Water Quality Improvement Plan
for

Lost Island Lake

Palo Alto and Clay Counties, Iowa

Total Maximum Daily Load
For Turbidity

Iowa Department of Natural Resources
Watershed Improvement Section
2008

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Report Summary

What is the purpose of this report?

This report has two purposes. First, it is a resource to be used by watershed planners, water quality action groups, individual citizens, and local, county and state government staff. It can serve as a guide to help these groups understand and identify how excessive algae and non-algal suspended solids cause Lost Island Lake's lack of clarity. Second, this report satisfies the Federal Clean Water Act requirement to establish a Total Maximum Daily Load (TMDL) for waterbodies on the impaired waters list.

What's wrong with Lost Island Lake?

Excessive algae growth and non-algal suspended solids impair Lost Island Lake for turbidity. Nuisance and potentially noxious blooms of blue green algae also have adverse impacts. These problems combine to limit recreational lake uses.

What is causing the problem?

The nuisance algae growth is caused by excessive phosphorus that comes from the resuspension of bottom sediment, mostly by carp, and from nonpoint sources in the watershed. Phosphorus is usually the limiting nutrient for excessive algal growth. Most of the phosphorus in this water body comes from the resuspension of lake bottom sediment by carp and other bottom feeding fish. Other sources are watershed agricultural activities and runoff from other land cover types.

What can be done to improve Lost Island Lake?

The resuspension of phosphorus and inorganic suspended solids (ISS) from bottom sediment by carp needs to be eliminated. Agricultural activities need to be modified to minimize erosion and the phosphorus content of eroded soil.

Who is responsible for a cleaner Lost Island Lake?

Lost Island Lake algae and clarity problems are caused by several phosphorus sources. IDNR, Palo Alto County, and other state and federal agency staff are working together to understand pollutant sources and are searching for solutions to Lost Island Lake water quality problems. However, everyone that lives, works and recreates in the watershed is responsible for correcting the problem. When unregulated sources are the contributors, water quality improvements can only happen if concerned citizens and landowners adopt practices and land use changes on a voluntary basis.

Required Elements of the TMDL

This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below:

Table 1 Elements of the TMDL Report

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Lost Island Lake, located in western Palo Alto County with a small part in eastern Clay County three miles north of Ruthven - Section 31, township 97N, Range 34W
Use designation classes:	Class A1 Primary Contact Recreation Class B (LW) Aquatic Life HH (Human Health)
Impaired beneficial uses:	Primary Contact Recreation (A1)
Identification of the pollutants and applicable water quality standards:	Class A1 Primary Contact Recreational use has been assessed as not supported due to aesthetically objectionable conditions caused by algae and turbidity. The TMDL target is a secchi depth transparency of one meter. As modeled, the total phosphorus (TP) and chlorophyll targets that achieve one-meter transparency are 42 µg/l and 24 µg/l, respectively.
Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	Nuisance algal blooms that result from excessive phosphorus reduce transparency. The average annual allowable TP load to the lake from all sources is 1,532 lbs/year and the maximum daily load is 151 lb TP/day.
Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain water quality standards:	The existing mean values for Secchi depth, chlorophyll and TP for 2000 to 2007 sampling are 0.45 meters, 32 µg/L and 93 µg/L, respectively. A minimum increase in Secchi transparency of 122% and minimum reductions of 25% for chlorophyll and 55% for TP will achieve and maintain lake water quality goals and protect for beneficial uses. The existing TP load from all sources is 6,284 pounds per year. Based on lake modeling the load capacity is 1,532 pounds per year for a target load reduction of 4,752 lbs/year. The largest TP source, 3,748 lbs/year, is from internal resuspension. It is assumed that this can be reduced 92 % by controlling carp.
Identification of pollution source categories:	The watershed, atmospheric deposition, and resuspended TP loads that are causing the impairment are from nonpoint sources.

Wasteload allocations for pollutants from point sources:	There are not any permitted point sources in the watershed and the WLA is zero.
Load allocations for pollutants from nonpoint sources:	The annual average TP load allocation is 1,378 lbs/year. The maximum daily load allocation is 136 lb/day.
A margin of safety:	The margin of safety for this TMDL is an explicit 10% of the annual average allowable TP load, or 153 lbs/year.
Consideration of seasonal variation:	This TMDL was developed based on the annual phosphorus load that will result in attainment of the transparency target.
Allowance for reasonably foreseeable increases in pollutant loads:	An allowance for increased phosphorus loading was not included in this TMDL. Significant changes in the Lost Island Lake watershed are unlikely. Much of the watershed and shoreline are parkland and wildlife management area and area residences are sewered. Land uses are row crop, wetlands and state managed wildlife areas.
Implementation plan:	The implementation plan in Section 4 of this document provides guidance for local citizens, government, and water quality groups.

1. Introduction

The Federal Clean Water Act requires that the states assess their waterbodies every even numbered year and incorporate these assessments into a report, the 305(b) Water Quality Assessment Report. Waters not meeting the Iowa Water Quality Standards are identified in this report and are placed on the 303(d) Impaired Waters List. A pollutant Total Maximum Daily Load (TMDL) must be calculated and a report written for each impaired waterbody on the impaired waters list.

A TMDL is a calculation of the maximum amount of a pollutant a waterbody can receive without exceeding the water quality standards. The total maximum daily load is allocated to permitted point sources (wasteload allocations), nonpoint sources (load allocations), and an allowance for a margin of safety to account for uncertainty in the TMDL calculation.

This TMDL report is for Lost Island Lake in Palo Alto and Clay Counties, Iowa. Lost Island Lake is on the 2004 impaired waters list for algae and turbidity due to excess phosphorus triggering algal blooms. Phosphorus is the nutrient that limits excess algal growth.

There are two primary purposes of this report:

1) Satisfy federal requirements of a Total Maximum Daily Load for all impaired waters, and
2) Serve as a resource for guiding water quality improvement projects in the Lost Island Lake watershed that address lake algae and inorganic suspended solids problems. Local citizens, water quality groups, and governments will find it useful for outlining the causes and solutions to the water quality issues.

A TMDL report has some limitations.

- The 305(b) water quality assessment is made with available data that may not sufficiently describe lake water quality. Additional targeted monitoring is often expensive and requires time. Assumptions and simplifications on the nature, extent, and causes of impairment can cause uncertainty in calculated values.
- A TMDL may not deal easily with unregulated nonpoint sources of pollutants. It can be challenging to reduce pollutant loads if nonpoint sources are significant contributors.

A TMDL report can guide projects that target the entire watershed. The water quality in a river or lake is a reflection of the land that drains to it and how that land is managed. Local landowners, tenants, and land managers often have the greatest influence in determining water quality.

2. Descriptions and History of Lost Island Lake

Lost Island Lake is located in mostly in western Palo Alto County with a small part in Eastern Clay County and is three miles north of Ruthven, Iowa. It is a shallow natural lake of glacial origin. Much of the surrounding watershed is parkland or wildlife management area, but there is also significant row crop agriculture. A large part of the shoreline is residential. Huston County Park and Prairie are on the east side of the lake and have facilities that include a campground and boat ramp. Lost Island Lake is classified as a Significant Publicly Owned Lake. Table 2 and on the Figure 1 map show basic information for the lake and its watershed.

Table 2 Lost Island Lake

Waterbody Name	Lost Island Lake
12 Digit Hydrologic Unit Code (HUC):	102300030704
IDNR Waterbody ID	IA 06-LSR-02390-L_0
Location	S31 T97N R34W
Latitude	43.1720
Longitude	94.9059
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B (LW) Aquatic Life HH (Human Health)
Tributaries	Blue Wing Marsh
Receiving Waterbody	Barringer Slough to Little Sioux River
Lake Surface Area	1151 acres
Maximum Depth	14 feet
Mean Depth	10.3 feet
Volume	11,870 acre-feet
Length of Shoreline	14.5 miles
Watershed Area (with lake)	6273 acres
Watershed/Lake Area Ratio	4.5
Lake Detention Time (outlet)	3.0 years

2.1 Lost Island Lake

Hydrology
Lost Island Lake is in a region of the Des Moines Lobe that is dotted with wetlands and shallow lakes of glacial origin. A majority or the watershed flows through the Blue Wing Marsh wetland complex on the east side of the lake. Lost Island Lake discharges through Barringer Slough and eventually to the Little Sioux River. The watershed consists of about one-half of a HUC 12 sub watershed. The average annual precipitation is 29.0 inches/year and the lake retention time is 3.0 years based on outflow. Lake detention time estimates were made using hydrological methods shown in Appendix D.

Morphometry & Substrate
Lost Island Lake has a mean depth of 10.3 feet and a maximum depth of 14.0 feet. The lake surface area is 1,151 acres and the storage volume is 11,870 acre-feet. Temperature and dissolved oxygen sampling indicate that Lost Island Lake does not stratify and is usually completely mixed and oxic.

2.2. The Lost Island Lake Watershed

Excluding lake area, the Lost Island Lake watershed is 5,122 acres. There are no cities or permitted point sources in the watershed. There are a number of residences along the shoreline but these are sewered and the wastewater goes to the Ruthven wastewater treatment facility located outside of the watershed. The watershed to lake area ratio is 4.5:1. This is a desirable ratio for water quality improvement potential.

Land Use
The Lost Island Lake benefits from having nearly 25% of its watershed protected as public land as well as a large wetland area through which most watershed runoff must pass. The estimated reduction in sediment delivered to the lake because of these wetlands and public land areas is 45 percent.

Table 3 lists the watershed landuse categories and areas. A landuse map can be found in Appendix E.

Table 3 Landuse in the Lost Island Lake Watershed

Land Uses from Assessment	Area, acres	Percent of total
Water	1,245	19.9%
Wetland	116	1.8%
Bottomland forest	27	0.4%
Coniferous forest	2	0.0%
Deciduous forest	134	2.1%
Ungrazed grassland	967	15.4%
Grazed grassland	96	1.5%
CRP grassland	258	4.1%
Alfalfa	20	0.3%
Corn	1,224	19.5%
Soybeans	2,076	33.1%
Other rowcrop	23	0.4%
Roads	38	0.6%
Commercial/industrial	8	0.1%
residential	36	0.6%
Total	**6,272**	**100%**

Soils and topography
There are four general soil associations in the Lost Island Lake watershed. Most of the watershed is a single soil association. The other three types are in the immediate vicinity of the lakeshore. See the soil map, Figure 8 in Appendix E, for location information.

The Lost Island Lake watershed lies mostly to the east. The soil association for this area is Storden-Nicollet-Clarion. It is nearly level to moderately steep, somewhat well drained to poorly drained. This soil group makes up 76.2 percent of the basin area. The lake covers 17.6 percent of the basin. The many depressions and marshes in this association provide habitat for a diversity of wildlife. The steeper slopes are associated with the potholes and large depressions and drainage ways. Lost Island Lake and Blue Wing Marsh and several smaller unnamed marshes, sloughs, and closed depressions are mostly within this association.

The soil association along the northwest shoreline about a quarter mile wide is Webster-Nicollet-Clarion-Canisteo (S1750). This soil is poorly drained to somewhat poorly drained with a moderate to very high available water capacity. Texture of the surface layer ranges from moderately coarse to fine. This soil association makes up 1.1 percent of the basin area.

The soil association along the west shoreline about a quarter mile wide is Wadena-Talcot-Cylinder-Biscay. This soil is well drained to poorly drained, medium textured and moderately fine textured, nearly level to strongly sloping soils on benches. This soil association makes up 1.9 percent of the basin area.

The soil association along the south shoreline about a half-mile deep is Wadena-Coland-Clarion. This soil is well drained on stream benches and glacial outwash areas to fine loamy well drained to poorly drained soil formed from till or local alluvium. This soil association makes up 3.1 percent of the basin area.

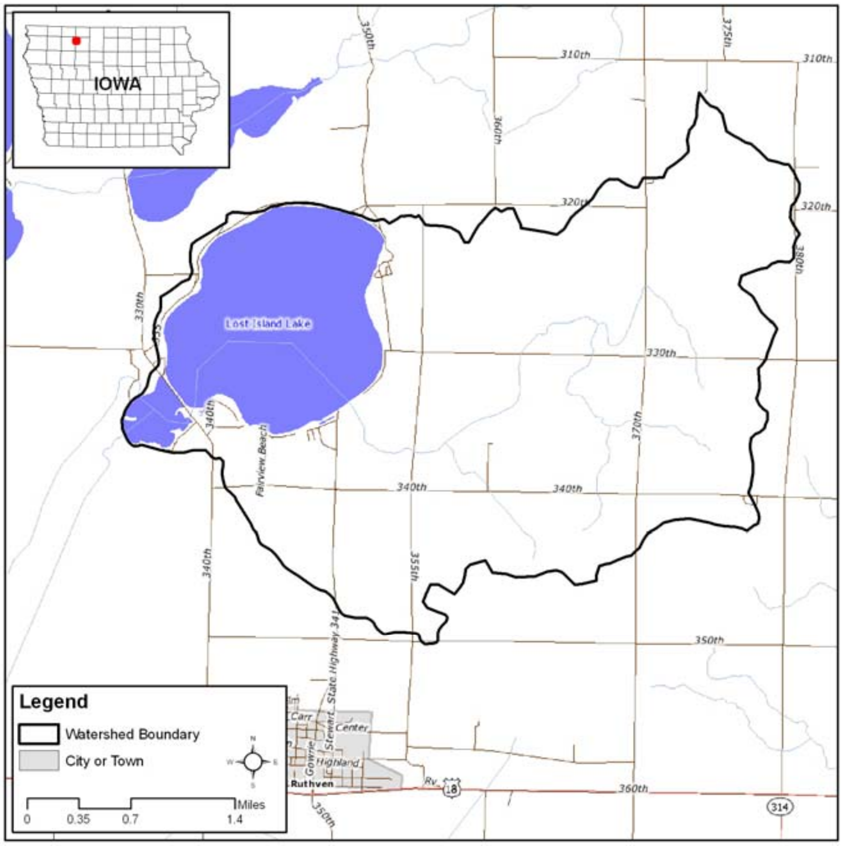

Figure 1. Lost Island Lake and its watershed

3. Total Maximum Daily Load (TMDL) for Turbidity and Algae

A Total Maximum Daily Load (TMDL) is required for Lost Island Lake by the Federal Clean Water Act since it is on the State of Iowa Impaired Waters List (303d). The impairment is for turbidity caused by inorganic suspended solids (ISS) and algae. It has been determined that the limiting nutrient for algae growth in this lake is phosphorus. The following sections estimate existing and maximum allowable phosphorus loads to the lake and reductions needed to achieve water quality standards.

3.1. Problem Identification

Applicable water quality standards
The Iowa Water Quality Standards (IAC 567-61) list the designated uses for Lost Island Lake as Primary Contact Recreational Use (Class A1) and Aquatic Life (Class B(LW)). The Lost Island Lake Primary Contact Recreational use has been assessed using narrative criteria for aesthetically objectionable conditions as not supporting the Class A1 use.

Problem statement
The following paragraphs are from the 2006 305(b) water quality assessment for Lost Island Lake and describe the reason that the recreational use is assessed as not supported.

> *The Class A (primary contact recreation) uses are assessed (monitored) as "partially supporting" due to very poor water transparency due primarily to high levels of non-algal turbidity. Large populations of blue green algae (noxious aquatic plants) suggest an additional impairment of these uses. The Class B(LW) aquatic life uses remain assessed (evaluated) as "fully supporting". High levels of nutrient loading to the water column and high levels of non-algal (inorganic) turbidity remain concerns regarding full support of the Class B(LW) uses. The sources of data for this assessment include:*
>
> *(1) Results of the statewide survey of Iowa lakes sponsored by IDNR and conducted by Iowa State University (ISU) from 2000 through 2004,*
> *(2) Surveys by IDNR Fisheries Bureau, and (3) information on plankton communities collected at Iowa lakes from 2000 through 2005 as part of the ISU lake survey.*
>
> *Results from the ISU statewide survey of Iowa lakes suggest that high levels of non-algal turbidity may adversely affect the Class A and Class B(LW) uses of Lost Island Lake. Using the median values from this survey from 2000 through 2004 (approximately 15 samples), Carlson's (1977) trophic state indices for total phosphorus, chlorophyll-a, and secchi depth are 68, 62, and 72, respectively. According to Carlson (1977), the index values for total phosphorus and chlorophyll-a are in the range between eutrophic and hyper-eutrophic lakes. The index value for Secchi depth is in the lower range of hyper-eutrophic lakes. These index values suggest relatively high levels of phosphorus in the water column,*

relatively low (and less than expected) levels of chlorophyll-a, and very poor water transparency.

According to Carlson (1991), the occurrence of a low chlorophyll-a TSI value relative to those for total phosphorus and secchi depth indicate non-algal particles or color dominate light attenuation. The ISU lake data suggest that non-algal particles do likely limit algal production at Lost Island Lake. The median level of inorganic suspended solids in the 131 lakes sampled for the ISU lake survey from 2000 through 2004 was 5.2 mg/l. Of 131 lakes sampled, Lost Island Lake had the 18th highest median level of inorganic suspended solids (14.3 mg/l), thus suggesting that non-algal turbidity limits the production of algae as well as contributes to impairments of both the primary contact recreation and aquatic life uses.

Algal production at this lake does not appear limited by either nitrogen availability or zooplankton grazers. Based on median values from ISU sampling from 2000 through 2004, the ratio of total nitrogen to total phosphorus for this lake is 22. This ratio does not suggest a strong possibility for nitrogen limitation.

The presence of typically large populations of zooplankton at Lost Island Lake that graze on algae, however, may explain the discrepancy between the TSI value for phosphorus (68) and that for chlorophyll-a (62). Sampling from 2000 through 2005 showed that Cladoceran taxa (e.g., Daphnia) comprised about half of the dry mass of the zooplankton community of this lake. The average per summer sample mass of Cladoceran taxa over the 2000-2005 period (112 mg/l) was the 49th highest of the 131 lakes sampled. This level of zooplankton grazers may influence algal production at this lake.

These conditions indicate impairments to the Class A uses through presence of poor water transparency that violates Iowa's narrative water quality criterion protecting against aesthetically objectionable conditions. Based on the ISU monitoring data, the causes of this poor transparency are primarily high levels of inorganic suspended solids; moderately high levels of suspended algae also likely contribute to this problem.

The presence of nuisance (=noxious) algal species (i.e., blue green algae) may also present an impairment of the Class A uses at Lost Island Lake. Data from the ISU survey from 2000 through 2004 suggest that blue green algae (Cyanophyta) comprise a significant portion of this lake's summertime phytoplankton community. Summer sampling during this period showed the percent wet mass of the total phytoplankton community in blue greens (Cyanobacteria) was approximately 75%. Also, the median per summer sample mass of blue green algae at this lake (42 mg/l) was the 21st highest of the 131 lakes sampled. This median is in the worst 25% of the 131 Iowa lakes sampled.

> *The presence of a large population of blue green algae at this lake suggests the potential violation of Iowa's narrative water quality standard protecting against occurrence of nuisance aquatic life. This assessment, however, is based strictly on a distribution of the lake-specific median blue green algae values for the 2000-2004 monitoring period. Median levels greater than the 75th percentile of this distribution (~29 mg/l) were arbitrarily chosen by IDNR staff to represent the condition of "potential impairment: partially supported." No criteria exist, however, upon which to base a more accurate identification of impairments due to blue green algae.*
>
> *Thus, while the ability to characterize the levels of blue green algae at this lake has improved over that of the previous (2004) assessment due to collection of additional data, the assessment category for assessments based on level of blue green algae nonetheless remains, of necessity, "evaluated" (indicating an assessment with relatively lower confidence) as opposed to "monitored" (indicating an assessment with relatively higher confidence).*
>
> *Information from the IDNR Fisheries Bureau suggests that the Class B(LW) aquatic life uses should be assessed as "fully supported". Excessive nutrient loading to the water column and high levels of non-algal turbidity, however, remain concerns for the Class B(LW) uses of this lake. Additional data for this lake are being generated as part of the ongoing ISU lake survey; these data will be used to improve the accuracy of future water quality assessments. The ISU lake survey data from 2000 through 2004 suggest good chemical water quality at Lost Island Lake: no violations of the Class B(LW) criteria for dissolved oxygen occurred in the 14 samples collected, and no violations of pH criteria occurred in the 15 samples collected.*

Data sources

The primary in-lake data used to assess Lost Island Lake water quality and to develop this TMDL are from the Iowa State University (ISU) Lake Study. Data were collected from 2000 to 2007 three times per season, usually in May, June, July, and August. The samples were analyzed for variables including total and volatile suspended solids, secchi depth, chlorophyll, phosphorus, and nitrogen. The eight-year average total phosphorus concentration was 93 µg/l. Samples were also examined for phytoplankton and zooplankton composition.

The Loading Function watershed model uses land use data interpreted from 2002 aerial photography and the erosion estimates are based on IDNR GIS coverages. Soil information is from an IDNR GIS coverage based on county soil maps.

Interpreting Lost Island Lake data

The total nitrogen to total phosphorus ratio can often suggest which of these two nutrients limits algae growth. Based on values from ISU sampling from 2000 to 2007, the mean ratio of total nitrogen to total phosphorus is 19.8 and the median ratio is 19.1. This ratio indicates that nitrogen is not the limiting nutrient in Lost Island Lake.

Review of inorganic suspended solids (ISS) data from the ISU sampling shows that this lake is subject to episodes of high non-algal (inorganic) turbidity. As noted previously, the 2006 305b water quality assessment ranked Lost Island Lake 18th highest of 131 Iowa lakes for median inorganic suspended solids. The median ISS for the 131 lakes sampled was 5.2 mg/L. The median ISS for Lost Island Lake during at the same time was 14.3 mg/l.

Carlson's Trophic State Index. Carlson's trophic state index (TSI) can be used to relate algae, as measured by chlorophyll, transparency, and total phosphorus to one another. It can also be used as a guide to establish water quality improvement targets. TSI values for the ISU monitoring data are shown in Appendix C, Table C-3. Further explanation of TSI procedures and their use in lake assessments can be found in Appendix E.

If the TSI values for the three variables are the same, the relationships between TP and algae and transparency are strong. If the TP TSI values are higher than the chlorophyll values, there are limitations to algae growth besides phosphorus. Figure 2 shows a comparison of the TSI values for chlorophyll, secchi depth and total phosphorus for Lost Island Lake. The secchi depth TSI values are generally higher than those calculated for chlorophyll and TP. This indicates that non-algal suspended solids are a factor and may limit algal productivity.

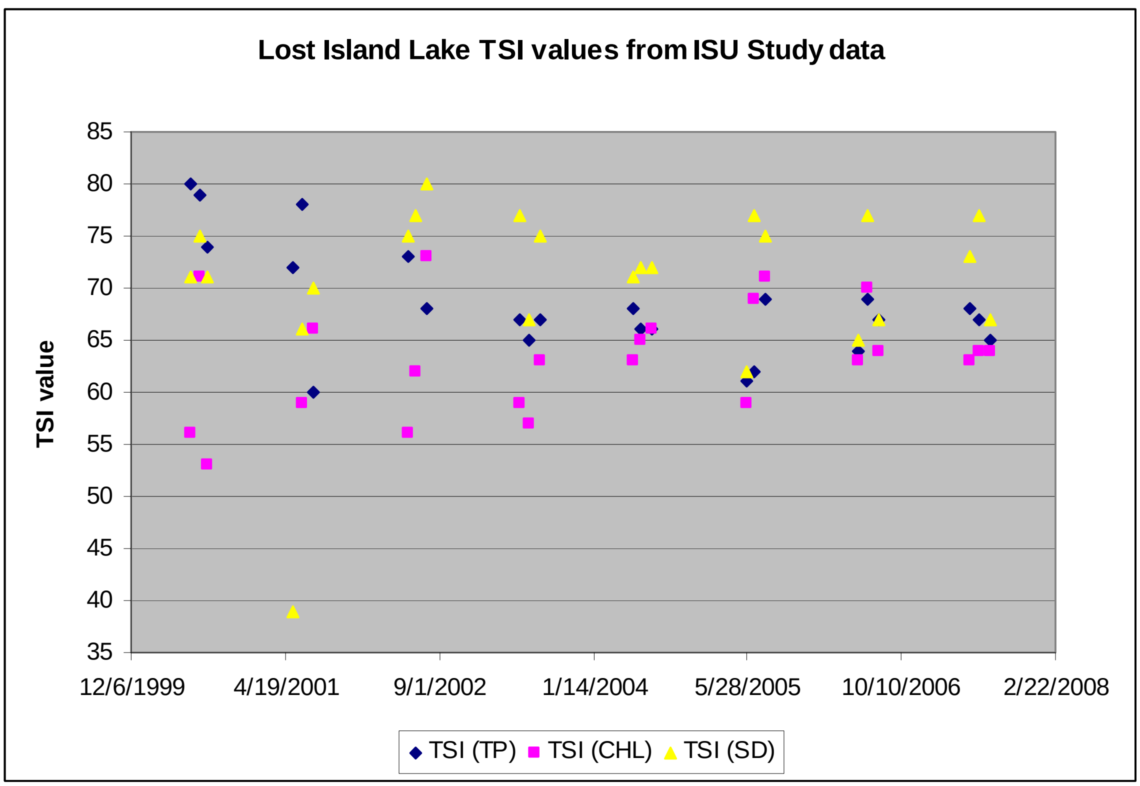

Figure 2. TSI values for ISU Study data, 2000 to 2007

Figure 3 shows plots that compare the three TSI variables and interpret their differences. This comparison shows that the Lost Island Lake system plots in the lower left quadrant. The interpretive plot on the right side of the figure shows that a point in this location indicates that there is surplus phosphorus, i.e., not all-available TP is expressed as algae. The other piece of information that this plot provides is that the system is on the line where suspended solids create light limitation, i.e., non-algal turbidity is a factor.

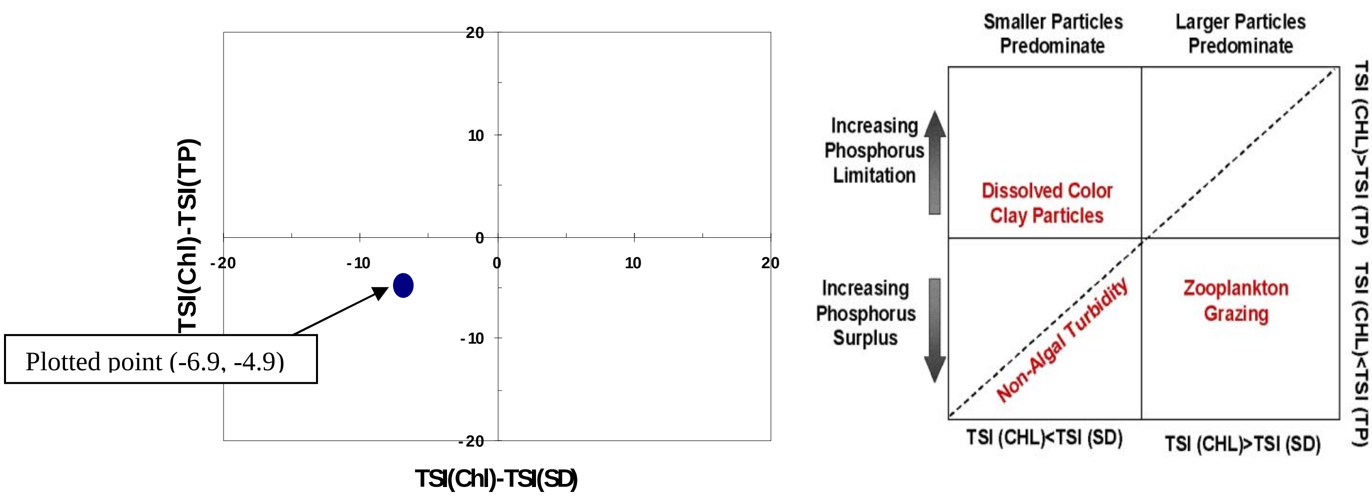

Figure 3. Lost Island Lake Mean TSI Multivariate Comparison Plot

Blue-green Algae: Phytoplankton (algae) composition can be an indicator of the extent of the algae problem. A significant blue-green phytoplankton fraction aggravates nuisance conditions and is a concern because it can grow rapidly in warm weather algal blooms. Blue-green algae cause taste and odor problems, form dense mats on the water surface, and can produce toxins such as microcystin. Microcystin and related compounds can be very harmful to plants and animals including humans. The toxin concentrations in a bloom can quickly exceed safe levels, so most algal blooms should be treated as potentially hazardous.

Data from the 2000 to 2004 ISU Lake Study sampling shows that, on average, blue-green algae are 75 percent of the total summertime phytoplankton community in Lost Island Lake. The median for blue green concentration makes Lost Island Lake the 21st highest of 131 Iowa lakes for blue-green algae, putting it in the worst 25 percent of sampled lakes.

3.2. TMDL Target

The target for this TMDL is a secchi depth transparency of 1.0 meter. The corresponding chlorophyll and total phosphorus concentrations estimated for this target using the BATHTUB lake nutrient model are 24 µg/l and 42 µg/l, respectively. Table 4 shows the existing and target values for concentration and TSI.

Table 4. Lost Island Lake Existing vs. Target Values

Parameter	2000-2007 Mean TSI	2000-2007 Mean Value	Target TSI	Target Value	Water quality improvement needed
Chlorophyll a	65	32 µg/L	NA	<24 µug/L	Decrease 25%
Secchi Depth	72	0.45 meters	<60	>1.0 meters	Increase 122%
Total Phosphorus	70	93 µug/L	NA	<42 µg/L	Decrease 55%

General description of the pollutant
Summer algal blooms directly relate to the TP load. Although it is not the only factor in algal productivity (light attenuation from non-algal turbidity and clouds also affect algal growth), excess TP is the primary reason for blooms of algae and the resulting turbidity.

Inorganic suspended solids (i.e. non-algal turbidity) also contribute to lake turbidity. Most TP is attached to soil particles, therefore to reduce the amount of phosphorous entering waterbody there must be a reduction of sediment inputs, which also reduces the turbidity caused by inorganic suspended solids. This will result in a reduction of both algal and non-algal turbidity. Future monitoring will determine if the targeted phosphorus reductions and corresponding reduction in suspended solids loading results in achievement of the TSI targets for chlorophyll and Secchi depth.

Selection of environmental conditions
The critical condition for which the TMDL TSI targets apply is the growing season of April through September. During this period, nuisance algal blooms are prevalent. The existing and target TP concentrations for the lake are expressed as annual averages as are the TP load estimates calculated for the existing and maximum allowable loads.

Potential Pollution Sources
There are no permitted point sources in the watershed. External watershed loads and internal loads resuspended from bottom sediment are the nonpoint sources that adversely affect water quality in Lost Island Lake. Specific nonpoint sources include agricultural activities, wildlife, residential runoff, atmospheric deposition, and internal resuspension.

Natural Background Conditions
The natural background conditions are atmospheric direct deposition to the lake surface and migrating waterfowl. The phosphorus load attributed to direct deposition is included separately in the BATHTUB lake model. Based on a literature review and BATHTUB model default values, estimated direct deposition is an annual average areal load of 30 $mg/m^2/yr$ for a load of 308 lbs/year. Estimated average migrating waterfowl TP loads are 78 lb/year. Groundwater is a part of the watershed load in this modeling scenario since it originates as precipitation infiltration and land use has a strong influence on the pollutant load it carries. Groundwater TP contributions were included as part of the watershed load in the Loading Function model.

Water body pollutant loading capacity
The chlorophyll and secchi depth targets are related through the BATHTUB lake nutrient model to total phosphorus. The load capacity is the annual average TP load Lost Island Lake can receive and still meet the chlorophyll and secchi depth targets. Based on meeting the annual average TP concentration of 42 µg/l estimated by the BATHTUB model, the annual average TP loading capacity is 1,532 lbs/year.

Criteria for water quality standards attainment
Iowa does not have numeric water quality criteria for algae or turbidity. The cause of the Lost Island Lake algae and turbidity impairments are algal blooms resulting from excessive phosphorus input to the lake and inorganic suspended solids from resuspension of lake sediment and watershed runoff.

The criteria for assessing lake algae and turbidity impairment are based on TSI scores for chlorophyll and secchi depth. The 305b assessment impairment thresholds for nuisance conditions are TSI values of 65 for both chlorophyll and secchi depth, giving a target chlorophyll concentration of 33 µg/l and a target secchi depth of 0.7 meters. IDNR fisheries and lake restoration staff have determined that the Lost Island Lake water quality goal should be a secchi depth transparency of one meter. The average annual TP concentration target for this goal has been estimated using the BATHTUB model and is 42 µg/l. The average annual chlorophyll concentration target for a one-meter Secchi depth has been estimated using the BATHTUB model and is 24 µg/l. *Appendix E – Carlson's Trophic State Index* contains a more detailed explanation of the TSI and its use in water quality assessments.

Inorganic suspended solids (non-algal turbidity) also contribute to lake turbidity. Since load reductions from phosphorus sources will require reductions in sediment and suspended solids loads, the targeted pollutant is phosphorus. Monitoring will determine if the targeted phosphorus reductions and corresponding reduction in suspended solids results in achievement of the chlorophyll and Secchi depth targets.

3.3. Pollution Source Assessment

There are three quantified phosphorus sources for Lost Island Lake in this TMDL. The first of these sources is the phosphorus from the watershed areas draining into the lake. The second is the phosphorus resuspended from lake sediments. The third is atmospheric deposition. The Loading Function model calculates estimates of watershed phosphorus loads. The BATHTUB model estimates internal resuspended and atmospheric deposition phosphorus loads.

Identification of pollutant sources
The TMDL approach is to separate pollutant sources into those that are regulated by discharge permits (point sources) from those that are not (nonpoint sources).

<u>Point Sources</u>: There are not any permitted point sources in the Lost Island Lake watershed.

Nonpoint Sources: Lake phosphorus delivery from internal resuspension nonpoint sources is estimated to be 60 percent of the overall load. . The watershed load is estimated to be 35 percent and atmospheric deposition to be 5 percent of the total load.

Existing load
The annual total phosphorus load to Lost Island Lake consists of external watershed loads and internal resuspension loads. The Loading Function model existing load is 2,228 lbs/year and the existing internal resuspension load is 3,748 lbs/year. Adding in the atmospheric deposition load of 308 lbs/year gives a total existing TP load of 6,284 lbs/year. Figure 4 shows the load distribution.

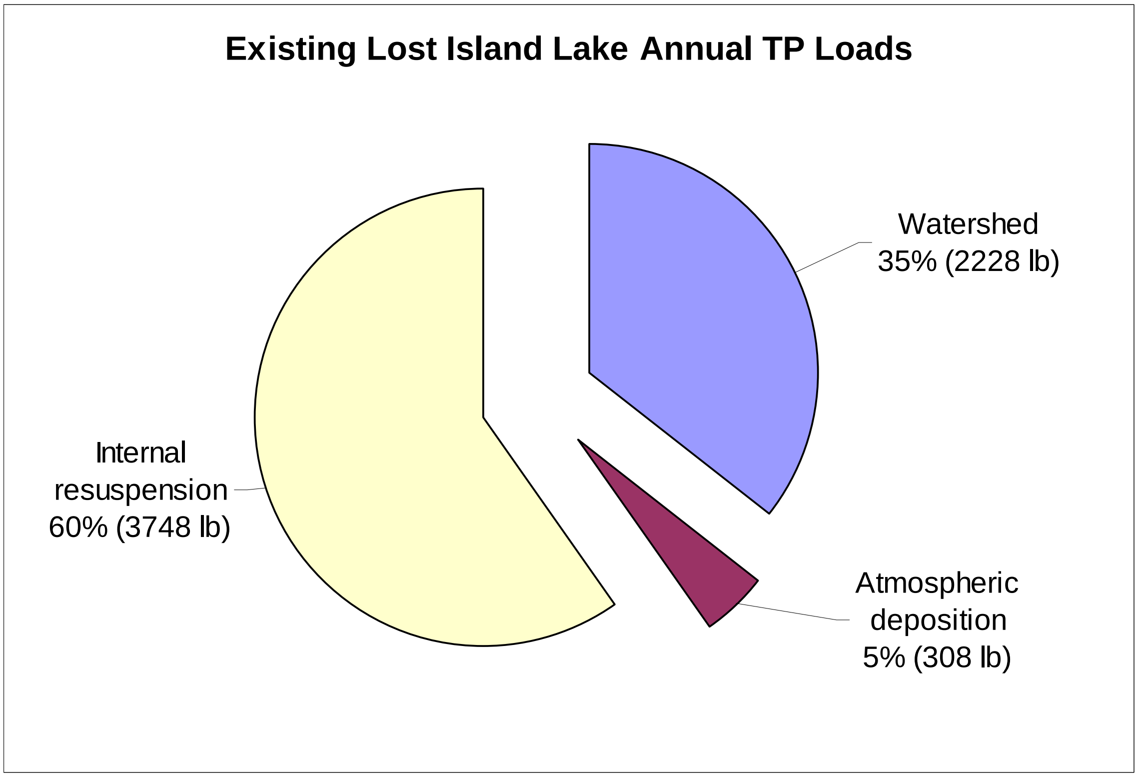

Figure 4 Existing TP loads from all general sources

Figure 5 shows only the watershed phosphorus load as estimated by the Loading Function Model. The largest contributing sources in the watershed load are row crops followed by other land uses. The entire area around the lake is sewered so there are not any septic tank system sources.

Departure from load capacity
The targeted total phosphorus load capacity for Lost Island Lake is 1,532 lbs/year and the existing TP load is 6,284 lbs/year. The difference, or departure from capacity, is 4,752 lbs/year. Figure 6 shows the loads after a suggested pollutant reduction scheme. Any potential improvement scenario is dependent on significant internal resuspension load reduction through carp management.

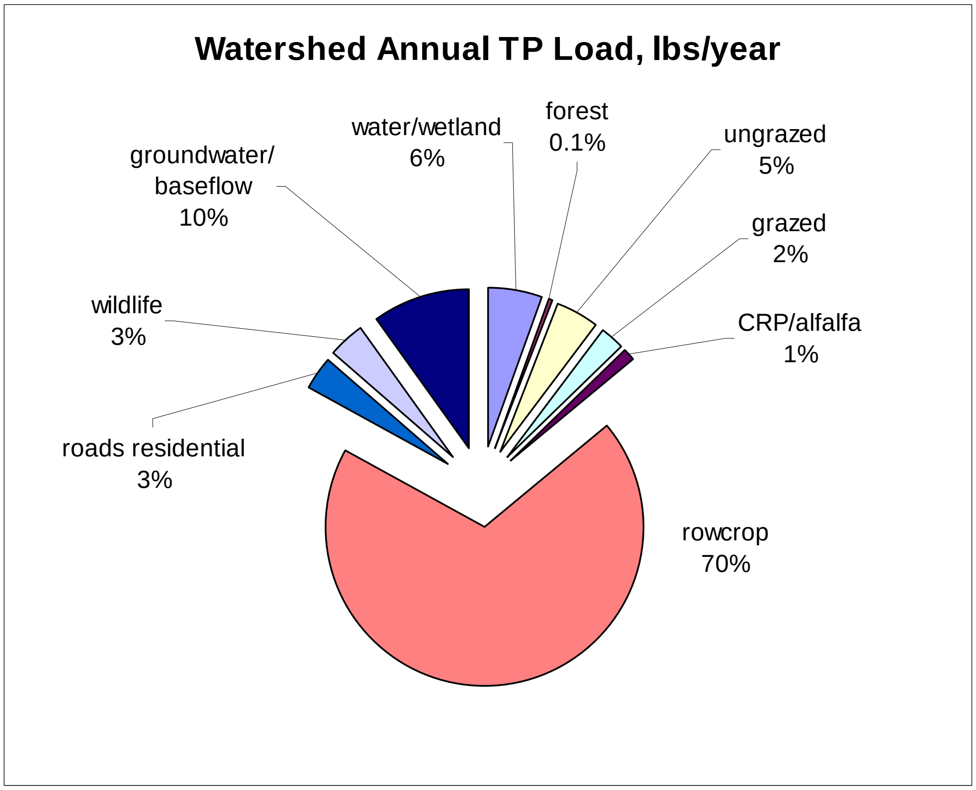

Figure 5 Existing watershed TP loads to Lost Island Lake by source

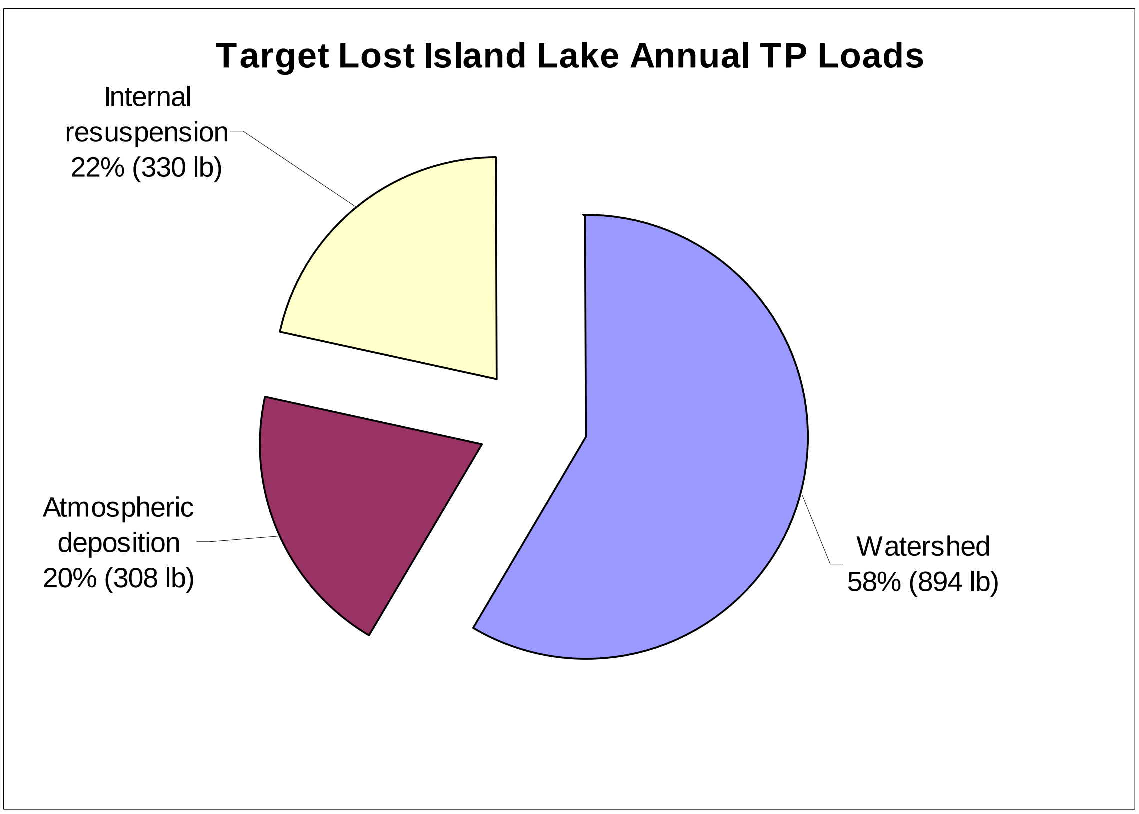

Figure 6 Target phosphorus loads to achieve water quality standards

Linkage of Sources to Target
The annual phosphorus load to Lost Island Lake originates entirely from nonpoint sources. These are categorized as watershed, internal resuspension and atmospheric deposition loads. The watershed TP sources are linked to the water quality impairment with the Loading Function model that estimates annual average phosphorus delivery. The internal resuspension and atmospheric deposition loads have been linked to the impairment through BATHTUB lake nutrient modeling.

Allowance for Increases in Pollutant Loads
An allowance for increased phosphorus loading was not included in this TMDL. Significant changes in the Lost Island Lake watershed are unlikely. The Iowa Department of Natural Resources (IDNR) maintains large parts of the watershed and shoreline around the lake. Much of the watershed land is in agricultural production with row crops predominating.

3.4. Pollutant Allocations

Wasteload allocations
There are not any permitted point sources in the watershed; therefore, the sum of the wasteload allocations is zero.

Load allocations
The total phosphorus load to Lost Island Lake has three components, the loads from the watershed, the loads from turbulent internal resuspension of phosphorus, and the loads from atmospheric deposition. The loads from the watershed were estimated using the Loading Function model as described in Appendix D and the TMDL Support Documentation. The internal and atmospheric loads were estimated using BATHTUB lake nutrient modeling. The load allocation for this TMDL is the allowable TP load less the 10% margin of safety.

Watershed Loads: The watershed load allocation was estimated using the Loading Function model average annual load. The existing TP load is 2,228 lbs/year and the load allocation is 804 lbs/year. A ten percent margin of safety has been applied to the allowable load of 894 lbs/year generated by the watershed model. Table 5 shows the existing watershed loads and the allocated loads in an allocation distribution example.

Table 5. Example category watershed load allocations

Source category	Existing Total-P Load (lbs/yr)	Allocated Total-P Load (lbs/yr)	Percent reduction needed
water/wetland	125	100	20%
forest	3	3	0%
ungrazed	103	50	51%
grazed	54	20	63%
CRP/alfalfa	27	15	43%
row crop	1542	325	79%
roads residential	73	36	51%
wildlife	78	78	0%
groundwater/baseflow	224	175	22%
TOTAL	**2228**	**802**	**64%**

Allocation of All Loads: The internal resuspension load is the most significant by a wide margin. The existing total load is 6,284 lbs/year of which 60%, 3,748 lbs/year is internal resuspension. Atmospheric deposition, 308 lbs/year, is 5% of the total load. It is assumed that atmospheric deposition cannot be reduced and that most of the load reduction will need to be from the internal resuspension fraction. The total target load to the lake is 1,532 lbs/year. The load allocation is 1,378 lbs/year and the ten percent MOS is 153 lbs/year as shown in Table 6.

Table 6. Annual average loads for TP target, allocation, and 10% MOS

Source	Allowable TP load, lb/yr	Load allocation, lb/yr	%Total	Margin of Safety, lb/yr
Watershed	894	804	55.4%	89
Atmospheric deposition	308	277	19.1%	31
Internal resuspension	330	297	25.6%	33
TOTAL TP load	**1,532 lb/yr**	**1,378 lb/yr[1]**	**100.0%**	**153 lb/year**

1. This is the sum of the load allocations in the TMDL equation.

Margin of safety

MOS for Maximum Annual Average Load: The procedures used to provide the margin of safety (MOS) for the maximum annual average load and maximum daily load are the same, and explicit ten percent decrease in the target TP loads. The margin of safety for the maximum annual average target load of 1,532 lbs/year is 153 lbs/year. Table 6 shows the MOS for each load category.

3.5. Total Maximum Daily Load Summary

The water quality of nutrient impaired lakes, such as Lost Island Lake, does not function hydrologically, ecologically or chemically in daily time steps. Average annual targets as previously described are more appropriate for analysis and modeling purposes. In addition, natural systems undergo extreme daily fluctuations and assessments using annual averages are better suited for bringing the system into compliance with water quality standards. Therefore, the TMDL is calculated based on average annual maximum load as well as maximum daily load. The daily load is included to meet regulatory requirements.

Average <u>Annual</u> Maximum Load
The TMDL based on a maximum average annual TP load is:

TMDL = WLA (zero lbs/year) + LA (1,378 lbs/year) + MOS (153 lbs/year) = 1,532 lbs/year

Total Maximum <u>Daily</u> Load
Federal regulations require that a maximum daily load be calculated for this report. As represented previously, the Lost Island Lake phosphorus load has three major components:

- The watershed load that consists of the land use phosphorus estimated by the Loading Function model, wildlife and groundwater. This load will vary greatly with precipitation and runoff.
- The internal resuspension load from the turbulent resuspension of sediment. This load is assumed consistent through the year because it is mainly the consequence of carp disturbing the lake bottom.
- The atmospheric deposition load that includes direct wet and dry deposition to the lake's surface. This load is also assumed consistent through the year.

<u>Internal Resuspension and Atmospheric Deposition Daily LA and MOS</u>: The internal resuspension load is caused primarily by constant bottom turbulence throughout the year. Therefore, the internal maximum daily load is the average annual internal TP load divided by 365 days. In the BATHTUB modeling the existing internal load is 3,748 lbs/year and the daily load is 10.3 lbs/day. The reduction target for the internal load is 90 percent of the existing load so the daily load target is 1.03 lbs/day. Applying the ten percent MOS of 0.103 lbs/day, the maximum daily load allocation is 0.927 lbs/day.

It is assumed that atmospheric deposition behaves similarly. The annual deposition load is divided by 365 days. In the BATHTUB modeling the existing and target atmospheric deposition load is 308 lbs/year and the daily load is 0.84 lbs/day. Applying the ten percent MOS of 0.084 lbs/day, the daily load allocation is 0.756 lbs/day. Together these two daily load allocation and MOS are 1.683 lbs/day and 0.168, respectively.

Watershed Daily LA and MOS: The 2-year return 24-hour duration storm is generally accepted as the condition that defines the maximum daily erosion load for TMDL purposes. During precipitation events, much of the delivered TP is attached to sediment and transported in runoff. The 2-year return 24-hour duration event in the Lost Island Lake region is 2.75 -inches. Figure 7 shows the Emmetsburg station precipitation from 1997 to 2007.

During this ten-year period, there were five days when precipitation events were equal to or exceeded 2.75 inches. One of these was much higher than the 2-year return event and was not included in the analysis. The remaining four all exceeded the two-year return event and so the next highest storm, 2.2 inches, was included in the averaging of the TP loads generated by runoff as estimated in the GWLF/BasinSims watershed model. The results are in Table 7.

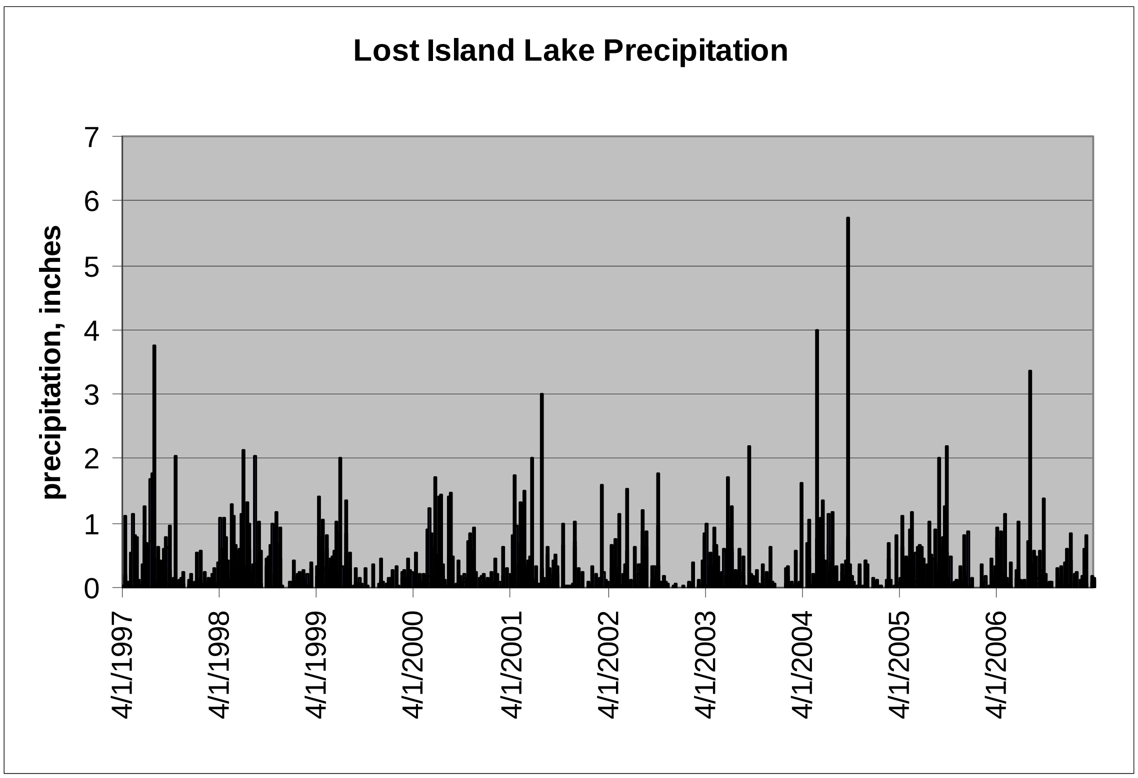

Figure 7 Ten-year precipitation, 1997 to 2007

Table 7. Events and loads used for development of maximum daily loads

Event date	24 hour rainfall, inches	Modeled daily load, lbs/day	Allowable daily load, 50 % reduction, lbs/day
5/22/2004	4.00	249	125
7/27/1997	3.75	697	348
8/2/2006	3.35	198	99
7/25/2001	3.01	212	106
9/25/2005	2.20	133	67
Average for 5 yr storms	**3.26**	**298**	**149**

Total Maximum Daily Load: Table 8 and the following equation show the total maximum daily load derivation.

Table 8 Load Allocations and MOS for total maximum daily loads

Source	Daily maximum allowable TP load	Margin of Safety	Daily Maximum TP Allocation
Watershed LA	149 lbs/day	15	134 lbs/day (MOS applied)
Atmospheric deposition	0.84 lbs/day	0.08	0.76 lbs/day (MOS applied)
Internal resuspension	1.03 lbs/day	0.10	0.93 lbs/day (MOS applied)
Total	**151 lbs/day**	**15.2 lbs/day**	**135.7 lbs/day**

TMDL = WLA (zero lbs/day) + LA (135.7 lbs/day)+ MOS 15.2) =151 lbs TP/day

4. Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the Iowa Department of Natural Resources recognizes that guidance is important to attaining the TMDL goals. Local watershed managers and citizens should use this report as a guideline for decision making and planning. The management practices discussed below are tools to direct watershed activities towards achievement of water quality goals. Ultimately, it is up to land managers, citizens, and local conservation professionals to determine how best to apply them.

4.1. Implementation Approach

The best way to reduce algae blooms in Lost Island Lake is to lower the lake phosphorus concentration by systematically reducing watershed and internally recycled TP loads starting with the most significant sources. As shown previously in Figures 4 and 5 (Section 3.3), the largest TP source is turbulent resuspension of sediment in the lake itself. Discussions with the local county conservation board and DNR Fisheries staff have indicated that a large fraction of the internal load could be originating from rough fish that disturb bottom sediment while feeding and swimming. Since carp and other rough fish cause the resuspension, reductions in their population should be a high priority.

The relatively long hydraulic detention time of the lake increases the negative impacts of internal loading. A pound of TP is recycled to the water column an average of five times before it is flushed from the lake. This is an additional reason to focus on reducing sediment resuspension. Another benefit from carp population reductions would be the growth of rooted aquatic plants that inhibit sediment resuspension and provide another sink for lake phosphorus besides algal blooms.

The following reductions are suggested for achieving water quality goals. Figures 4 and 5 show the existing watershed and total loads and loads after suggested reductions are shown in Figure 6. The suggested load reduction scenario requires the following:

- A 92 percent reduction in the resuspension of lake bottom sediment by carp and wind driven wave action implemented through the reduction of common carp populations and the establishment of aquatic plants in shallow areas susceptible to waves. Encourage the growth of rooted aquatic plants in shallow areas to stabilize bottom sediments.
- A 79 percent reduction in row crop loads by implementing best management practices (BMP). The suggested watershed changes should be managed to give the most practical and effective reductions that achieve the allocated load. As an example, unit reductions (lbs/acre) for ungrazed grassland cannot be expected to be as great as those that can be achieved for row-cropped land uses where management of erosion and fertilizer application can have a significant impact. BMPs may include the following:

1. Nutrients applied to production agricultural ground should be managed to achieve the optimum soil test category. Over the long term, maintaining this soil test category is the most profitable for producers.
2. Manure and commercial fertilizer should be incorporated while controlling soil erosion. Incorporation physically separates phosphorus from surface runoff.
3. Adoption of no till and reduced tillage systems should be encouraged.

4.2 Executing the Implementation Plan, the IDNR Fisheries Strategy

IDNR Fisheries staff and other partners have initiated a Lost Island Lake restoration project based on strong local support, a high potential for success, and the potential for significant benefits from improved lake water quality. This section is meant to act as guide to developing a community based implementation plan.

Lost Island, like many of Iowa's natural lakes, exhibits poor water quality from a variety of factors. Key factors influencing water quality have been identified in this report, but an understanding of Iowa's natural lake systems is needed so informed decisions concerning restoration can be made.

The water quality of Iowa's lakes begins with the land draining to them. Without a healthy watershed, it is virtually impossible for a waterbody to have or maintain good water quality. A healthy watershed exhibits historic or pre-settlement characteristics of water delivery, and soil and nutrient delivery to the lake. Restoration of watersheds to this state using BMP's and restoring critical wetlands can be possible without drastically altering current land use practices.

The lake itself must also exhibit qualities and characteristics from pre-settlement time. Healthy natural lakes often exhibit dense stands of emergent species of aquatic vegetation on and near the shoreline and extensive beds of submergent aquatic vegetation in shallow water. Aquatic vegetation consolidates lake-bottom sediments, absorbs and diminishes wind and wave action, provides a healthy habitat for a variety of fish and invertebrate species, and utilizes nutrients that otherwise fuel algae blooms.

Most species of emergent vegetation require drying of the lake bottom for germination. Static high water levels from man-made water level control structures and excess drainage from many of Iowa's natural lake watersheds have caused a gradual recession, and in many cases, a complete loss of emergent vegetation. Only during Iowa's most extensive droughts are conditions right for emergent vegetation to germinate and spread. A lack of water clarity during much of the growing season causes the recession of submergent vegetation. When sunlight cannot penetrate to the bottom of the lake, submergent vegetation cannot grow.

<u>Watershed Management</u> - The importance of controlling sedimentation, nutrient loading, and volume of water delivered from Lost Island Lake's watershed should not be minimized. Watershed improvements undoubtedly increase the chances of a successful

lake restoration project. Watershed improvements and land use planning add stability and resilience of the watershed to erosion, developmental threats, and pollution.

Lake Management - In-lake management can be much more challenging to plan for and implement. Watershed tools and processes are well understood and developed. Tools for assessing key factors for impairment within the lake are much harder to partition. For example, internal loading for Lost Island Lake has been calculated as 70% of the total loading for the lake. Factors influencing this 70% are most likely from a lack of aquatic vegetation, abundance of rough fish, wind and wave action, and loosely consolidated bottom sediments. Determining the extent of influence of each of these factors is nearly impossible. Interactions among these factors further confound efforts to partition causal relationships. Addressing these factors as a whole will offer the best chance for successful restoration.

Restoration

Restoration efforts for Lost Island Lake should be targeted at watershed improvements, common carp control, and lake water level mitigation.

Watershed restoration

An assessment and analysis of Lost Island Lake's watershed may reveal critical areas needing protection and help identify areas where land management improvements can be made. A watershed assessment should identify key sets of existing data and critical gaps of information to be addressed. Analysis of this data will help to prioritize placement of key wetlands, installation of best management practices (BMPs), and identify other potential pollution threats. A watershed management plan should be developed to incorporate these findings into a plan of action to treat identified watershed concerns.

Common Carp

Attempts in the past to control common carp populations in Iowa and many other states have had limited success. Strategies for control must not only reduce the overall biomass of the population, but also reduce recruitment or reproduction. A systematic and multi-faceted approach to carp control is critical for improving the chance for success. Strategies for common carp control should be aimed at monitoring population characteristics and numbers/biomass throughout the period of restoration. Populations control measures should be implemented that include, but are not limited to large-scale removal, heavy predator stocking, and limiting reproduction.

Common carp removal

- Population estimates should be conducted throughout restoration efforts
- Objective levels for removal need to be established and based on research from other successful studies
- Logistics addressing removal costs and disposal or utilization need to be considered
- Removal should be targeted during times when common carp are concentrated

Common carp reproduction

- Adjacent wetlands and sloughs provide common carp habitat for rapid reproduction. Limiting or removing access to these areas before removal efforts begin is important.
- Renovating and improving the adjacent wetlands in also vital to improving their health and contribution to improving lake water quality.
- Barriers designed to prevent undesirable fish species from entering these critical areas should be considered.
- A maintenance schedule of periodic drawdown of these wetlands should be considered to protect these resources and provide long-term benefit.
- Introductions of predatory fish is a biological method for reducing common carp numbers. Stocking and maintaining several types of species should be considered as a way to augment other efforts.

Lake water level management

Other natural lake restoration efforts have been successful because they address lake water levels as part of the multi-faceted approach. Manipulations in lake water levels are important to help re-establish critical emergent plant species. These plants buffer shorelines and shallow water areas from wind and wave action. They also provide critical habitat for a host of aquatic organisms including many species of sport fish. Lowering water levels also helps to consolidate bottom sediments in shallow water areas further reducing sediment resuspension after water levels return to normal.

Previous successful natural lake restoration projects in the Midwest have utilized water level manipulation to simulate the effects of a natural drought cycle. Drawdowns vary in scope and have lasted from 1 to 3 years. They are also repeated when necessary to re-establish vegetation.

Water level drawdown can be very contentious among lake residents because of potential navigation issues, and adjustments in riparian access. Any temporary sacrifices must be weighed by the local community against the potential benefits that can be realized through these efforts.

Monitoring

Monitoring during restoration efforts is vital to understanding the lake and documenting improvements and ultimately success. Monitoring will lead to a better understanding of variations in water quality biological and chemical process, and watershed inputs.
Fish populations including common carp populations should be monitored on a yearly basis.

- Aquatic vegetation surveys should be conducted yearly.
- Water quality parameters should be collected regularly. Parameters should include those documented in Iowa Lakes Classification for Restoration (Downing et al. 2005)
- Wildlife response can be documented through bird surveys
- If needed, watershed based water quality monitoring strategies may need to be created to better understand and quantify watershed inputs.

4.3. Implementation Timeline

In monitoring, data analysis, and modeling there is always some uncertainty as to how representative sampling and models are of actual conditions and system dynamics. While some natural variability and data gaps are inevitable, the procedures used in this report are a reasonable explanation of the pollutant sources and water quality situation. In the TMDL report, uncertainty is dealt with through the application of a margin of safety.

As the stakeholders move to implementation of phosphorus reductions, adaptive management of remediation activities and best management practices can be a sensible and efficient way to ensure that these measures are having the desired impact. Adaptive management reduces both resuspension and watershed loads by incrementally applying management practices and monitoring the resulting water quality to see if progress is being made towards achieving goals. Watershed load reduction requires carp management and adjustment to agricultural practices. Changes like these require time to implement. For these reasons, the following watershed improvement timeline in Table 9 is recommended.

Table 9 Implementation timeline

Source	Existing loads, lb/year	2011 target loads, lb/year	2015 target loads, lb/year
Resuspension, carp management	3,748	1,500	330
Row Crop	1,542	850	325
Other Land Cover	684	500	396
Total	**5,974**	**2,850**	**1051**

5. Future Watershed and Water Quality Monitoring

Watershed and in-lake water quality monitoring are important elements in any plan to improve Lost Island Lake. It plays a key role in both the analysis and modeling of pollutant sources and water quality. Monitoring is necessary to track the effectiveness of lake water quality improvement measures.

5.1. Monitoring to Support Lake System Evaluation

Monitoring similar to that done for the ISU Lake Study sampling will continue at Lost Island Lake. This monitoring, consisting of three to six samples taken in the growing season, provides enough information for 305b assessment purposes. Over a long enough time, this data is also sufficient to detect trends when evaluated using the right statistical tools. It is not adequate for a mechanistic understanding of the lake system.

The hydrology of the Lost Island Lake watershed and the region have a large impact on lake water quality. Lost Island Lake monitoring should include components that describe hydrologic factors such as water table and water surface elevations and their relationship to the lake water balance.

The variability in lake systems from year to year is considerable and averaging available data over a few or many years will likely conceal important responses to shifting hydrology and other factors. Data collection must take place in an analytical framework that accounts for precipitation and can explain observed variability.

Monitoring that will support this analysis and modeling should include the following:

- Measurement of the water surface elevation. This can be as simple as putting up a gage staff in a protected area, and reading and recording from it every day. There is a point of outflow through Barringer Slough that might provide worthwhile discharge information. Accurately determining lake detention time will help calibrate the watershed and lake models and help explain TP and chlorophyll response to changing conditions.
- Measurement of flows into the lake from Blue Wing Marsh and sampling for total and dissolved phosphorus, turbidity, ISS and TSS will help clarify watershed loading.
- Biweekly sampling of important water quality variables to support a mechanistic representation of the lake system.
- Measure precipitation, wind speed, and temperature near the lake.
- Continuous monitoring of dissolved oxygen and temperature for improved lake model calibration.

5.2. Monitoring Plan for Prospective Watershed Projects

The recommendations for water quality improvement focus on reducing the carp population and implementing management practices on agricultural land that will reduce nutrient loss and encouraging the growth of aquatic plants in shallow areas of the lake.

Monitoring to see if goals are being accomplished should incorporate each of these:

- Assess changing carp populations and aquatic plant coverage each year.
- Do an assessment of agricultural practices and check in five years for BMP implementation.

Modeled watershed scenarios can estimate potential TP reduction as sources are removed and land uses are modified. Improved lake sampling and hydrologic measurement may permit the modeling and evaluation of seasonal changes in algal productivity and the impact of precipitation. Reduced carp populations can be modeled to describe how algal blooms respond to these changes in specific conditions.

6. Public Participation

Public involvement is important in the TMDL process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in Lost Island Lake. During the development of this TMDL, an effort was made to ensure that local stakeholders were involved in a decision-making process aimed at feasible and achievable goals for improving Lost Island Lake.

6.1. Public Meetings

A stakeholder meeting was held at the Palo Alto County Conservation Board Lost Island Lake Nature Center on June 25, 2007. The purpose of the meeting was to gather information from regional agency staff and local stakeholders on lake water quality and watershed conditions contributing to the turbidity and algae and to explore remedies. It was noted that

Lost Island Lake is an underutilized and underperforming resource based on expectations for a lake with:

- a good watershed to lake ratio, 4.5:1;
- a mean depth of ten feet;
- a sewer constructed 1988 that removed septic tanks discharges;
- a large well-placed wetland area that provides suspended solids settling in the major drainage (Blue Wing Marsh) and a buffer to poor watershed practices.

The meeting consensus was that water quality should be better than what is now seen. Rooted aquatic plants have mostly disappeared contributing to shoreline erosion and aggravating resuspension of bottom sediment. IDNR staff said that the fishery would improve with improved water quality.

PUBLIC MEETING HELD DURING 30 DAY COMMENT PERIOD - NOTES

To: Lost Island Lake TMDL File
From: William Graham
Date: June 6, 2008
Subject: June 4, 2008 Public Meeting – Lost Island Lake Water Quality Improvement Plan

Location: Palo Alto County Conservation Board Nature Center
Meeting coordinators: Bill Graham, IDNR Watershed Improvement Section; Mike Hawkins, IDNR Fisheries

Bill Graham, IDNR, Watershed Improvement, 515 281 5917
william.graham@dnr.state.ia.us

Mike Hawkins, IDNR Regional Fisheries Biologist, 712 336 1840
michael.hawkins@dnr.state.ia.us

IDNR Staff Attending

George Antoniou, IDNR Lake Restoration Program, Wallace State Office Building, Des Moines, IA 50311, 515 281 0482, george.antoniou@dnr.iowa.gov

Allen Bonini, IDNR Watershed Improvement Section Supervisor, allen.bonini@dnr.iowa.gov

Mark Gulick, IDNR Wildlife Regional Supervisor, email Mark.Gulik@dnr.iowa.gov

Jim Wahl, IDNR Fisheries Regional Supervisor, email Jim.Wahl@dnr.iowa.gov

Meeting Outline:

- IDNR Lake Restoration Program presentation and funding options – George Antoniou
- IDNR Water Quality Improvement Plan (TMDL) Presentation – Bill Graham
- IDNR Fisheries –implementing water quality improvement. Background information on carp removal. Mike Hawkins
- Discussion and questions – All Attendees

Narrative

The meeting was opened by Gary Small, the president of the Lost Island Lake Protection Association. The meeting was attended by 37 stakeholders including federal, state, and county agency staff, homeowners, and farmers.

George Antoniou said that Lost Island Lake was on the IDNR Lake Restoration Program priority list for attention and funding. He outlined procedures for local stakeholders to arrange to meet with lake restoration staff about plans to improve Lost Island Lake water quality. He described the program and available funding and noted that Lost Island Lake was to receive $100,000 in program funds this year.

Bill Graham presented an evaluation of the Lost Island Lake water quality problems that are caused by algae and inorganic suspended solids. It was explained that excess phosphorous was the major factor causing algal blooms and that the most significant phosphorus sources were sediment resuspension by carp and watershed runoff. Small particles (clay and silt size) also cause turbidity. These originate from watershed runoff and bottom sediment resuspension caused by wave and bottom feeding fish turbulence. Recommendations are to significantly reduce the numbers of carp, minimize wind-driven turbulence in shallow areas with aquatic vegetation, and reduce phosphorus in watershed runoff.

Mike Hawkins presented the outline of a practical implementation plan for improving Lost Island Lake water quality and fishery by managing carp numbers in the lake. This is to be accomplished through carp removal in the lake and controlling reproduction in the adjacent Blue Wing Marsh and Barringer Slough.

The open discussion with stakeholders touched on the issues of carp removal, fishing quality, and aquatic vegetation.

Lost Island Lake Public Meeting Sign in Sheet

Name	Affiliation	Email Address	Telephone	Address
Bill & Marcia Nelson			712 837 4650	3555 320th Ave, Ruthven 51358
DJ Vogeler		dvogeler@gmail.com		605 13th St. Spirit Lake
Al Peterbaugh			712 837 4825	1004 Bluen St., Ruthven
Frank Hoffman			712 262 3572	2855 260th Ave., Spencer, IA
Darrell Frank			712 837 4401	3325 340th Ave., Ruthven, IA 51358
David Marks	homeowner		712 837 4492	33502 Electric Park, Ruthven
Bob Nawey, DRVM			712 837 4430	3354 320th St., Ruthven 51358
Eli Grimm			515 887 4356	407 3rd Ave.SW, West Bend, IA
Jon Josephson	LI-R Betterment Assoc.	jojose@ruthven.k12.ia.us	712 260 3212	34320 320th St., Ruthven
Wilbert Bielfeldt		Wbiel@ruthventel.com	712 877 5403	3260 335th Ave., Ruthven
Jack Van Norma			712 837 5535	3258 335th St., Ruthven
Heather Penney	LIPA, homeowner	jhpenney@mchsi.com	712 837 5207	3350 320th St., Ruthven
Nancy A. Drum	LIPA	bndrum@ruthventel.com	712 837 4430	3354 320th St., Ruthven 51358
Jim Nighbors	LIBA	jimnighbors@ruthventel.com	712 837 4806	34834 320th St. Ruthven
Jim Penney	LIBA	jhpenney@mchsi.com	712 837 5207	3350 320th St., Ruthven
Cassy Bohnet		cjbohnet@gmail.com	712 363 1544	
Miriam Patton	PACCB	paccb@ruthventel.com	712 837 4866	3259 355th Ave., Ruthven
Brian Waldstein		bjwfarms@new.net	712 283 2830	1738 430th St., Sioux Rapids, IA 50535
Steve Pitt	PACCB	paccb@ruthventel.com	712 837 4866	3259 355th Ave., Ruthven
Gary Mohr	Contract Carp Removal		712 336 3418	3216 Center Lake Dr., Spirit Lake, 51360
Jeremy Thiges	NRCS	Jeremy.thilges@ia.usda.gov	712 852 3386 x3	3302 Main, Emmetsburg, 50536
Gary Small	L. I. Prot. Assoc.	bgsmall@smunet.net ?	712 262 7420	1611 Grand Plaza Dr., Sorensen, 51301

6.2. Written Comments

Written comments and the response to these comments by IDNR staff can be found in Appendix G.

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8. Appendices

Appendix A --- Glossary of Terms and Acronyms

303(d) list:	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."
305(b) assessment:	Refers to section 305(b) of the Federal Clean Water Act, it is a assessment of the state's water bodies ability to support their general and designated uses. Those found to be not supporting their uses are placed on the 303(d) list.
319:	Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. States receive EPA grants to provide technical & financial assistance, education, and monitoring for local nonpoint source water quality improvement projects.
AFO:	Animal Feeding Operation. A livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed to become concentrated.
Base flow:	The fraction of stream flow from ground water.
BMP:	Best Management Practice. A general term for any structural or upland soil or water conservation practice. Examples are terraces, grass waterways, sediment retention ponds, and reduced tillage systems.
CAFO:	Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof.
Cyanobacteria (blue-green algae):	Phytoplankton that are not true algae but can photosynthesize. Some species produce toxins that can be harmful to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecologic activities that a specific water body is intended to support. See Appendix B for a description of general and designated uses.
DNR (or IDNR):	Iowa Department of Natural Resources.
Ecoregion:	A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features.
EPA (or USEPA):	United States Environmental Protection Agency.
FSA:	Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.
General use(s):	Refer to narrative water quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of general and designated uses.

GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.
Gully erosion:	Soil loss occurring in upland channels and ravines that are too wide and deep to fill with traditional tillage methods.
HEL:	Highly Erodible Land. Land defined by NRCS as having the potential for long term annual soil losses that exceed the tolerance for an agricultural field eightfold.
LA:	Load Allocation. The fraction of a waterbody pollutant load that comes from *nonpoint sources* in a watershed.
Load:	The total amount (mass) of a particular pollutant in a waterbody.
MOS:	Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.
Nonpoint source pollutants:	Contaminants that originate from diffuse sources not covered by NPDES permits.
NPDES:	National Pollution Discharge Elimination System. A federal system of regulatory discharge controls that sets pollutant limits in permits for point source discharges to waters of the United States.
NRCS:	Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.
Periphyton:	Algae that are attached to stream substrates (rocks, sediment, wood, and other living organisms).
Phytoplankton:	Collective term for all suspended photosynthetic organisms that are the base of the aquatic food chain. Includes algae and cyano-bacteria.
Point source pollution:	Point sources are regulated by an NPDES permit. Point source discharges are usually from a location of flow concentration such as an outfall pipe.
PPB:	Parts per Billion. A measure of concentration that is the same as micrograms per liter (µg/l).
PPM:	Parts per Million. A measure of concentration that is the same as milligrams per liter (mg/l).
Riparian:	The area near water associated with streambanks and lakeshores and the physical, chemical, and biological characteristics that cause them to be different from dry upland sites.
RUSLE:	Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.
Secchi disk:	A device used to measure transparency in water bodies. The greater the secchi depth, the greater the water transparency.
Sediment delivery ratio:	The fraction of total eroded soil that is actually delivered to the stream or lake.

Seston:	All suspended particulate matter (organic and inorganic) in the water column.
Sheet & rill erosion	Water eroded soil loss that occurs diffusely over large flatter landscapes before the runoff concentrates.
Storm flow (or stormwater):	The fraction of stream flow that is direct surface runoff from precipitation.
SWCD:	Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.
TMDL:	Total Maximum Daily Load. The maximum allowable amount of a pollutant that can be in a waterbody and still comply with the Iowa Water Quality Standards and support designated uses.
TSI (or Carlson's TSI):	Trophic State Index. A standardized scoring system (scale of 0-100) used to characterize the amount of algal biomass in a lake or wetland. Index values for TP, chlorophyll, and transparency are calculated for this purpose.
TSS:	Total Suspended Solids. The quantitative measure of seston, all materials, organic and inorganic, which are held in the water column. It is defined by the lab filtration procedures used to measure it.
Turbidity:	A measure of the scattering and absorption of light in water caused by suspended particles.
UHL:	University Hygienic Laboratory (University of Iowa). Collects field samples and does lab analysis of water for assessment of water quality.
USGS:	United States Geologic Survey. Federal agency responsible for flow gauging stations on Iowa streams.
Watershed:	The land surface that drains to a particular body of water or outlet.
WLA:	Waste Load Allocation. The allowable pollutant load that a point source NPDES permitted point source may discharge without exceeding water quality standards.
WQS:	Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.
WWTP:	Waste Water Treatment Plant. A facility that treats municipal and industrial wastewater so that the effluent discharged complies with NPDES permit limits.
Zooplankton:	Collective term for small suspended animals that are secondary producers in the aquatic food chain and are a primary food source for larger aquatic organisms.

Appendix B --- General and Designated Uses of Iowa’s Waters

Introduction

Iowa’s Water Quality Standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria used to assess water bodies for support of their aquatic life, recreational, and drinking water uses. There are different criteria for different waterbodies depending on their designated uses. All waterbodies must support the general use criteria.

General Use Segments

A general use water body does not have perennial flow or permanent pools of water in most years, i.e. ephemeral or intermittent waterways. General use water bodies are defined in IAC 567-61.3(1) and 61.3(2). General use waters are protected for livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses.

Designated Use Segments

Designated use water bodies maintain year-round flow or pools of water sufficient to support a viable aquatic community. In addition to being protected for general use, perennial waters are protected for three specific uses, primary contact recreation (Class A), aquatic life (Class B), and drinking water supply (Class C). Within these categories, there are thirteen designated use classes as shown in Table B1. Water bodies can have more than one designated use. The designated uses are found in IAC 567-61.3(1).

Table B-1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Appendix C --- Water Quality Data

Table C-1. ISU Lake Study monitoring data, 2000 to 2007

Sample Date	Total Phos. µg/l	Chlor-a, µg/l	secchi Depth, m	Total Nitrogen, mg/l	Inorganic Suspended Solids, mg/l	Volatile Suspended Solids, mg/l	Total Suspended Solids, mg/l
06/15/00	197.55	13.90	0.480	1.98	22.50	6.50	29.00
07/14/00	177.02	64.24	0.350	2.12	16.43	7.14	23.57
08/07/00	127.97	10.17	0.470	2.10	16.67	8.75	25.42
05/16/01	112.63	26.40	0.410	2.26	1.80	2.20	4.00
06/14/01	165.94	17.22	0.650	2.39	15.43	9.35	24.78
07/19/01	48.01	35.58	0.500	1.81	15.53	14.74	30.26
05/22/02	119.74	13.76	0.350	2.02	0.33	1.33	1.67
06/19/02	101.00	23.94	0.300	1.45	28.72	21.03	49.74
07/25/02	82.05	77.80	0.250	1.58	16.00	13.33	29.33
05/22/03	80.41	18.28	0.300	0.42	14.29	9.52	23.81
06/19/03	66.29	14.66	0.600	1.84	10.50	13.50	24.00
07/23/03	77.32	26.10	0.350	1.56	5.00	15.00	20.00
05/20/04	84.78	25.86	0.475	1.52	6.67	18.79	25.45
06/17/04	71.83	32.60	0.450	1.69	12.72	9.21	21.93
07/21/04	70.49	37.46	0.450	1.48	8.50	15.00	23.50
05/26/05	52.15	18.72	0.850	1.94	1.93	9.40	11.32
06/22/05	54.01	48.17	0.300	1.63	10.40	12.00	22.40
07/25/05	86.75	62.71	0.350	1.65	4.00	20.00	24.00
05/24/06	65.00	27.00	0.700	2.01	11.00	16.00	27.00
06/21/06	92.00	56.00	0.300	1.73	12.00	24.00	36.00
07/27/06	79.00	29.00	0.600	1.56	3.00	23.00	26.00
05/23/07	85.00	28.60	0.400	1.52	12.00	14.00	25.00
06/20/07	78.00	30.20	0.300	1.55	13.00	11.00	24.00
07/25/07	66.00	30.70	0.600	0.26	2.00	19.00	21.00
Mean	93.4	32.0	0.449	1.7	10.9	13.07	23.88
Median	81.2	27.8	0.4	1.7	11.5	13.4	24.0
Std. Dev.	39.12	17.69	0.15	0.49	7.00	6.01	9.35
Coef. Of Var.	0.42	0.55	0.34	0.29	0.65	0.46	0.39

Table C2 Lost Island Lake TSI Values based on ISU Lake Study data

Sample Date	TSI (TP)	TSI (CHL)	TSI (SD)
06/15/00	80	56	71
07/14/00	79	71	75
08/07/00	74	53	71
05/16/01	72	NA	39
06/14/01	78	59	66
07/19/01	60	66	70
05/22/02	73	56	75
06/19/02	NA	62	77
07/25/02	68	73	80
05/22/03	67	59	77
06/19/03	65	57	67
07/23/03	67	63	75
05/20/04	68	63	71
06/17/04	66	65	72
07/21/04	66	66	72
05/26/05	61	59	62
06/22/05	62	69	77
07/25/05	69	71	75

Appendix D --- Analysis and Modeling

Lake Hydrology

Flow and watershed characteristics for 26 USGS gauging stations with small drainage areas were evaluated using simple and multiple linear regressions. These provide the average annual flow estimates used in this report. For Lost Island Lake, simple regression equations using drainage area as the only variable calculated average annual flow to the lake. The difference in reliability between simple and multiple regressions as measured by R-squared was negligible. Table D1 shows the basic statistics for the small basins used.

Table D-1. Basin Characteristic Range Used for Regression Equations

Basin Characteristic	Minimum	Mean	Maximum
Drainage Area (mi^2)	2.94	80.7	204
Mean Annual Precip (inches)	26.0	34.0	36.2
Average Basin Slope (%)	1.53	4.89	10.9

Simple regression models were developed for annual average and monthly average statistics with drainage area as the sole explanatory variable. All data were log transformed. Explanatory variables with regression coefficients that were not statistically different from zero (p-value greater than 0.05) were not utilized. The equations were developed from stream gauge data for watersheds with little open water fraction relative to other types of land cover. The drainage area does not include the lake surface. Morphology and hydrologic regression equation results are shown in Table D-4.

Table D-2. Regression Equation Variables

Annual Average Flow (cfs)	$\overline{Q}_A$
Monthly Average Flow (cfs)	$\overline{Q}_{MONTH}$
Annual Flow – calendar year (cfs)	Q_{YEAR}
Drainage Area (mi^2)	DA
Mean Annual Precip (inches)	$\overline{P}_A$
Mean Monthly Precip (inches)	$\overline{P}_{MONTH}$
Antecedent Mean Monthly Precip (inches)	$\overline{A}_{MONTH}$
Annual Precip – calendar year (inches)	P_{YEAR}
Antecedent Precip – calendar year (inches)	A_{YEAR}

Table D-3. Drainage Area Only Equations

Equation	R^2 adjusted (%)	PRESS (log transform)
$\overline{Q}_A = 0.832DA^{0.955}$	96.1	0.207290
$\overline{Q}_{JAN} = 0.312DA^{0.950}$	85.0	0.968253
$\overline{Q}_{FEB} = 1.32DA^{0.838}$	90.7	0.419138
$\overline{Q}_{MAR} = 0.907DA^{1.03}$	96.6	0.220384
$\overline{Q}_{APR} = 0.983DA^{1.02}$	93.1	0.463554
$\overline{Q}_{MAY} = 1.97DA^{0.906}$	89.0	0.603766
$\overline{Q}_{JUN} = 2.01DA^{0.878}$	88.9	0.572863
$\overline{Q}_{JUL} = 0.822DA^{0.977}$	87.2	0.803808
$\overline{Q}_{AUG} = 0.537DA^{0.914}$	74.0	1.69929
$\overline{Q}_{SEP} = 0.123DA^{1.21}$	78.7	2.64993
$\overline{Q}_{OCT} = 0.284DA^{1.04}$	90.2	0.713257
$\overline{Q}_{NOV} = 0.340DA^{0.999}$	89.8	0.697353
$\overline{Q}_{DEC} = 0.271DA^{1.00}$	86.3	1.02455

Table D-4. Lost Island Lake Hydrology

Characteristic or calculated variable	
Type	Natural, glacial origin
Inlet(s)	One major inlet
Outlet(s)	One major outlet
Volume	11,870 acre-feet
Surface Area	1,151 acres
Watershed Area	6,273 acres
Mean Annual Precipitation	29.0 inches
Mean Annual Class A Pan Evaporation	48 inches
Evaporation Coefficient	0.70
Mean Depth	10.3 feet
Drainage Area	5,122 acres (without lake area)
Watershed/Lake Area ratio	4.5
Mean Annual Lake Evaporation	33.6 inches
Mean Annual Lake Evaporation	3,223 acre-feet/year
Annual Average Inflow	4,389 acre-feet/year
Direct Precipitation on Lake Surface	2,782 acre-feet/year
Inflow + Direct Precipitation	7,170 acre-feet/year
Percent Inflow	61.2%
Percent Direct Precipitation	38.8%
Outflow	3,947 acre-feet/year
HRT Based on Inflow + Direct Precipitation	1.66 years
HRT Based on Outflow	3.01 years

Modeling Procedures

The procedures used to estimate TP loads to Lost Island Lake consist of:

- Estimates of the delivered loads from watershed sources used the Loading Function Model component of EUTROMOD.
- Estimates of the annual Lost Island Lake TP load used mean observed TP lake concentrations and the hydrologic information in Table D4 were used as input to the BATHTUB lake nutrient model.
- The Loading Function Model output was used as input to the BATHTUB model and the internal resuspension load was then adjusted until the modeled and observed in-lake TP, chlorophyll concentrations, and secchi transparency matched.
- Estimates of the allowable TP loads for the secchi depth transparency target of one meter were reduced until the goal was achieved. This also required a reduction in non-algal turbidity.

The Loading Function Model is in the spreadsheet *Lost Island Lake TP Model8.*xls on the worksheet called Land Cover Loads. This spreadsheet also includes worksheets containing the hydrologic calculations and the Carlson's TSI calculator used to generate the diagnostic TSI chart.

The loading function procedure is based on the Annual Loading Function Model within the Eutromod Watershed and Lake Model developed to evaluate nutrient load delivered to lakes. It incorporates approximations of both soluble runoff and sediment attached phosphorus. It is derived from erosion modeling and a delivery ratio that considers watershed size and ecoregion. The sediment delivery ratio is reduced to 2.5 percent because of the character of the stream that drains most of the watershed into the lake. This stream runs through Blue Wing Marsh for most of its length. Blue Wing Marsh is an area of wetlands and low gradient landscape. Runoff is slowed and much of the sediment falls out before it gets to the lake. Recent bathymetry does not show a sediment accumulation where the tributary discharges into the lake. The other parts of the watershed also drain through wetlands, parkland, and forest. For these reasons, the sediment delivery ratio used for estimating external watershed loads is 2.5%, less than the 4.5% derived using an NRCS equation that only considers watershed area and ecoregion.

<u>Lake response load estimates</u>: In-lake monitoring data is used in conjunction with the BATHTUB model to estimate TP loads delivered to the lake from all sources. These loads include the watershed, sediment resuspension, and atmospheric deposition loads. A large and shallow lake with considerable numbers of carp, Lost Island Lake has a large TP resuspension component.

An evaluation of the watershed conditions and potential TP and sediment sources shows that much has been done to reduce both dissolved and sediment attached TP loads. Discussions with county conservation and DNR Fisheries staff indicate that much of the sediment and TP loading to Lost Island Lake originates as resuspended bottom sediment.

Analysis and Model Documentation

The detailed data analysis and modeling specifics for the Lost Island Lake TMDL are contained in the spreadsheet files listed below in Table D-6. These spreadsheets are located in the folder *TMDL support documentation* and include annotations explaining the modeling and assumptions used.

Table D-5. List of Analysis and Model Documentation Spreadsheets

Spreadsheet file name	Description of contents
rainfallemmetsburg97to07.xls	Temperature and precipitation data from the Emmetsburg weather station.
ISU Study Data LIL.xls	Original water quality data from the ISU Lake Study.
LIL Data Evaluation 2.xls	Analysis and evaluation of all ISU Lake Study and UHL water quality data, 2000 to 2006.
Lost Island Lake TP Model8.xls	IDNR phosphorus loading and lake response model.
LILbtboutputexistingrev2.xls	BATHTUB output for existing lake water quality conditions.
LILbtboutputTMDLrev2.xls	BATHTUB output for TMDL lake water quality conditions
GWLFdailyLIL3.xls	GWLF/BasinSims daily output.
BATHTUB Lake Eutrophication Model Input Files	
lostislandexistingrev2.btb	Lake model response to existing TP loads from watershed, rainfall, and internal resuspension.
lostislandTMDLrev2.btb	Lake response to reductions in watershed and internal resuspension loads that achieve TMDL TP targets.
LIL loads and allocations 3.xls	Watershed nonpoint source allocations output summary. This spreadsheet contains the summarized BATHTUB model output and the allocation and MOS calculation.

EUTROMOD Loading Function Model Assumptions and Parameterization

The IDNR Lake TP Spreadsheet Model intersects three empirical models. The first is the hydrologic regression model described in the first part of Appendix D. This provides the lake inflow data in the hydrology worksheet from which lake hydraulic detention time and other important hydrologic variables are derived. Other information is directly input into the hydrology worksheet and together these drive the lake response model equations and the   to drive the other models are calculated. The regression equation used to derive the average annual lake inflow is primarily based on basin land area.

The Eutromod Loading Function Model uses runoff coefficients to estimate runoff from each land use. For Lost Island Lake the worksheet, Lake Response Models has not been used for in-lake eutrophication evaluation. Instead, as noted previously, the BATHTUB model has been applied for this purpose.

The Eutromod Loading Function does not include a dissolved phosphorus component for non-event flows into the lake. In the IDNR Lake TP Spreadsheet this has been addressed by included a load in the *Other Loads* worksheet called groundwater loads. This is intended to account for this omission in the Loading Function Model. In the case of Lost Island Lake, it is assumed that the groundwater/baseflow component is the difference between the total annual flow (regression equation for small-ungaged streams) and the runoff flow (runoff coefficients) estimates. This difference is of 1,650 acre-feet. This has less impact on TP load that might be expected since most of the TP load comes from the watershed during runoff events.

The groundwater/baseflow component infiltrates through the soil before flowing to the lake. Because of this infiltration and the affinity of phosphorus for soil particle adsorption, the soluble TP fraction in groundwater is relatively lower. Groundwater TP concentration is assumed 0.04 mg/l based on tables in the GWLF User Manual since this component is not considered in the Loading Function Model documentation. The groundwater fraction of the delivered watershed TP load is 10%. Groundwater phosphorus is 3.5% of all TP loading.

The Lost Island Lake watershed loads have been evaluated using Option B in the *Land Cover Loads* worksheet. The land use information comes from a GIS coverage derived from 2002 satellite imagery. The sediment erosion loads are from RUSLE modeling implemented in ArcView using SURGO soil coverages for the K and LS factors. The runoff coefficients are from the Eutromod model user manual (Table 6.3) as are the dissolved nutrient concentrations (Table 6.1). The sediment delivery ratio (cell H8) has been manually input. The attached TP value of 575 mg/kg is derived from typical soil values in the Iowa Phosphorus Index and other references. It is calculated using a soil value of 575 mg/kg and multiplying it by an enrichment ratio of 1.3. The enrichment ratio accounts for the smaller particle size in runoff sediment and its higher TP content due to greater surface area.

The *Other Loads* worksheet includes all of the Lost Island Lake TP sources that are not dissolved land use runoff or transported attached to sediment particles. Direct precipitations loads are included here but not in the watershed input to the lake. TP loads resulting from direct precipitation on the lake surface are added in the BATHTUB nutrient model.

BATHTUB Model Assumptions and Parameterization

The BATHTUB model was setup using the out put from the Eutromod Loading Function Model This model divides phosphorus loads into soluble and attached parts. It is assumed that the dissolved fraction represents orthophosphate (Portho) and that the attached fraction represents the particulate fraction of the TP load.

There is some data for soluble reactive phosphorus in the Iowa State University Lake Study data found in the support documentation folder. This is a good representation of Portho in the BATHTUB model. The average SRP in the lake is 4 µg/l and this has been included in the observed TP – Portho box in the segment data window of BATHTUB as 93 (TP) – 4 (Portho) = 89 µg/l (particulate phosphorus). This has no affect on the model's predicted output since it is observed data.

BATHTUB model load response
The predicted values from the BATHTUB model for total phosphorus, chlorophyll and Secchi depth are compared to the observed values from the in-lake monitoring data in the BATHTUB model output spreadsheet called *LILbtboutputexistingrev2.xls.* These loads include the watershed load generated by the Loading Function Model, atmospheric deposition, and internal resuspension. The TMDL target TP, chlorophyll and Secchi depth and the corresponding watershed and internal resuspension loads needed to achieve the targets are found in the spreadsheet *LILbtboutputTMDLrev2.xls*.

The model has been calibrated to account for the refractory nature and unavailability of a fraction of the measured total phosphorus. The internal load has been adjusted to the watershed model loads and is estimated to be 1 mg/m^2/day. Multiplying the areal loads by the lake area in square meters and converting the resulting values from milligrams to pounds gives the annual internal load of 3,748 lbs/year.

The lake nutrient model has been calibrated by increasing the phosphorus decay rate to 1.50 of that in the standard model. The reason for this is that chlorophyll response to phosphorus is inhibited by non-algal particles as well as by algae and the same sort of calibration is needed for the TP-Portho model.

The tables in the *LIL loads and allocations 3.xls* spreadsheet have the existing watershed loads from the Loading Function Model that have been input into the BATHTUB lake nutrient model, the BATHTUB output for existing loads, and the BATHTUB output for the TMDL target conditions. There are also tables showing the load allocations and margins of safety for the general source categories (watershed, deposition, and internal resuspension) and suggested allocations for the landuses, wildlife and groundwater/baseflow. The two charts in this worksheet are the ones that appear in the TMDL document as Figures 4 and 6. The existing and allocated table appears in the TMDL document as Table 5 and the load allocation table appears as Table 6. The BATHTUB out put tables are from the spreadsheets LILbtboutputexistingrev2.xls and LILbtboutputTMDLrev2.xls, respectively, the modeled existing and TMDL target loads.

Appendix E --- Carlson's Trophic State Index

Carlson's Trophic State Index is a numeric indicator of the continuum of the biomass of suspended algae in lakes and thus reflects a lake's nutrient condition and water transparency. The level of plant biomass is estimated by calculating the TSI value for chlorophyll-a. TSI values for total phosphorus and Secchi depth serve as surrogate measures of the TSI value for chlorophyll.

The TSI equations for total phosphorus, chlorophyll and Secchi depth are:

$$TSI\ (TP) = 14.42 \ln(TP) + 4.15$$

$$TSI\ (CHL) = 9.81 \ln(CHL) + 30.6$$

$$TSI\ (SD) = 60 - 14.41 \ln(SD)$$

TP = in-lake total phosphorus concentration, µg/L

CHL = in-lake chlorophyll-a concentration, µug/L

SD = lake Secchi depth, meters

The three index variables are related by linear regression models and *should* produce the same index value for a given combination of variable values. Therefore, any of the three variables can theoretically be used to classify a waterbody.

Table E-1. Changes in temperate lake attributes according to trophic state[1]

TSI Value	Attributes	Primary Contact Recreation	Aquatic Life (Fisheries)
50-60	eutrophy: anoxic hypolimnia; macrophyte problems possible	[none]	warm water fisheries only; percid fishery; bass may be dominant
60-70	blue green algae dominate; algal scums and macrophyte problems occur	weeds, algal scums, and low transparency discourage swimming and boating	Centrarchid fishery
70-80	hyper-eutrophy (light limited). Dense algae and macrophytes	weeds, algal scums, and low transparency discourage swimming and boating	Cyprinid fishery (e.g., common carp and other rough fish)
>80	algal scums; few macrophytes	algal scums, and low transparency discourage swimming and boating	rough fish dominate; summer fish kills possible

1. Modified from U.S. EPA 2000, Carlson and Simpson 1995, and Oglesby et al. 1987

Table E-2. Summary of ranges of TSI values and measurements for chlorophyll-a and Secchi depth used to define Section 305(b) use support categories for the 2004 reporting cycle.

Level of Support	TSI value	Chlorophyll-a (µg/l)	Secchi Depth (m)
fully supported	<=55	*<=12*	*>1.4*
fully supported / threatened	55 → 65	*12 → 33*	*1.4 → 0.7*
partially supported (evaluated: in need of further investigation)	65 → 70	*33 → 55*	*0.7 → 0.5*
partially supported (monitored: candidates for Section 303(d) listing)	65-70	*33 → 55*	*0.7→ 0. 5*
not supported (monitored or evaluated: candidates for Section 303(d) listing)	>70	*>55*	*<0.5*

Table E-3. Descriptions of TSI ranges for Secchi depth, phosphorus, and chlorophyll-a for Iowa lakes.

TSI value	Secchi description	Secchi depth (m)	Phosphorus & Chlorophyll-a description	Phosphorus levels (µg/l)	Chlorophyll-a levels (µg/l)
> 75	extremely poor	< 0.35	extremely high	> 136	> 92
70-75	very poor	0.5 – 0.35	very high	96 - 136	55 – 92
65-70	poor	0.71 – 0.5	high	68 – 96	33 – 55
60-65	moderately poor	1.0 – 0.71	moderately high	48 – 68	20 – 33
55-60	relatively good	1.41 – 1.0	relatively low	34 – 48	12 – 20
50-55	very good	2.0 – 1.41	low	24 – 34	7 – 12
< 50	exceptional	> 2.0	extremely low	< 24	< 7

The relationship between TSI variables can be used to identify potential causal relationships. For example, TSI values for chlorophyll that are consistently well below those for total phosphorus suggest that something other than phosphorus limits algal growth. The TSI values can be plotted to show potential relationships as shown in Figure E-1.

Appendix F --- Maps

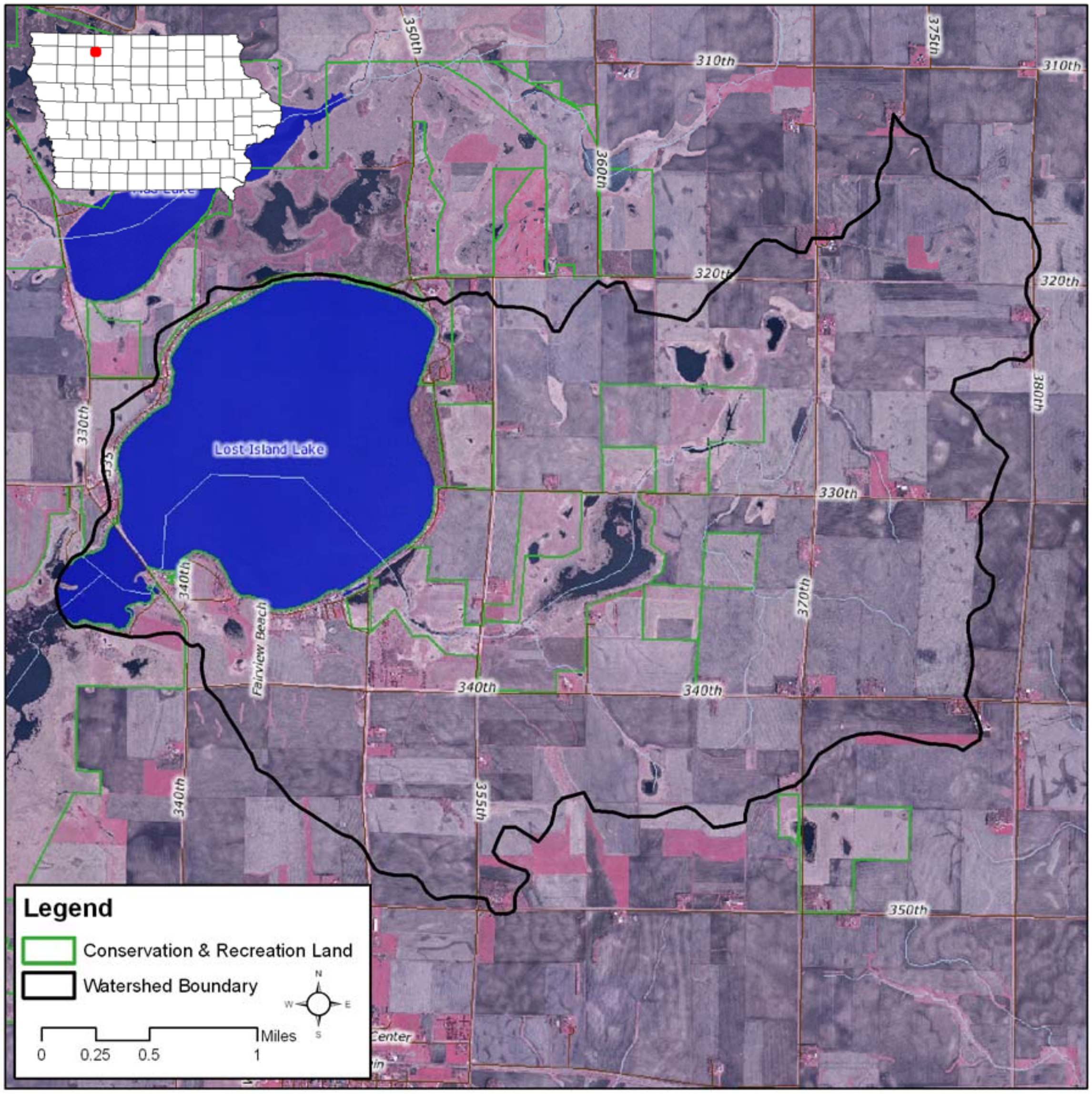

Figure 8 Lost Island Lake and its watershed

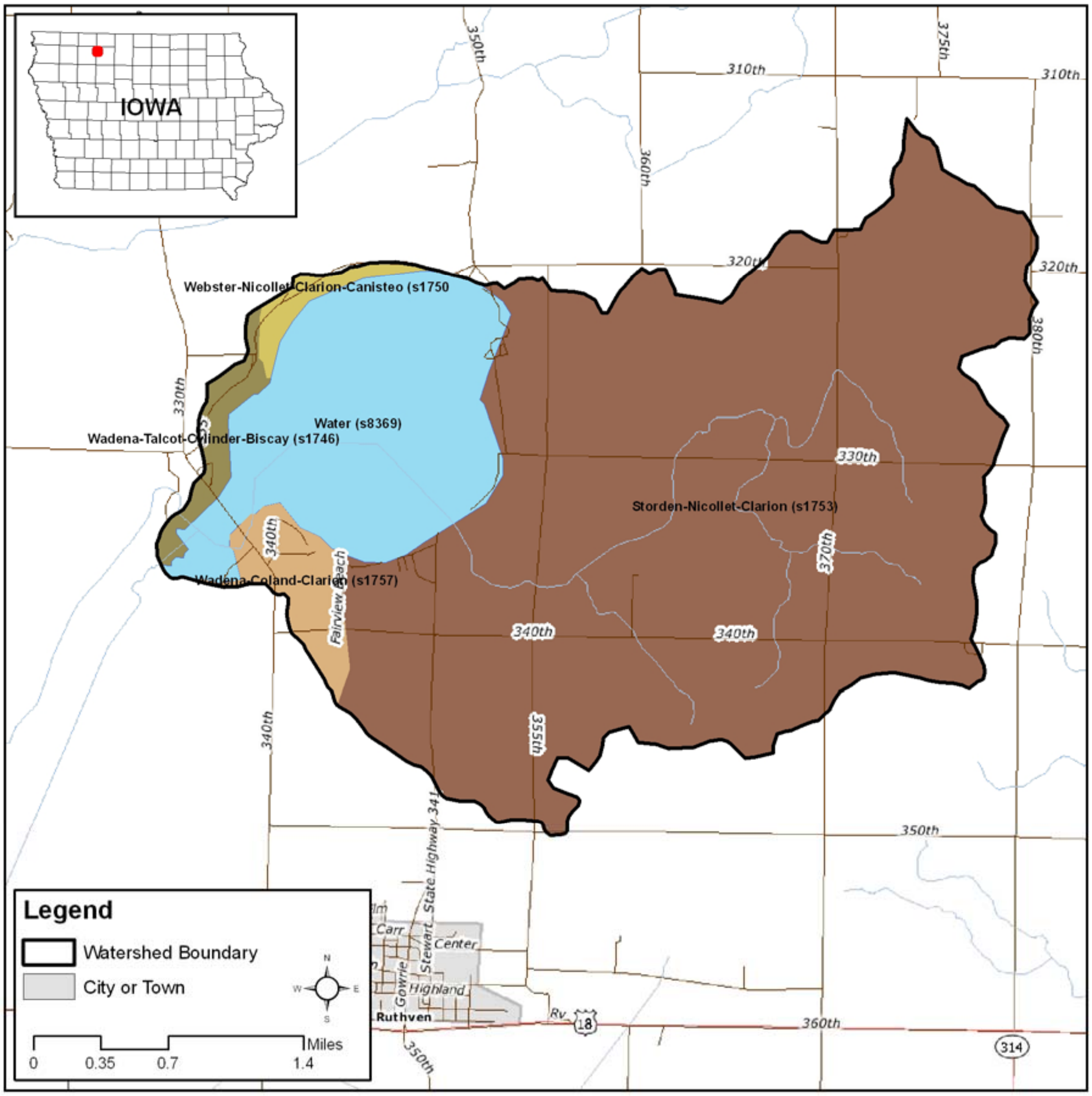

Figure 9 Lost Island Lake watershed soil classes

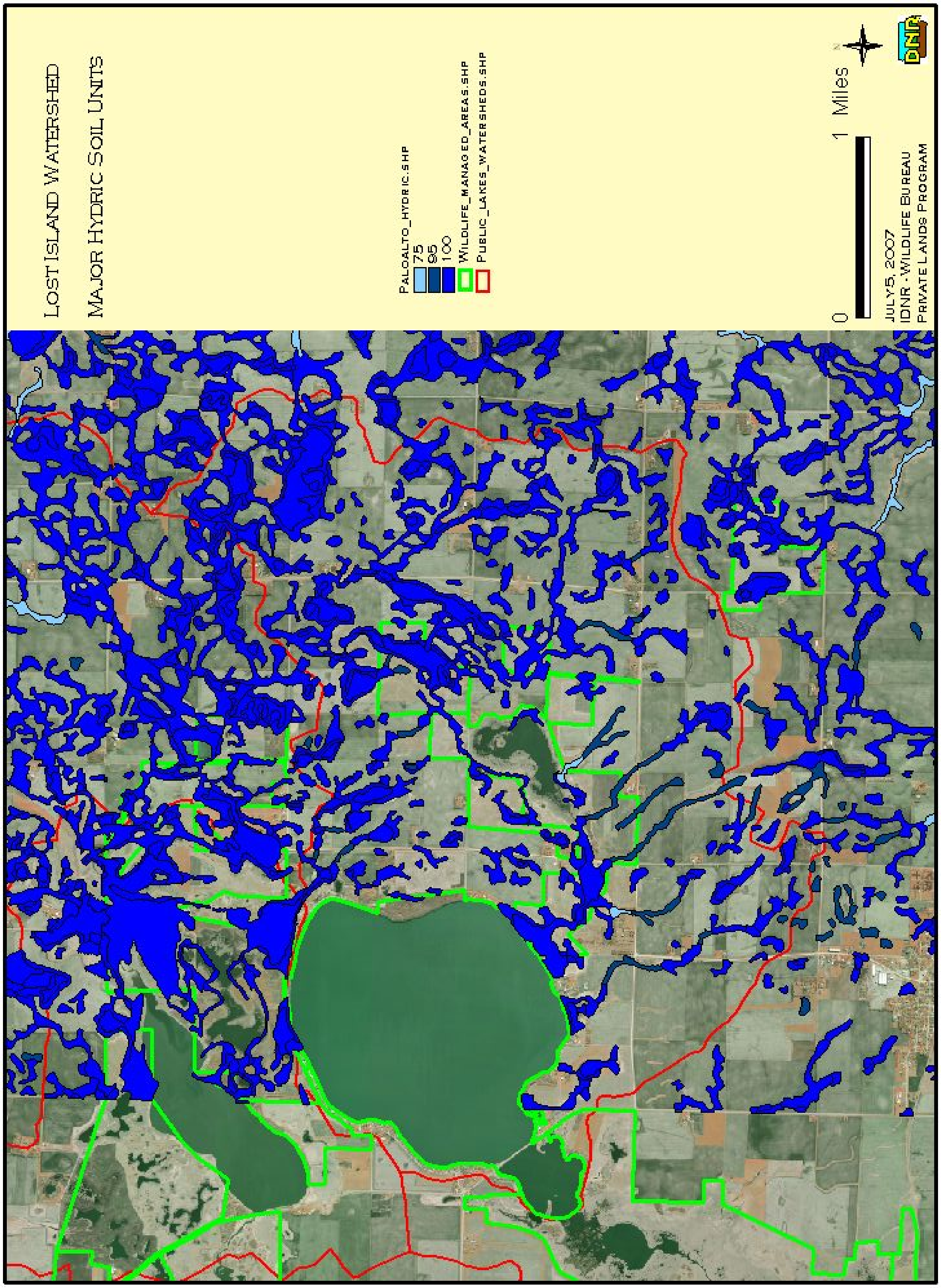

Figure 10 Major Hydric Soil Units

Appendix G --- Public Comments

Berckes, Jeff [DNR]

From:	Adkins.Tabatha@epamail.epa.gov
Sent:	Monday, June 23, 2008 4:21 PM
To:	Bonini, Allen [DNR]
Subject:	Fw: Lost Island Lake
Follow Up Flag:	Follow Up
Flag Status:	Red

Lost Island
ake_06-23-2008.do.

Allen,

Attached are EPA comments on the draft public noticed Lost Island Lake.
Thanks.

TJ

(See attached file: Lost Island Lake_06-23-2008.doc)

Tabatha Adkins, WQMB
WWPD, USEPA Region 7
901 North 5th Street
Kansas City, KS 66101
913.551.7128
adkins.tabatha@epa.gov

Regarding: Draft TMDL for Lost Island Lake for Turbidity (WBID IA 06-LSR-02390-L)

EPA has reviewed the draft document and has the following comments which need to be addressed in the draft TMDL:

Comments:

- The TMDL needs to identify and discuss which model was used for targeting loading.
- The TMDL calculated secchi depth water quality improvement indicates a 55 percent increase. Our calculations indicate more than 100 percent.
- The TMDL needs a discussion on the historical total suspended solids.
- The TMDL needs a discussion on the established linkage on total phosphorus and the translation to turbidity.
- The TMDL needs an explicit (quantified) linkage between phosphorus and turbidity.

Berckes, Jeff [DNR]

From: Graham, William [DNR]

Sent: Wednesday, June 25, 2008 3:37 PM

To: Adkins.Tabatha@epamail.epa.gov

Cc: Bonini, Allen [DNR]; Berckes, Jeff [DNR]

Subject: Lost Island Lake draft TMDL

TJ: Thanks for your comments on the draft Lost Island Lake TMDL. The following ftp site link will take you to a folder with eight spreadsheets in it. Table D-5 in Appendix D contains descriptions of these spreadsheet files. The TMDL data analysis and modeling input and output are in the se.

ftp://ftp.igsb.uiowa.edu/pub/Download/BillG/LostIsland

Here are my responses to your specific comments:

The TMDL needs to identify and discuss which model was used for targeting loading.

The watershed modeling used the IDNR GIS based RUSLE model for erosion estimates and the IDNR spreadsheet version of Eutromod for annual total phosphorus load delivery estimates. The lake response modeling used BATHTUB. The maximum daily load procedure used 10 years of precipitation data in a BasinSims/GWLF watershed model refined to provide estimates of daily loads.

The TMDL calculated secchi depth water quality improvement indicates a 55 percent increase. Our calculations indicate more than 100 percent.

This has been changed to a 122% increase in secchi depth required (Tables 1 and 4). Appears to have been a typo.

The TMDL needs a discussion on the historical total suspended solids.

An evaluation of Lost Island Lake TSS is in section *3.1 Problem Identification*. This section includes the entire 2006 305b Report Lost Island Lake assessment. This assessment is the basis for the recreational use impairment. The assessment uses turbidity and suspended solids interchangeably. There is additional discussion of SS on page 16 paragraph 2.

The TMDL needs a discussion on the established linkage on total phosphorus and the translation to turbidity.

TP and turbidity (measured as secchi depth) are linked in the section *Interpreting Lost Island Lake Data* through the TSI equations and in the BATHTUB water quality modeling. BATHTUB input and output values for both existing and target TP, chlorophyll loads and concentrations and secchi depth are in the spreadsheets *lostislandoutputexisting.xls* and *lostislanoutputTMDL.xls*. The modeled linkage is specifically discussed in the section *Linkage of Sources to Target* on page 20. Additional discussion of the modeling and TSI are in Appendices *D – Analysis and Modeling* and *E – Carlson's Trophic State Index*.

The TMDL needs an explicit (quantified) linkage between phosphorus and turbidity

See above.

Hope this addresses your concerns. Regards, Bill Graham

William Graham, P.E.
Senior Environmental Engineer
Geological and Water Survey
Iowa Department of Natural Resources
Wallace State Office Building, Des Moines, IA 50319
email: william.graham@dnr.iowa.gov
phone: 515-281-5917
fax: 515-281-8895