of the City of Highland, is unsewered. In rural Illinois, many unsewered areas use individual surface discharging sewage disposal systems (generally either sand filters with chlorination, or aerobic systems). It has been estimated that statewide, between 20 and 60 percent of surface discharging systems are failing or have failed (IEPA, 2004b), suggesting that such systems may be a significant source of pollutants. At the present time, these systems are not routinely inspected; inspections occur only when complaints are received (MCPD, 2004). A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. IEPA has committed to working with the County Health Department, using 319 funds, to promote septic system investigation and repair work if necessary (LTI, 2005, Responsiveness Summary). This alternative would require the commitment of staff time for Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing Health Department staff or would require additional personnel.

DREDGING

In-place sediments have been identified as significant sources of phosphorus, manganese, aldrin, and chlordane. In addition, sedimentation reduces the water volume of the lake, with a corresponding reduction in the lake's assimilative capacity. Dredging of the existing sediments is one alternative to address this source. It is, however, an expensive alternative, and would be only a temporary solution; if sediment and phosphorus loads are not reduced in the watershed, it is likely that sedimentation and nutrient flux from the sediments will continue to be a problem in the future. In addition, dredging might also release chlordane and aldrin from the sediments, and is therefore unlikely to be a desirable alternative. Costs for dredging have been estimated at $6 to $20 per cubic yard of sediment removed for hydraulic dredging (IEPA, 1998).

PHOSPHORUS INACTIVATION

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006). This translates to a cost of $550,000 to $715,000 for Highland Silver Lake.

SUMMARY OF ALTERNATIVES

Table 4 summarizes the alternatives identified for the Highland Silver Lake watershed. These alternatives should be evaluated by the local stakeholders to identify those most likely to provide the necessary load reductions, based on site-specific conditions in the Highland Silver Lake watershed.

Table 4. Summary of Implementation Alternatives

Alternative	Estimated Cost	Notes
Restrict Livestock Access	Fencing: $3,500 to $4,000 per mile Pipeline watering: $0.32 - $2.60 per foot Watering tanks and troughs: $291 - $1,625 each	
Conservation Buffers	$200 - $360/acre	• Common around the lake; rare within the watershed
Shoreline Enhancement & Protection	$5/linear foot for plantings $67-$73/ton for rip-rap	
Sediment Control Basins	$1,200 to $229,000 per basin, depending on size	• Some basins already in the watershed
Streambank Stabilization	$629,750 for 109 incised locations on East Fork Silver Creek Other streambank stabilization projects at priority sites, cost varies depending on nature and size of site	• Recommended by IL Dept. of Agriculture • Additional study required to identify priority sites
Nutrient Management Plans	$6 to $20/acre	• May lead to cost savings
Conservation Tillage	$12 to $83/acre	
Grassed Waterways	$1,800/acre	
Aeration/Destratification	$65,000 - $72,000	
Septic System Inspection & Maintenance	Variable	• Cost would be low if existing staff could accomplish
Dredging	$6 - $20/cubic yard removed	• Only in concert with watershed reductions
Phosphorus Inactivation	$550,000 - $715,000 for whole lake	• Only in concert with watershed reductions

IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a review of available information. Information reviewed included: tributary water quality data (no recent data were identified); an aerial assessment report; and GIS-based data. Based on this review, it is recommended that streambank stabilization be initiated to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Tributary monitoring at three locations is also recommended to assess current conditions and monitor improvement as controls are implemented.

TRIBUTARY MONITORING

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and no recent tributary monitoring data were identified. It is recommended that flow, phosphorus and total suspended solids data be collected at several locations to better understand where sediment and phosphorus loads are being generated in the watershed. Suggested locations for initial tributary data collection include: Silver Creek at the Rte. 160 bridge near the lake; Little Silver Creek at Fairview Rd.; and East Fork Silver Creek at Niggli Rd.

AERIAL ASSESSMENT REPORT

A 2005 report (IDOA, 2005) examined streambank conditions in East Fork Silver Creek. The reach of interest for this implementation plan begins at Highland Silver Lake and proceeds upstream to approximately the route 140 crossing. This study found that the channel of East Fork Silver Creek above Highland Silver Lake is incised in all locations, except a short reach of about 4,000 feet where a natural rock outcrop in the channel bed has prevented the downcutting process. This report recommends installation of Rock Riffle Grade controls at a spacing of approximately 6 bankfull widths to reduce bank erosion, prevent additional incision and subsequent bank failure, dissipate energy, increase aeration and instream dissolved oxygen and reduce sediment loadings to Highland Silver Lake.

GIS ANALYSIS

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus loads. Within the GIS, maps were generated to show areas with steep slopes (Figure 2), highly erodible soils (Figure 3), and finally, priority areas for BMPs (Figure 4). The priority areas are defined as agricultural areas that have both steep slopes and highly erodible soils. Priority areas are logical locations for targeting phosphorus control projects, to maximize the benefit of the controls. Other locations that should be investigated for control projects are those that have either erodible soils or steep slopes, because both of these characteristics make soil more prone to erosion.

GIS analysis was also used to investigate the presence of hydric soils in each lake's watershed to determine whether wetland restoration or creation is a viable option within this watershed. To support this analysis, areas having hydric soils, which are not already developed, forested, or covered by water or wetlands were identified. A significant proportion (38%) of the Highland Silver Lake watershed was identified as being potentially suitable for wetland restoration or creation. These areas are shown in Figure 5.

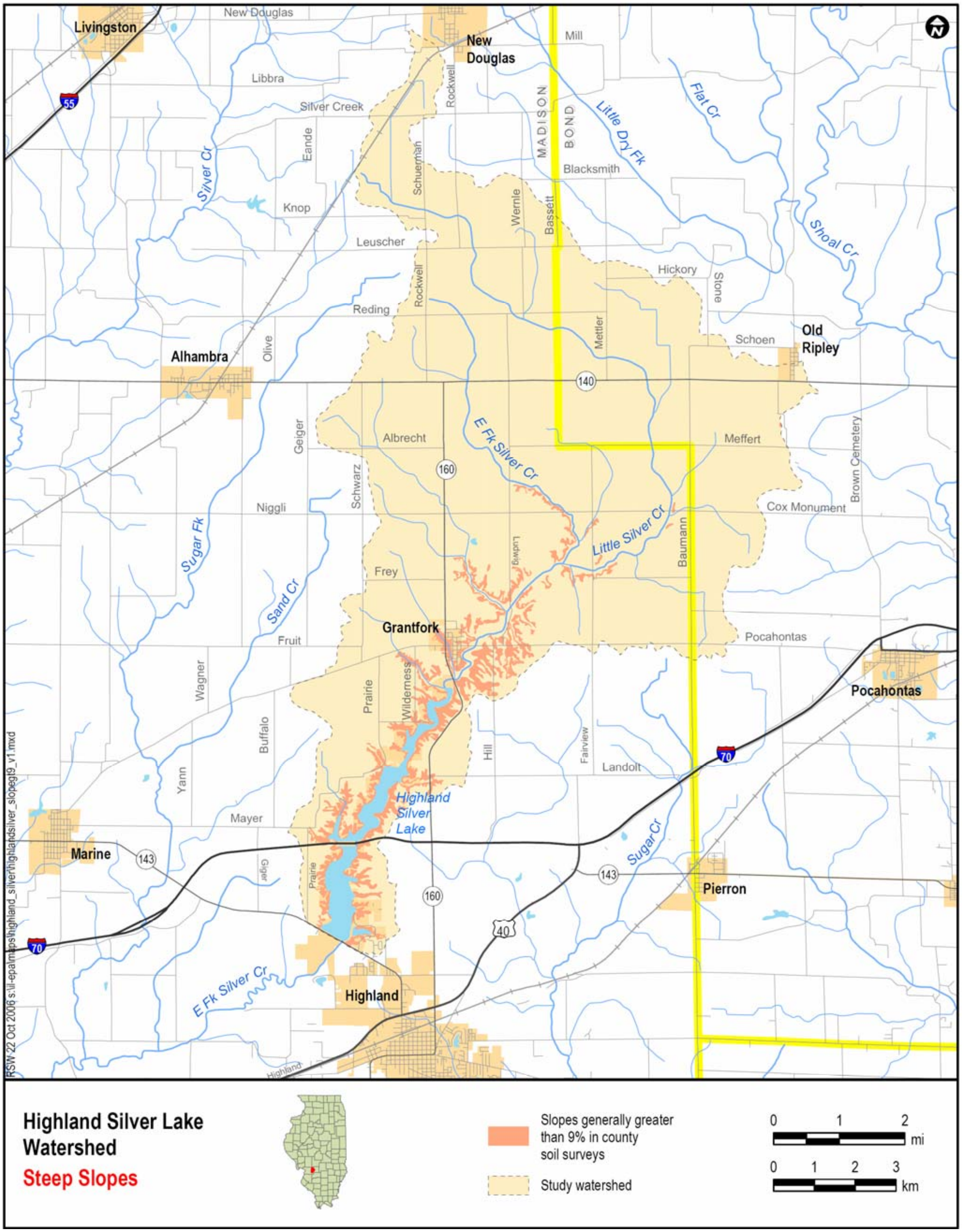

Figure 2. Areas with Steep Slopes

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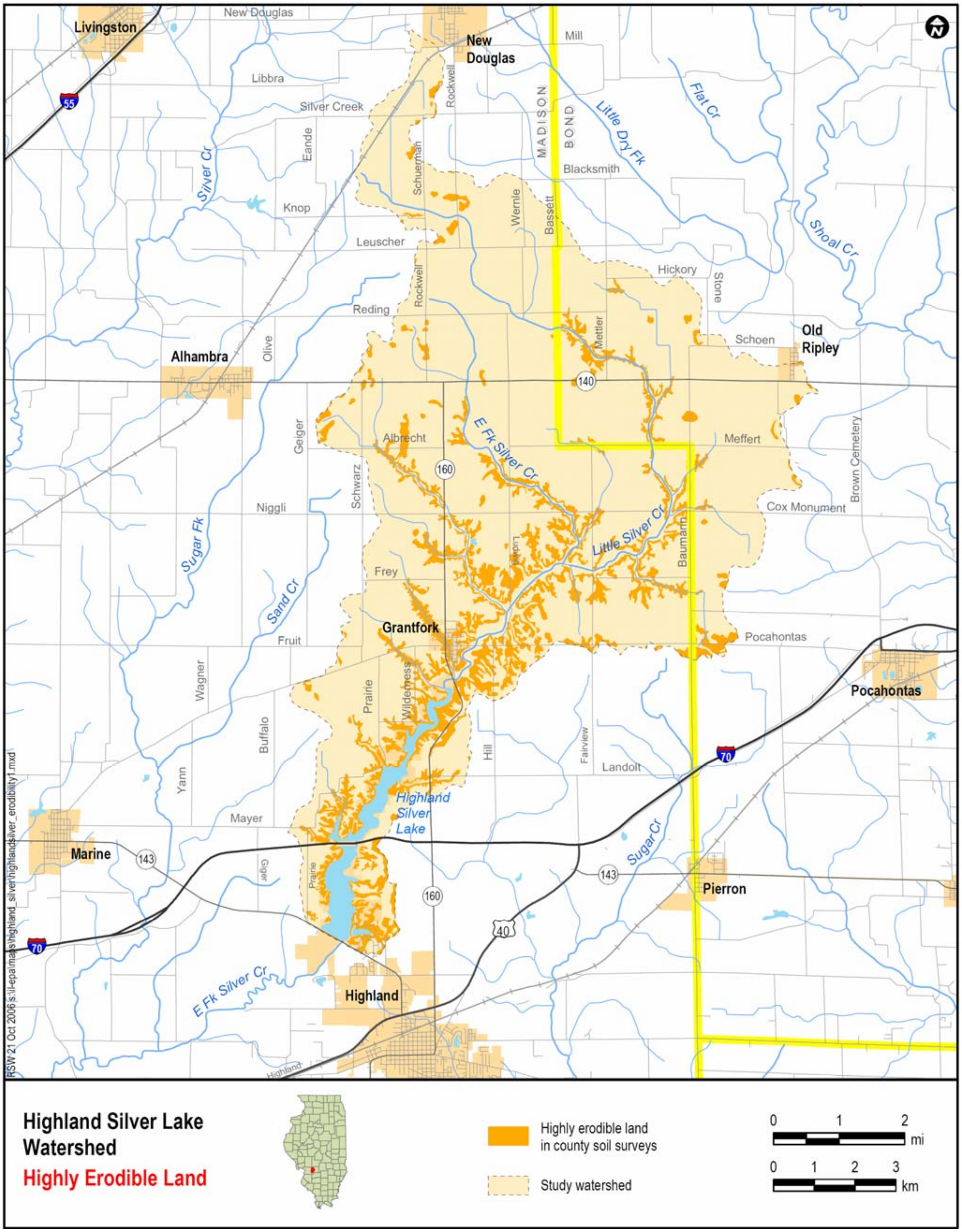

Figure 3. Areas with Highly Erodible Soils

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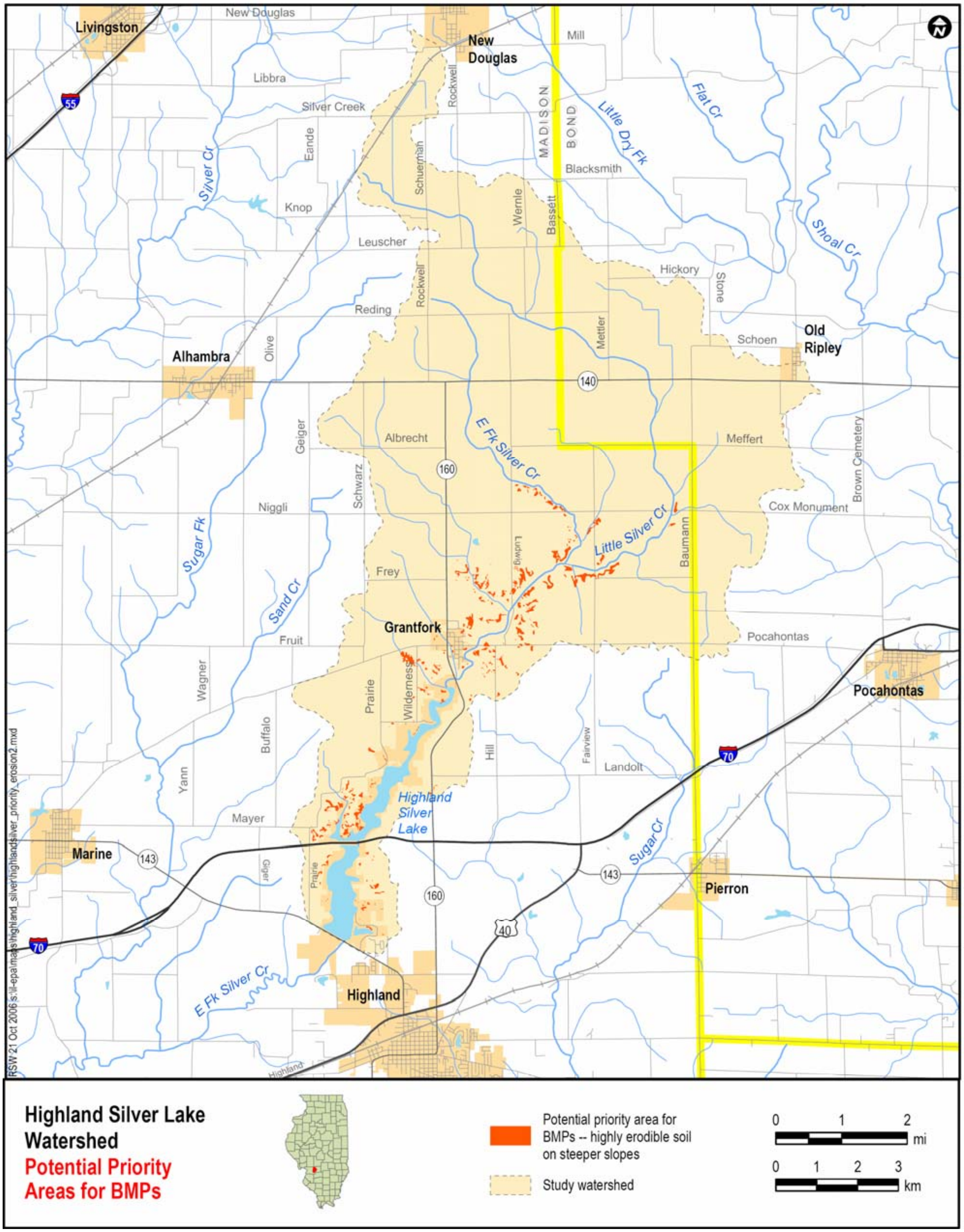

Figure 4. Potential Priority Areas for Best Management Practices

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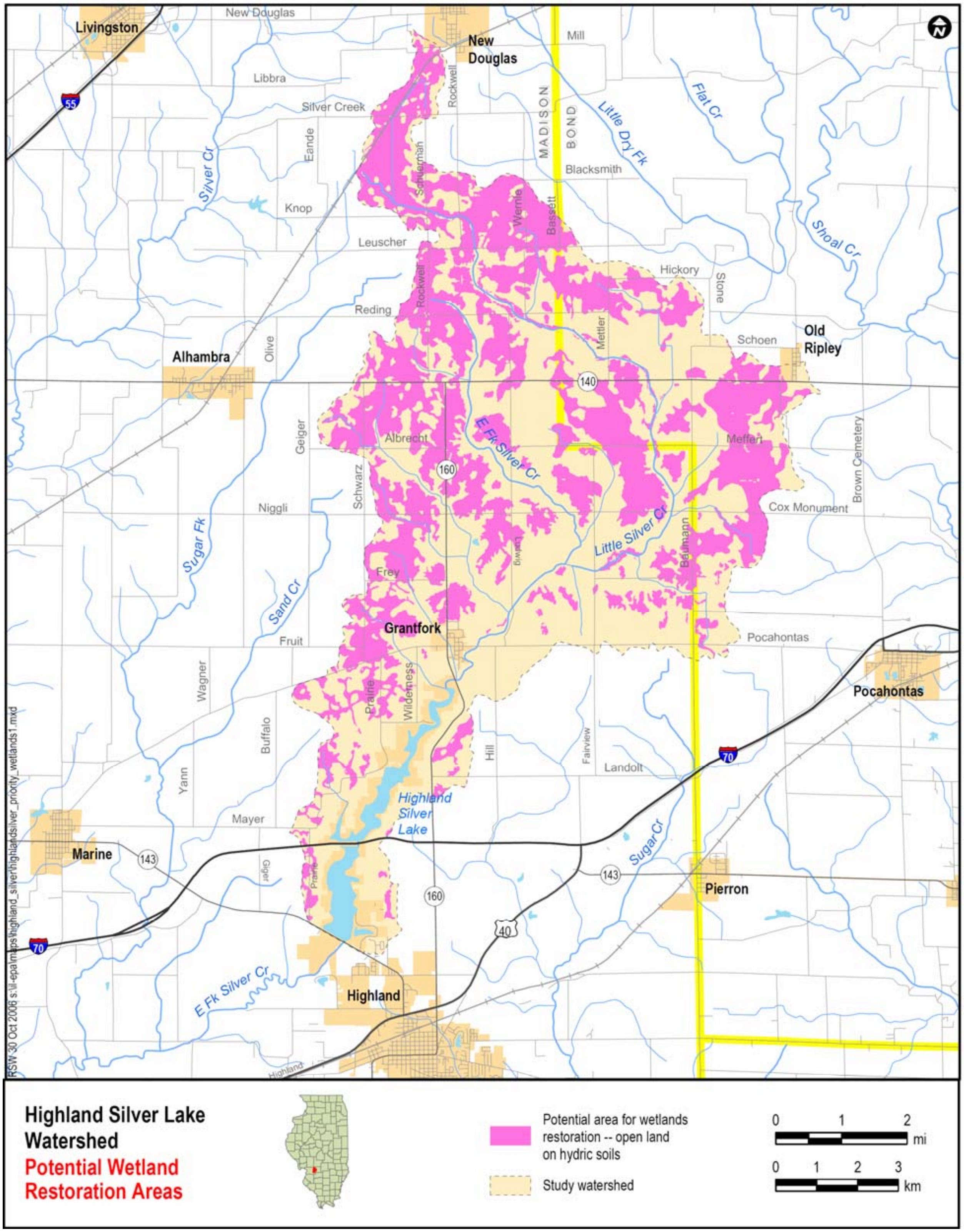

Figure 5. Potential Wetland Restoration Areas

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REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting, and CAFO permitting. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. The permit for the only point source discharger in the watershed (Highland Water Treatment Plant) will be modified if necessary to ensure it is consistent with the applicable wasteload allocation. This permit expired in November 2004 and is currently in the process of being reissued.

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing non-point source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including the following:

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water

resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.

- *Conservation Practices Cost-Share Program* (http://www.agr.state.il.us/Environment/conserv/index.html). Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.
- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. It has been suggested that participation in this program could be increased if local sources such as the City of Highland provided some additional funding to supplement the CRP funds and encourage greater participation (MCSWCD, 2006a).
- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Madison County SWCD staff indicated that there probably is land eligible for this program in the Highland Silver Lake watershed, although there has not been interest in the program (MCSWCD, 2006a). Figure 5 shows potential wetland restoration areas. These are areas with hydric soils, that are not currently developed, covered by water or forested.
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.
- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private

lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Using the results of future monitoring to conduct adaptive management

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MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network; an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Highland Silver Lake is also considered a core lake by IEPA, and is monitored approximately every three years. In addition, monitoring was conducted as part of a Phase 1 Clean Lakes Study between September 2004 and October 2005, at three in-lake stations. The results of that sampling are summarized in the recent report titled Phase 1 Diagnostic/Feasibility Study of Highland Silver Lake, Highland, IL (Cochran & Wilken, 2006). Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lakes.

These ongoing efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

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