Silver Lake Nutrient Loading Project

USGS-MI Water Science Center & GVSU-AWRI

In cooperation with the Silver Lake Improvement Board

Update June 7, 2014

U.S. Department of the Interior
U.S. Geological Survey

Project Problem

- Since 1989, elevated chlorophyll-*a* concentrations were found to be related to persistent algal blooms on Silver Lake
- Elevated chlorophyll-*a* concentrations, high phosphorus concentrations, as well as decreased water clarity
  - Indicated potential accelerated eutrophication during recent years
- A study was needed to characterize the water and nutrient sources to Silver Lake

USGS

Project Objectives

- Characterize hydrologic inputs & outputs and develop water and nutrient budgets for Silver Lake

- Provide information to local water managers & stakeholders to help identify nutrient sources and loads to Silver Lake

USGS

PROJECT TASKS

USGS

Task 1:
Groundwater Reconnaissance **(COMPLETED)**

- Temporary wells (piezometers) were used to sample groundwater
  - Measured water chemistry and nutrients
- Results were used to identify 4 locations for longer-term groundwater monitoring

USGS

Task 2:
Septic and Groundwater Influence **(ONGOING)**

- Monitor groundwater levels and nutrient chemistry for 2 years using 4 piezometers (North, South, East, & West)

- Measure 10 private wells for one year to supplement groundwater flow data (water levels)
- Observe groundwater flow by installing seepage meters

Task 3: Monitoring Surface Water Flow & Water Budget Data Analysis **(ONGOING)**

- Install & operate a continuous stream gage on Hunter Creek
- Install & monitor staff gage at the Silver Lake channel dam
- Collect atmospheric data
  - Determine evaporation and evapotranspiration rates using existing data sources

USGS

Task 3 cont…

- Establish a water budget

Water Budgets: Foundations for Effective Water-Resources and Environmental Management

By Richard W. Healy, Thomas C. Winter, James W. LaBaugh, and O. Lehn Franke

A The Water-Budget Equation

The water-budget equation is simple, universal, and adaptable because it relies
movement and storage. A basic water budget for a small watershed can be expresse

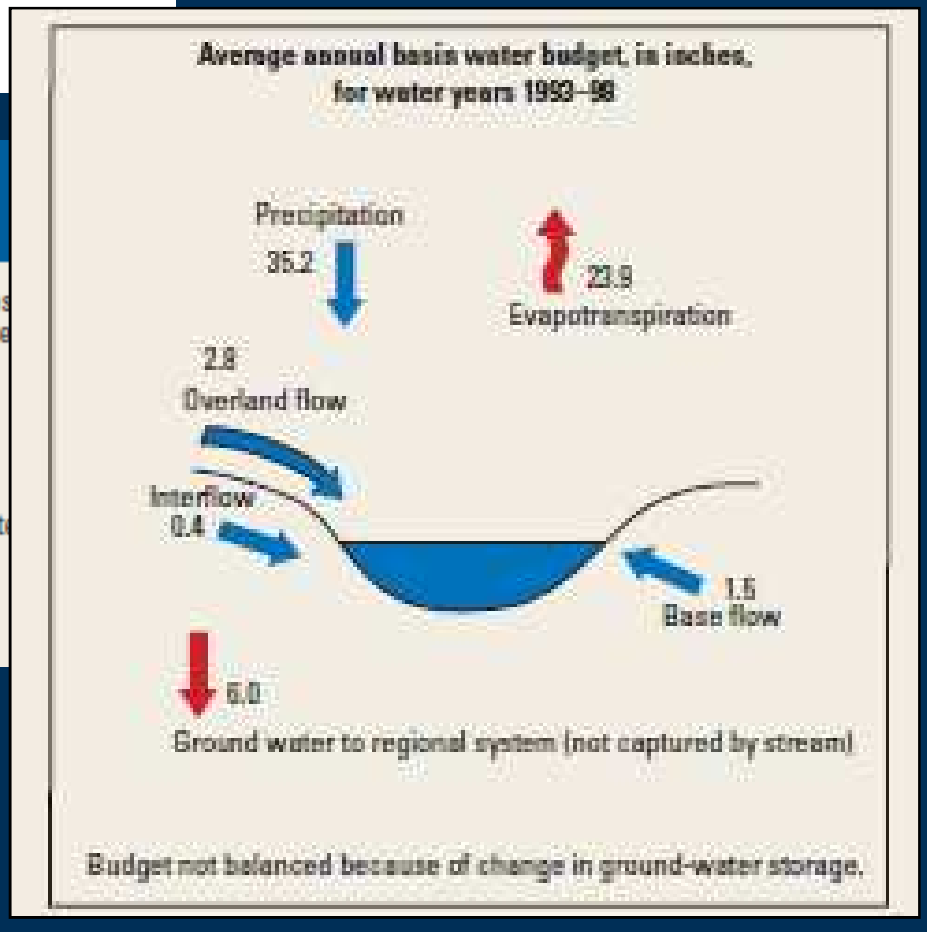
$$P + Q_{in} = ET + \Delta S + Q_{out}$$

where

- P is precipitation,
- Q_{in} is water flow into the watershed,
- ET is evapotranspiration (the sum of evaporation from soils, surface-wat
- ΔS is change in water storage,

and

- Q_{out} is water flow out of the watershed.



USGS

Task 4: Water Chemistry **(ONGOING)**

- Monitoring lake and stream chemistry 4 times per year for 2 years, plus 2-3 storm events (annually)

- 5 monitoring locations on lake
  - Water temp, DO, Conductivity, pH
  - Secchi disc transparency
  - Chlorophyll-*a*, phytoplankton, N, P (surface & bottom)
  - Common ions, color, turbidity, alkalinity, total dissolved solids, and silica (Middle site, 1x per year)
- Hunter Creek, Trib at State Pk, Trib at N Shore Drive, and Silver Creek:
  - Turbidity, chlorophyll-*a*, phytoplankton, N, P

Task 4 cont…

- Discharge measurements at Hunter Creek and Silver Creek
- Groundwater chemistry & drainage tiles for N & P
- Explore lake changes in response to reduction in nutrients from identified source(s)
  - BATHTUB model
    - Predict lake response to various % reductions in nutrients from identified sources

USGS

Task 5: Other Potential Nutrient Sources or Conditions **(ONGOING)**

- Precipitation
  - Wet (rain and snow) & dry (several days following no ppt) samples to determine nutrient deposition
- Nutrient inputs from lawn runoff and waterfowl
  - Estimated from previously published literature values

USGS

Task 6: Identify Nutrient Controlling Algal Blooms (AWRI) (SPRING/SUMMER 2013)

Task 7: Internal Phosphorus Loading Estimates (AWRI) (2013-14)

USGS

Task 8: Data Interpretation and Reporting **(ONGOING)**

- Presentation of project results to the Silver Lake Improvement Board
- Interpretive report of project study results (Published by Sept. 30th, 2015) (USGS & GVSU-AWRI)
  - Data summary and analysis (Ongoing)
  - Water budget, nutrient budget, groundwater and BATHTUB models (2015)

USGS

PROJECT RESULTS

Project Results

- It is important to note that the monitoring for this project is not completed

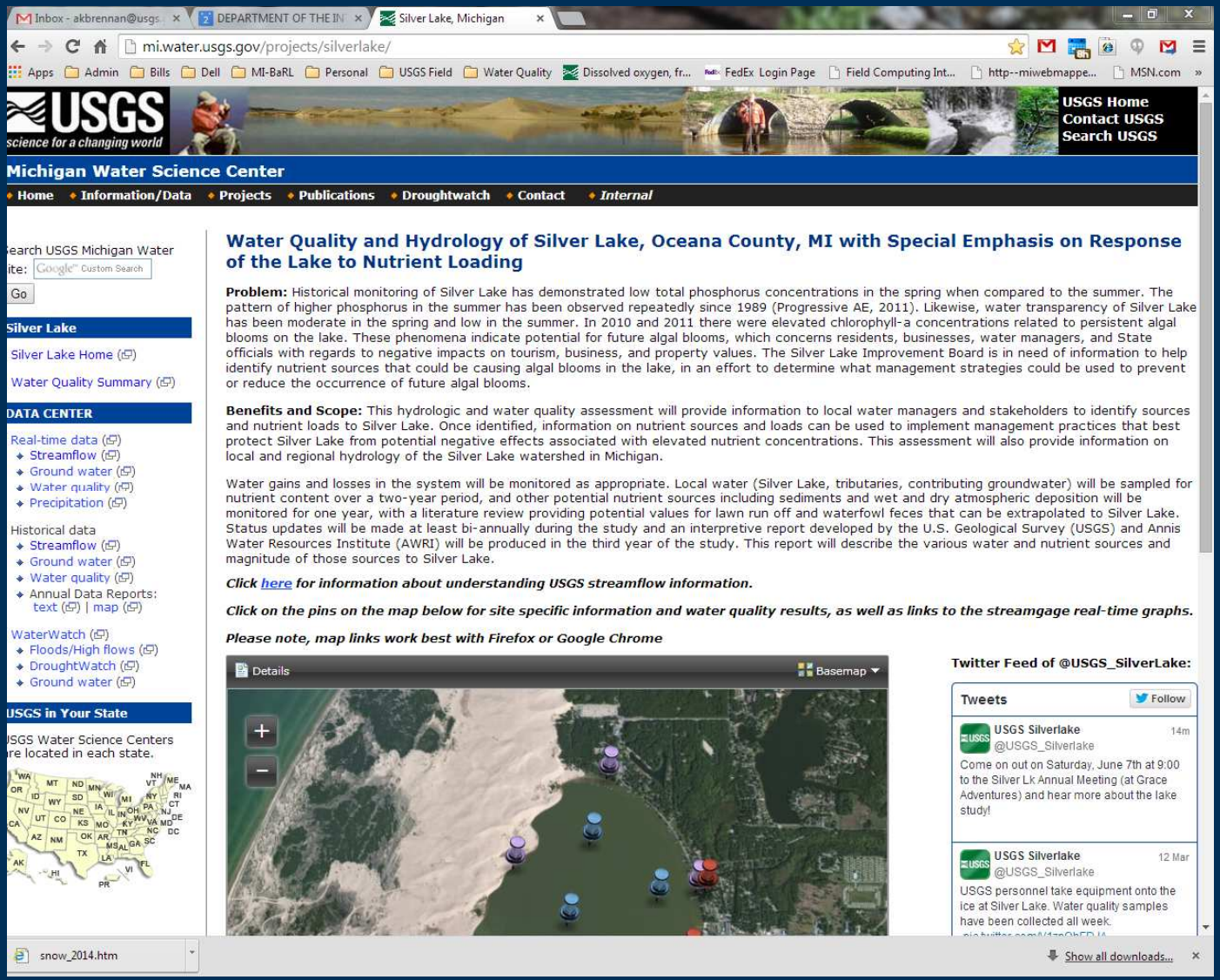
- Thus the data analysis and results may change as a result of additional data (data is preliminary) & subject to revision

USGS

USGS Project results - Website

USGS Silver Lake Website

mi.water.usgs.gov/projects/silverlake/



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Water Quality Summary

DATA CENTER

Real-time data
- Streamflow
- Ground water
- Water quality
- Precipitation

Historical data
- Streamflow
- Ground water
- Water quality
- Annual Data Reports: text | map

WaterWatch
- Floods/High flows
- DroughtWatch
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USGS in Your State

USGS Water Science Centers are located in each state.

identify nutrient sources that could be causing algal blooms in the lake, in an effort to determine what management strategies could be used to prevent or reduce the occurrence of future algal blooms.

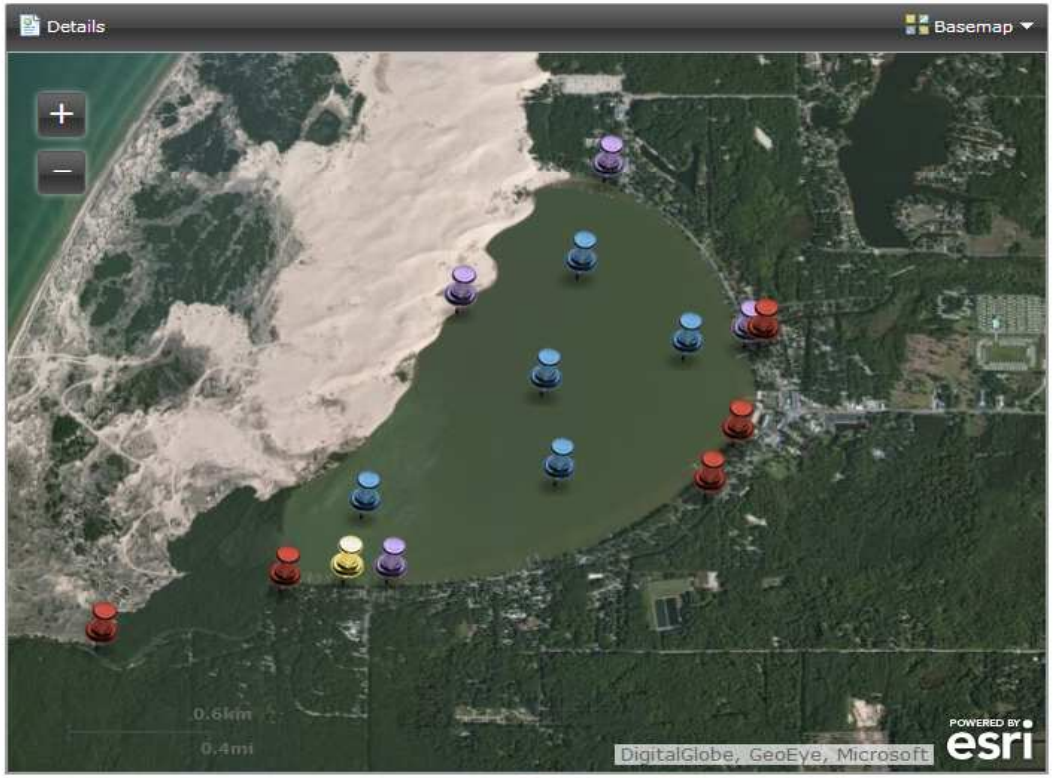
Benefits and Scope: This hydrologic and water quality assessment will provide information to local water managers and stakeholders to identify sources and nutrient loads to Silver Lake. Once identified, information on nutrient sources and loads can be used to implement management practices that best protect Silver Lake from potential negative effects associated with elevated nutrient concentrations. This assessment will also provide information on local and regional hydrology of the Silver Lake watershed in Michigan.

Water gains and losses in the system will be monitored as appropriate. Local water (Silver Lake, tributaries, contributing groundwater) will be sampled for nutrient content over a two-year period, and other potential nutrient sources including sediments and wet and dry atmospheric deposition will be monitored for one year, with a literature review providing potential values for lawn run off and waterfowl feces that can be extrapolated to Silver Lake. Status updates will be made at least bi-annually during the study and an interpretive report developed by the U.S. Geological Survey (USGS) and Annis Water Resources Institute (AWRI) will be produced in the third year of the study. This report will describe the various water and nutrient sources and magnitude of those sources to Silver Lake.

Click here for information about understanding USGS streamflow information.

Click on the pins on the map below for site specific information and water quality results, as well as links to the streamgage real-time graphs.

Please note, map links work best with Firefox or Google Chrome



Legend

Twitter Feed of @USGS_SilverLake:

Tweets — Follow

USGS Silverlake @USGS_Silverlake — 14m
Come on out on Saturday, June 7th at 9:00 to the Silver Lk Annual Meeting (at Grace Adventures) and hear more about the lake study!

USGS Silverlake @USGS_Silverlake — 12 Mar
USGS personnel take equipment onto the ice at Silver Lake. Water quality samples have been collected all week.
pic.twitter.com/V1zpQhFDJA
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USGS Silverlake @USGS_Silverlake — 26 Feb
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Expand

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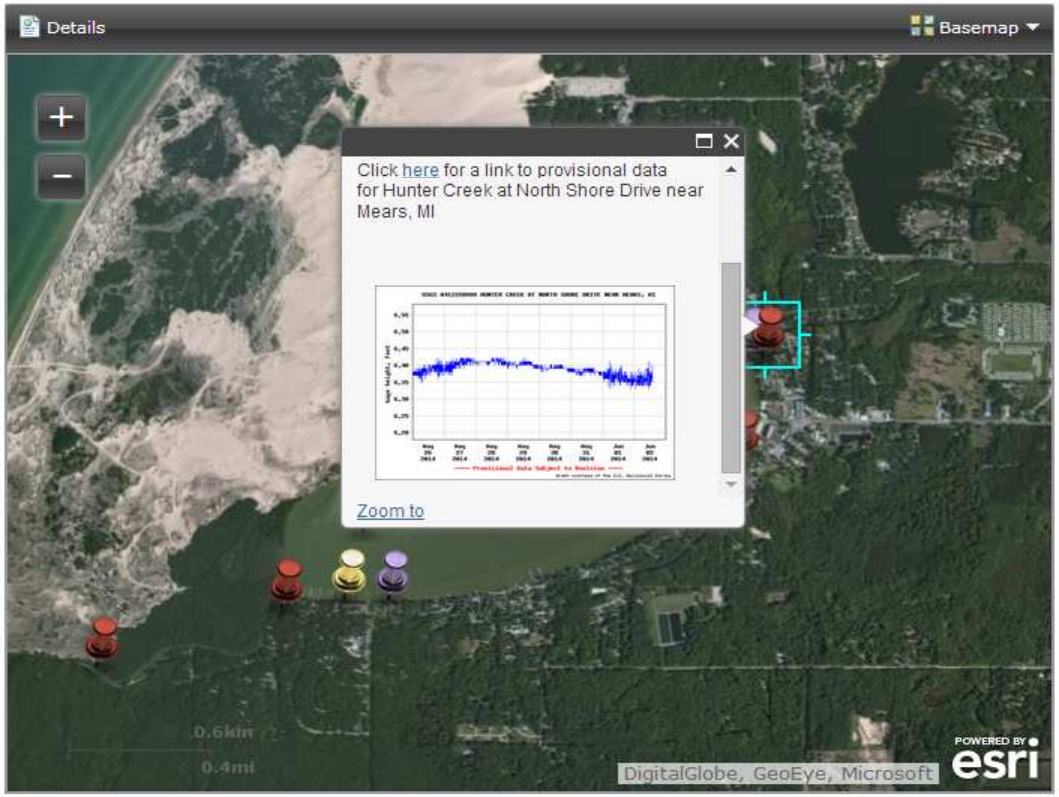

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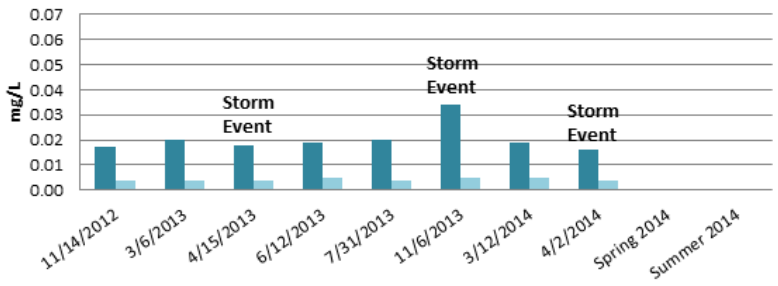
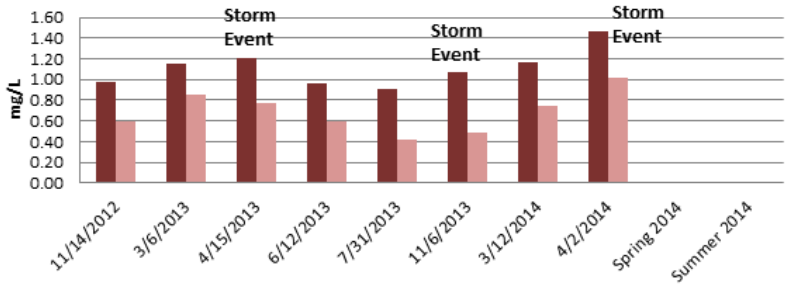
Selected Silver Lake Water Quality Parameters by Date *(Oceana Co., MI)*

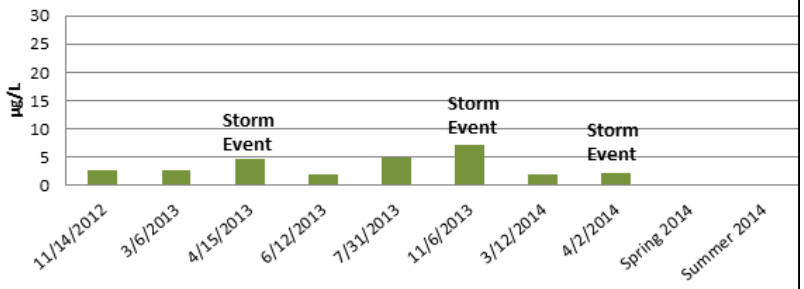
Hunter Creek - Total Phosphorus & Orthophospha



Hunter Creek - Total Nitrogen & Nitrite + Nitrate



Hunter Creek - Chlorophyll *a*



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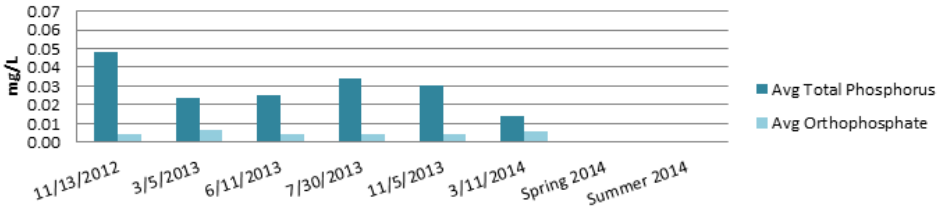
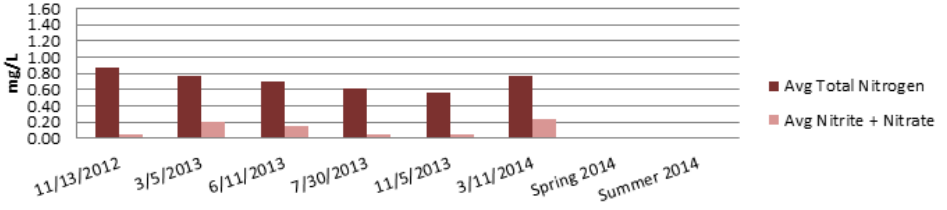
For more information, visit nwis.waterdata.usgs.gov/nwis/qw

Selected Silver Lake Water Quality Parameters by Date *(Oceana Co., MI)*

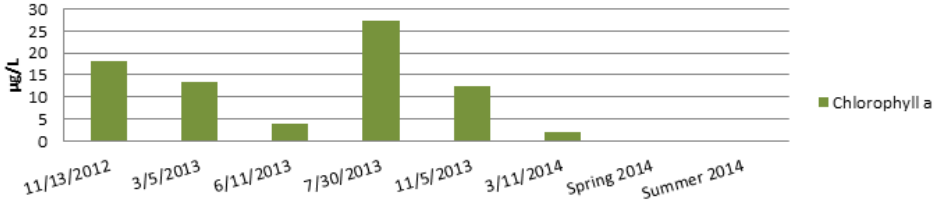
Silver Lake Middle - Average Total Phosphorus & Orthophosphate



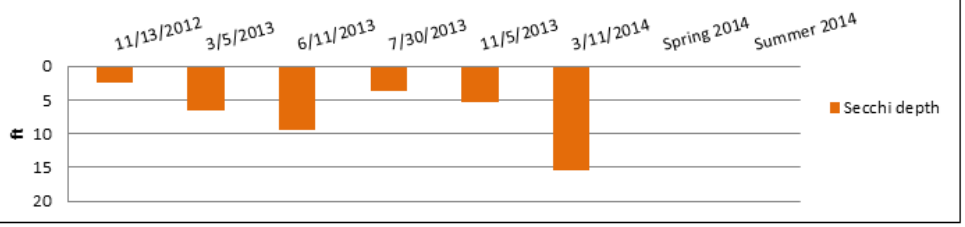
Silver Lake Middle - Average Total Nitrogen & Nitrite + Nitrate



Silver Lake Middle - Chlorophyll *a*



Silver Lake Middle - Secchi Disc Depth (Transparency)



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A Brief Summary - Water Quality and Nutrients in Michigan Inland Lakes

Why Study Lakes in Michigan?

In the State of Michigan, there are more than 11,000 inland lakes. Lakes have always been important natural resources and are highly valued for their recreational, aesthetic, and scenic qualities. In Michigan alone, the lake recreational industry is estimated to bring $15 billion per year to the State (Stynes, D.J., 2002, Michigan statewide tourism spending and economic impact estimates, 1998—2000).

Lakes constitute important habitats and food resources for a diverse array of fish, aquatic life, and wildlife, but lake ecosystems are fragile. Lake ecosystems can undergo rapid environmental changes, often leading to significant declines in their aesthetic, recreational, and aquatic ecosystem functions. Exposed to external effects from the atmosphere, their watersheds, and ground water, lakes are subject to change through time. Human activities can further accelerate the rates of change. If the causes of the changes are known, however, human intervention (lake-management practices) sometimes can control, or even reverse, detrimental changes (USGS Fact Sheet 063-03, 2003, "Why Study Lakes? An Overview of USGS Lake Studies in Wisconsin").

Why are Nutrients Important?

Nutrients are essential for natural plant and animal growth. However, excessive concentrations of nutrients can adversely affect aquatic life and human health. Elevated nutrient concentrations in streams and lakes can trigger eutrophication, which results in excessive, often unsightly, growth of algae and other aquatic plants. As the plants and algae decay, there are often foul odors associated with the decay as well as low dissolved oxygen in water (hypoxia) which can harm fish and shellfish. High nutrient concentrations also can cause growth of harmful algae, which can be potentially toxic to fish and other organisms, including humans. (USGS Circular 1359, Nutrients in the Nation's Streams and Groundwater).

A Summary of Nutrients

Nutrients can come from natural sources such as eroding soils, decomposing plant material, and wildlife waste. However excess nutrients enter surface waters from point source discharges (a discrete pipe) as well as non-point sources (overland runoff).

In Michigan, nutrient control has focused on phosphorus since the majority of surface waters are limited in this nutrient. Nitrogen reductions have been necessary when this nutrient was considered the limiting factor for plant productivity or has been the direct cause of water quality impairment (Michigan Department of Environmental Quality (MDEQ) Michigan Framework to Reduce Phosphorus and Nitrogen Pollution).

Phosphorus

Phosphorus plays a major role in biological metabolism, and is an essential nutrient used by all organisms for the basic processes of life. Its natural source is the weathering and leaching of phosphate-rich geological formations. However, phosphorus is used extensively in agricultural and residential fertilizers, and is a component of domestic sewage (wastewater discharge, failing septic systems). Phosphorus can also enter the system through wet and dry deposition, waterfowl feces, and plant decomposition. Phosphorus is considered a limiting nutrient in most midwestern lakes, as phosphorus typically "limits" aquatic plant growth (macrophytes and algae) because it is less available for uptake than other nutrients, such as nitrogen, in aquatic systems (Robert Wetzel, "Limnology", 2nd ed., 1983). Aquatic plants may struggle to grow in lakes with little to no phosphorus, but may grow rapidly in systems with excessive amounts of phosphorus.

Orthophosphate (Soluble Reactive Phosphorus)

Orthophosphate typically constitutes only a small percent (<5%) of total phosphorus, however orthophosphate represents the fraction of total phosphorus that is immediately available to plants and animals for growth. Because it is so readily available, small increases in orthophosphate

snow_2014.htm
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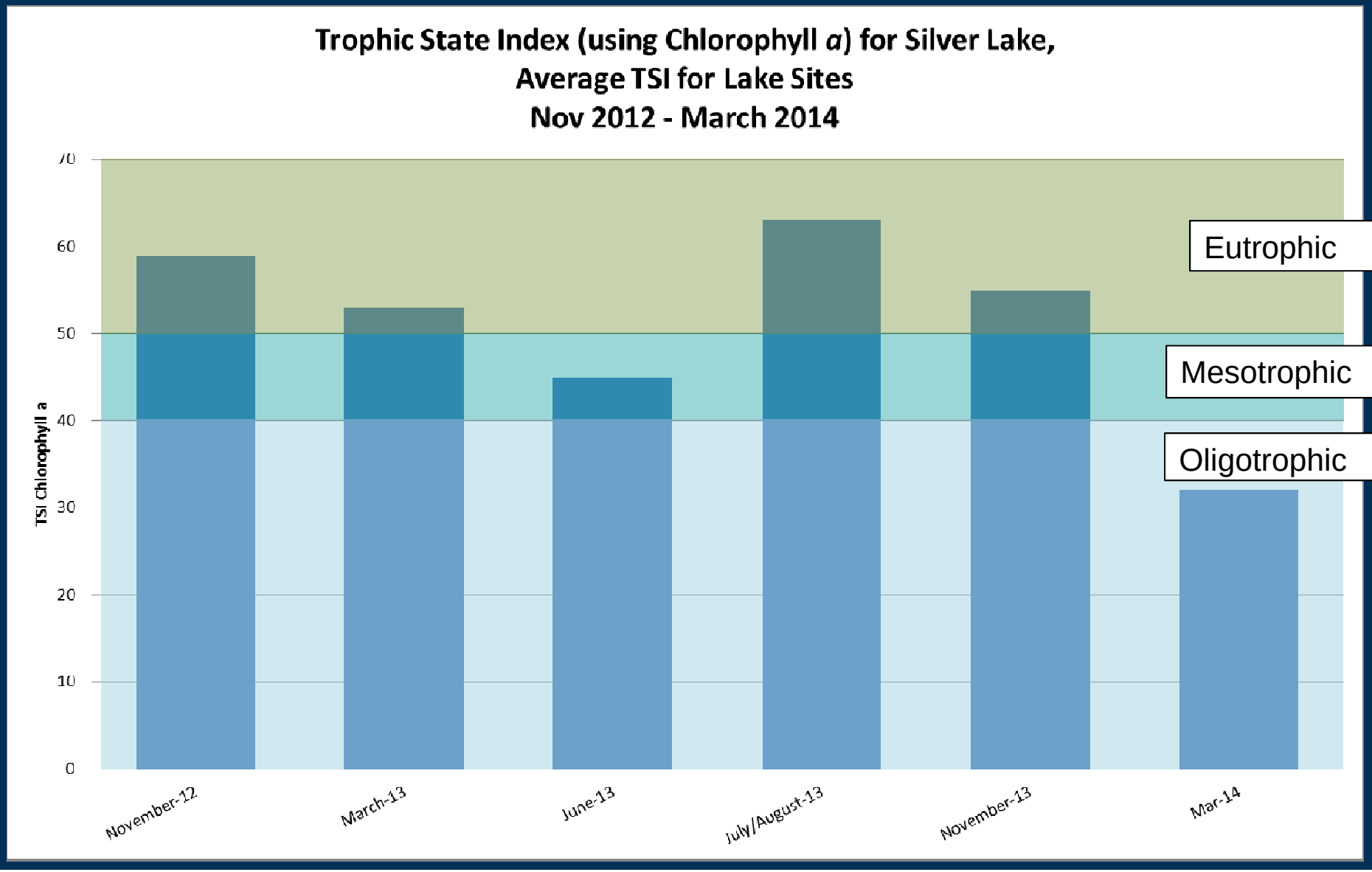
USGS Project results – Trophic Status

- Chlorophyll *a*, is an indicator of water quality and is frequently used as a measure of algal biomass

- Chlorophyll *a* is often used to determine the **trophic status** of a lake, or the plant biological productivity of the lake

USGS

USGS Project results – Trophic Status

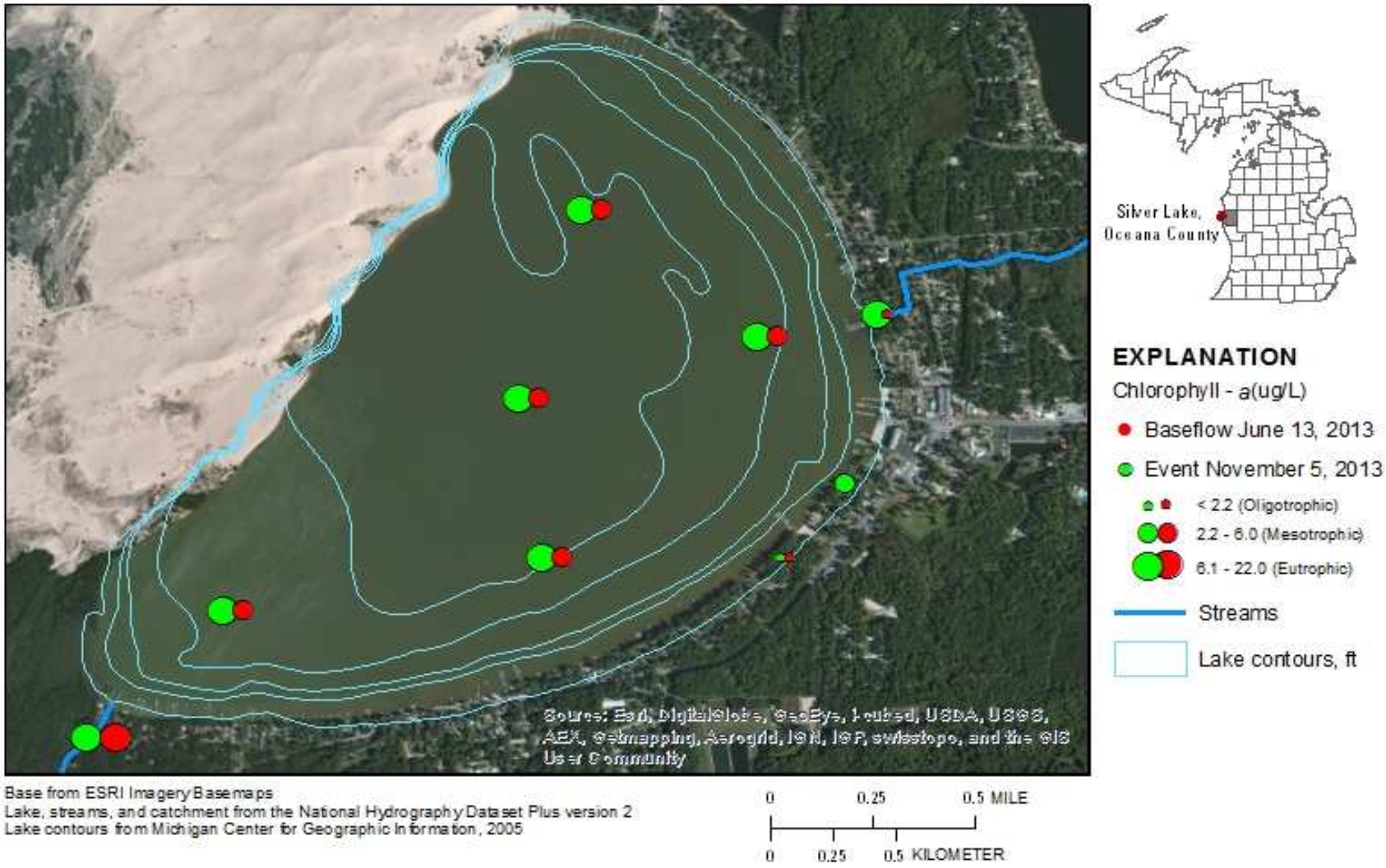


USGS Project Results – Nutrients

- Nutrients
  - Essential for natural plant and animal growth
  - Excessive nutrients can adversely affect aquatic life and human health
  - Elevated nutrient concentrations in streams and lakes can trigger eutrophication, resulting in excessive growth of algae and other aquatic plants
  - High nutrient concentrations also can cause growth of harmful algae

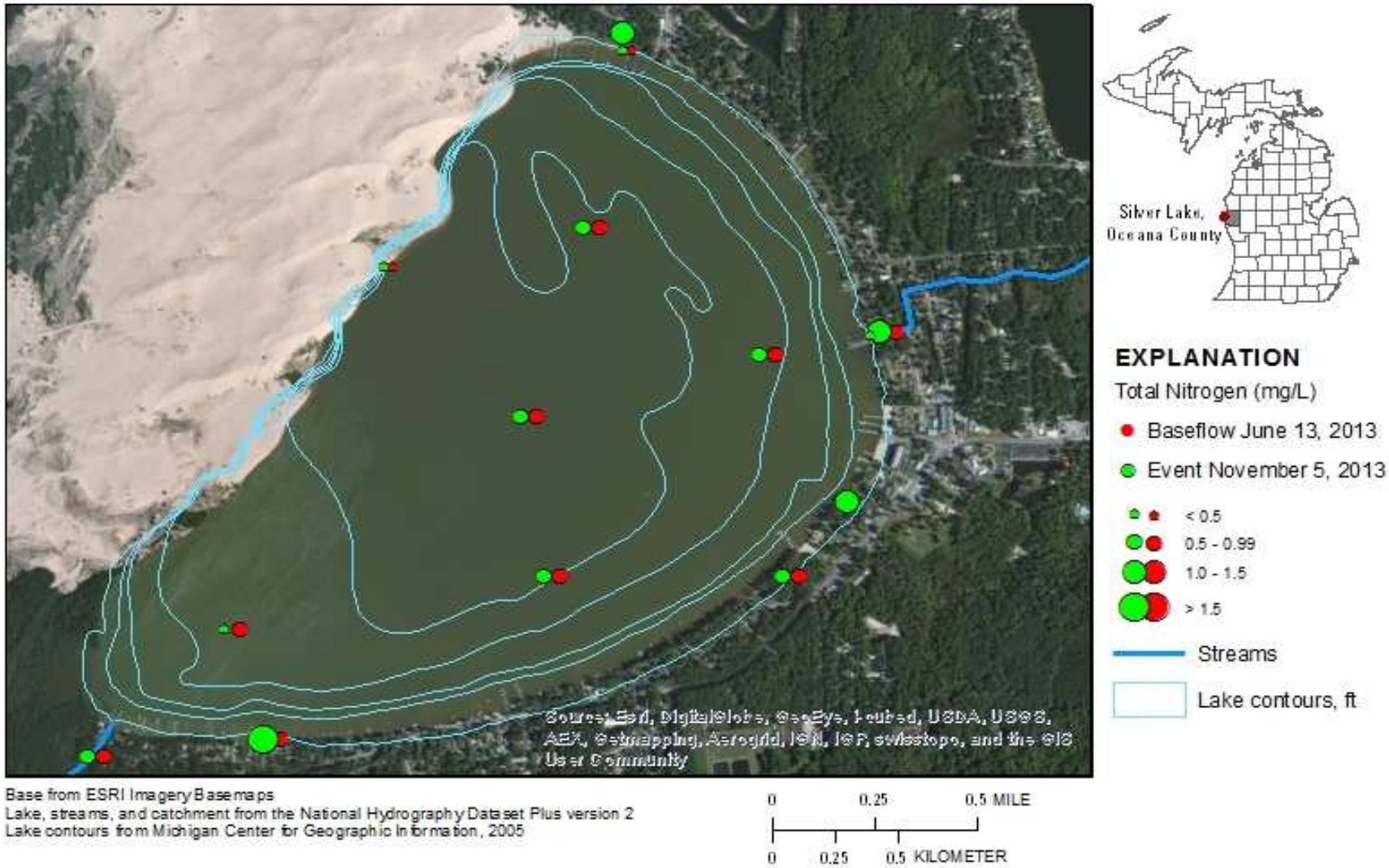
USGS

USGS Project Results – Nutrient Concentrations (Chlorophyll *a*)



Data are preliminary and subject to revision

USGS Project Results – Nutrient Concentrations (Total Nitrogen)



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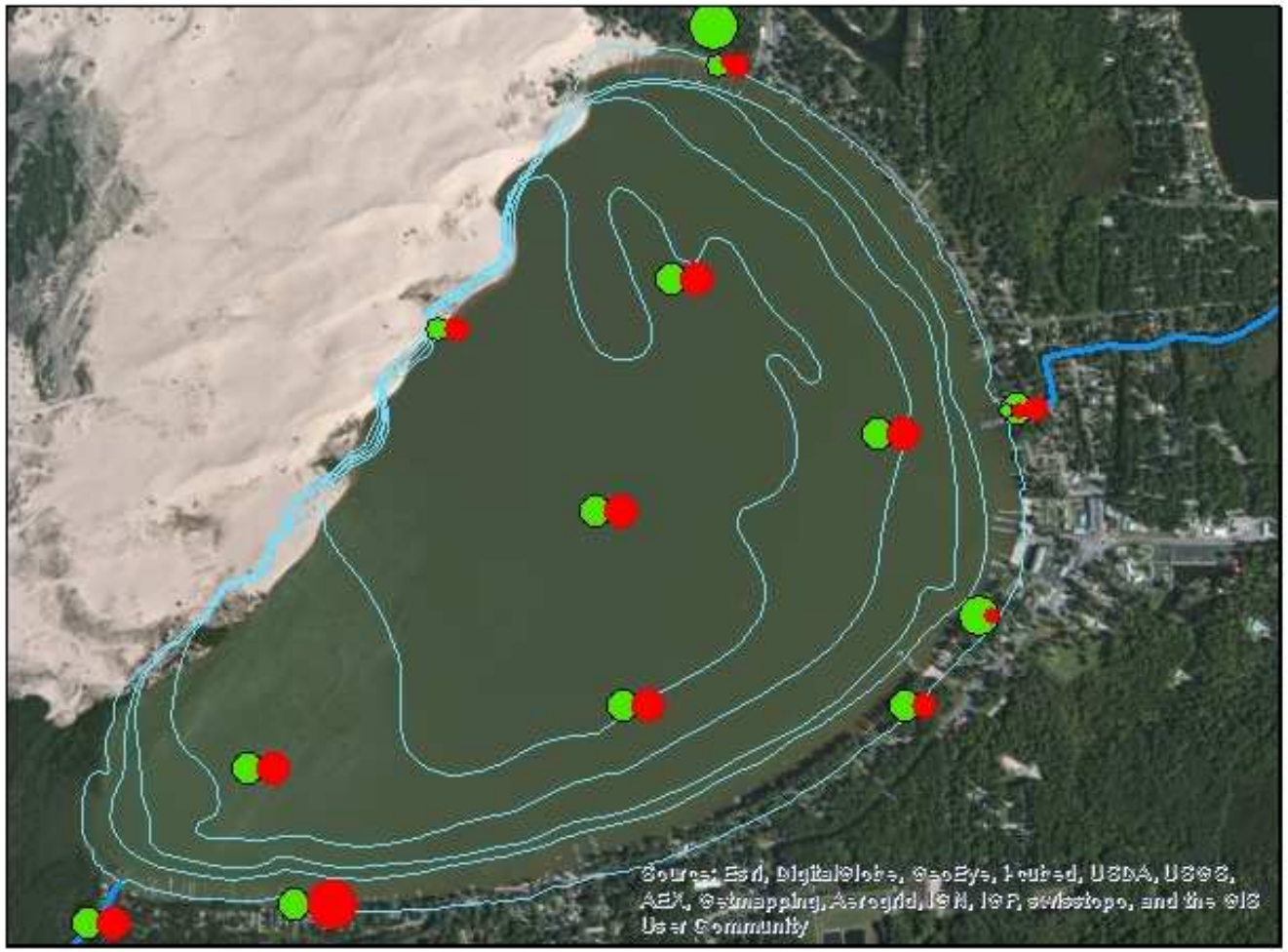

EXPLANATION

Total Phosphorus (mg/L)

- Baseflow June 13, 2013
- Event November 5, 2013

- < 0.01
- 0.01 - 0.02
- 0.021 - 0.05
- 0.051 - 0.08
- > 0.08

- Streams
- Lake contours, ft

Base from ESRI Imagery Basemaps
Lake, streams, and catchment from the National Hydrography Dataset Plus version 2
Lake contours from Michigan Center for Geographic Information, 2005

0 0.25 0.5 MILE

0 0.25 0.5 KILOMETER

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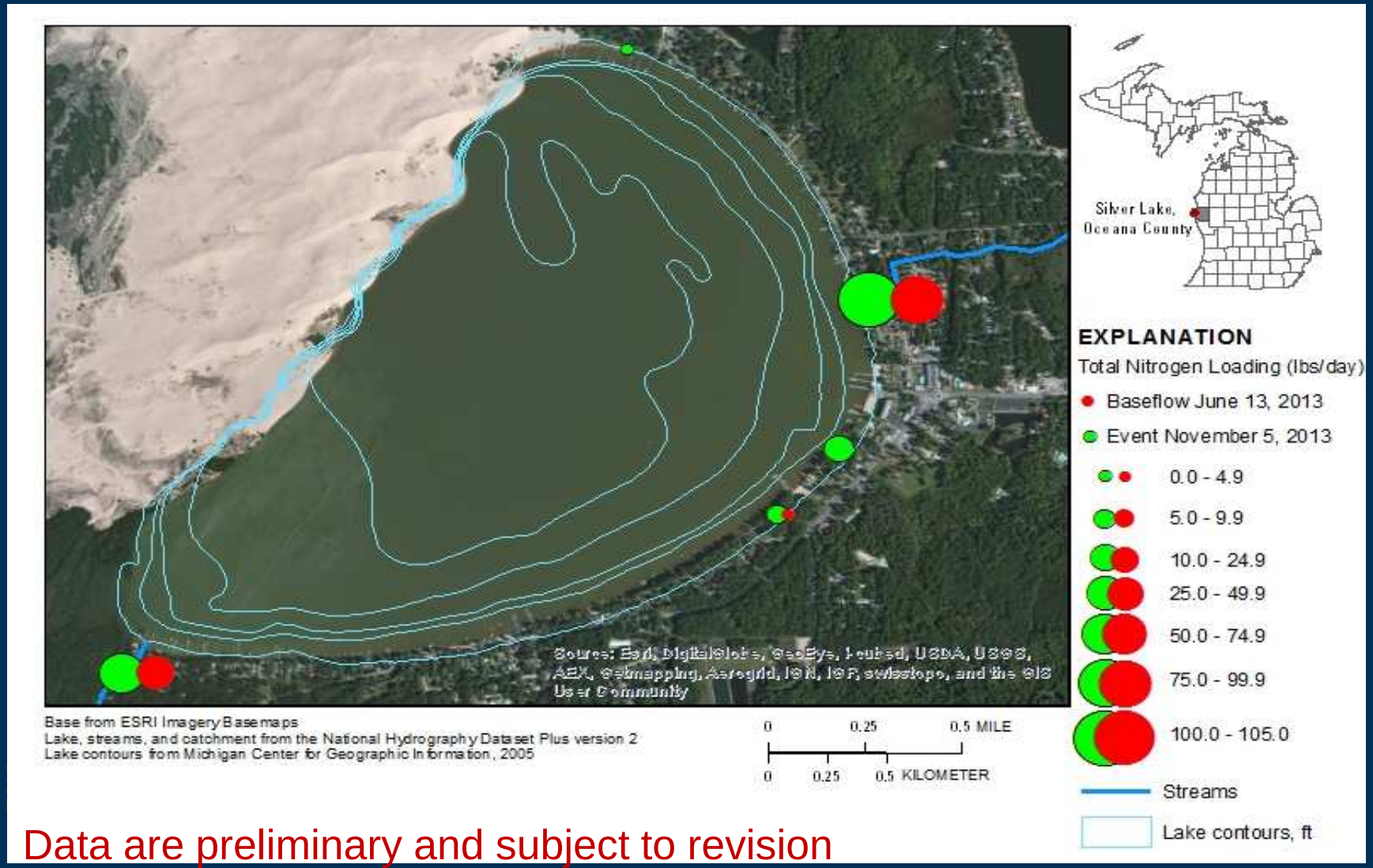
USGS Project Results – Nutrient Loading (Total Nitrogen)



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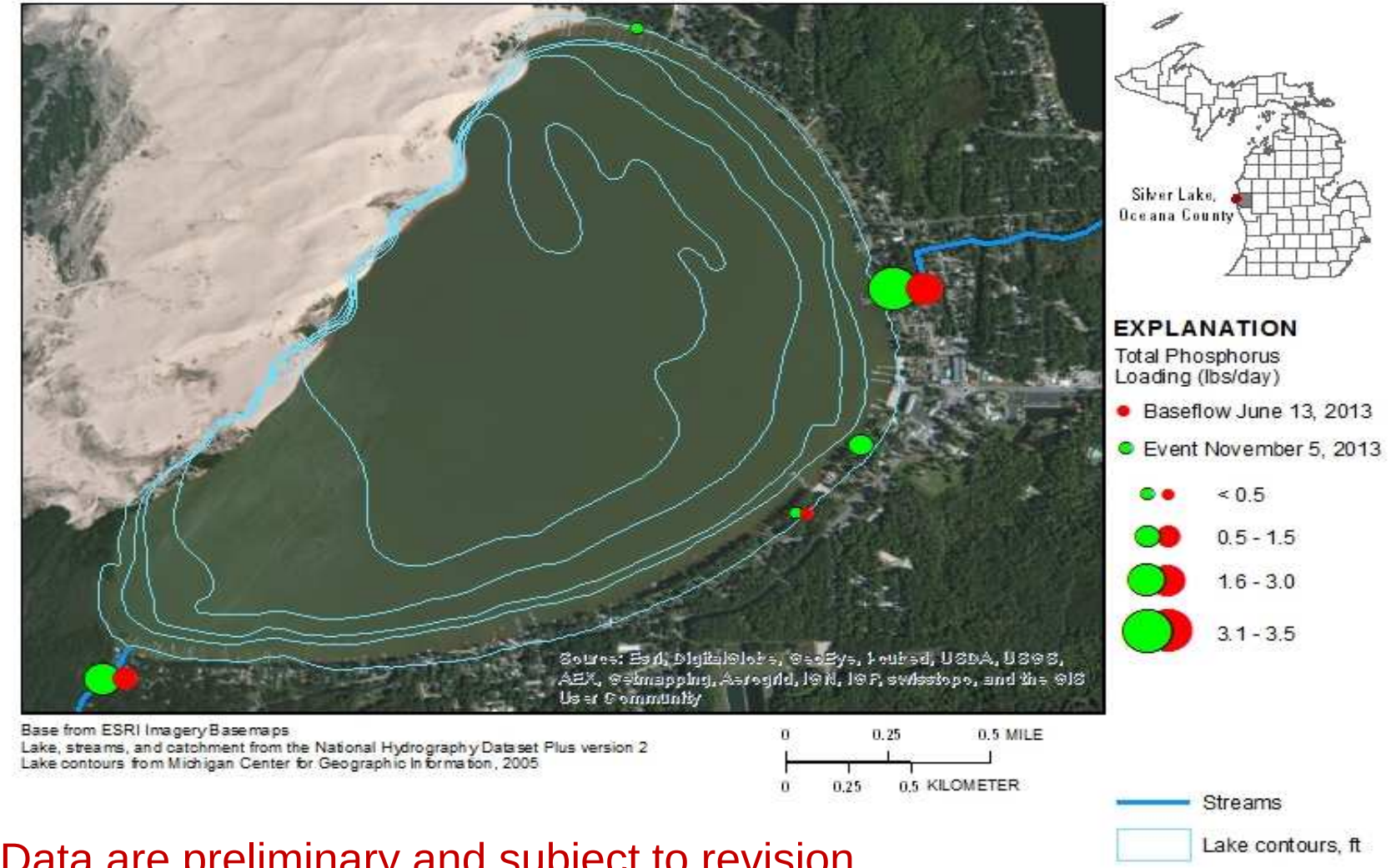

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Next steps

- 2014
  - Complete Spring, Summer, and event sampling
- 2015
  - Decommission stream gage & other equipment
  - Compile final data, build models & scenario testing
  - Report writing, report publication
  - Final presentation to the Silver Lake Improvement Board

USGS

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Joseph Duris,
Water Quality
Specialist

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(517) 887- 8942

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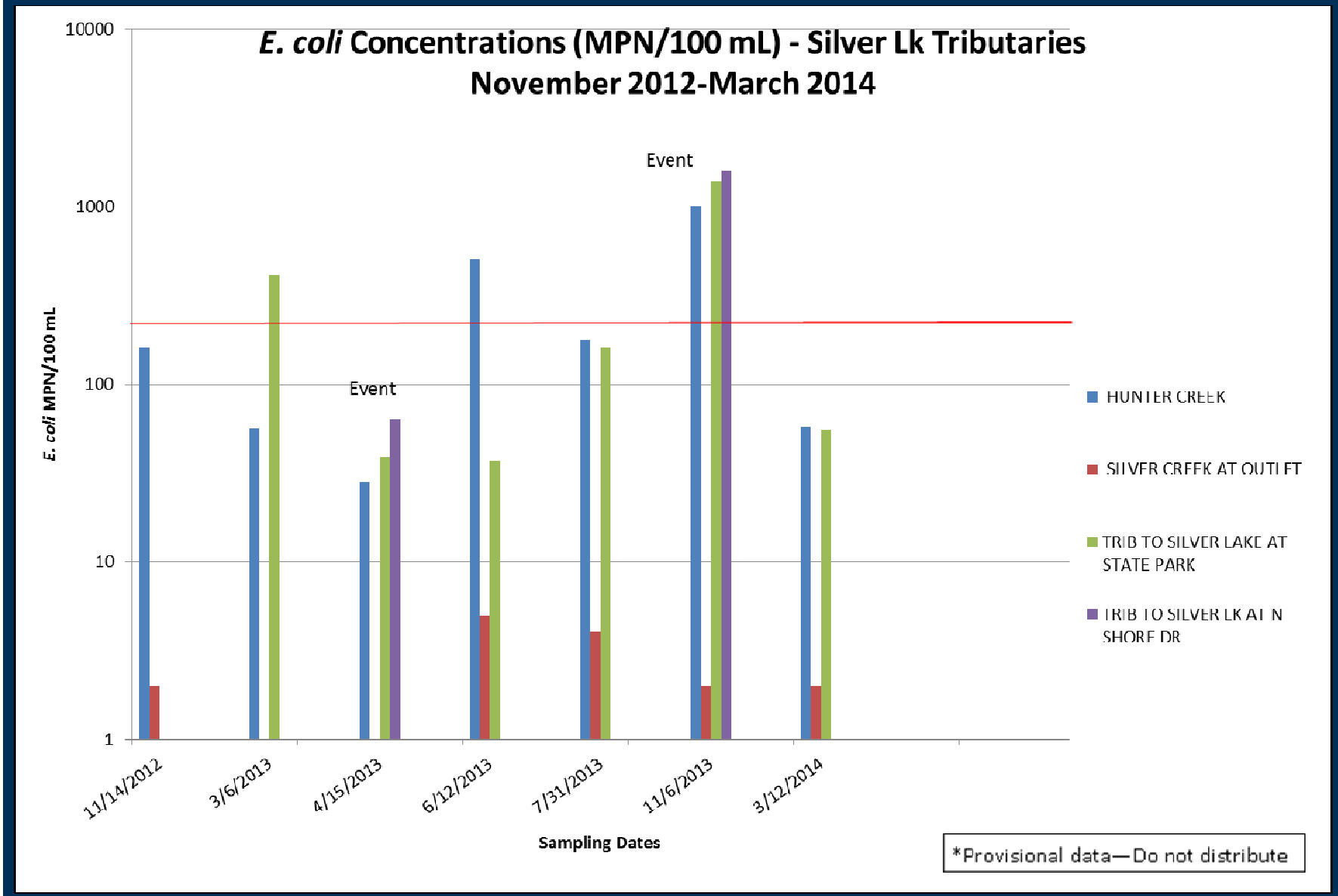
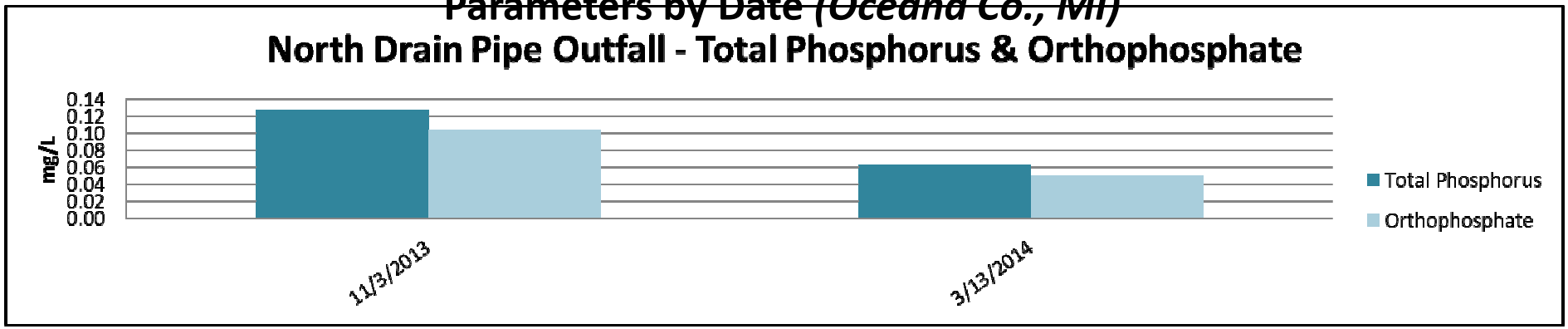
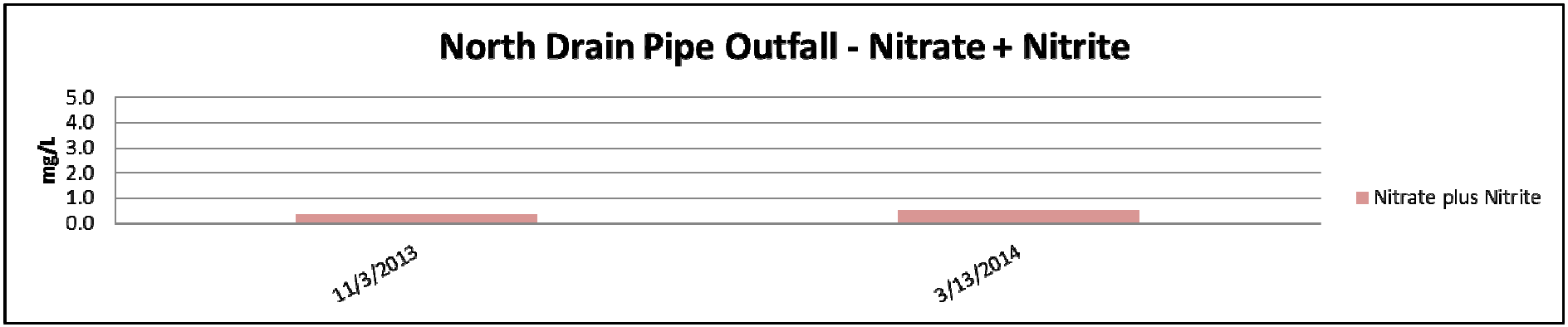
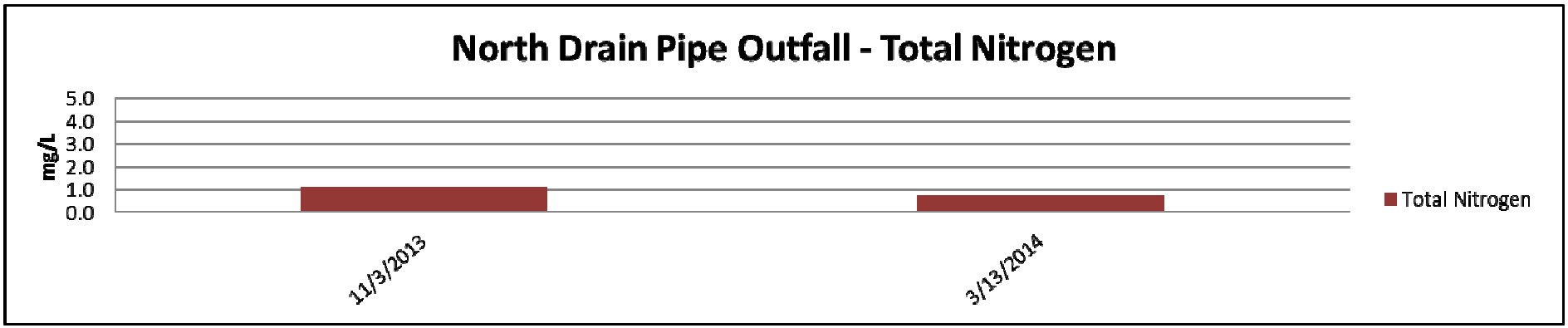
Other data


E. coli Concentrations (MPN/100 mL) - Silver Lk Tributaries
November 2012-March 2014
10000
1000
100
10
1
E. coli MPN/100 mL
Event
Event
11/14/2012
3/6/2013
4/15/2013
6/12/2013
7/31/2013
11/6/2013
3/12/2014
Sampling Dates
HUNTER CREEK
SILVER CREEK AT OUTLET
TRIB TO SILVER LAKE AT STATE PARK
TRIB TO SILVER LK AT N SHORE DR
*Provisional data—Do not distribute

Selected Silver Lake Groundwater Water Quality Parameters by Date *(Oceana Co., MI)*







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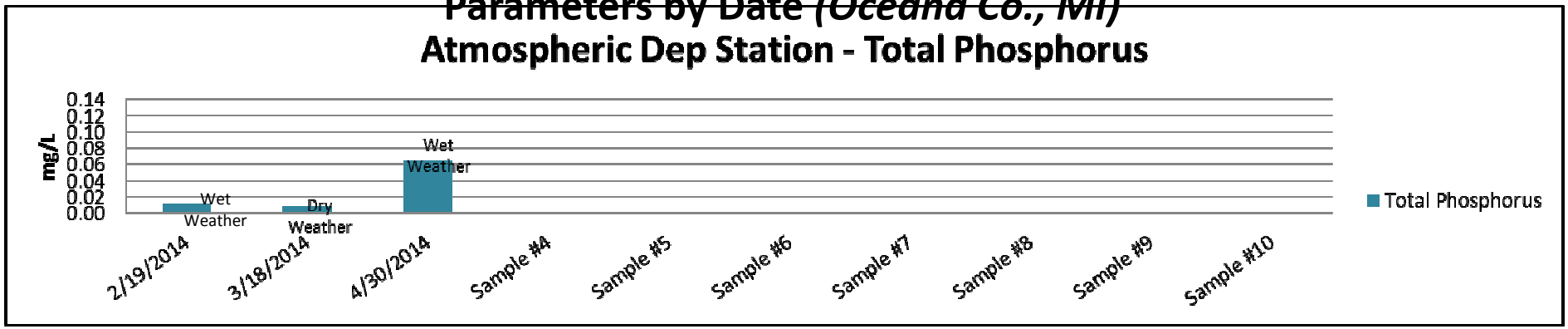

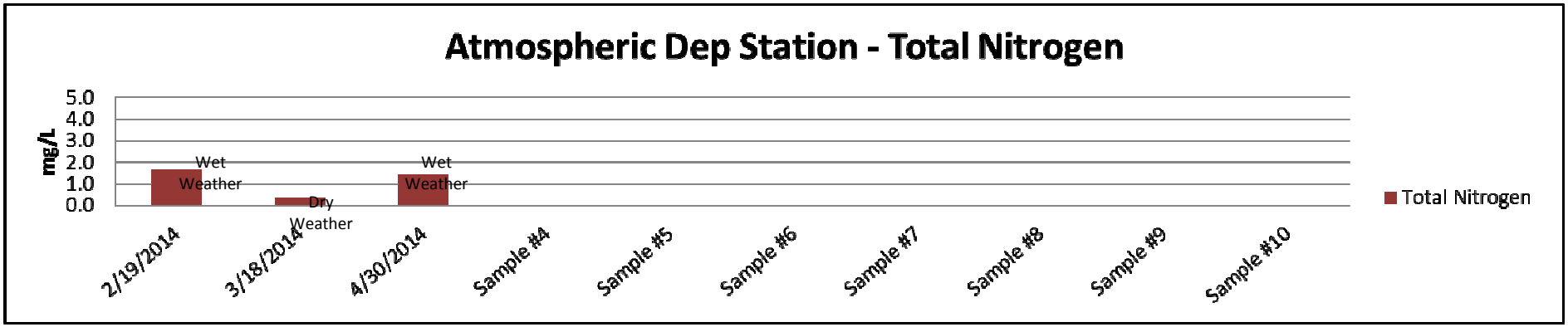

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