UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

12/03/2020

Ms. Lori McDaniel
Water Quality Bureau Chief
Iowa Department of Natural
Resources Wallace Building,
Wallace State Office Building E. 9th St.
Des Moines, Iowa 50319

RE: Approval of TMDL document for Prairie Rose Lake

Dear Ms. McDaniel:

This letter responds to the submission from the Iowa Department of Natural Resources, originally received by the U.S. Environmental Protection Agency, Region 7 on September 16, 2020, for a Total Maximum Daily Load document which contained TMDLs for algae and turbidity. The final revised version was received on November 10, 2020. Prairie Rose Lake was identified on the 2018 Iowa Section 303(d) List as impaired by not supporting its primary contact use, as a result of excess algae and turbidity. This submission fulfills the Clean Water Act statutory requirement to develop TMDLs for impairments listed on a state's §303(d) List. The specific impairment (water body segment and causes) are:

Water Body Name	WBIDs	Causes
Prairie Rose Lake	IA 05-NSH-1462	Algae and Turbidity

EPA has completed its review of the TMDL document with supporting documentation and information. By this letter, EPA approves the submitted TMDL document. Enclosed with this letter is Region 7 TMDL Decision Document which summarizes the rationale for EPA's approval of the TMDL document. EPA believes the separate elements of the TMDLs described in the enclosed document adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety.

Although EPA does not review the monitoring or implementation plans submitted by the state for approval, EPA acknowledges the state's efforts. EPA understands that the state may use the monitoring plan to gauge the effectiveness of the TMDL and determine if future revisions are necessary or appropriate to meet applicable water quality standards. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in these TMDLs.

Therefore, the implementation plan in the TMDL document provides information regarding implementation efforts to achieve the loading reductions identified. EPA appreciates the thoughtful effort that IDNR has put into this TMDL. We will continue to cooperate with and assist, as appropriate, in future efforts by IDNR, to develop TMDLs. If you have any questions, contact Jared Schmalstieg, of my staff, at Schmalstieg.Jared@epa.gov or (913) 551-7688.

Sincerely,

JEFFERY ROBICHAUD

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Date: 2020.12.03 14:58:40 -06'00'

Jeffery Robichaud
Director
Water Division

Enclosure

cc: Mr. Allen Bonini, Supervisor, Watershed Improvement Program, IDNR

United States Environmental Protection Agency
Region 7
Total Maximum Daily Load Approval

Prairie Rose Lake, Iowa
Algae and Turbidity

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Date: 2020.12.03 15:01:57 -06'00'

Jeffery Robichaud
Director
Water Division

Date

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EPA Region 7 TMDL Review

TMDL ID: IA 05-NSH-1462 **State:** IA
Document Name: Prairie Rose Lake TMDL
Basin(s): East Branch West Nishnabotna River Basin
HUC(s): 102400020104
Water body(ies): Prairie Rose Lake
Tributary(ies): Unnamed Tributaries
Number of Segments: 1
Number of Segments for Protection 303(d)(3): None
Cause(s): Algae and Turbidity

Submittal Date: Initial 09/16/20, Final 11/10/20 **Approved:** Yes

Submittal Letter and Total Maximum Daily Load Revisions

The state submittal letter indicates final TMDL(s) for specific pollutant(s) and water(s) were adopted by the state and submitted to EPA for approval under Section 303(d) of the Clean Water Act [40 CFR § 130.7(c)(1)]. Include date submitted letter was received by EPA, date of receipt of any revisions and the date of original approval if submittal is a revised TMDL document.

The Iowa Department of Natural Resources (IDNR) officially submitted the Total Maximum Daily Load document (TMDL) to Region 7 of the U.S. Environmental Protection Agency (EPA) on September 16, 2020. IDNR submitted a revised version on November 10, 2020, in response to EPA's comments. EPA approves this TMDL document.

Water Quality Standards Attainment

The targeted pollutant is validated and identified through assessment and data. The water body's loading capacity for the applicable pollutant is identified and the rationale for the method used to establish the cause-and- effect relationship between the numeric target and the identified pollutant sources is described. The TMDL(s) and associated allocations are set at levels adequate to result in attainment of applicable water quality standards [40 CFR § 130.7(c)(1)]. A statement that the WQS will be attained is made.

The target pollutant, total phosphorus, is validated and identified through assessment and data. The TMDL targets are set at a level to attain and maintain water quality standards (WQS).

IDNR' s review and interpretation of the water quality provides justification for linking phosphorus loads to the algae and turbidity impairments. The TMDL document shows that reductions in phosphorus will prevent high levels of algal production and turbidity caused by phosphorus loads to the lake. The TMDL document links the narrative standards for chlorophyll-a and Secchi transparency to total phosphorus by use of the BATHTUB model. The Loading Capacity (LC) is calculated at monitoring stations, but the targeted total phosphorus concentrations apply at all points in the water body.

The Loading Capacity calculation is as follows:

TMDL = LC = WLA + LA + MOS

Where: TMDL = total maximum daily load; LC = loading capacity; WLA = sum of wasteload allocations (point sources); LA = sum of load allocations (nonpoint sources); MOS = margin of safety (to account for uncertainty).

Expressed as the allowable annual average which is helpful for water quality assessment and for watershed planning and management:
TMDL = LC = WLA (0 lbs-TP/year) + LA (1,868 lbs-TP/year) + MOS (208 lbs-TP/year) = **2,076 lbs-TP/year**

Expressed as the maximum daily load:
TMDL = LC = WLA (0 lbs-TP/day) + LA (15.9 lbs-TP/day) + MOS (1.8 lbs-TP/day) = **17.7 lbs-TP/day**

The TMDL document, through BATHTUB modeling, shows that the loading capacity for total phosphorus is 2,076 pounds per year (17.7 pounds/day). The current load is estimated to be 3,988 pounds per year based on the STEPL watershed loading model. A 48% reduction is required (1,912 lb/year) to meet the allowable TP load.

EPA agrees that the TMDL targets will attain and maintain water quality standards.

Designated Use(s), Applicable Water Quality Standard(s) and Numeric Target(s)

The submittal describes applicable water quality standards, including beneficial uses, applicable numeric and/or narrative criteria, and a numeric target. If the TMDL(s) is based on a target other than a numeric water quality criterion, then a numeric expression, site specific if possible, was developed from a narrative criterion and a description of the process used to derive the target is included in the submittal.

Prairie Rose Lake is a Significant Publicly Owned Lake, and is protected for the following designated uses:

Primary Contact Recreational Use – Class A1: Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing and water contact recreational canoeing.

Aquatic Life – Class B(LW): Man-made and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like conditions.

Drinking Water- Class C: Waters which are used as a raw water source of potable water supply.

Human Health – Class HH: Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption. The 2018 assessment/listing cycle has Prairie Rose Lake listed as not meeting the following uses: Primary Contact (not supported-IR 5a) and Aquatic life (partially supported- IR 3b).

The following EPA-approved water quality standards that apply to the lake's impairments are found in the Iowa Administrative Code, Environmental Protection Rule 567, Chapter 61:

> 61.3(2) General water quality criteria. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(l)"a."
>
> a. Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.
>
> b. Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.
>
> c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.
>
> d. Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.
>
> e. Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.

To meet these narrative general water quality criteria, the state has targeted the numerical translator in the TMDL that it would use to delist the water. In order to remove the water body/ pollutant from the 303(d) list for the algae and turbidity impairment to uses, the water body will need to meet WQS, and the median growing season chlorophyll-a and Secchi depth TSI must not exceed 63 TSI units in two consecutive listing cycles, per DNR de-listing methodology.

Using TSI analysis the document shows that target Secchi transparencies should be achieved through the reduction of chlorophyll-a concentrations to the TMDL target. The document also shows that the total phosphorus loading capacity developed using the BATHTUB model will meet both the Secchi transparency and chlorophyll-a targets.

Pollutant(s) of Concern

A statement that the relationship is either directly related to a numeric water quality standard, or established using surrogates and translations to a narrative WQS is included. An explanation and analytical basis for expressing the TMDL(s) through surrogate measures, or by translating a narrative water quality standard to a numeric target is provided (e.g., parameters such as percent fines and turbidity for sediment impairments, or chlorophyll-a and phosphorus loadings for excess algae). For each identified pollutant, the submittal describes analytical basis for conclusions, allocations and a margin of safety that do not

exceed the loading capacity. If the submittal is a revised TMDL document, there are refined relationships linking the load to water quality standard attainment. If there is an increase in the TMDL(s), there is a refined relationship specified to validate that increase (either load allocation or wasteload allocation). This section will compare and validate the change in targeted load between the versions.

The TMDL document establishes a link between the narrative water quality standards and the total phosphorus targets. Excessive nutrients can lead to eutrophic conditions associated with the algae and turbidity impairments. Chlorophyll-a concentrations and the corresponding trophic state index are used to measure algal growth and the extent of nutrient enrichment and excursions of the narrative water quality standards.

Prairie Rose Lake is impaired for excessive algae growth and turbidity. Data interpretation indicates that phosphorus load reduction will best address these impairments. The phosphorus loads to the lake lead to high levels of algal production. Much of the phosphorus enters the lake attached to sediments. Therefore, practices to reduce phosphorus will also reduce any sediment levels impacting turbidity. The primary focus of the TMDL document is quantifying and reducing phosphorus loads to achieve water quality standards.

The linkage between total phosphorus and the listed impairments is appropriate and will attain and maintain water quality standards.

EPA agrees that the TMDL document targets the appropriate pollutant.

Source Analysis

Important assumptions made in developing the TMDL document, such as assumed distribution of land use in the watershed, population characteristics, wildlife resources and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources, are described. Point, nonpoint and background sources of pollutants of concern are described, including magnitude and location of the sources. The submittal demonstrates all significant sources have been considered. If this is a revised TMDL document any new sources or removed sources will be specified and explained.

In the absence of a national pollutant discharge elimination system permit, the discharges associated with sources were applied to the load allocation, as opposed to the wasteload allocation for purposes of this TMDL document. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDL(s) with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL document are found to be, or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLAs in this TMDL document. Any WLA in addition to that allocated here is not available.

The TMDL document describes the history of the lake in its location in the East Branch West Nishnabotna River watershed. As there are no point sources located in the lake's watershed, all load is nonpoint in origin. The document uses a STEPL watershed loading model to estimate an average phosphorus load to the lake. This spreadsheet model uses land use/land cover, precipitation and soil characteristics to estimate loads from the watershed. The modeling parameters and information is provided in an appendix to the document. The watershed boundary of Prairie Rose Lake itself is 4,655 acres which calculates to a watershed: lake ratio of 23:1. According to the TMDL document, this ratio represents the ideal condition between lake surface area and watershed area. This indicates a potential for successful lake restoration based on watershed and lake interactions. There are no regulated point source discharges of phosphorus in the watershed. Nonpoint sources of phosphorus include fertilizer and manure from row crops, sheet and rill erosion form row cops and pasture, wildlife, septic systems, groundwater, atmospheric deposition and others.

Table 1: Average Annual TP Loads from each Source. (Table 3-6 in TMDL document)

Source	**Descriptions and Assumptions**	**TP Load (lb/yr)**	**Percent (%)**
Pastureland	Seasonally grazed grassland	18.6	0.3
Row Crops	Sheet and rill erosion from corn and soybeans dominated agriculture	3220.7	80.8
User Defined	Ungrazed Grassland, Alfalfa/Hay	95.7	2.4
Forest	Forest park grounds surrounding lake	93.3	2.3
Urban	Urban areas, roads, and farmsteads	214.9	5.4
Groundwater	Agricultural tile discharge, natural groundwater flow	270.4	6.8
All others	Wildlife, atmospheric deposition, septics	74.4	2.0
Total		3988	100.0

The two predominate land uses are row crops and state park ground. Row crops consist of corn and soybeans. Additionally, 90 percent of the total cropland is terraced to some extent, with the remaining 10 percent of cropland on upland ground too flat to terrace. Grassland is an aggregate of Alfalfa/Hay and ungrazed land.

Table 2. Prairie Rose Lake Watershed Land Uses (Table 2-3 in TMDL document)

Land Use	**Description**	**Areas (acres)**	**Percent (%)**
Terraced Cropland	Corn and Soybeans with terraces	3295.3	70.8
State Park	Forested bottomland, camping sites	429.4	9.2
Row Crop	Corn and Soybeans	366.3	7.9
Water	Lake and sediment basins	200.9	4.3
Road	Gravel road and highways	111.1	2.4
Riparian	Grassland adjacent to waterways	107.0	2.3
Farmstead	Residential area, farm yard	105.8	2.3
Grassland	Ungrazed, ground with few trees	25.7	0.55
Pasture	Grazed land	13.9	0.25
Total		4,655.4	100.0

There are no municipal separate storm sewer permits in the applicable watershed.

No Animal Feeding Operations (AFOs) were identified by Iowa DNR. However, any new or newly identified AFO that meets the definition of a Concentrated Animal Feeding Operation (CAFO) that does not obtain an NPDES permit must operate as a no-discharge facility. A discharge from an unpermitted CAFO is a violation of Section 301 of the CWA. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements. This TMDL document does not reflect a determination by EPA that no AFOs are present or that such facilities do not meet the definition of a CAFO nor that such a facility does not need to obtain a permit. To the contrary, a CAFO that discharges has a duty to obtain a permit. If it is determined that a CAFOs are present and discharge, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL document as approved. document as approved.

As submitted, the TMDL document contains a complete listing of all know pollutant sources.

Allocation - Loading Capacity

The submittal identifies appropriate loading capacities, wasteload allocations for point sources and load allocations for nonpoint sources. If no point sources are present, the WLA is stated as zero. If no nonpoint sources are present, the LA is stated as zero [40 CFR § 130.2(i)]. If this is a revised TMDL document the change in loading capacity will be documented in this section. All TMDLs must give a daily number. Establishing TMDL "daily" loads consistent with the U.S. Court of Appeals for the D.C. circuit decision in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006).

The TMDL document uses modeling to determine the maximum total phosphorus (TP) load the lake can receive and meet applicable WQS. The form of the load capacity equation is:

For this TMDL:

TP LC = 2,076 lbs/year = 0 lbs/year + 1,868 lbs/year + 208 lbs/year on an annual loading basis accounts for how lakes function across a hydrological cycle.

And;

TP LC= 17.7 lbs/day= 0 lbs/day + 15.9 lbs/day + 1.8 lbs/day on a maximum daily basis using a statistical method outlined in a document appendix.

The LCs are calculated at the monitoring station, but the targeted TP concentrations apply at all points in the segments covered by this TMDL document.

EPA agrees that the LC will attain and maintain water quality standards.

Wasteload Allocation Comment

The submittal lists individual wasteload allocations for each identified point source [40 CFR § 130.2(h)]. If a WLA is not assigned it must be shown that the discharge does not

cause or contribute to a water quality standard excursion, the source is contained in a general permit addressed by the TMDL, or extenuating circumstances exist which prevent assignment of individual WLA. Any such exceptions must be explained to a satisfactory degree. If a WLA of zero is assigned to any facility it must be stated as such [40 CFR § 130.2(i)]. If this is a revised TMDL document, any differences between the original TMDL(s) WLA and the revised WLA will be documented in this section.

There are no permitted facilities in the watershed of Prairie Rose Lake. The WLA is zero.

Load Allocation Comment

All nonpoint source loads, natural background and potential/or future growth are included. If no nonpoint sources are identified, the load allocation must be given as zero /40 CFR § 130.2(g)J. If this is a revised TMDL document, any differences between the original TMDL(s) LA and the revised LA will be documented in this section.

The LA is the amount of the pollutant load that is assigned to nonpoint sources and includes all existing and future nonpoint sources, as well as natural background contributions. LAs are calculated as the remainder of the LC after the allocations to the WLA and the MOS.

The TMDL document expresses the LA as an annual load of 1,868 pounds and a daily maximum of 15.9 pounds TP. While estimates are made of load by land use/land cover and the TMDL document provides examples of load reductions and BMPs effective for different land uses/land covers, the LA is given as a sum of all LAs and not broken out by and subdivision of source.

The TMDL document has identified all known nonpoint sources of TP in the watershed.

Margin of Safety

The submittal describes explicit and/or implicit margins of safety for each pollutant [40 CFR § 130.7(c)(1)]. If the MOS is implicit, the conservative assumptions in the analysis for the MOS are described. If the MOS is explicit, the loadings set aside for the MOS are identified and a rationale for selecting the value for the MOS is provided. If this is a revised TMDL document, any differences in the MOS will be documented in this section.

The TMDL document identifies an explicit 10 percent margin of safety. This results in a MOS of 208 pounds per year TP with a maximum daily MOS of 1.8 pounds TP.

EPA agrees that the state has provided explicit MOS to support the TMDL.

Seasonal Variation and Critical Conditions

The submittal describes the method for accounting for seasonal variation and critical conditions in the TMDL(s) [40 CFR § 130.7(c)(1)]. Critical conditions are factors such as flow or temperature which may lead to the excursion of the WQS. If this is a revised TMDL document, any differences in conditions will be documented in this section.

Models used in this TMDL document estimate and use annual loads to generate predictions of annual condition. This is appropriate as the lake is assessed against narrative targets for algae and turbidity

EPA agrees that the state considered seasonal variation and critical conditions during the analysis of this TMDL and the setting of TMDL targets.

Public Participation

The submittal describes required public notice and public comment opportunities and explains how the public comments were considered in the final TMDL(s) [40 CFR § 130.7(c)(1)(ii)].

A public presentation was posted on the Iowa DNR's YouTube channel on August 6, 2020. A link to the presentation also remained on the Iowa DNR TMDL webpage through the public comment period for the presentation.

A press release was issued in tandem with the posting of the presentation to the Iowa DNR's YouTube channel. The press release began a 30-day public comment period, which ended on September 8, 2020.

The official public comment period was from August 6, 2020 through September 8, 2020. No public comments were received during this period. EPA agrees that the public has had a meaningful opportunity to comment on the TMDL document.

Monitoring Plan for TMDL(s) Under a Phased Approach

The TMDL identifies a monitoring plan that describes the additional data to be collected to determine if the load reductions required by the TMDL lead to attainment of water quality standards, and a schedule for considering revisions to the TMDL(s) (where a phased approach is used) [40 CFR § 130.7]. If this is a revised TMDL document, monitoring to support the revision will be documented in this section. Although EPA does not approve the monitoring plan submitted by the state, EPA acknowledges the state's efforts. EPA understands that the state may use the monitoring plan to gauge the effectiveness of the TMDLs and determine if future revisions are necessary or appropriate to meet applicable water quality standards.

The TMDL document outlines plans for future monitoring. This includes continued ambient monitoring under the IDNR Ambient Lake Monitoring Program which was initiated in the year 2000. Implementation monitoring is identified to determine the effect of best management practices undertaken in the watershed. Any such monitoring could include automated samplers as well as grab samples during runoff events. This implementation monitoring would include a greater sampling frequency than that currently undertaken with the ambient monitoring program. It will also require local stakeholders to implement BMPs and monitor success.

Reasonable Assurance

Reasonable assurance only applies when less stringent wasteload allocation are assigned based on the assumption that nonpoint source reductions in the load allocation will be met [40 CFR § 130.2(i)]. This section can also contain statements made by the state concerning the state's authority to control pollutant loads. States

are not required under Section 303(d) of the Clean Water Act to develop TMDL implementation plans and EPA does not approve or disapprove them. However, this TMDL document provides information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL document. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL document. Therefore, the discussion of reduction efforts relating to point and nonpoint sources can be found in the implementation section of the TMDL document and are briefly described below.

The states have the authority to issue and enforce state operating permits. Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to the state should provide reasonable assurance that instream water quality standards will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for wasteload allocations to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL(s)' combined nonpoint source load allocations and point source WLAs do not exceed the WQS- based loading capacity and there is reasonable assurance that the TMDL(s)' allocations can be achieved. Discussion of reduction efforts relating to nonpoint sources can be found in the implementation section of the TMDL document.

As there are no point sources located in this watershed, reasonable assurances are not a required component of this TMDL. However, the TMDL document does identify a general approach for planning and implementation which, if followed, will lead to the attainment of applicable water quality standards. Both management and structural BMPs are identified as well as potential total phosphorus reductions to be expected from their implementation.

IOWA DEPARTMENT OF NATURAL RESOURCES

GOVERNOR KIM REYNOLDS
LT. GOVERNOR ADAM GREGG
DIRECTOR KAYLA LYON

September 16, 2020

Jeff Robichaud
U.S. EPA, Region VII
11201 Renner Blvd.
Lenexa, KS 66219

Subject: Submittal of Final Lake Prairie Rose Lake, Shelby County TMDL for EPA approval

Dear Mr. Robichaud:

The Final Prairie Rose Lake, Shelby County Total Maximum Daily Load document completed by the Iowa Department of Natural Resources is enclosed. This lake was recently included on Iowa's 2018 303(d) list. Included is:

- Prairie Rose Lake, TMDL for Algae and Turbidity (IA 05-NSH-1462)

The draft TMDL was posted on the Iowa Department of Natural Resources website on August 6, 2020 and comments were accepted from August 6, 2020 to September 8, 2020. A video recording of a standard public meeting presentation was posted to the DNR website coincident with the opening of the Public Notice period and was available for viewing throughout. The Iowa DNR received no public comments on the draft.

Please accept this document for approval as the completed TMDL for Prairie Rose Lake, Shelby County.

Sincerely,

Allen
Bonini
Digitally signed by Allen Bonini
Date: 2020.09.16 08:26:06 -05'00'

Allen P. Bonini, Supervisor
Watershed Improvement Section

Enclosure

Water Quality Improvement Plan
for

Prairie Rose Lake

Shelby County, Iowa

Total Maximum Daily Load for:
Algae and Turbidity

Prepared by:
Andrew Frana

clean water
starts with you.
IOWA DNR WATERSHED IMPROVEMENT

DNR

Iowa Department of Natural Resources
Watershed Improvement Section
2020

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List of Abbreviations

Units of measure:

ac	acre	M	meter
cfs	cubic feet per second	mg	milligram
cfu	colony-forming unit	Mg	megagram (= 1 mt)
cm	centimeter	mi	mile
cms	cubic meters per second	mL	milliliter
d	day	mo	month
g	gram	mt	metric ton (= 1 Mg)
ha	hectare	orgs	E. *coli* organisms
hm	hectometer	ppm	parts per million
hr	hour	ppb	parts per billion
in	inch	s	second
kg	kilogram	t	ton (English)
km	kilometer	yd	yard
L	liter	yr	year
lb	pound		

Other abbreviations:

AFO	animal feeding operation
BMP	best management practice
Chl-a	chlorophyll a
E. coli	Escherichia coli
GM	geometric mean (pertains to WQS for E. coli, = 126 orgs/100 mL)
LDC	load duration curve
N	nitrogen
ortho-P	ortho-phosphate
P	phosphorus
SSM	single-sample max (pertains to WQS for E. coli, = 235 orgs/100 mL)
TN	total nitrogen
TP	total phosphorus
WQS	water quality standard

General Report Summary

What is the purpose of this report?

This report serves multiple purposes. First, it is a resource for increased understanding of watershed and water quality conditions in and around Prairie Rose Lake. Second, it satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) for impaired waterbodies. Third, it provides a foundation for locally-driven watershed and water quality improvement efforts. Finally, it may be useful for obtaining financial assistance to implement projects to remove Prairie Rose Lake from the federal 303(d) list of impaired waters.

What's wrong with Prairie Rose Lake?

Prairie Rose Lake is listed as impaired on the 2018 303(d) list for not supporting its primary contact recreation designated use. The impairment is due to elevated levels of algae and turbidity, which is caused by overly-abundant nutrients and sediment, including sediment-bound phosphorus in the lake.

What is causing the problem?

The amount of phosphorus transported to the lake from the surrounding watershed is sufficient to cause excessive growth of algae and excessive levels of turbidity, which reduces water clarity. Phosphorus is carried to the lake in two primary forms: (1) attached to eroded soil that is transported to the lake by rainfall runoff and stream flow, and (2) dissolved phosphorus in runoff and subsurface flow (e.g., shallow groundwater). Phosphorus and sediment within the water column and on the lake bed may become resuspended under certain conditions, which can add to algae and turbidity issues. There are no allowable discharging point sources in the Prairie Rose Lake watershed; therefore all phosphorus loads to the lake are attributed to nonpoint sources.

Nonpoint sources are discharged in an indirect and diffuse manner and often are difficult to locate and quantify. Nonpoint sources of phosphorus in the Prairie Rose Lake watershed include sheet and rill erosion from various land uses, runoff and subsurface flows from lands that receive fertilizer application, grazed pasture land, poorly functioning septic systems, manure deposited by wildlife, and particles carried by dust and wind (i.e., atmospheric deposition). A portion of the phosphorus carried to the lake eventually settles to the lake bottom and accumulates. Under certain conditions, this accumulated phosphorus can become available for algal uptake and growth through an internal recycling process.

What can be done to improve Prairie Rose Lake?

Reducing phosphorus loss from pasture, row crops, and implementing or improving existing structural BMPs such as terraces, grass waterways, and constructed sediment basins in beneficial locations will significantly reduce phosphorus loads to the lake. Increasing the trapping efficiency of the existing sediment basins may be the most cost effective structural alternative. Additionally, in-lake practices such dredging or phosphorus stabilization have been used in recent years in order to address algae and turbidity concerns. Consideration should be given to reductions in the population of grass carp, which graze on aquatic plants reducing the uptake of phosphorous. Finally, removal of curly-leaf pondweed will help improve water quality. Curly-leaf pondweed dies back in the summer releasing nutrients that may contribute to algal blooms.

Who is responsible for a cleaner Prairie Rose Lake?

Everyone who lives, works, or recreates in the Prairie Rose Lake watershed has a role in water quality improvement. Nonpoint source pollution is unregulated and responsible for all of sediment and phosphorus entering the lake. Therefore, voluntary management of land, animals, and the lake itself will be required to achieve measurable improvements to water quality. Many of the practices that protect and improve water quality also benefit soil fertility and structure, the overall health of the ecosystem, and the value and productivity of the land. Practices that improve water quality and enhance the long-term viability and profitability of agricultural production should appeal to producers, land owners, and lake users alike. Improving water quality in Prairie Rose Lake, while also improving the quality of the surrounding land, will continue to require collaborative participation by various stakeholder groups, with land owners playing an especially important role. Additionally, those looking to develop sites within the Prairie Rose Lake watershed should recognize the impact of improved water quality on property values.

Does a TMDL guarantee water quality improvement?
The Iowa Department of Natural Resources (DNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). The TMDL itself is only a document, and without implementation, will not improve water quality. Therefore, a basic implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. This implementation plan should be used as a guide or foundation for detailed and comprehensive planning by local stakeholders.

Reducing pollutants from unregulated nonpoint sources requires voluntary implementation of best management practices. Many solutions have benefits to soil health and sustained productivity as well as water quality. However, quantifying the value of those ecosystem services is difficult, and those benefits are not commonly recognized. Consequently, wide-spread adoption of voluntary conservation practices is often difficult to achieve. A coordinated watershed improvement effort for Prairie Rose Lake could address some of these barriers by providing financial assistance, technical resources, and information/outreach to landowners to encourage and facilitate adoption of conservation practices.

What are the primary challenges for water quality implementation?
In most Iowa landscapes, implementation requires changes in land management and/or agricultural operations. Management decisions may include changes in the number of acres that are actively tilled and the diversity and rotation of crops produced. These changes present challenges to producers by requiring new equipment (e.g., no-till planters), narrowing planting, harvesting and fertilization windows, and necessitating more active and complex farm management.

Additionally, potential short-term losses in yields are more easily recognized and quantified than long-term benefits to soil health and sustained productivity. It is not easy to overcome existing incentives and the momentum of current practices. Promoting a longer-term view with an emphasis on long-term soil fertility, production, agroecosystem health, and reduced input costs will be essential for successful, voluntary implementation by willing conservation partners. However, water quality improvement and enhancement of Prairie Rose Lake as a recreational resource are certainly attainable goals, and are appropriate and feasible near-term goals for a coordinated watershed improvement effort.

Required Elements of the TMDL

This Water Quality Improvement Plan 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 in Table 1-1.

Table 1-1. Technical Elements of the TMDL.

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Prairie Rose Lake, Waterbody ID IA 05-NSH-1462, located in S36, T79N, R38W, 6 miles southeast of Harlan
Surface water classification and designated uses:	A1 – Primary Contact B(LW) – Aquatic life C – Drinking Water HH – Human health (fish consumption)
Impaired beneficial uses:	A1 – Primary Contact (IR 5a) B(LW) – Aquatic Life (IR 3b)
TMDL priority level:	Priority Tier 1
Identification of the pollutants and applicable water quality standards (WQS):	Aesthetically objectionable conditions due to algal and non-algal turbidity leading to poor water transparency
Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of WQS:	Excess algae and turbidity are associated with total phosphorus (TP). The allowable average annual TP load = 2,076 lbs/year; the maximum daily TP load = 17.7 lbs/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 WQS:	The existing growing season load of 3,988 lbs/year must be reduced by 1,912 lbs/year to meet the allowable TP load. This is a reduction of approximately 48 percent.
Identification of pollution source categories:	There are no regulated point source discharges of phosphorus in the watershed. Nonpoint sources of phosphorus include fertilizer and manure from row crops, sheet and rill erosion from row crops and pasture, wildlife, septic systems, groundwater, atmospheric deposition, and others.
Wasteload allocations (WLAs) for pollutants from point sources:	There are no allowable point source discharges.

Load allocations (LAs) for pollutants from nonpoint sources:	The allowable annual average TP LA is 1,868 lbs/year, and the allowable maximum daily LA is 15.9 lbs/day.
A margin of safety (MOS):	An explicit 10 percent MOS is incorporated into this TMDL.
Consideration of seasonal variation:	The TMDL is based on annual TP loading. Although daily maximum loads are provided to address legal uncertainties, the average annual loads are critical to in-lake water quality and lake/watershed management decisions.
Reasonable assurance that load and wasteload allocations will be met:	Reasonable assurances for reductions in nonpoint source pollution are provided by (1) a list of BMPs (see Section 4 of this WQIP) that would provide phosphorus reductions, (2) a group of nonstructural practices that prevent transport of phosphorus, (3) proposed methodology for prioritizing and targeting BMPs on the landscape, and (4) best available data for estimating the efficiency/reduction associated with BMPs.
Allowance for reasonably foreseeable increases in pollutant loads:	Although watershed development may continue in the future, an increase in the pollutant load from land use change is not expected.
Implementation plan:	An implementation plan is outlined in Section 4 of this Water Quality Improvement Plan. Phosphorus loading and associated impairments must be addressed through a variety of voluntary management strategies and structural practices. Removal of grass carp and curly-leaf pondweed.

1. Introduction

The Federal Clean Water Act requires all states to develop lists of impaired waterbodies that do not meet water quality standards (WQS) and support designated uses. This list of impaired waterbodies is referred to as the state's 303(d) list. In addition to developing the 303(d) list, a Total Maximum Daily Load (TMDL) must be developed for each impaired waterbody included on the list. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can tolerate without exceeding WQS and impairing the waterbody's designated uses. The TMDL calculation is represented by the following general equation:

$$\text{TMDL} = \text{LC} = \Sigma\,\text{WLA} + \Sigma\,\text{LA} + \text{MOS}$$

Where: TMDL = total maximum daily load
LC = loading capacity
Σ WLA = sum of wasteload allocations (point sources)
Σ LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

One purpose of this Water Quality Improvement Plan (WQIP) for Prairie Rose Lake, located in Shelby County in western Iowa, is to provide a TMDL for algae and turbidity, which has decreased water quality in the lake. Another purpose is to provide local stakeholders and watershed managers with a tool to promote awareness and understanding of water quality issues, develop a comprehensive watershed management plan, obtain funding assistance, and implement water quality improvement projects. Over-abundance of phosphorus is largely responsible for excessive algal growth and inorganic turbidity, which impairs the primary contact designated use of Prairie Rose Lake. The impairments are addressed by development of a TMDL that limits total phosphorus (TP) loads to the lake. Phosphorus reductions should be accompanied by reduced algal growth and increased water clarity.

The plan also includes descriptions of potential solutions to the impairments. This group of solutions is presented as a toolbox of best management practices (BMPs) for improving water quality in Prairie Rose Lake, with the ultimate goal of meeting water quality standards and supporting designated uses. These BMPs are outlined in the implementation plan in Section 4.

The Iowa Department of Natural Resources (DNR) recommends a phased approach to watershed management. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict. Iterative implementation of improvement practices and additional water quality assessment (i.e., monitoring) will help ensure gradual progress towards water quality standards, maximize cost efficiency, and prevent unnecessary or ineffective implementation of costly BMPs. Implementation guidance is provided in Section 4 of this report, and water quality monitoring guidance is provided in Section 5.

This plan will be of limited value unless additional watershed improvement activities and BMPs are implemented. This will require the active engagement of local stakeholders and land owners. Experience has shown that locally-led watershed plans have the highest potential for success. The Watershed Improvement Section of DNR has designed this plan for stakeholder use and may be able to provide technical support for the improvement of water quality in Prairie Rose Lake.

2. Description and History of Prairie Rose Lake

Prairie Rose Lake is located in Center Township, Shelby County approximately 6 miles southeast of the City of Harlan and 8 miles north of Walnut. Prairie Rose Lake and Prairie Rose State Park received their names from a small town called Village of Prairie Rose, which was located near the present park location. Plans for Prairie Rose State Park were initiated in the 1930's, however, actual construction of the dam started in 1958 with the park dedication taking place in 1962. The lake and state park provide fishing, camping and other outdoor recreation activities for the public. Figure 2-1. Prairie Rose Lake Vicinity Map. is a 2017 aerial photograph with the boundaries of the watershed and extent of public grounds marked.

Improvements

Efforts to improve conditions at Prairie Rose Lake go back to shortly after its construction, but recent projects include jetties and fish structure (1998), sediment basin and rip rap (2001), sediment basins (2004). More recently, a diagnostic / feasibility analysis was done by Iowa DNR in 2008 with key in-lake restoration activities being identified with work slated to begin in the following years. Prairie Rose Lake was then drawn down in July 2011 and refilled in September 2012 for restoration purposes. Stabilization of the eroding shoreline and removal of 60,000 cubic yards of sediment was completed and undesirable fish species (e.g. common carp) were removed from the lake and watershed. The lake was restocked starting in April of 2013. In lake dredging started in mid-July with approximately 185,000 CY of sediment removed from Prairie Rose Lake during the draw down.

Table 2-1 lists some of the general characteristics of Prairie Rose Lake and its watershed, as it exists today. Figure 2-1 shows the vicinity map for the lake system and its watershed as it exists today. Estimation of physical characteristics such as surface area, depth, and volume are based on a bathymetric survey conducted by the DNR in October of 2015.

Table 2-1. Prairie Rose Lake Watershed and Lake Characteristics.

DNR Waterbody ID	ID Code: IA 05-NSH-1462
12-Digit Hydrologic Unit Code (HUC)	102400020104
12-Digit HUC Name	East Branch West Nishnabotna River
Location	Shelby County, S36, T79N, R38W; 6 miles southeast of Harlan
Latitude	41.6013° N (ambient lake monitoring location)
Longitude	95.2274° W (ambient lake monitoring location)
Designated Uses	A1 – Primary Recreation B(LW) – Aquatic Life C – Drinking Water HH – Human health (fish consumption, drinking water)
Tributaries	Unnamed tributaries
Receiving Waterbody	East Branch West Nishnabotna River
Lake Surface Area (1)	196 acres
Length of Shoreline	5.99 miles
Shoreline Development Index	3.2
Maximum Depth (1)	25.0 feet
Mean Depth (1)	8.5 feet
Lake Volume (1)	1653 acre-feet
Watershed Area	4,655 acres (includes lake)
Watershed:Lake Ratio (2)	23:1
Hydraulic Lake Residence Time (3)	131 days

(1) Per October 2015 bathymetric survey.
(2) (Watershed Area - Lake Area) / Lake Area
(3) BATHTUB model prediction for average annual conditions (2002-2015)

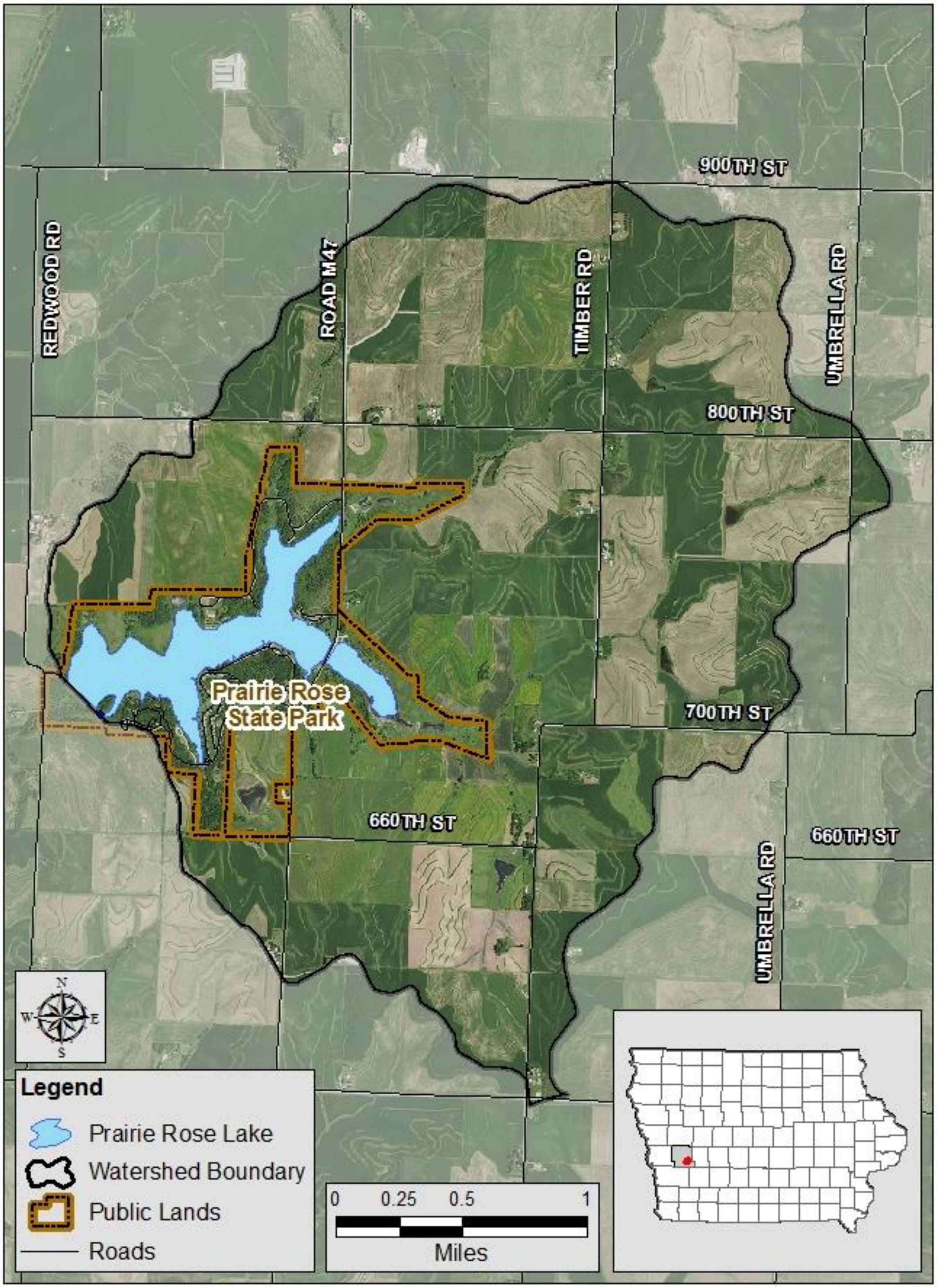

Figure 2-1. Prairie Rose Lake Vicinity Map.

Water Quality History

Water quality data has been collected through the statewide survey of Iowa Lakes, which was conducted from 2000 through 2017 by Iowa State University (ISU). A statewide ambient lake monitoring program conducted in 2008 by the State Hygienic Laboratory (SHL) also provided data on the water quality in Prairie Rose Lake. Supplemental sampling at the assessment point and two other locations occurred in 2016 and 2017 following the most recent assessment period are discussed in Section 5 and listed in Appendix C.

Prairie Rose Lake has also been part of an enhanced beach monitoring program to assess bacteria levels in sand and the near shore swimming area from 2016 through 2017. Samples were taken weekly with dates targeting the immediate time after rainfall events when possible.

However, for the purposes of this report and calculations, only data collected prior to and during the most recent lake assessment period will be used. This will include the data collected from 2002-2015.

2.1. Prairie Rose Lake

Hydrology

Due to proximity, the Harlan weather station was chosen for daily precipitation data from the Iowa Environmental Mesonet downloadable from the IEM.

Daily potential evapotranspiration (PET) data were obtained from the Iowa Ag Climate Network, downloadable from the IEM (IEM, 2017b). The Iowa State Climatologist provides quality control of these data. Daily observations between January 1, 2002 and December 31, 2015 were used in climate assessment and model development. Table 2-2 reports weather station information.

Table 2-2. Weather Station Information for Prairie Rose Lake.

Data	Temperature/Precipitation	Potential ET
Network	IACLIMATE	ISU AgClimate/ISU Soil Moisture
Station Name (ID)	Harlan (IA3632)	Lewis (A134759)
Latitude	41.65°	41.313°
Longitude	-95.32°	-95.173°

Source: https://mesonet.agron.iastate.edu/climodat

Average annual precipitation near Prairie Rose Lake was 35.5 inches from 2002-2015. The average precipitation of the three driest years (2002, 2003, and 2005) was 25.9 inches, while the average of the three wettest years in this period (2010, 2014, and 2015) was 45.6 inches. Figure 2-2 illustrates the annual precipitation totals, along with lake evaporation (estimated as 70 percent of annual PET). This chart shows an inverse relationship between precipitation and lake evapotranspiration (ET), mainly due to climatological factors such as cloud cover and temperature. Wet years of 2010, 2014, and 2015 show a surplus of precipitation, while 2011 and 2012 show a precipitation deficit in comparison to lake ET.

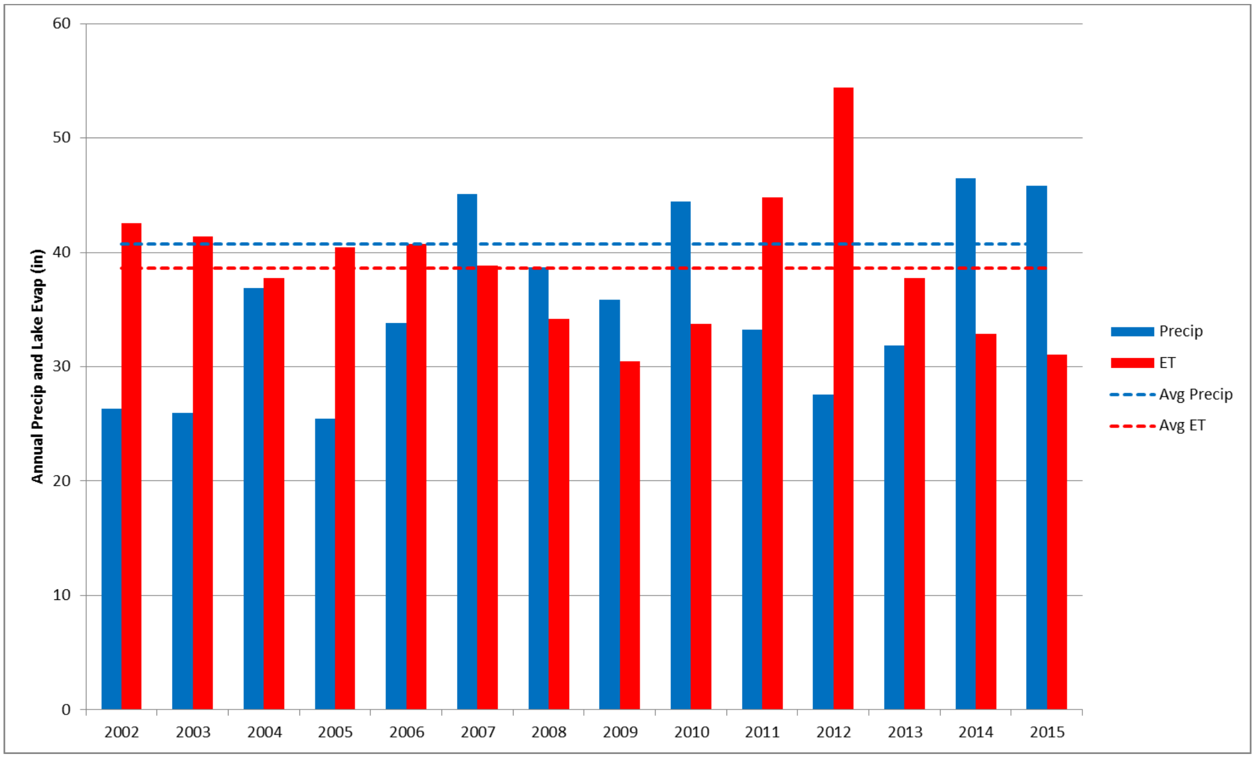

Figure 2-2. Annual Precipitation and Estimated Lake Evaporation.

Precipitation varies greatly by season in western Iowa, with approximately 75 percent of annual rainfall taking place in half of the year (April through September). Monthly average precipitation is illustrated in Figure 2-3, along with estimated ET in the watershed based on vegetation cover. Although precipitation is highest during the growing season, so is ET, and a monthly moisture deficit occasionally occurs. Note that watershed ET is typically higher than lake evaporation in the summer months, a result of high temperatures and vegetation transpiring large volumes of moisture from the soil during the peak of the growing season. It is often during this period that harmful algal blooms develop in waterbodies, as water heats up and lake flushing is minimal.

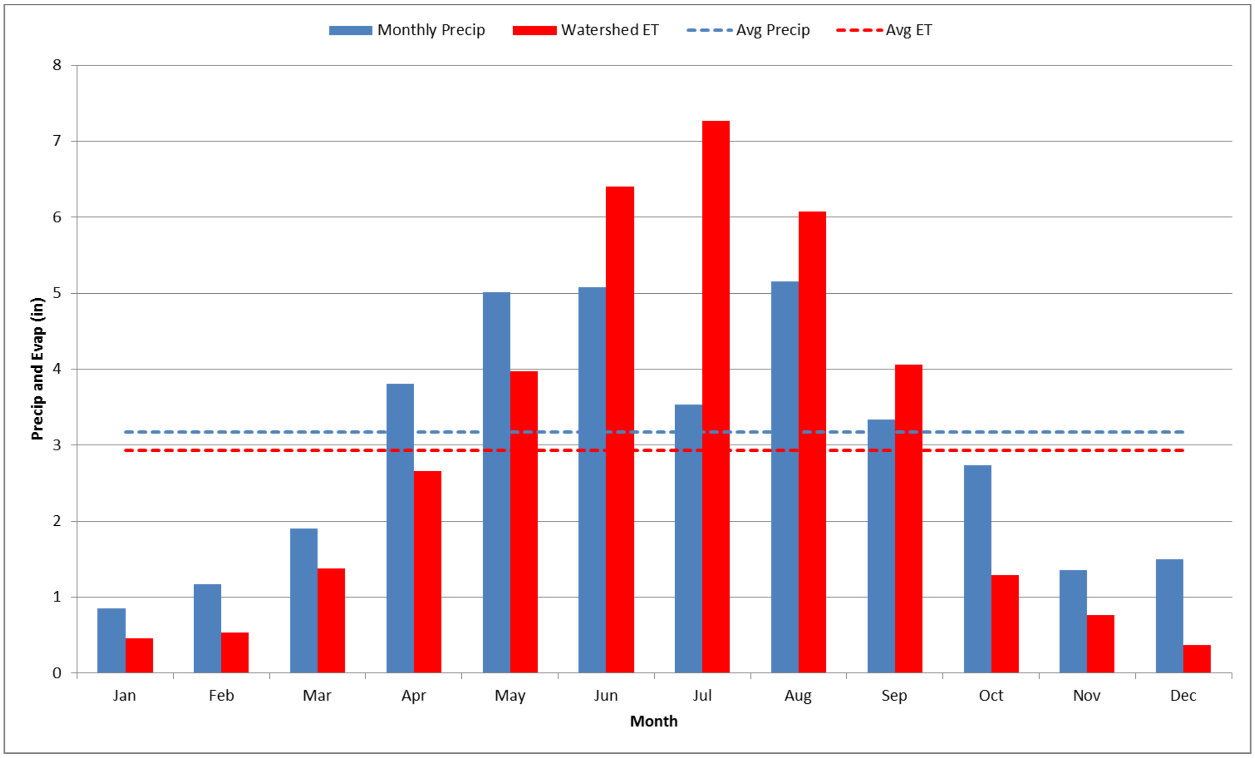

Figure 2-3. Monthly Precipitation and Estimated ET for the Watershed.

Rainfall runoff, direct precipitation, evapotranspiration, shallow groundwater flow, and deep aquifer recharge are all part of the lake's hydrologic system. Estimated residence time is based on annual precipitation and evaporation data, Spreadsheet Tool for Estimating Pollutant Load (STEPL) estimates of average annual inflow, and a water balance calculated within the BATHTUB model. The BATHTUB water balance calculation includes: inflows (from STEPL), direct precipitation, evaporation calculated from measured PET at Lewis, Iowa and lake morphometry.

During years of below average precipitation, residence time increases. In wet years, the opposite is true as residence time decreases. In lakes with smaller watershed to lake ratios the residence time may be longer than lakes with larger watershed to lake ratios.

Morphometry

According to the most current bathymetric data (October 2015), the surface area of Prairie Rose Lake is 196 acres. Estimated water volume of the main lake is 1,653 acre-feet (ac-ft), with a mean depth of 8.5 ft and a maximum depth of 25.0 ft in the western section of the lake near the outfall. The reservoir, like most man-made stream impoundments, has an irregular shape, with several small dissected arms that lead to upland overland flow paths. Evidence of sedimentation in the lake suggests that the watershed of Prairie Rose Lake has a large impact on water quality. The significance of sediment (and associated phosphorus) loading from the watershed is further evidenced by the shoreline development index of 3.2, which is high. Values greater than 1.0 suggest the shoreline is highly dissected and indicative of a high degree of watershed influence (Dodds, 2000). High indexes are frequently observed in man-made reservoirs, and it is not surprising that watershed processes are critically important for the chemical, physical, and biological processes that take place in Prairie Rose Lake. Lake morphometry and bathymetry data are shown in Figure 2-4.

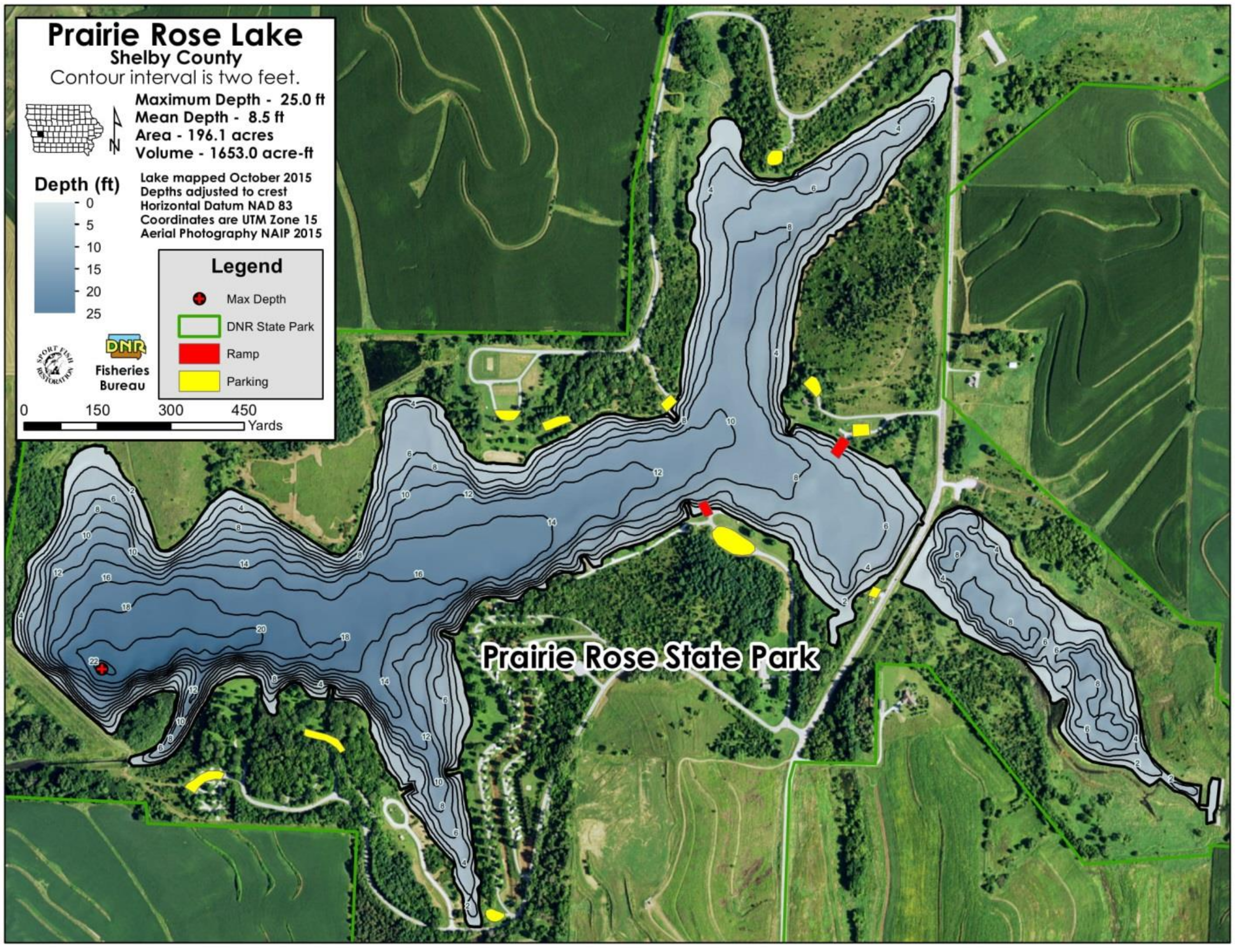

Figure 2-4. 2015 Bathymetric Map of Prairie Rose Lake

2.2. The Prairie Rose Lake Watershed

The watershed boundary of Prairie Rose Lake encompasses 4,655 acres (including the lake) and is illustrated in Figure 2-1. Prairie Rose Lake Vicinity Map. The watershed-to-lake ratio of 23:1 represents the ideal condition between lake surface area and watershed area. This indicates a potential for successful lake restoration based on watershed and lake interactions. Mitigation of watershed influence will be required, and in-lake techniques may have short effective life spans in the absence of watershed improvements and renovations. A prudent watershed management strategy should focus on problem areas that can be most easily addressed and implementing alternatives that provide multiple benefits in addition to water quality, such as increased soil health, erosion reduction, and habitat enhancement. Watershed management and implementation strategies are discussed in more detail in Section 4 – Implementation Planning.

Land Use

Land use information for the area was created from a series of windshield surveys conducted of the area in the summers of 2016 and 2017, and from 2015 aerial photography (2015_NAIP). The two predominate land uses are row crops and state park ground, with row crops making up approximately 78.6 percent and park ground making up 9.2 percent of the watershed (Table 2-3 and Figure 2-5). Row crops consist of corn and soybeans. Additionally, 90 percent of the total cropland is terraced to some extent, with the remaining 10 percent of cropland on upland ground too flat to terrace. Grassland is an aggregate of Alfalfa/Hay and ungrazed land. In the past, CRP land existed but has all been converted back to crop land.

Table 2-3. Prairie Rose Lake Watershed Land Uses.

Land Use	Description	Area (acres)	Percent (%)
Terraced Cropland	Corn and Soybeans with terraces	3295.3	70.8
State Park	Forested bottomland, camping sites	429.4	9.2
Row Crop	Corn and Soybeans	366.3	7.9
Water[1]	Lake and sediment basins	200.9	4.3
Road	Gravel road and highways	111.1	2.4
Riparian	Grassland adjacent to waterways	107.0	2.3
Farmstead	Residential area, farm yard	105.8	2.3
Grassland	Ungrazed, ground with few trees	25.7	0.55
Pasture	Grazed ground	13.9	0.25
Total		**4,655.4**	**100.0**

(1) Includes Prairie Rose Lake Surface Area.

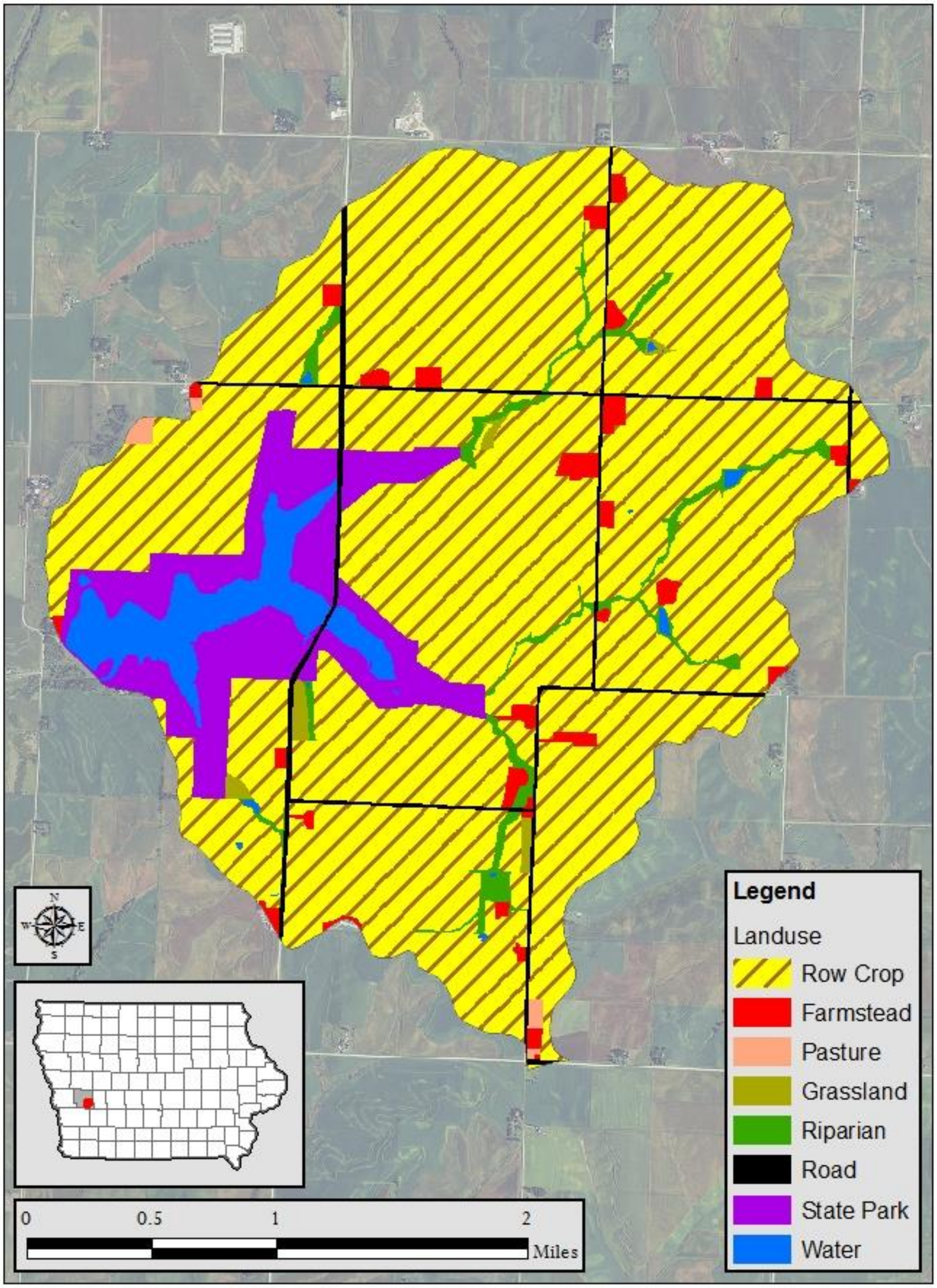

Figure 2-5. Prairie Rose Lake Watershed Land Use Map.

Soils, Climate, and Topography

The Prairie Rose Lake watershed is in the Iowa Deep Loess Hills. This landscape consists sharp features with alternating peaks and saddles. A dense network of drainage ways forming closed-in hollows, narrow ravines, and steep-sided gullies contributes to the intricately carved terrain. (Prior, 1991).

The watershed is made up mainly of the Marshall soil association (59.6 percent) and the Judson-Nodaway-Zook soil complex (26.7 percent). The Marshall association is mainly found on interfluves and hill slopes on uplands and terraced stream flood plains (USDA-NRCS, 1980).

As seen from Table 2-4 the majority of the Prairie Rose Lake watershed consists of one main soil type – Marshall. This soil type will have a much larger influence on watershed contributions than other types because of this. Table 2-4 shows the soils, map units, area, percent area of the watershed, general description and typical slopes of each soil in the watershed. Figure 2-6 is a map of the soil types in the watershed.

Table 2-4. Predominant Soils of the Prairie Rose Lake Watershed.

Soil Name	Map Units	Area (ac)	Area (%)	Description	Hydric Soil Group	Typical Slopes (%)
Marshall	0009B, 0009D	2776.0	59.6	Very deep, well drained, formed in loess	B/D	0 – 25
Judson-Nodway-Zook	8011B1	1241.1	26.7	Very deep, well drained, silty colluvium	B	0 – 12
Shelby	0024D2, 0024D3	181.8	3.9	Clay loam, well drained, strongly sloping to steep sloping	C	9-25
Adair	0192D2, 0192E2	119.3	2.6	Very deep, somewhat poorly drained soils formed in loess or loess heavy glacial outwash	C/D	2-30
Nodaway Shallow	0430A0	80.4	1.7	Very deep, moderately well drained soils formed in alluvium under the lake	A	0-2
Monona	0010C2, 0010D3	54.1	1.16	Very deep, well drained, formed in loess	C/D	0-40
Judson	8008B1	37.6	0.8	Very deep, well drained, silty colluvium	B	0-12
Clarinda	0222E2	20.1	0.44	Very deep, poorly drained soils formed in a till paleosol	C/D	5-18
Road / Other Minor Soils	varies	145.0	3.1	Varies	B / D	0-18
Totals		4,655.4	**100.0**	**Varies**		**Varies**

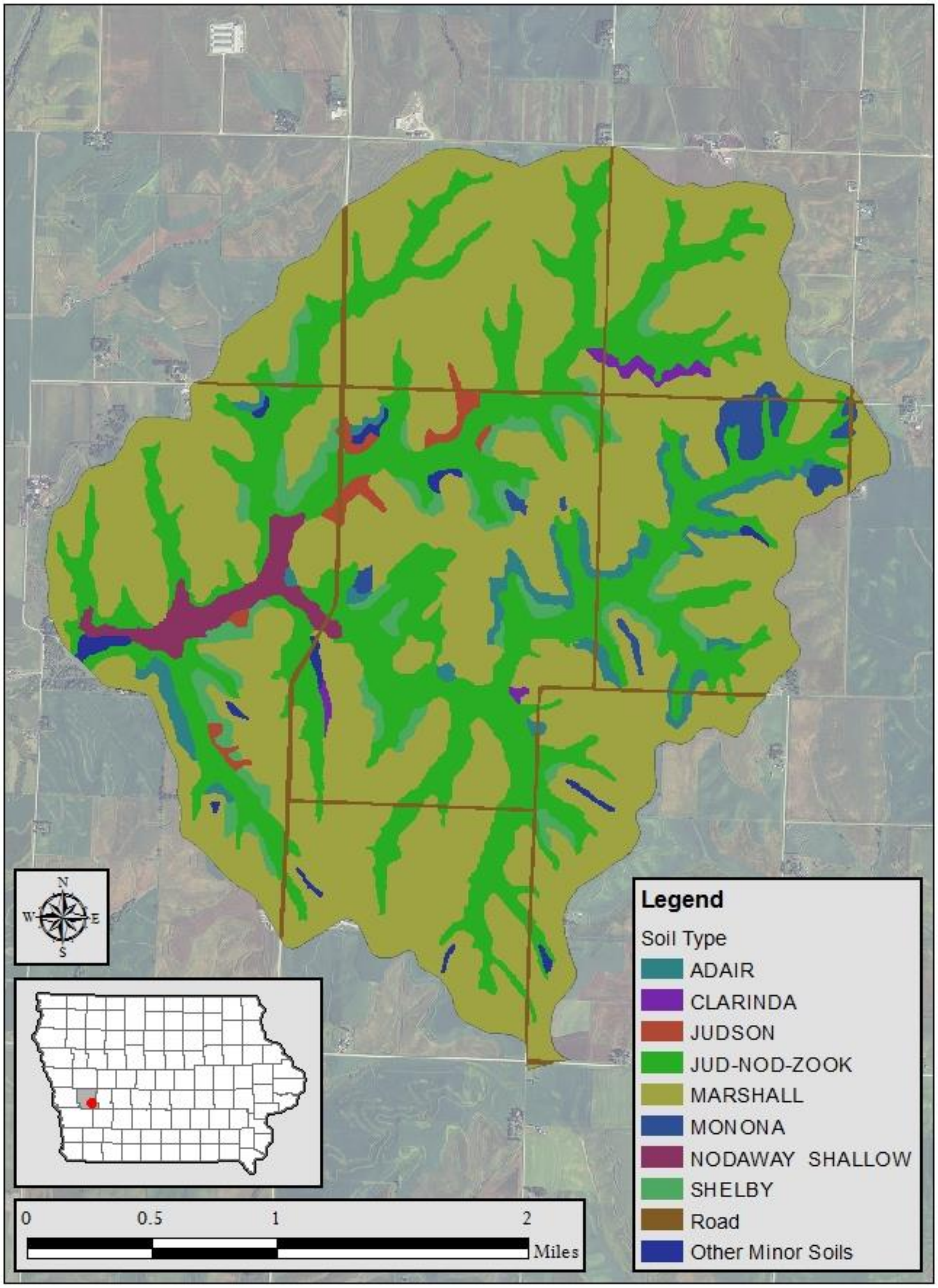

Figure 2-6. Prairie Rose Lake Soil Classification Map.

Elevations in the watershed range from a maximum of 1398.7 feet North American Vertical Datum 1988 (NAVD 88) to a minimum of 1222.7 feet NAVD 88. The average slope of the watershed is 8.9 percent with strongly sloping (8 -15 percent slope) regions making up a large percentage of the watershed at 38 percent. Table 2-5 shows the percentage breakdown of slope classifications throughout the watershed, and Figure 2-7 illustrates the distribution of the slopes within the Prairie Rose Lake watershed.

Table 2-5. Slope Classifications of the Prairie Rose Lake Watershed.

Slope Class (%)	Area (%)	Description of Slope Class
Class A (0 – 2)	8.8	Nearly Flat
Class B (2 – 5)	20.9	Gently sloping
Class C (5 – 8)	19.9	Moderately Sloping
Class D (8 – 15)	38.1	Strongly Sloping
Class E (15 – 30)	8.7	Moderately Steep
Class F (30 and up)	3.6	Steep to Very Steep
Total	100.0	---

The combination of soil classification, slope, topography, and hydrologic soil group (discussed more in Appendix D) indicate that the majority of agricultural areas in the Prairie Rose Lake watershed would not be tile drained, but are excellent candidate combinations for terracing. The absence of drainage district data and anecdotal data on tile drainage location also indicate that minimal drainage is present in the watershed. However, agricultural management practices related to tile drainage may change in the future, which would lead to changes in watershed loading and its effects on Prairie Rose Lake.

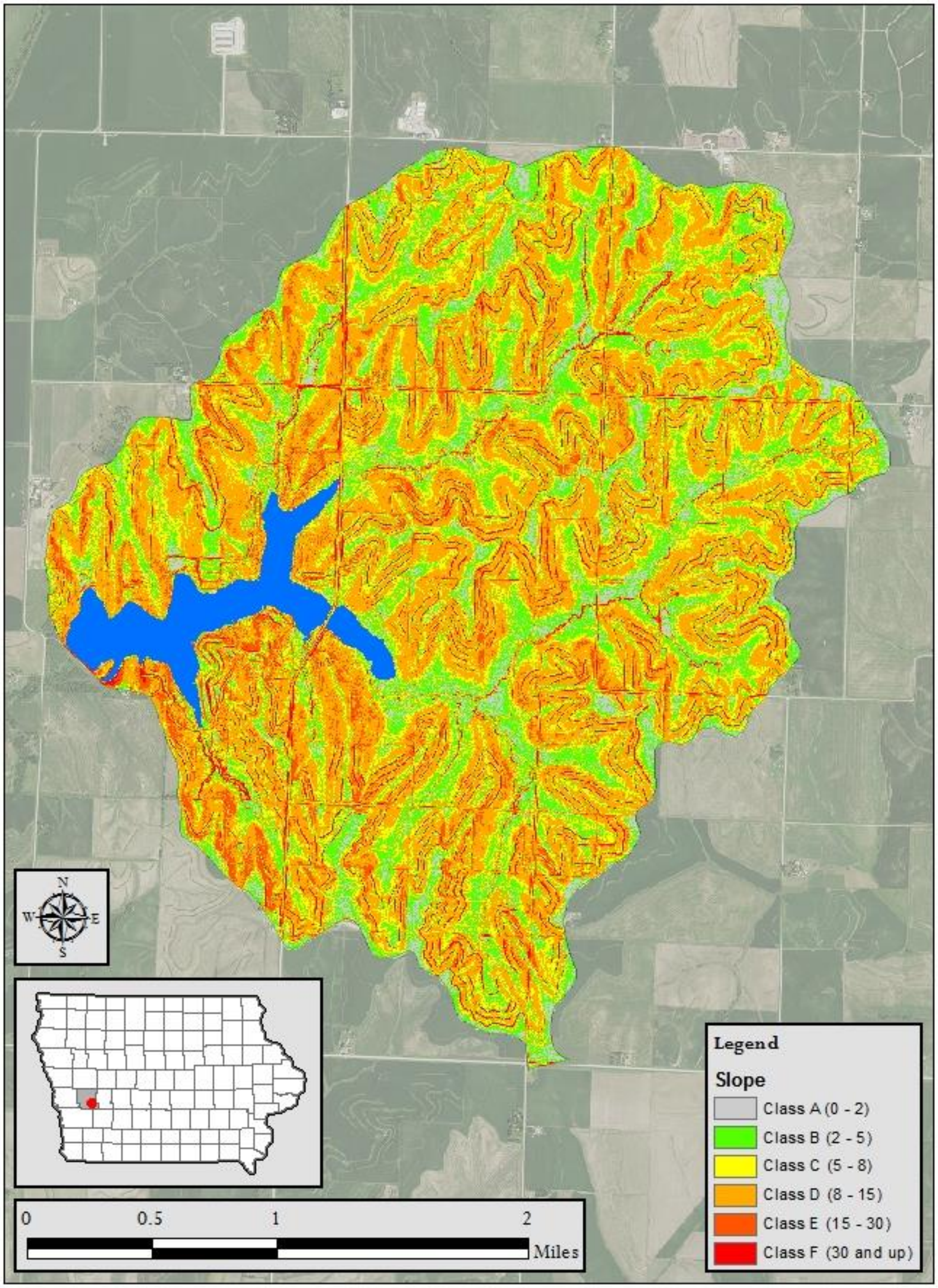

Figure 2-7. Slope Classifications in the Prairie Rose Lake Watershed.

3. TMDL for Algae and Turbidity

A Total Maximum Daily Load (TMDL) is required for Prairie Rose Lake by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) quantifies the maximum amount of total phosphorus (TP) the lake can assimilate and still fully support primary contact recreation in Prairie Rose Lake, which is impaired by algae and non-algal turbidity. This section includes an evaluation of Prairie Rose Lake water quality, documents the relationship between algae, turbidity, and TP in Prairie Rose Lake, and quantifies the in-lake target and corresponding TMDL.

3.1. Problem Identification

Prairie Rose Lake is a Significant Publicly Owned Lake, and is protected for the following designated uses:

Class A1 – Primary Contact Recreational Use
Class B(LW) – Aquatic Life
Class C – Drinking Water
Class HH – Human Health

The 2018 Section 305(b) Water Quality Assessment Report states that primary contact designated uses in Prairie Rose Lake are assessed as "not supported due to aesthetically objectionable conditions caused by and algae blooms and non-algal turbidity". The 2018 assessment is included in its entirety in Appendix H, and can be accessed at https://programs.iowadnr.gov/adbnet/Segments/1462/Assessment/2018

Applicable Water Quality Standards

The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61 (http://www.legis.iowa.gov/DOCS/ACO/IAC/LINC/Chapter.567.61.pdf) [Note: This link must be copied and pasted into a web browser]. Although the State of Iowa does not have numeric criteria for sediment, nutrients, or algae (chl-a), general (narrative) water quality criteria below do apply:

61.3(2) General water quality criteria. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(1)"a."

a. *Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.*
b. *Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.*
c. *Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.*
d. *Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.*
e. *Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.*

For 303(d) listing purposes, aesthetically objectionable conditions are present in a waterbody when Carlson's Trophic State Index (TSI) for the median growing season chl-a exceeds 65 (DNR, 2017). In order to de-list the algae and turbidity impairments for Prairie Rose Lake, the median growing season for both chl-a and Secchi depth TSI must not exceed 63 for two consecutive listing cycles, per DNR de-listing methodology.

Problem Statement
Water quality assessments indicate that Prairie Rose Lake is impaired because primary contact uses in the lake are not supported “due to aesthetically objectionable conditions caused by algal blooms and non-algal turbidity.” High levels of algal production and turbidity fueled by phosphorus loads to the lake cause the impairment. TP loads must be reduced in order to reduce algae and fully support the lake’s designated uses. Excess nutrients, particularly phosphorus, can cause eutrophic conditions associated with the impairments to Prairie Rose Lake. Phosphorus laden sediment deposits can also cause transparency issues.

Data Sources and Monitoring Sites
Sources of data used in the development of this TMDL include those used in the 2018 305(b) report, several sources of additional water quality data, and non-water quality related data used for model development. Sources include:

- Ambient Lake Monitoring and / or TMDL monitoring including:
  - results of available statewide surveys of Iowa lakes sponsored by DNR and conducted by Iowa State University 2002-2015
  - available water quality data collected by the State Hygienic Laboratory (SHL) at the University of Iowa from 2005-2008
- Precipitation data at Harlan, Iowa, the ISU Iowa Environmental Mesonet. (IEM, 2018a)
- PET data at Lewis, Iowa, the ISU Ag Climate Network (IEM, 2018b)
- 3-m Digital Elevation Model (DEM) available from DNR GIS library
- SSURGO soils data maintained by United States Department of Agriculture –Natural Resource Conservation Service (USDA-NRCS)
- Aerial images (various years) collected and maintained by DNR
- Lake bathymetric data collected in October 2015

Although water quality data was available post 2016, the 2018 305(d) assessment did not use this data in the impaired water status determination. See Section 4 and 5 for implementation and monitoring strategies that include most recent collected data.

Interpreting Prairie Rose Lake Data
The 2018 305(b) assessment was based on results of the ambient monitoring program conducted from 2010 through 2014 by ISU and information from the DNR Fisheries Bureau. Assessment of available in-lake water quality in this TMDL utilized available ISU data from 2002-2015. All in-lake data was collected at the ambient monitoring location, which is shown in Figure 3-1. Development of the in-lake target, the TMDL, and impairment status are based on data collected at this location, per DNR assessment methodology. In-lake water quality data is shown in Appendix C, Table C-1.

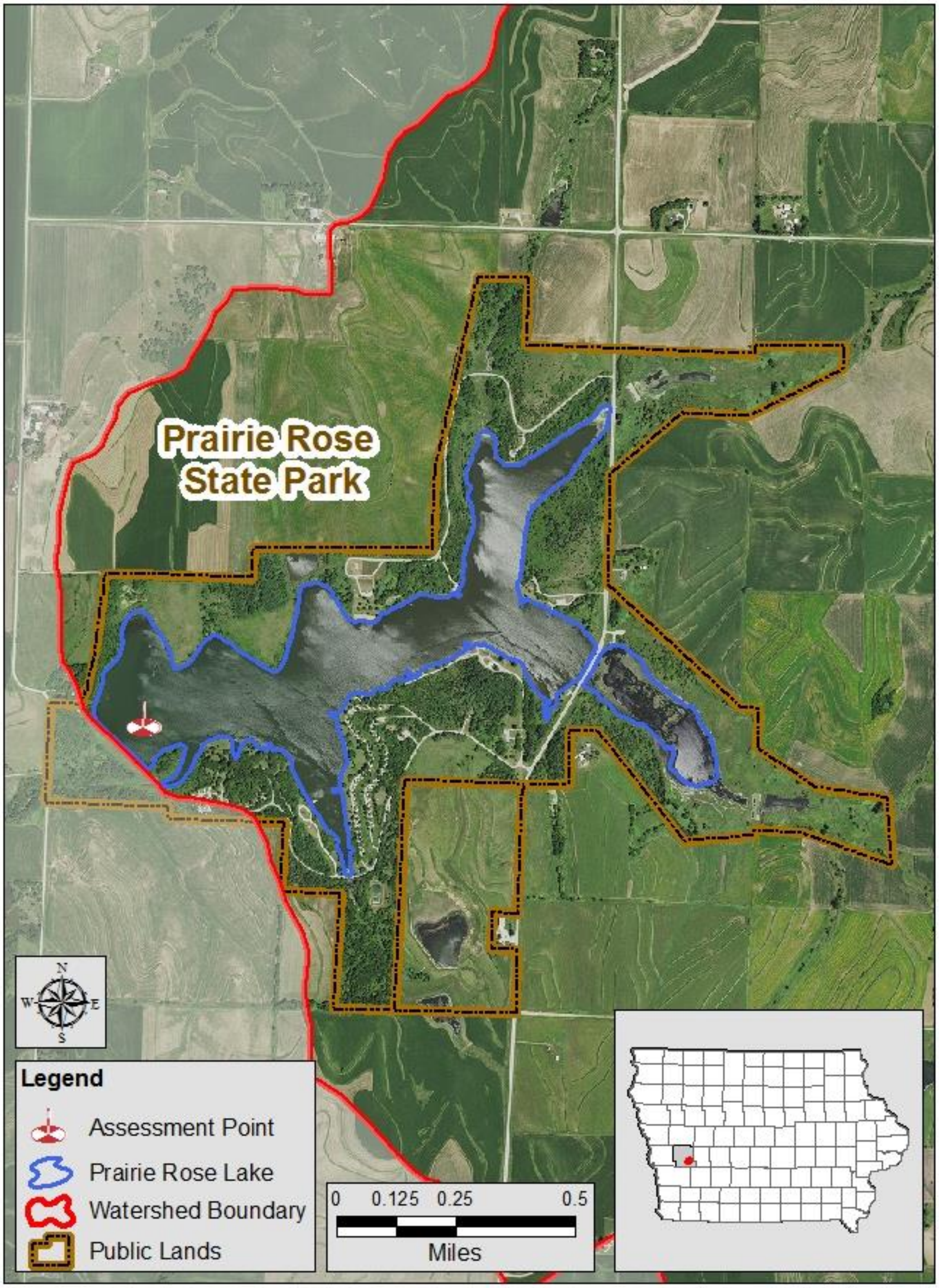

Figure 3-1. Ambient Monitoring Location for Water Quality Assessment.

Carlson's Trophic State Index (TSI) was used to evaluate the relationships between total phosphorus, algae (chl-a), and transparency (Secchi depth) in Prairie Rose Lake. TSI values are not a water quality index but an index of the trophic state of the water body. However, the TSI values for Secchi depth and chl-a can be used as a guide to establish water quality improvement targets.

If the TSI values for the three parameters are the same, the relationships between the TP, algae, and transparency are strong. If the TP TSI value is higher than the chl-a TSI, it suggests there are limitations to algal growth besides phosphorus. Figure 3-2 is a plot of the individual TSI values throughout the analysis period (2002-2015). TSI values that exceed the 303(d) listing threshold of 65 (for chl-a and Secchi depth) are contained within the red box and TSI values from the 2018 305(b) (2012-2015) assessment period are within the blue box.

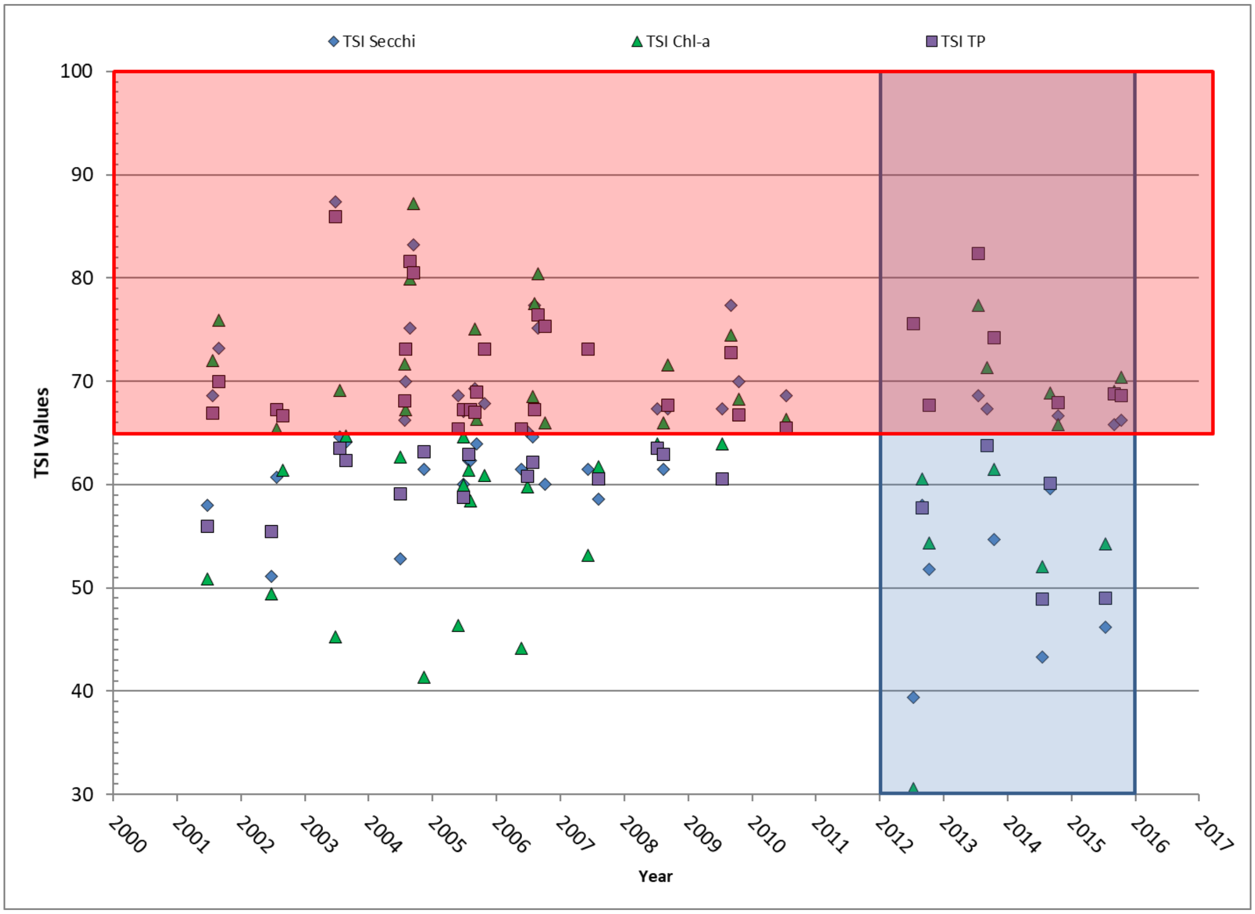

Figure 3-2. TSI Values for Individual Samples the Analysis Period.

Annual average TSI values for the analysis period can be seen in Figure 3-3 and Table 3-1 shows the overall average TSI values for Secchi depth, chl-a, and TP for the analysis period. The water clarity trend for the analysis period shows a steady TSI value for chl-a and TP. In addition, there is a improving trend for Secchi depth TSI values. However, chl-a TSI and Secchi values are abnormally low in 2012 after the lake was allowed to refill skewing the historical trend. The low chlorophyll values could be a result of 1) depopulation of algae when renovating the lake or 2) a large amount of submergent vegetation along the shoreline as the lake refilled, which could tie up phosphorous making less available for algal production. Table 3-2 describes the implications of TSI scores on attributes of lakes.

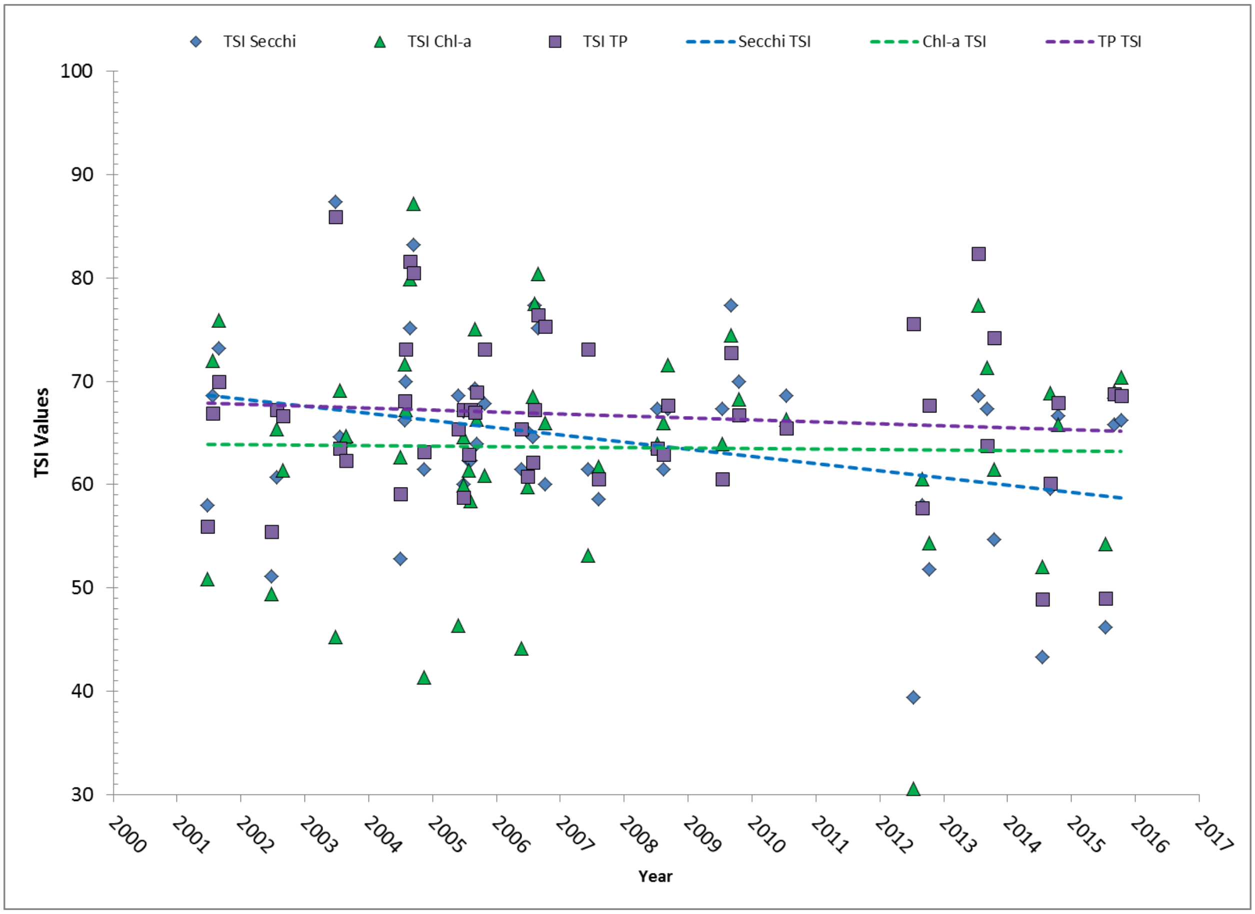

Figure 3-3. Average Annual TSI Values.

Table 3-1. Overall Average TSI Values in Prairie Rose Lake (2002-2015).

	Secchi Depth	Chlorophyll-a	Total Phosphorus
Average TSI Values	63	66	68

Table 3-2. Implications of TSI Values on Lake Attributes.

TSI Value	Attributes	Primary Contact Recreation	Aquatic Life (Fisheries)
50-60	eutrophy: anoxic hypolimnia; macrophyte problems possible	[none]	Warm water fisheries only; percid fishery(1); 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(2)
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) Fish commonly found in percid fisheries include walleye and some species of perch
(2) Fish commonly found in centrarchid fisheries include crappie, bluegill, and bass
Note: Modified from Carlson and Simpson (1996).

Subsequent analyses show the link between the three indices of in-lake water quality. Figure 3-4 shows the relationship between total phosphorus and Secchi depth TSI values. Figure 3-5 shows the relationship between chl-a and TP. Figure 3-6 shows the relationship between Secchi depth and chl-a. The R^2 values between the various TSI indices are summarized in Table 3-3. There is a strong positive correlation between TP and Secchi depth, and between chl-a and Secchi depth. This suggests that transparency issues can be linked to sediment, sediment bound phosphorus, and also algae in the water column. This may indicates that targeting phosphorus reductions in the watershed should improve Secchi depth TSI values. Additionally, the lack of correlation between total nitrogen and all three trophic state indices may indicate total nitrogen is not the limiting nutrient.

Table 3-3. Total Phosphorus, Chl-a, Secchi depth, and Total Nitrogen Relationships and R^2 Values.

TSI indicator	Total Phosphorus	Chlorophyll-a	Total Nitrogen
Total Phosphorus	---	0.079	0.002
Chlorophyll-a	0.079	---	0.032
Secchi depth	0.352	0.340	0.004

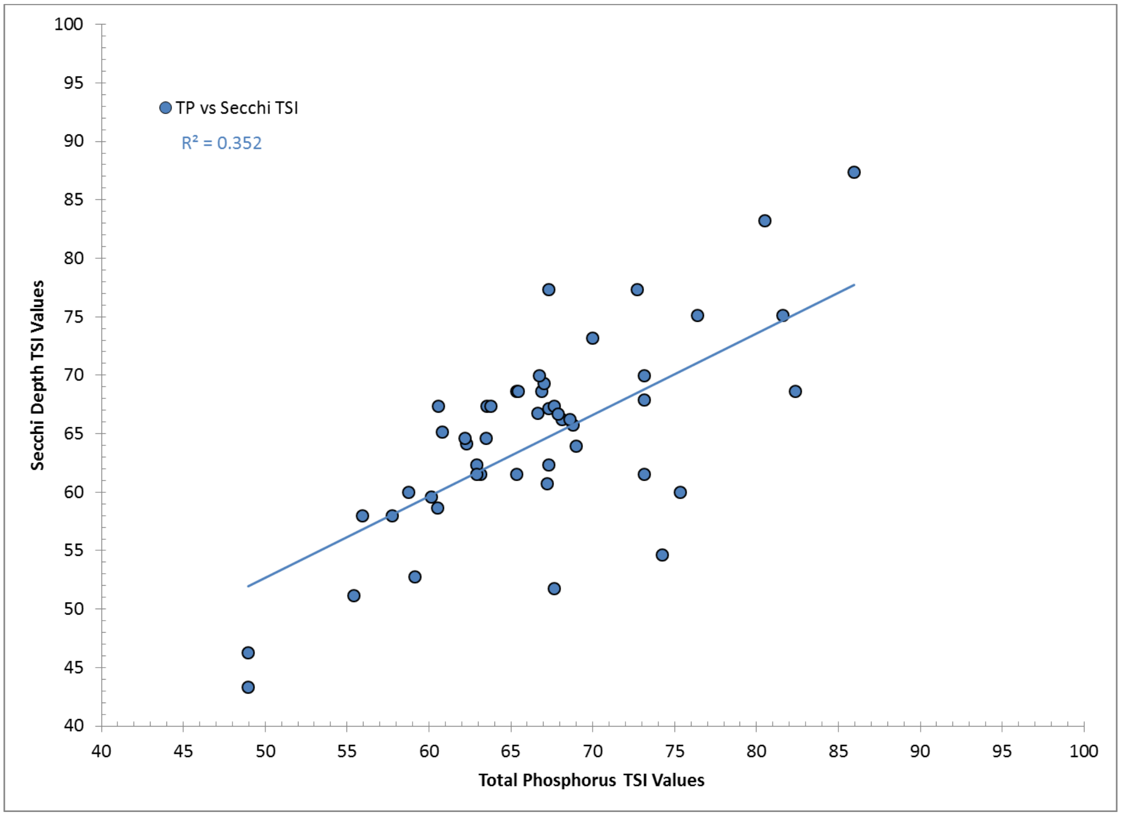

Figure 3-4. Analysis Period TSI Values for Total Phosphorus and Secchi Depth.

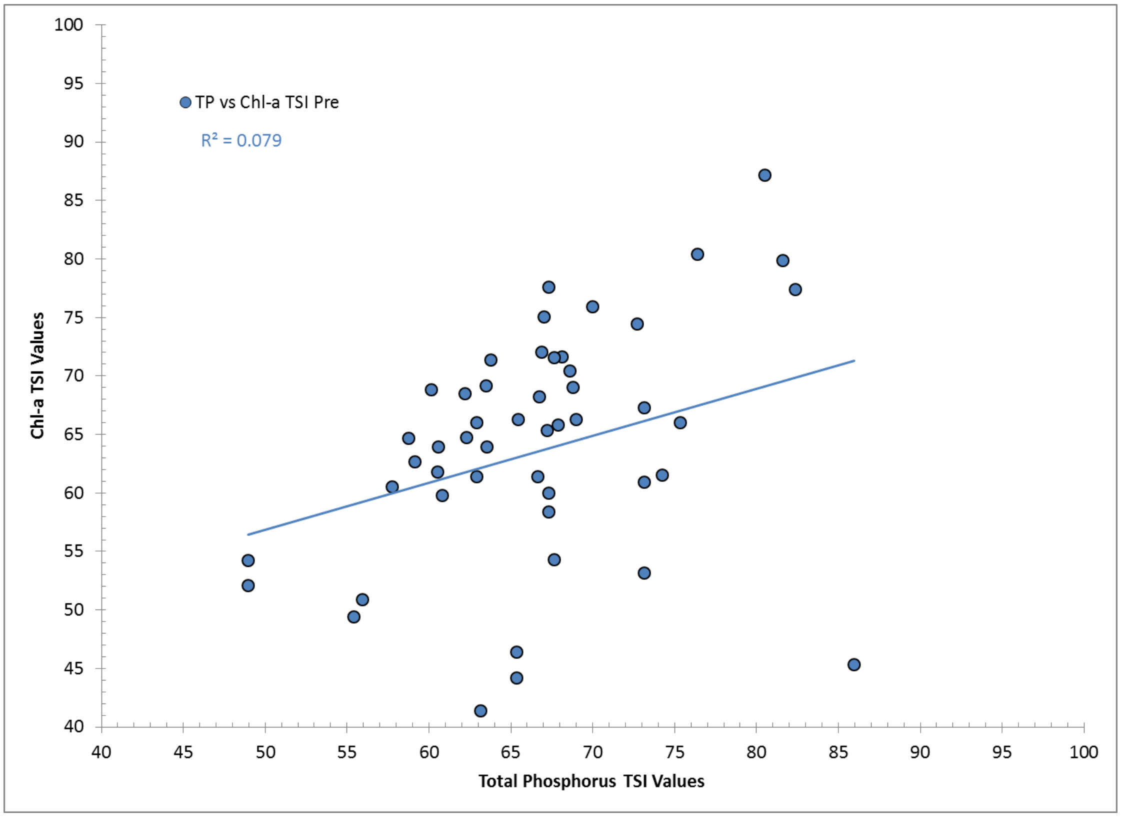

Figure 3-5. Analysis Period TSI Values for Total Phosphorus and Chlorophyll-A.

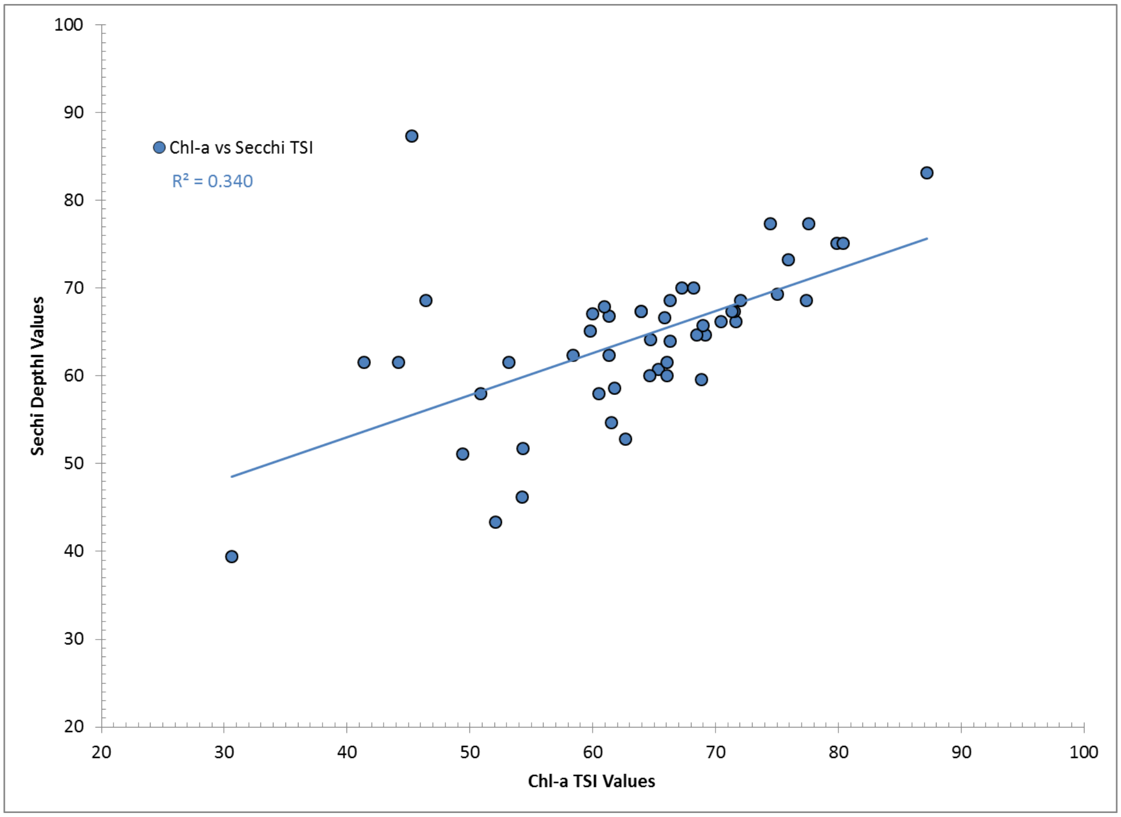

Figure 3-6. Analysis Period TSI Values for Chlorophyll-A and Secchi Depth.

Figure 3-7 and Figure 3-8 illustrate a method for interpreting the meaning of the deviations between Carlson's TSI values for TP, Secchi depth, and chl-a. Each quadrant of the chart indicates the potential factors that may limit algal growth in a lake. A detailed description of this approach is available in A Coordinator's Guide to Volunteer Lake Monitoring Methods (Carlson and Simpson, 1996). If the deviation between the chl-a TSI and TP TSI is less than zero (Chl TSI < TP TSI), the data point will fall below the X-axis. This suggests phosphorus may not be the limiting factor in algal growth. The X-axis, or zero line, is related to TN:TP ratios of greater than 33:1 (Carlson, 1996). Because phosphorus is thought to become limiting at ratios greater than 10:1, TP deviations slightly below the X-axis do not necessarily indicate nitrogen limitation.

Points to the left of the Y-axis (Chl TSI < SD TSI) represent conditions in which transparency is reduced by non-algal turbidity, whereas points to the right reflect situations in which transparency is greater than chl-a levels would suggest, meaning that large particles, rather than fine clay particles, influence water clarity. Deviations to the right may also be caused by high zooplankton populations that feed on algae, keeping the algal populations lower than expected given other conditions.

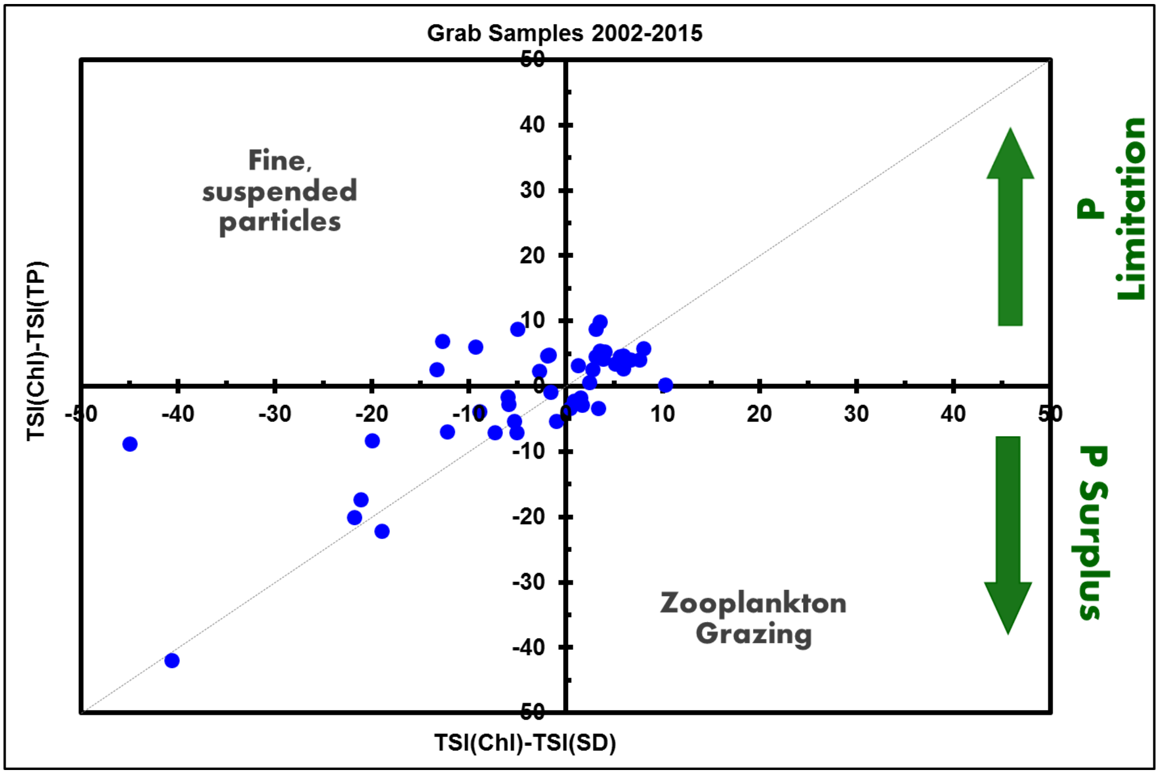

Figure 3-7. Phosphorus TSI Deviations Grab Samples for Analysis Period.

Chlorophyll-a and TP TSI deviations are split fairly evenly between positive and negative deviations with slightly less than half (21 of 50 samples) below the x-axis as shown in Figure 3-7. A majority of the deviations are located in the upper right hand quadrant (22 of 50 samples, 44%) and the lower left hand quadrant (16 of 50 samples, 32%). Samples located in the upper right hand quadrant would indicate large particles dominate and that phosphorus limits the growth of algae. Samples in the lower left hand quadrant would indicate smaller particles dominate and something other than phosphorus limits the algae growth. Samples in the lower right hand quadrant (7 of 50 samples, 14%) suggest transparency is limited by large particles, with a surplus of phosphorus, and possible limited algae growth due to zooplankton grazing.

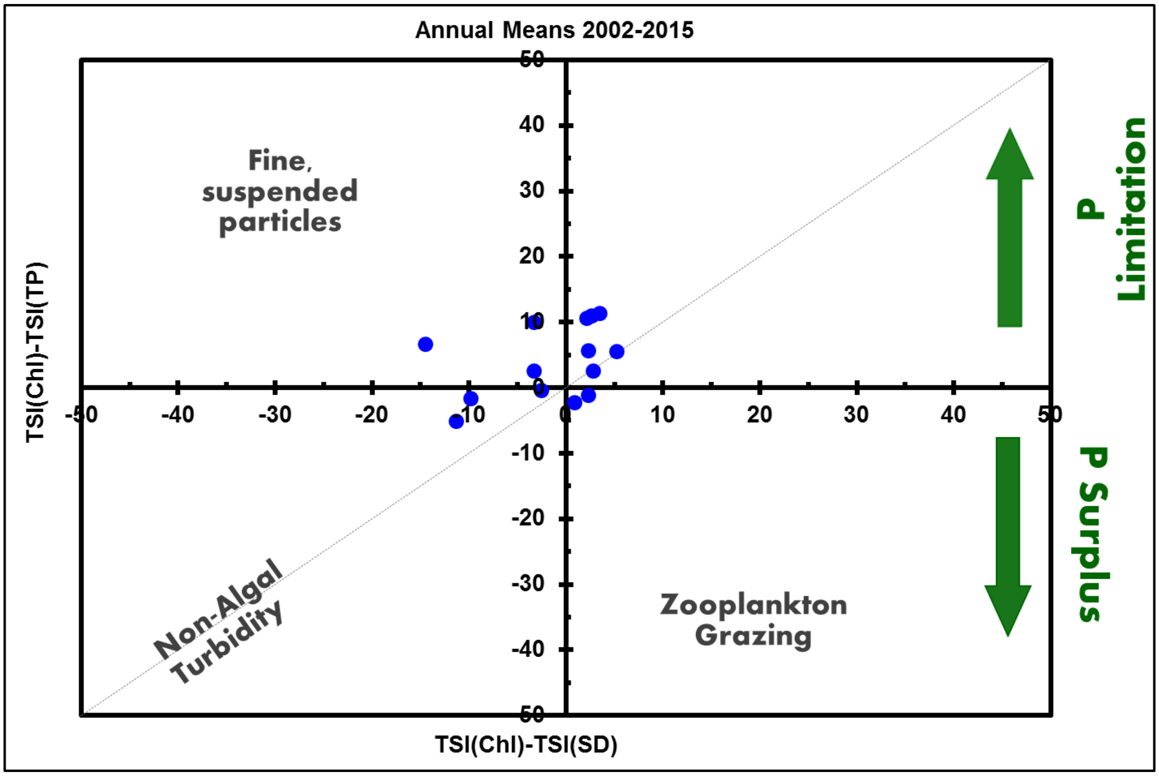

Figure 3-8. Phosphorus TSI Deviations Annual Averages for Analysis Period.

Chl-a, Secchi depth, and total phosphorus TSI values do not show any correlation to annual or growing season precipitation as shown (Figure 3-9 through Figure 3-10). This will allow mean annual average assumptions, as opposed to growing season averages in watershed and waterbody models.

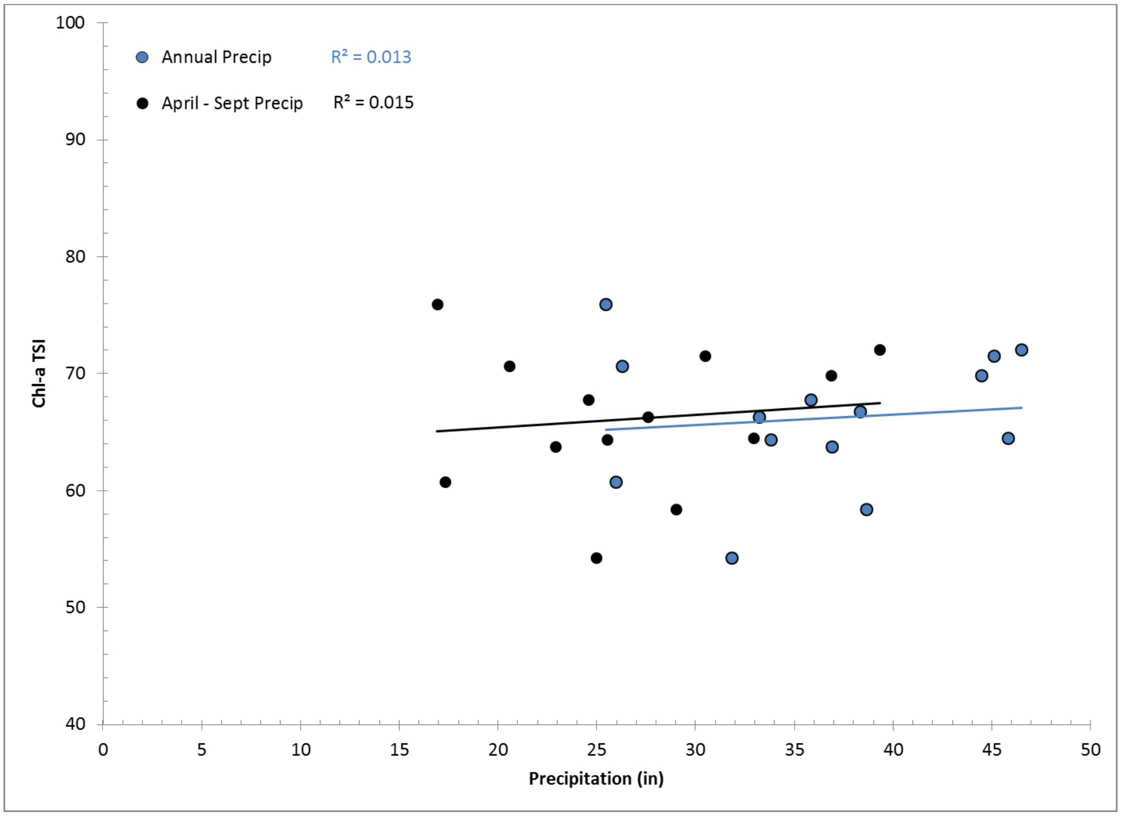

Figure 3-9. Chl-a TSI Values vs Annual and Growing Season Precipitation.

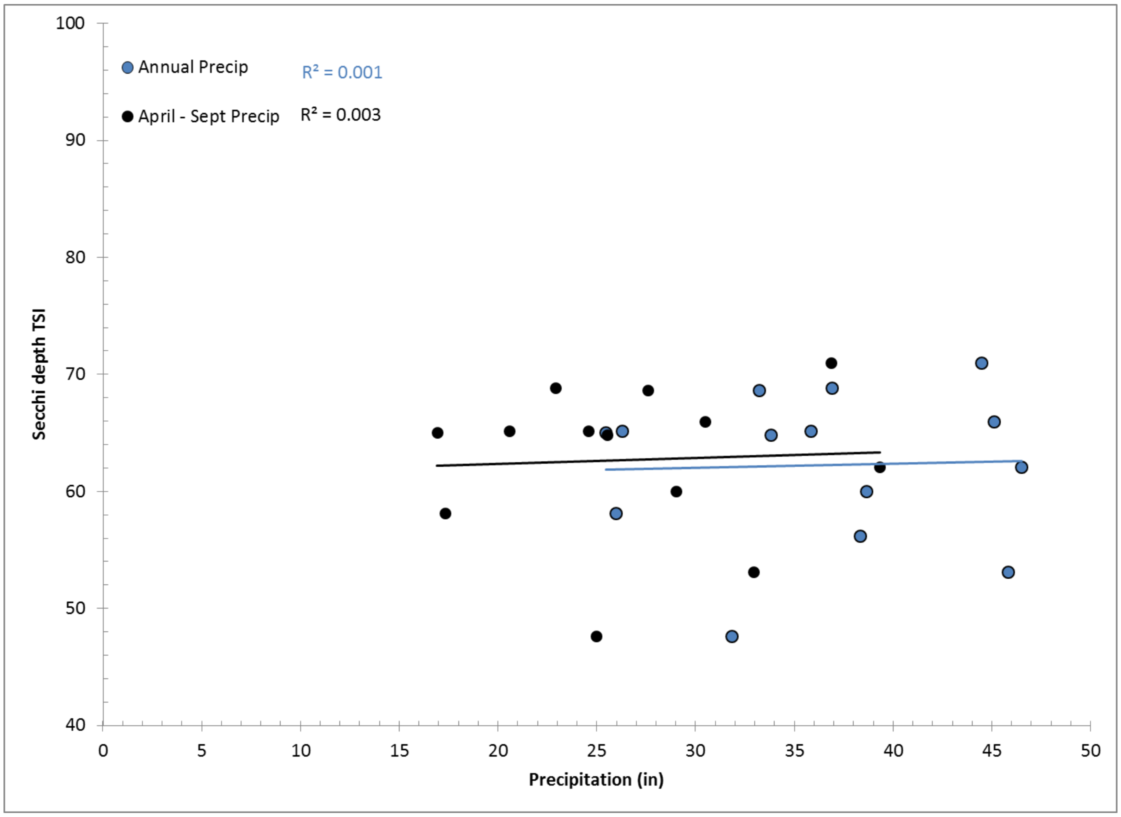

Figure 3-10. Secchi Depth TSI Values vs Annual and Growing Season Precipitation.

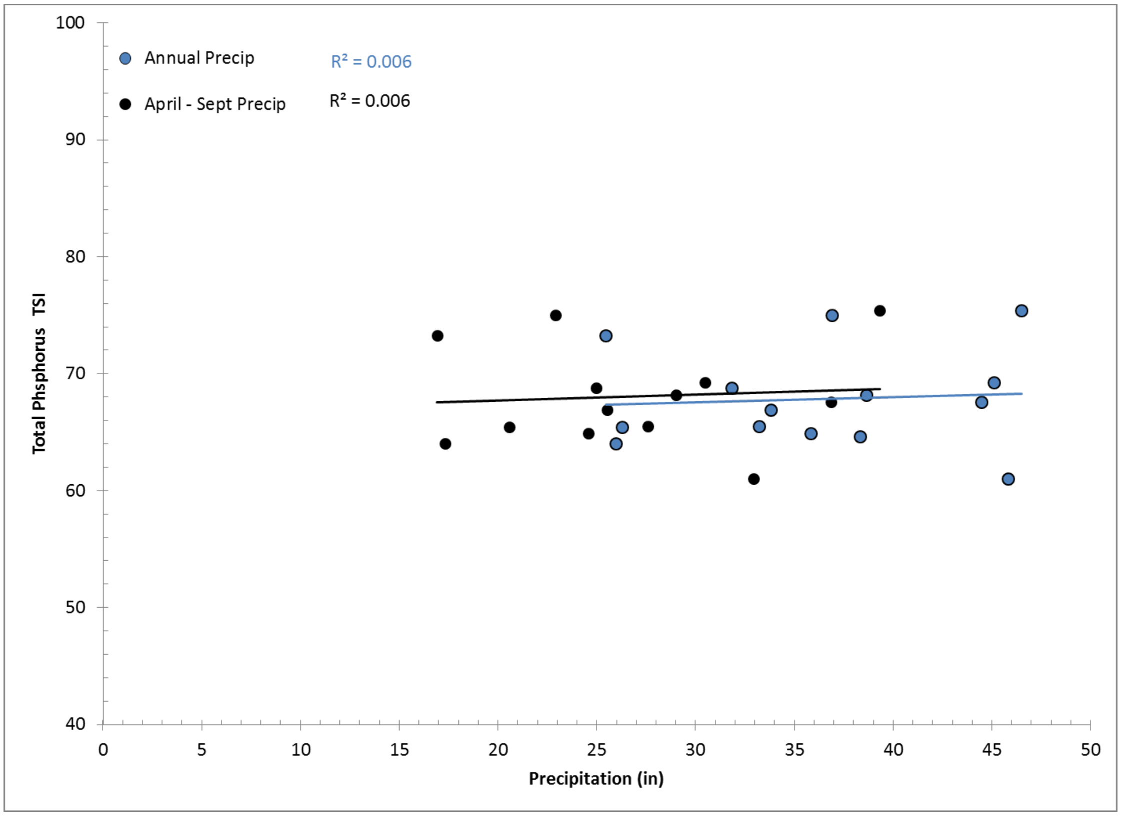

Figure 3-11. Total Phosphorus TSI Values vs Annual and Growing Season Precipitation.

Within lakes, the main two nutrients necessary for algal bloom development are nitrogen and phosphorus. When one nutrient is in short supply relative to the other, this nutrient supply will be exhausted first during growth. Once this nutrient is no longer available, growth is limited. Generally, in Iowa lakes, phosphorus is the limiting nutrient. Ratios of nitrogen to phosphorus can provide clues as to which nutrient is limiting growth in a given waterbody.

The overall TN:TP ratio in water quality samples from Prairie Rose Lake, using average grab sample concentrations from 2002-2015, is 26.5. According to a study on blue-green algae dominance in lakes, ratios greater than 17 suggest a lake is phosphorus, rather than nitrogen, limited (MPCA, 2005). Carlson states that phosphorus may be a limiting factor at TN:TP ratios greater than 10 (Carlson and Simpson, 1996). Ratios that fall between 10 to 17 are often considered “co-limiting,” meaning either nitrogen or phosphorus is the limiting nutrient or light is limited due to high non-algal turbidity.

Table 3-4 lists number of samples for each nutrient limiting condition for all samples, when TSI(chl-a) is greater than 65, and when TSI(SD) is greater than 65. Analysis of the TN:TP ratio in Prairie Rose Lake samples reveals that the lake is P-limited over 60 percent of the time and co-limited over 30 percent of the time. In addition, when the chl-a TSI exceeds 65, the lake is either P-limited or co-limited 85 percent of the time. When the Secchi depth TSI exceeds 65, the lake is either P-limited or co-limited 85 percent of the time. This analysis reveals that water quality improvement of algal blooms and turbidity via TP reduction is most feasible. If phosphorus reductions are not accompanied by reductions in algal blooms, then reductions in nitrogen may prove necessary to reduce algae to an acceptable level.

Table 3-4. TN:TP Ratio Summary in Prairie Rose Lake.

Samples Collected	# of Samples	N-Limited (<10)	Co-Limited (10-17)	P-Limited (>17)
All Samples, 2002-2015	43	4 (9.3%)	13 (30.2%)	26 (60.5%)
Samples with Chl-a TSI > 65	20	3 (15%)	8 (40%)	9 (45%)
Samples with Secchi TSI >65	20	3 (15%)	10 (50%)	7 (35%)

3.2. TMDL Target

General description of the pollutant

The 2018 305(b) assessment attributes poor water quality in Prairie Lake to excess algae and no-algal turbidity, and the data interpretation described in Section 3.1 indicates phosphorus load reduction will best address the impairment. It will be important to continue to assess TSI values for chl-a and Secchi depth as phosphorus reduction practices are implemented. If phosphorus reductions are not accompanied by reductions in algal blooms and turbidity levels, then reductions of nitrogen may prove necessary to reduce algae to an acceptable level. However, phosphorus should be reduced first, as it is the primary limiting nutrient in algal growth. Additionally, reductions in nitrogen that result in nitrogen limitation favor growth of harmful cyanobacteria, which have the ability to fix nitrogen from the atmosphere. These bacteria, often referred to as blue-green algae, can emit cyanotoxins to the water, which can harm humans, pets, and wildlife if ingested.

Table 3-5 reports the simulated chl-a, TP, and Secchi depth at the ambient monitoring location for both existing and target conditions. In-lake water quality was simulated using the BATHTUB model, which is described in more detail in Appendix E. The chl-a TSI target of 63 complies with the narrative “free from aesthetically objectionable conditions” criterion. The Secchi depth and chl-a targets of 63 or less complies with the algal and non-algal turbidity impairments. Meeting both of these targets will result in delisting Prairie Rose Lake if attained in two consecutive 303(d) listing cycles. Note that TP values in Table 3-5 are not TMDL targets. Rather, they represent in-lake water quality resulting from TP load reductions required to obtain the chl-a and Secchi depth TSI targets in Prairie Rose Lake.

Table 3-5. Existing and Target Water Quality (Ambient Monitoring Location).

Parameter	2002-2015 Calibration	TMDL Target Conditions
Secchi Depth (meter)	0.9	1.3
TSI (Secchi Depth)	62.2	56
Chlorophyll-a (µg/L)	43.5	27.1
TSI (Chlorophyll-a)	67.6	63.0
TP (µg/L)	86.2	59.8
TSI (TP)	68.4	63.1

Selection of environmental conditions

The critical period for poor water clarity is the growing season (April through September). However, long-term phosphorus loads lead to buildup of phosphorus in the reservoir and can contribute to algal growth and turbidity regardless of when phosphorus first enters the lake. Therefore, both existing and allowable TP loads to Prairie Rose Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with EPA guidance.

Waterbody pollutant loading capacity (TMDL)
This TMDL establishes a chl-a TSI target of 63 and a Secchi depth TSI target of 63 or less using analyses of existing water quality data and Carlson's trophic state index methodology. The allowable TP loading capacity was developed by performing water quality simulations using the BATHTUB model. BATHTUB is a steady-state water quality model that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). The BATHTUB model was calibrated to available water quality data collected by ISU and SHL from 2002 through 2015.

The BATHTUB model is driven by weather, lake morphometry (i.e., size and shape), watershed hydrology, and sediment and nutrient loads predicted by the STEPL model. STEPL utilizes simple equations to predict sediment and nutrient loads from various land use and animal sources, and includes a tool that estimates potential sediment and nutrient reductions resulting from implementation of Best Management Practices (BMPs). STEPL input included local soil, land use, and climate data. A detailed discussion of the parameterization and calibration of the STEPL and BATHTUB models is provided in Appendices D through F.

The annual TP loading capacity was obtained by adjusting the TP loads (tributary concentrations) in the calibrated BATHTUB model until chl-a and Secchi depth TSIs no greater than 63 were attained for the lake segment in which ambient monitoring data is collected. This model will be used to quantify maximum daily loads, while acknowledging that multiple solutions exist. Modeling reductions in external loading shows the annual loading capacity of Prairie Rose Lake is 2,076 lbs/yr (941.6 kg/yr).

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

As recommended by EPA, the loading capacity of Prairie Rose Lake for TP is expressed as a daily maximum load, in addition to the annual loading capacity of 2,076 lbs/year. The annual average load is applicable to the assessment of in-lake water quality and water quality improvement actions, while the daily maximum load satisfies EPA's recommendation for expressing the loading capacity as a daily load.

The maximum daily load was estimated from the growing season average load using a statistical approach that is outlined in more detail in Appendix G. This approach uses a log-normal distribution to calculate the daily maximum from the long-term (e.g., annual) average load. The methodology for this approach is taken directly from a follow-up guidance document entitled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), and was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control*. Using the approach, the annual loading capacity of 2,076 lbs/yr is equivalent to an average daily load of 0.56 pounds per day (lbs/day) and a maximum daily load of 17.7 lbs/day.

Decision criteria for WQS attainment

The narrative criteria in the water quality standards require that Prairie Rose Lake support primary contact for recreation. The metrics for WQS attainment for de-listing the impairments are a chl-a TSI and Secchi depth TSI of 63 or less in two consecutive 303(d) listing cycles.

Compliance point for WQS attainment

The TSI target for listing and delisting of Prairie Rose Lake is measured at the ambient monitoring location shown in Figure 3-1. To maintain consistency with other Clean Water Act programs implemented by the Iowa DNR, such as the 305(b) assessment and 303(d) listing process, the TMDL target is based on water quality of the main body of the lake in the one BATHTUB segment, which best represents the ambient monitoring location in Prairie Rose Lake.

3.3. Pollution Source Assessment

Existing load

Average annual simulations of hydrology and pollutant loading were developed using the STEPL model (Version 4.1). STEPL was developed by Tetra Tech, for the US EPA Office of Wetlands, Oceans, and Watersheds (OWOW), and has been utilized extensively in the United States for TMDL development and watershed planning. Model description and parameterization are described in detail in Appendix D.

Using STEPL and BATHTUB to simulate annual average conditions between 2002-2015, the annual TP load to Prairie Rose Lake was estimated to be 3,988 lbs/yr.

Departure from load capacity

The TP loading capacity for Prairie Rose Lake is 2,076 lbs/yr and 17.7 lbs/day (maximum daily load). To meet the target loads, an overall reduction of 48 percent of the TP load is required. The implementation plan included in Section 4 describes potential BMPs, potential TP reductions, and considerations for targeted selection and location of BMPs.

Identification of pollutant sources

The existing TP load to Prairie Rose Lake is entirely from nonpoint sources of pollution. Table 3-6 reports estimated annual average TP loads to the lake from all known sources, based on the STEPL simulation of average annual conditions from 2002-2015. The predominant sources of phosphorus to Prairie Rose Lake include erosion from row crops, non-grazed grassland, and pastureland. Row crops comprise 70.8 percent of the watershed and 80.8 percent of the phosphorus loads to the lake. (Table 3-6 and Figure 3-12).

Table 3-6. Average Annual TP Loads from each Source.

Source	Descriptions and Assumptions	TP Load (lb/yr)	Percent (%)
Pastureland	Seasonally grazed grassland	18.6	0.3
Row Crops	Sheet and rill erosion from corn and soybeans dominated agriculture	3220.7	80.8
User Defined	Ungrazed Grassland, Alfalfa/Hay	95.7	2.4
Forest	Forested park grounds surrounding lake	93.3	2.3
Urban	Urban areas, roads, and farmsteads	214.9	5.4
Groundwater	Agricultural tile discharge, natural groundwater flow	270.4	6.8
All others	Wildlife, atmospheric deposition, septics	74.4	2.0
Total		**3988**	**100.0**

Internal recycling of phosphorus in the lake was not explicitly simulated or calculated, because predicted phosphorus loads to the lake from the watershed were large enough to fully account for observed phosphorus levels in the lake. The BATHTUB model empirically and indirectly accounts for low to moderate levels of internal loading without the addition of an internal loading input to the model. In lakes with substantial internal loading issues, inclusion of additional internal load inputs is sometimes necessary, but that was not the case for Prairie Rose Lake. Internal recycling of phosphorus may be important in extremely dry conditions, typically late in the growing season, when the water level falls below the spillway crest, creating a stagnant pool in the reservoir. Reduction of internal lake loads is a valid water quality improvement strategy, but watershed loads are more critical to long-term water quality in the lake.

Allowance for increases in pollutant loads

There is no allowance for increased phosphorus loading included as part of this TMDL. A majority of the watershed is in agricultural row crop production or grassland, and is likely to remain in these land uses in the future. Any future residential or urban development may contribute similar sediment loads and therefore will not increase phosphorus to the lake system. There are currently no incorporated unsewered communities in the watershed; therefore it is unlikely that a future WLA would be needed for a new point source discharge. Any future development of animal feeding operations (AFO) qualifying as large concentrated animal feeding operations (CAFO) or meeting the requirements for NPDES permits as small or medium sized CAFOs will have zero discharge permits.

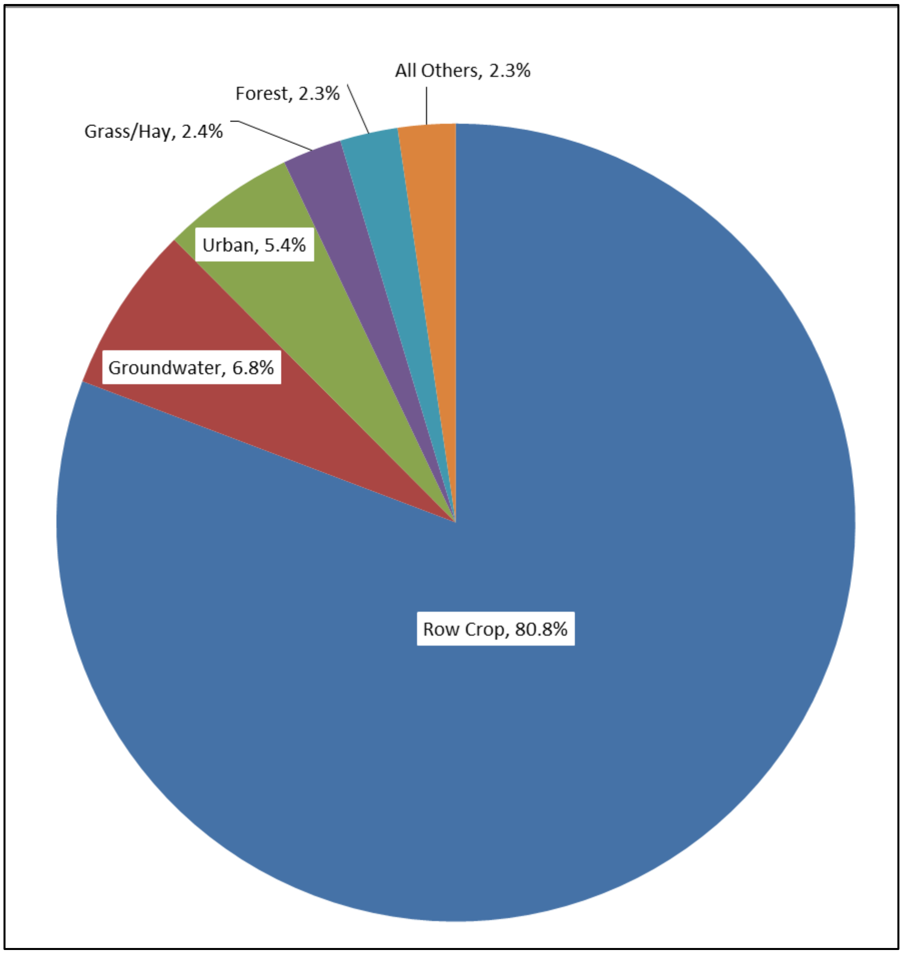

Figure 3-12. Relative TP Loads by Source.

3.4. Pollutant Allocation

Wasteload allocation

Although there were a limited number of construction permits during the lake renovations, there are no permitted point source dischargers of phosphorus in the Prairie Rose Lake watershed.

Load allocation

Nonpoint sources of phosphorus to Prairie Rose Lake include erosion from land in pasture and row crop production, erosion from grasslands, erosion from timber/wooded areas, transport from developed areas (roads, residences, etc.), wildlife defecation, and atmospheric deposition (from dust and rain), and groundwater contributions. Septic systems in this watershed, which are not regulated or permitted under the Clean Water Act, but can fail or drain illegally to ditches, also contributed phosphorus to the lake during the assessment period.

Changes in agricultural land management, implementation of structural best management practices (BMPs), repair or replacement of failing septic systems, and in-lake restoration techniques can reduce phosphorus loads and improve water quality in Prairie Rose Lake. Based on the inventory of sources, management and structural practices targeting surface runoff contributions of phosphorus offer the largest potential reductions in TP loads. This may include repairing of existing terraces on cropland and constructing new terraces where applicable.

Table 3-7 shows an example load allocation scenario for the Prairie Rose Lake watershed that meets the overall TMDL phosphorus target. The LA is 1,868 lbs/year, with a maximum daily LA of 15.9 lbs/day. The daily maximum LA was obtained by subtracting the daily WLA and daily MOS from the statistically derived TMDL (as described in Section 3.2 and Appendix G). The specific reductions shown in Table 3-7 are not required, but provide one of many possible combinations of reductions that would achieve water quality goals.

Table 3-7. Example Load Allocation Scheme to Meet Target TP Load.

TP Source	Existing Load (lb/year)	LA (lb/year)	NPS Reduction (%)
Pastureland	18.6	9.3	50
Row Crops	3,221	1,288	60
[1]User Defined	95.7	47.8	50
Forest	93.3	46.6	50
Urban	214.9	107.4	50
Groundwater	270.4	270.4	0
Septic	29.2	14.6	50
[2]All others	44.9	44.9	0
Total	**3,988**	**1,868**	**--**

(1) Non grazed grassland and Alfalfa/Hay
(2) Atmospheric contributions, direct lake contributions by waterfowl

Margin of Safety
To account for uncertainties in data and modeling, a margin of safety (MOS) is a required component of all TMDLs. An explicit MOS of 10 percent (208 lbs/year, 1.8 lbs/day) was utilized in the development of this TMDL. These uncertainties may include seasonal changes in nutrient concentrations of influent to Prairie Rose Lake, changes in internal recycling that may be seasonal in nature, maintenance and efficiency of existing BMPs.

Reasonable Assurance
Under current EPA guidance, when a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurance that nonpoint source control measures will achieve expected load reductions. There are no permitted or regulated point source discharges contributing phosphorus to Prairie Rose Lake and the WLA is zero, therefore reasonable assurance of point source reductions is not applicable. Reasonable assurance for reduction of nonpoint sources is provided by the list of potential best management practices that would deliver phosphorus reductions, a group of nonstructural practices that prevent transport of phosphorus, a proposed methodology for prioritizing and targeting BMPs on the landscape, and monitoring for best available data for estimating the reductions associated with implemented BMPs.

3.5. TMDL Summary

The following general equation represents the total maximum daily load (TMDL) calculation and its components:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS$$

Where:
TMDL = total maximum daily load
LC = loading capacity
Σ WLA = sum of wasteload allocations (point sources)
Σ LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Prairie Rose Lake watershed, the general equation above can be expressed for the Prairie Rose Lake algae and turbidity TMDL.

Expressed as the allowable annual average, which is helpful for water quality assessment and watershed management:

TMDL = LC = Σ WLA (0 lbs-TP/year) + Σ LA (1,868 lbs-TP/year)
+ MOS (208 lbs-TP/year) = **2,076 lbs-TP/year**

Expressed as the maximum daily load:

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (15.9 lbs-TP/day)
+ MOS (1.8 lbs-TP/day) = **17.7 lbs-TP/day**

4. Implementation Planning

An implementation plan is not a requirement of the Federal Clean Water Act. However, the Iowa Department of Natural Resources (DNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). Therefore, this implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. The best management practices (BMPs) discussed are potential tools that will help achieve water quality goals if appropriately utilized. It is possible that only a portion of BMPs included in this plan will be feasible for implementation in the Prairie Rose Lake watershed. Additionally, there may be potential BMPs not discussed in this implementation plan that should be considered. This implementation plan should be used as a guide or foundation for detailed and comprehensive planning by local stakeholders.

Collaboration and action by residents, landowners, lake users, and local agencies will be essential to improve water quality in Prairie Rose Lake and support its designated uses. Locally-led efforts have proven to be the most successful in obtaining real and significant water quality improvements. Improved water quality results in economic and recreational benefits for people that live, work, and recreate in the watershed. Therefore, each group has a stake in promoting awareness and educating others about water quality, working together to adopt a comprehensive watershed improvement plan, and applying BMPs and land management changes in the watershed.

4.1. Previous Watershed Planning and Implementation

In the past twenty years there has been significant work done in the watershed and in the body of the lake. The Shelby County Soil and Water Conservation District was awarded $510,611 in 2008. This helped construct over 225,000 ft of terraces, grassed waterways and nutrient management plans.

In 2010, Iowa DNR in partnership with Pheasants Forever acquired a 77-acre dredge spoil site as phase I of a multiphase program for in-lake restoration work. Prairie Rose Lake was dewatered in 2011 and had significant shoreline stabilization work done. In addition to 60,000 cubic yards of sediment removed during this time. Phase II included hydraulic dredging of approximately 185,000 cubic yards of material from 2014 to 2015. Other projects include small sediment basins upstream to allow larger sediment particles to settle out before reaching the lake. Significant fish habitat construction and restoration was also part of both in-lake restoration phases. In total, over $4 million was spent in the four year, two phase project.

Post restoration work included two additional years of supplemental water quality monitoring to assess the efficacy of the in-lake and watershed restoration practices. This water quality data can be found in Appendix C and in discussions in Section 5.

4.2. Future Planning and Implementation

General Approach

Watershed management and BMP implementation to reduce algae and turbidity in the lake should utilize a phased approach to improving water quality. The existing loads, loading targets, a general listing of BMPs needed to improve water quality, and a monitoring plan to assess progress are established in this WQIP. Completion of the WQIP should be followed by the development of a watershed management plan by a local planning group. The watershed plan should include more comprehensive and detailed actions to better guide the implementation of specific BMPs. Tasks required to obtain real and significant water quality improvements include continued monitoring, assessment of water quality trends, assessment of water quality standards (WQS) attainment, and adjustment of proposed BMP types, location, and implementation schedule to account for changing conditions in the watershed.

Timeline

Planning and implementation of future improvement efforts may take several years, depending on stakeholder interest, availability of funds, landowner participation, and time needed for design and construction of any structural BMPs. Realization and documentation of significant water quality benefits may take 5-10 years or longer, depending on weather patterns, amount of water quality data collected, and the successful selection, location, design, construction, and maintenance of BMPs. Monitoring should continue throughout implementation of BMPs and beyond to document water quality improvement.

Tracking milestones and progress

This WQIP, including the proposed monitoring plan outlined in Section 5, would address several of the elements required for a nine-element plan approved by EPA for the use of 319 funds, or other state and federal funding sources, as available. Establishment of specific short, intermediate, and long-term water quality goals and milestones would also be needed for additional funding from available sources. A path to full attainment of water quality standards and designated uses must be included for most funding sources, but efforts should first focus on documenting water quality improvement resulting from BMPs and elimination of any phosphorus “hot spots” that may exist.

4.3. Best Management Practices

No stand-alone BMP will be able to sufficiently reduce phosphorus loads to Prairie Rose Lake. Rather, a comprehensive package of BMPs will be required to reduce sediment and phosphorus loads to the lake, which can cause elevated algal growth and turbidity issues. The majority of phosphorus enters the lake via nutrient loss from cropland, non-grazed grassland and forested land through sheet / rill and gully erosion. These sources have distinct phosphorus transport pathways and processes; therefore, each requires a different set of BMPs and strategies.

Other sources, although relatively small on an annualized basis, can have important localized and seasonal effects on water quality. It is important that all sources are considered to reduce phosphorus loads in the most comprehensive manner possible. Experience has shown that watershed projects that involve widespread “ownership” of potential solutions have the best chance of success. At the same time, resources to address the various sources of phosphorus should be allocated in a manner that is reflective of the importance to the impairment: algal blooms and turbidity issues caused primarily by excess phosphorus loads to the lake and in the lake. Potential BMPs are grouped into three types: land management (prevention), structural (mitigation), and in-lake alternatives (remediation).

Land Management (Prevention Strategies)

Many agricultural BMPs are designed to reduce erosion and nutrient loss from the landscape. These BMPs provide the highest level of soil conservation and soil health benefits, because they prevent erosion and nutrient loss from occurring. Land management alternatives implemented in row crop areas should include conservation practices such as no-till and strip-till farming, diversified crop rotation methods, utilization of in-field buffers, and cover crops. Incorporation of fertilizer into the soil by knife injection equipment reduces phosphorus levels, as well as nitrogen and bacteria levels, in runoff from application areas. Strategic timing of fertilizer application and avoiding over-application may have even greater benefits to water quality. Application of fertilizer on frozen ground should be avoided, as should application when heavy rainfall is forecasted. Land retirement programs such as the conservation reserve program (CRP), and conservation reserve enhancement program (CREP) constructed wetlands may be considered where appropriate. Table 4-1 summarizes land management BMPs and associated phosphorus reduction estimates.

Table 4-1. Potential Land Management BMPs (Prevention Strategies).

BMP or Activity	[1] Potential TP Reduction
Conservation Tillage:	
Moderate vs. Intensive Tillage	50%
No-Till vs. Intensive Tillage	70%
No-Till vs. Moderate Tillage	45%
Cover Crops	50%
Diversified Cropping Systems	50%
In-Field Vegetative Buffers	50%
Pasture/Grassland Management:	
Livestock Exclusion from Streams	75%
Rotational Grazing vs. Constant Intensive Grazing	25%
Seasonal Grazing vs. Constant Intensive Grazing	50%
Phosphorus Nutrient Application Techniques:	
[2]Deep Tillage Incorporation vs. Surface Broadcast	-15%
[2]Shallow Tillage Incorporation vs. Surface Broadcast	-10%
Knife/Injection Incorporation vs. Surface Broadcast	35%
Phosphorus Nutrient Application Timing and Rates:	
Spring vs. Fall Application	30%
Soil-Test P Rate vs. Over-Application Rates	40%
Application: 1-month prior to runoff event vs. 1-day	30%

(1) Adopted from Dinnes (2004). Actual reduction percentages may vary widely across sites and runoff events.
(2) Note: Tillage incorporation can increase TP in runoff in some cases.

Structural BMPs (Mitigation Strategies)

Although they do not address the underlying generation of sediment or nutrients, structural BMPs such as sediment control basins, terraces, grass waterways, saturated buffers, riparian buffers, and wetlands can play a valuable role in reduction of sediment and nutrient transport to Prairie Rose Lake. These BMPs attempt to mitigate the impacts of soil erosion and nutrient loss by intercepting them before they reach a stream or lake. Structural BMPs should be targeted to "priority areas" to increase their cost effectiveness and maximize pollutant reductions. Landowner willingness and the physical features of potential sites must also be considered when targeting structural practices. These practices may offer additional benefits not directly related to water quality improvement. These secondary benefits are important to emphasize to increase landowner and public interest and adoption. Potential structural BMPs are listed in Table 4-2, which includes secondary benefits and potential TP reductions.

Table 4-2. Potential Structural BMPs (Mitigation Strategies).

BMP or Activity	Secondary Benefits	[1] Potential TP Reduction
Terraces	Soil conservation, prevent in-field gullies, prevent wash-outs	50%
Grass Waterways	Prevent in-field gullies, prevent washouts, some ecological services	50%
[2]Sediment Control Structures	Some ecological services, gully prevention	Varies
[3]Wetlands	Ecological services, potential flood mitigation, aesthetic value	15%
Riparian Buffers	Ecological services, aesthetic value, alternative agriculture	45%
Saturated Buffers	Nitrate removal	[4]Varies

(1) Adopted from Dinnes (2004). Actual reduction percentages may vary widely across sites and runoff events.
(2) Not discussed in Dinnes (2004). Phosphorus removal in sediment basins varies widely and is dependent upon the size of the structure relative to the drainage area, the length:width ratio, and drawdown time of a specified rainfall/runoff event.
(3) Note: TP reductions in wetlands vary greatly depending on site-specific conditions, such as those listed for sediment control structures. Generally, removal of phosphorus is lower in wetlands than in sediment control structures. Wetland can sometimes be sources, rather than sinks, of phosphorus
(4) Limited research in total phosphorus reduction values

Landowner buy-in, ease of construction, and difficulty implementing preventative land management measures all contribute to the popularity of sediment control structures as a sediment and phosphorus mitigation strategy. This is a proven practice, if properly located, designed, constructed, and maintained. However, if not properly designed and constructed, sediment control basins may trap substantially less sediment and phosphorus than widely-used rules-of-thumb that are often assumed when quantifying reductions in the context of a watershed management plan.

To obtain reductions in TP load necessary to meet water quality targets, land management strategies and structural BMPs should be implemented to obtain the largest and most cost-effective water quality benefit. Targeting efforts should consider areas with the highest potential phosphorus loads to the lake. Factors affecting phosphorus contribution include: land cover, steep slopes; proximity to waterbodies; tillage practices and method, timing, and amount of manure and commercial fertilizer application.

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was used in TMDL development to predict phosphorus loads to Prairie Rose Lake. Figure 4-1 shows the annual phosphorus export from each subbasin in the Prairie Rose Lake watershed STEPL model. Red-shaded basins indicate the heaviest phosphorus export and green shaded basins indicate the lowest export rates and loads relative to the sub basins in this study. The figures reveal that the most phosphorus is annually exported from Subbasin 5 (989.1 lbs) and the least from Subbasin 1 (450.2 lbs). Figure 4-2 shows TP export rates in for each subbasin after adjusting for drainage area (scale was adjusted to emphasize difference in subbasins.) Annual averages normalized by area ranged from 0.85 lbs/ac-yr to 0.95 lbs/ac-yr, showing the relative uniformity of landuse, soil type, and BMPs throughout the watershed.

Subbasin-level information indicates that best management practices reducing phosphorus export should concentrate efforts on improving effectiveness of existing BMPs such as terraces, in basins 1 and 4 to lower export of phosphorus per acre, while targeting manure management practices in subbasins 2, 3, and 5 may help reduce total phosphorus export.

More detailed information should be collected in order to target specific BMPs to specific areas (e.g., singular fields or waterways) within a subwatershed. This level of detailed targeting is best accomplished by local officials working collaboratively with local stakeholders and land owners.

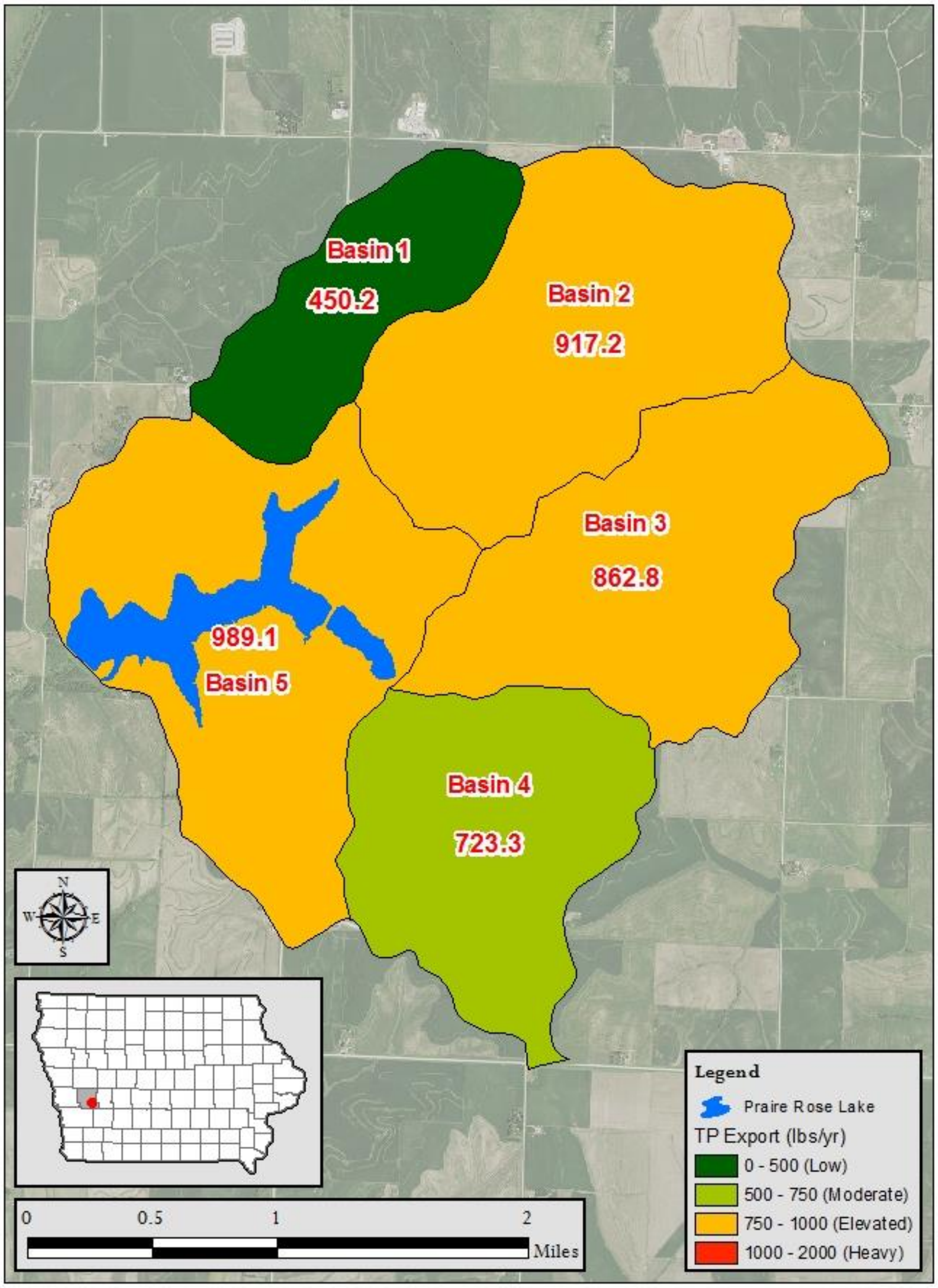

Figure 4-1. Predicted TP Load from each STEPL Subwatershed.

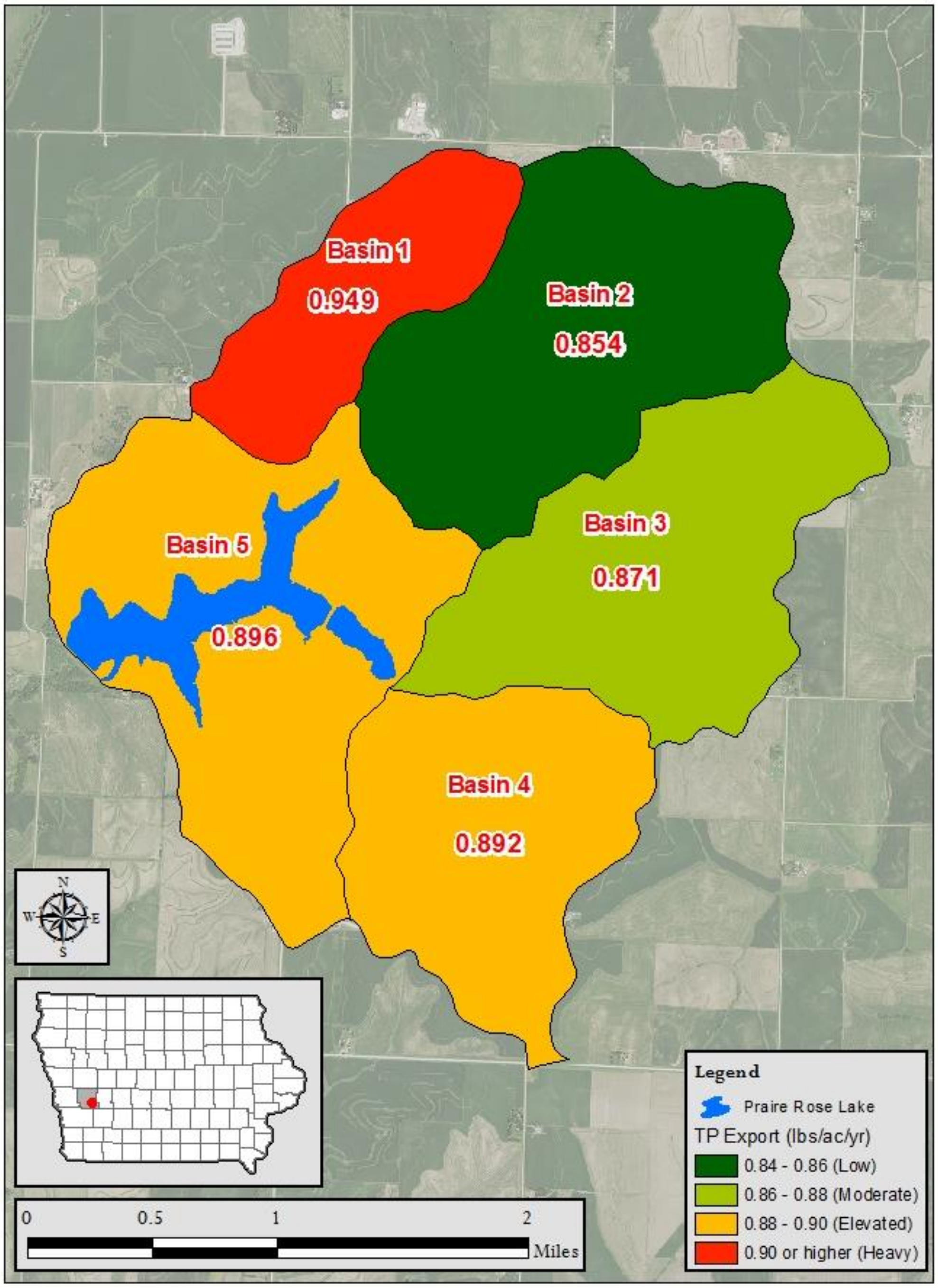

Figure 4-2. Predicted per-Acre TP Export for each STEPL Subwatershed.

In-Lake BMPs (Remediation Strategies)

Phosphorus recycled between the bottom sediment and water column of the lake has the potential to be a contributor of bioavailable phosphorus to lakes. The average annual contribution of TP to the system from internal loading appears to be relatively small in Prairie Rose Lake. The reservoir has a large watershed-to-lake ratio, so external inputs typically dwarf internal recycling. However, internal loading may influence in-lake water under certain conditions despite its relatively insignificant average annual phosphorus contribution. Internal loads may exacerbate algal blooms in late summer periods, especially if lake outflow ceases and water temperatures exceed normal levels. It is important to understand that external phosphorus loads from wet weather supply the build-up of phosphorus in the bottom sediments. Estimates of external loads from the Prairie Rose Lake watershed are of large enough magnitude to fully account for observed in-lake phosphorus and subsequent algae levels. Even in lakes with high suspected internal loads, uncertainty regarding the magnitude of internal loads is one of the biggest challenges to TMDL development and lake restoration. Because of these factors, reductions from watershed sources of TP should be given implementation priority. If and when monitoring shows that the external watershed load has been adequately reduced, then additional in-lake measures may be warranted.

Brief descriptions of potential in-lake restoration methods are included in Table 4-3. Phosphorus reduction impacts of each alternative will vary and depend on a number of site-specific factors. It is difficult to determine how much of the internal load is due to each of the contributing factors, and equally difficult to predict phosphorus reductions associated with individual improvement strategies. In-lake measures should be a part of a comprehensive watershed management plan that includes watershed practices in order to enhance, prolong, and protect the effectiveness of in-lake investments.

Table 4-3. Potential in-lake BMPs for Water Quality Improvement.

In-Lake BMPs	Comments
Fisheries management	Low to moderate reductions in internal phosphorus load may be attained via continued fisheries management. The reduction of in-lake phosphorus as a result of this practice is variable, but the overall health of the aquatic ecosystem may be improved, which typically improves overall water quality as well. Resident grass carp may be a problem and could be controlled through this method.
Targeted dredging and sediment basin improvement	Strategic dredging would also increase the sediment capacity, thereby reducing sediment and phosphorus loads to the main body where ambient conditions are monitored.
Shoreline stabilization	Helps establish and sustain vegetation, which provides local erosion protection and competes with algae for nutrients. Impacts of individual projects may be small, but cumulative effects of widespread stabilization projects can help improve water quality.
Phosphorus stabilization	Adding compounds, such as alum, to the water column can help stabilize phosphorus that may be resuspended from the lake bottom. This additive precipitates a layer of floc that removes phosphorus as it settles to the lake bottom, and can combine with phosphorus as it is released from sediment

Holistic Approach

An example of a holistic implementation plan would involve prevention, mitigation, and remediation practices across the Prairie Lake watershed. These may include any of the practices from Table 4-3 at any scale. Extending grass waterways in conjunction with renovation of existing terraces and contour buffers in corn and soybean ground will help mitigate soil loss from row crop ground. Further adoption of agricultural prevention measures like those listed in Table 4-1 will retain topsoil in the soil profile of the fields and prevent erosion. Potential in-lake strategies such phosphorus stabilization treatments in Prairie Rose Lake are included as well.

5. Future Monitoring

Water quality monitoring is critical for assessing the current status of water resources as well as historical and future trends. Furthermore, monitoring is necessary to track the effectiveness of best management practice (BMP) implementation and to document attainment of Total Maximum Daily Loads (TMDLs) and progress towards water quality standards (WQS).

Future monitoring in the Prairie Rose Lake watershed can be agency-led, volunteer-based, or a combination of both. The Iowa Department of Natural Resources (Iowa DNR) Watershed Monitoring and Assessment Section administer a water quality monitoring program that provides training to interested volunteers. More information can be found at the program website: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Volunteer-Water-Monitoring.

Volunteer-based monitoring efforts should include an approved water quality monitoring plan, called a Quality Assurance Project Plan (QAPP), in accordance with Iowa Administrative Code (IAC) 567-61.10(455B) through 567-61.13(455B). The IAC can be viewed here: https://www.legis.iowa.gov/docs/iac/chapter/01-18-2017.567.61.pdf

Failure to prepare an approved QAPP will prevent data collected from being used to evaluate waterbody in the 305(b) Integrated Report – the biannual assessment of water quality in the state, and the 303(d) list – the list that identifies impaired waterbodies.

5.1. Routine Monitoring for Water Quality Assessment

Data collection in Prairie Rose Lake to assess water quality trends and compliance with water quality standards (WQS) will include monitoring conducted as part of the DNR Ambient Lake Monitoring Program. The Ambient Lake Monitoring Program was initiated in 2000 in order to better assess the water quality of Iowa lakes. Typically, one location near the deepest part of the lake is sampled, and many chemical, physical, and biological parameters are measured. Supplemental monitoring done from 2016 to 2017 was done at the assessment point and two other points in the lake, discussed in the advanced monitoring section. Results from the supplemental monitoring are shown in Figure 5-1 and indicate that although Secchi depths are increasing, total phosphorus and chl-a issues remain. Further indicating a surplus of phosphorus in Prairie Rose Lake may be the core issue. Years of supplemental monitoring are shown in the blue box with individual results listed in Appendix C.

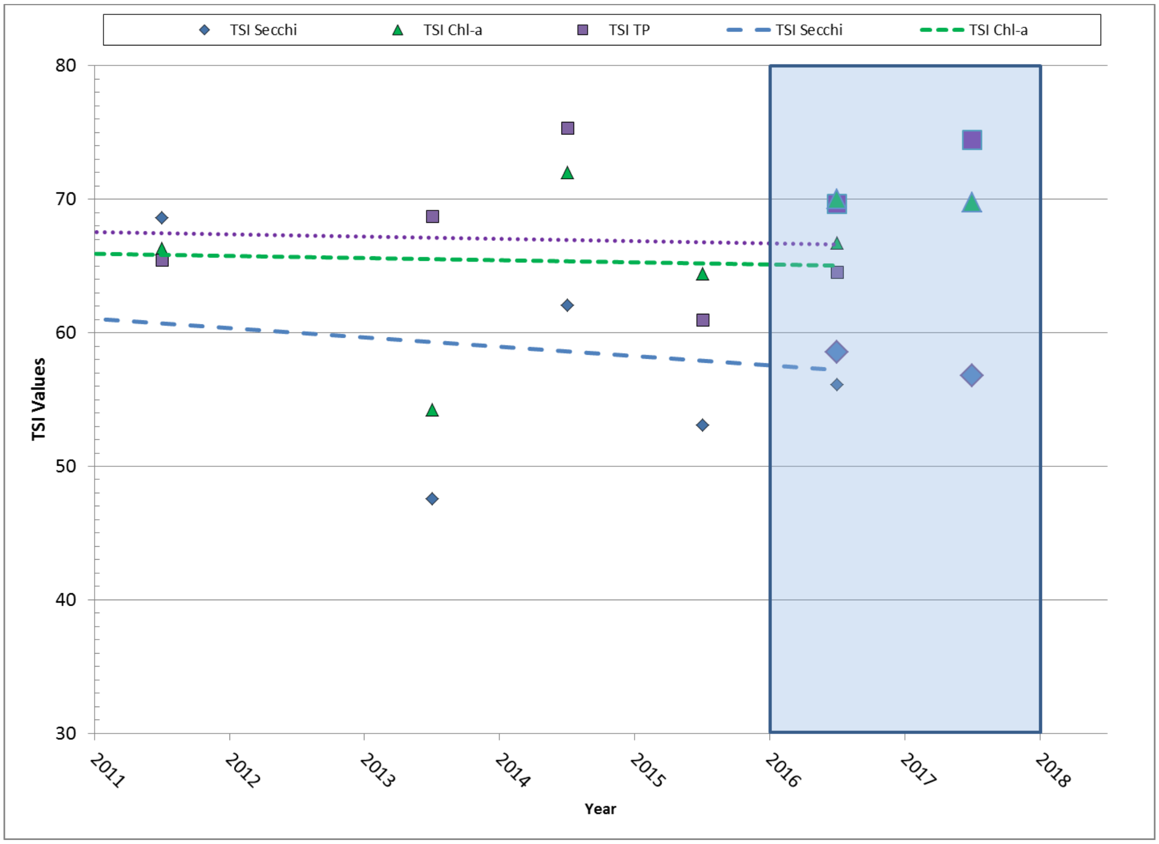

Figure 5-1. Annual results of supplemental monitoring at assessment point

Sampling parameters are reported in Table 5-1. At least three sampling events are scheduled every summer, typically between Memorial Day and Labor Day. While the ambient monitoring program can be used to identify trends in overall, in-lake water quality, it does not lend itself to calculation of watershed loads, identification of individual pollutant sources, or the evaluation of BMP implementation.

Table 5-1. Ambient Lake Monitoring Program Water Quality Parameters.

Chemical	Physical	Biological
• Total Phosphorus (TP) • Soluble Reactive Phosphorus (SRP) • Total Nitrogen (TN) • Total Kjeldahl Nitrogen (TKN) • Ammonia • Un-ionized Ammonia • Nitrate + Nitrite Nitrogen • Alkalinity • pH • Total Organic Carbon • Total Dissolved Solids • Dissolved Organic Carbon	• Secchi Depth • Temperature • Dissolved Oxygen (DO) • Turbidity • Total Suspended Solids (TSS) • Total Fixed Suspended Solids • Total Volatile Suspended Solids • Specific Conductivity • Thermocline Depth • Lake Depth	• Chlorophyll a • Phytoplankton (mass and composition) • Zooplankton (mass and composition)

5.2. Expanded Monitoring for Detailed Analysis

Given current resources and funding, future water quality data collection in the Prairie Rose Lake watershed to assess water quality trends and compliance with WQS may be limited. Unless there is strong and continued local interest in collecting additional water quality data, it will be difficult to implement a watershed management plan and document TMDL effectiveness and water quality improvement.

Data available from the Iowa DNR Ambient Lake Monitoring Program and supplemental monitoring will be used to assess general water quality trends and WQS violations and attainment. More detailed monitoring data is required to reduce the level of uncertainty associated with water quality trend analysis, better understand the impacts of implemented watershed projects (i.e., BMPs), and guide future water quality modeling and BMP implementation efforts.

If the goal of monitoring is to evaluate spatial and temporal trends and differences in water quality resulting from implementation of BMPs, a more watershed intensive monitoring program will be needed. Table 5-2 outlines potential locations, type of monitoring, parameters collected, and the purpose of each type of data collected as part of an expanded monitoring effort. It is unlikely that available funding will continue to allow collection of all data included in Table 5-2, but the information should be used to help stakeholders identify and prioritize data needs. Locations for expanded monitoring in the Prairie Rose Lake watershed have been chosen to take into account sub basin boundaries and can be used in assigning nutrient concentrations to each sub basin if deployed in such a manner.

Table 5-2. Recommended Monitoring Plan.

Parameter(s)	Intervals	Duration	[1]Location(s)
Routine grab sampling for flow, sediment, P, and N	Every 1-2 weeks	April through October	Ambient location in Prairie Rose Lake, plus secondary locations
Continuous flow	15-60 minute	April through October	Prairie Rose Lake inlet & outlet
Continuous pH, DO, and temperature	15-60 minute	April through October	Ambient location in Prairie Rose Lake
Runoff event flow, sediment, P, and N	15-60 minute intervals during runoff	5 events between April and October	Select tile and/or culvert discharge locations in areas of focused BMP implementation to evaluate efficacy
Event or continuous tile drain flow, N, and P sampling	15-60 minute	10 to 14-day wet weather periods if continuous sampling is not feasible	Select tile and/or culvert discharge locations in areas of focused BMP implementation to evaluate efficacy
Shoreline mapping, bathymetry studies	Before and after dredging or construction, every 5 years	Design lifespan of waterbody	Near dredging operations, or near lake inlets, upstream sediment basins

(1) Tributary, tile drain, and gully site selection to be based on suspected pollutant source location, BMP placement, landowner permission, and access/installation feasibility.

It may be useful to divide the recommended monitoring plan into several tiers based on ease of deployment and cost effectiveness. This will help stakeholders and management personnel best direct their resources. This monitoring plan may be reevaluated at any time to change the management strategy. Data collection should commence before new BMPs are implemented or existing ones are renovated in the watershed to establish baseline conditions. Selection of tributary sites should consider location of BMPs, location of historical data (for comparative purposes), landowner permission (if applicable), and logistical concerns such as site access and feasibility of equipment installation (if necessary). This data could form the foundation for assessment of water quality trends; however, more detailed information will be necessary to make any statements about water quality trends with certainty. Therefore, routine grab sampling should be viewed only as a starting point for assessing trends in water quality. Possible monitoring scenarios above the current monitoring condition are described below.

Basic Monitoring

Targeted grab sampling of the Prairie Rose Lake ambient monitoring point should be continued on a bi-weekly basis. Grab samples on a seasonal basis at the inlet would be done to support data provided by the main lake.

Targeted Monitoring
Grab samples should continue on a routine and runoff event based schedule. Flow data may be recorded with manual flow readings based on developed rating curves. Locations and sampling approaches would include the ambient monitoring station and upstream inlets.

Advanced Monitoring
Automated data recorded by ISCO devices would provide information on continuous flow, and continuous pH, DO, and temperature. Routine grab sampling for flow, sediment, P, and N will help provide a check on the automated sampling. In addition to routine sampling, runoff event sampling for event flow, sediment, N, and P will help show the effects of high recurrence interval events. Locations and sampling approaches would include the ambient monitoring station, inlets and outlets of newly constructed sedimentation basins, and outlets from upstream tributaries- such as roadway culverts. Reliable long-term flow data is also important because hydrology drives many important processes related to water quality, and a good hydrologic data set will be necessary to evaluate the success of BMPs such as reduced-tillage, saturated buffers, terraces and grassed waterways, riparian buffers, and wetlands.

To further gather information on erosion in the watershed, a “rapid assessment of stream conditions along length” (RASCAL) procedure would be done on gullies and channels that show significant erosion. An initial assessment will provide a benchmark of current conditions and will allow stakeholders to identify potential problem areas for implementation of BMPs.

To bolster data sets for other potential impaired uses in Prairie Rose Lake, beach monitoring should continue to evaluate bacteria concentrations and potential seasonality of load. This can be done by adding biweekly sand and water grab samples on several transects along the beach.

The proposed monitoring information would assist utilization of watershed and water quality models to simulate various scenarios and water quality response to BMP implementation. Monitoring parameters and locations should be continually evaluated. Adjustment of parameters and / or locations should be based on BMP placement, newly discovered or suspected pollution sources, and other dynamic factors. The IDNR Watershed Improvement Section may provide technical support to locally led efforts in collecting further water quality and flow monitoring data in the Prairie Rose Lake watershed. A look at how these proposed monitoring plans may be deployed in the Prairie Rose Lake watershed is shown in Figure 5-2.

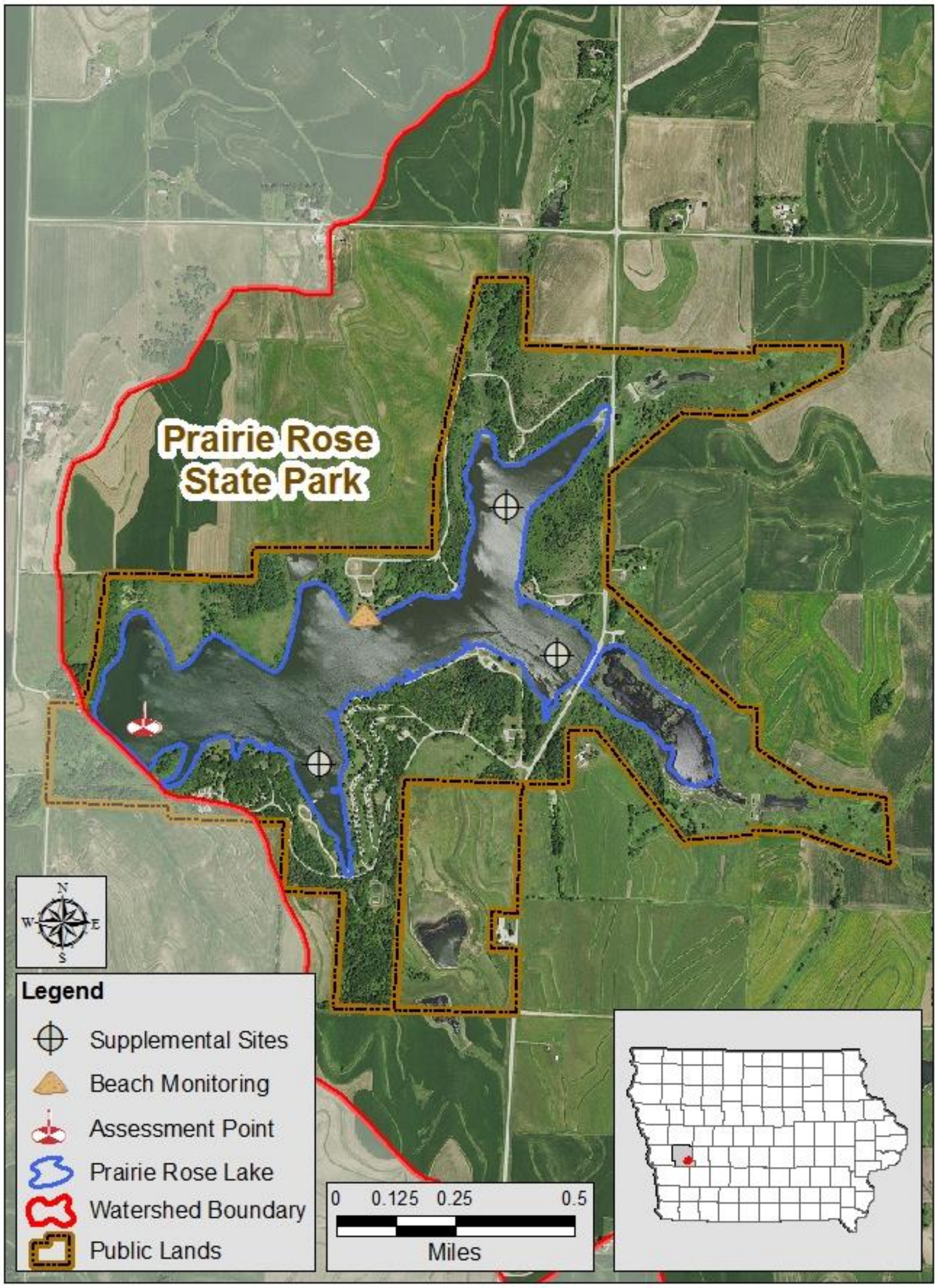

Figure 5-2. Potential Monitoring Locations.

6. Public Participation

Public involvement is important in the Total Maximum Daily Load (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 Prairie Rose Lake.

6.1. Public Meeting

Public Presentations

A public presentation was posted on the Iowa DNR’s YouTube channel for public viewing on August 6, 2020. A link to the presentation will remain on the Iowa DNR TMDL webpage through the public comment period for the presentation.

6.2. Written Comments

A press release was issued in tandem with the posting of the presentation to the Iowa DNR’s YouTube channel. The press release began a 30 day public comment period, which ended on September 8, 2020. No public comments were received during the public comment period.

7. References

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22(2):361-369.

Carlson, R, and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Dinnes, D.L. 2004. Assessments of practices to reduce nitrogen and phosphorus nonpoint source pollution of Iowa's surface waters. Iowa Department of Natural Resources; USDA-ARS National Soil Tilth Laboratory, Ames, Iowa.

Dodds, W. 2000. Freshwater Ecology: Concepts and Environmental Applications. Draft textbook. Division of Biology, Kansas State University, Manhattan, Kansas.

Iowa Department of Natural Resources (IDNR), 2008, Prairie Rose Lake 319 Water Quality Improvement and Protection Project Final Report.

Iowa Department of Natural Resources, December 31, 2014, Lake Restoration Program 2014 Report and 2015 Plan.

Iowa Department of Natural Resources, March 28, 2017, Draft Methodology for Iowa's 2016 Water Quality Assessment, Listing and Reporting Pursuant to Sections 305(b0 and 303(d) of the Federal Clean Water Act

Iowa Environmental Mesonet (IEM). 2018a. Iowa State University Department of Agronomy. NWS COOP Network. IEM "Climodat" Reports. Download available at https://mesonet.agron.iastate.edu/climodat/. Accessed in March 2018.

Iowa Environmental Mesonet (IEM). 2018b. Iowa State University Department of Agronomy. Iowa Ag Climate Network. Download available at http://mesonet.agron.iastate.edu/agclimate/hist/dailyRequest.php. Accessed in March 2018.

Minnesota Pollution Control Agency (MPCA). 2005. Lake Water Quality Assessment Report: Developing Nutrient Criteria. Third Edition.

Prior, Jean Cutler. *Landforms of Iowa*. Iowa City: U of Iowa for the Dept. of Natural Resources, 1991. Print.

U.S. Environmental Protection Agency (EPA). 1991. Technical Support Document for Water Quality-based Toxics Control. EPA/505/2-90-001. EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA). 2006. Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits. Memorandum from Benjamin Grumbles, Assistant Administrator, EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA). 2007. Options for Expressing Daily Loads in TMDLs (Draft). EPA Office of Wetlands, Oceans & Watersheds, Washington, DC.

Walker, William W., Draft 1983, Published 1985, "Empirical Methods for Predicting Eutrophication in Impoundments - Report 3: Model Refinements", prepared for Office, Chief of Engineers, U.S. Army, Washington, D.C., Technical Report E-81-9, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Walker, W., 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

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Appendix A. Glossary of Terms, Abbreviations, and Acronyms

303(d) list:	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface waterbodies (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 comprehensive assessment of the state's public waterbodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or only partially 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. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water quality projects.
AFO:	Animal Feeding Operation. A lot, yard, corral, building, or other area in which animals are confined and fed and maintained for 45 days or more in any 12-month period, and all structures used for the storage of manure from animals in the operation. Open feedlots and confinement feeding operations are considered to be separate animal feeding operations.
AU:	Animal Unit. A unit of measure used to compare manure production between animal types or varying sizes of the same animal. For example, one 1,000 pound steer constitutes one AU, while one mature hog weighing 200 pounds constitutes 0.4 AU.
Benthic:	Associated with or located at the bottom (in this context, "bottom" refers to the bottom of streams, lakes, or wetlands). Usually refers to algae or other aquatic organisms that reside at the bottom of a wetland, lake, or stream (see periphyton).
Benthic macroinvertebrates:	Animals larger than 0.5 mm that do not have backbones. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.
Base flow:	Sustained flow of a stream in the absence of direct runoff. It can include natural and human-induced stream flows. Natural base flow is sustained largely by groundwater discharges.
Biological impairment:	A stream segment is classified as biologically impaired if one or more of the following occurs, the FIBI and or BMIBI scores fall below

	biological reference conditions, a fish kill has occurred on the segment, or the segment has seen a > 50% reduction in mussel species.
Biological reference condition:	Biological reference sites represent the least disturbed (i.e. most natural) streams in the ecoregion. The biological data from these sites are used to derive least impacted BMIBI and FIBI scores for each ecoregion. These scores are used to develop Biological Impairment Criteria (BIC) scores for each ecoregion. The BIC is used to determine the impairment status for other stream segments within an ecoregion.
BMIBI:	Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.
BMP:	Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.
CAFO:	Concentrated Animal Feeding Operation. A federal term defined as any animal feeding operation (AFO) with more than 1,000 animal units confined on site, or an AFO of any size that discharges pollutants (e.g. manure, wastewater) into any ditch, stream, or other water conveyance system, whether man-made or natural.
CBOD5:	5-day Carbonaceous Biochemical Oxygen Demand. Measures the amount of oxygen used by microorganisms to oxidize hydrocarbons in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.
CFU:	A Colony Forming Unit is a cell or cluster of cells capable of multiplying to form a colony of cells. Used as a unit of bacteria concentration when a traditional membrane filter method of analysis is used. Though not necessarily equivalent to most probably number (MPN), the two terms are often used interchangeably.
Confinement feeding operation:	An animal feeding operation (AFO) in which animals are confined to areas which are totally roofed.
Credible data law:	Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate. To be considered "credible," data must be collected and analyzed using methods and protocols outlined in an approved Quality Assurance Project Plan (QAPP).

Cyanobacteria (blue-green algae):	Members of the phytoplankton community that are not true algae but are capable of photosynthesis. Some species produce toxic substances that can be harmful to humans and pets.
Designated use(s):	Refer to the type of economic, social, or ecological activities that a specific waterbody is intended to support. See Appendix B for a description of all general and designated uses.
DNR:	Iowa Department of Natural Resources.
Ecoregion:	Areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources based on geology, vegetation, climate, soils, land use, wildlife, and hydrology.
EPA (or USEPA):	United States Environmental Protection Agency.
Ephemeral gully erosion:	Ephemeral gullies occur where runoff from adjacent slopes forms concentrated flow in drainage ways. Ephemerals are void of vegetation and occur in the same location every year. They are crossable with farm equipment and are often partially filled in by tillage.
FIBI:	Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.
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 waterbodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.
Geometric Mean (GM):	A statistic that is a type of mean or average (different from arithmetic mean or average) that measures central tendency of data. It is often used to summarize highly skewed data or data with extreme values such as wastewater discharges and bacteria concentrations in surface waters. In Iowa's water quality standards and assessment procedures, the geometric mean criterion for *E. coli* is measured using at least five samples collected over a 30-day period.
GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.
Groundwater:	Subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.

Gully erosion:	Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.
HEL:	Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land, which has the potential for long-term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.
IDALS:	Iowa Department of Agriculture and Land Stewardship
Integrated report:	Refers to a comprehensive document that combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public waterbodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.
LA:	Load Allocation. The portion of the loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. (The total pollutant load is the sum of the wasteload and load allocations.)
LiDAR:	Light Detection and Ranging. Remote sensing technology that uses laser scanning to collect height or elevation data for the earth's surface.
Load:	The total amount of pollutants entering a waterbody from one or multiple sources, measured as a rate, as in weight per unit time or per unit area.
Macrophyte:	An aquatic plant that is large enough to be seen with the naked eye and grows either in or near water. It can be floating, completely submerged (underwater), or partially submerged.
MOS:	Margin of Safety. A required component of the TMDL that accounts for the uncertainty in the response of the water quality of a waterbody to pollutant loads.
MPN:	Most Probable Number. Used as a unit of bacteria concentration when a more rapid method of analysis (such as Colisure or Colilert) is utilized. Though not necessarily equivalent to colony forming units (CFU), the two terms are often used interchangeably.
MS4:	Municipal Separate Storm Sewer System. A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, city, town, borough,

	county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.
Nonpoint source pollution:	Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.
NPDES:	National Pollution Discharge Elimination System. The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Section 307, 402, 318, and 405 of the Clean Water Act. Facilities subjected to NPDES permitting regulations include operations such as municipal wastewater treatment plants and industrial waste treatment facilities, as well as some MS4s.
NRCS:	Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.
Open feedlot:	An unroofed or partially roofed animal feeding operation (AFO) in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation.
Periphyton:	Algae that are attached to substrates (rocks, sediment, wood, and other living organisms). Are often located at the bottom of a wetland, lake, or stream.
Phytoplankton:	Collective term for all photosynthetic organisms suspended in the water column. Includes many types of algae and cyanobacteria.
Point source pollution:	Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources are generally regulated by a federal NPDES permit.
Pollutant:	As defined in Clean Water Act section 502(6), a pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, heat,

	wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.
Pollution:	The man-made or man-induced alteration of the chemical, physical, biological, and/or radiological integrity of water.
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).
RASCAL:	Rapid Assessment of Stream Conditions Along Length. RASCAL is a global positioning system (GPS) based assessment procedure designed to provide continuous stream and riparian condition data at a watershed scale.
Riparian:	Refers to areas near the banks of natural courses of water. Features of riparian areas include specific physical, chemical, and biological characteristics that differ from upland (dry) sites. Usually refers to the area near a bank of a stream or river.
RUSLE:	Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.
Scientific notation:	See explanation on page 72.
Secchi disk:	A device used to measure transparency in waterbodies. The greater the Secchi depth (typically measured in meters), the more transparent the water.
Sediment delivery ratio:	A value, expressed as a percent, which is used to describe the fraction of gross soil erosion that is delivered to the waterbody of concern.
Seston:	All particulate matter (organic and inorganic) suspended in the water column.
SHL:	State Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring, ambient monitoring, biological reference monitoring, and impaired water assessments.
Sheet & rill erosion:	Sheet and rill erosion is the detachment and removal of soil from the land surface by raindrop impact, and/or overland runoff. It occurs on slopes with overland flow and where runoff is not concentrated.

Single-Sample Maximum (SSM):	A water quality standard criterion used to quantify *E. coli* levels. The single-sample maximum is the maximum allowable concentration measured at a specific point in time in a waterbody.
SI:	Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.
Storm flow (or stormwater):	The discharge (flow) from surface runoff generated by a precipitation event. *Stormwater* generally refers to runoff that is routed through some artificial channel or structure, often in urban areas.
STP:	Sewage Treatment Plant. General term for a facility that treats municipal sewage prior to discharge to a waterbody according to the conditions of an NPDES permit.
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.
TDS:	Total Dissolved Solids: The quantitative measure of matter (organic and inorganic material) dissolved, rather than suspended, in the water column. TDS is analyzed in a laboratory and quantifies the material passing through a filter and dried at 180 degrees Celsius.
TMDL:	Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses. A TMDL is mathematically defined as the sum of all individual wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS).
Trophic state:	The level of ecosystem productivity, typically measured in terms of algal biomass.
TSI (or Carlson's TSI):	Trophic State Index. A standardized scoring system developed by Carlson (Carlson, 1977) that places trophic state on an exponential scale of Secchi depth, chlorophyll, and total phosphorus. TSI ranges between 0 and 100, with 10 scale units representing a doubling of algal biomass.
TSS:	Total Suspended Solids. The quantitative measure of matter (organic and inorganic material) suspended, rather than dissolved, in the water column. TSS is analyzed in a laboratory and quantifies the material retained by a filter and dried at 103 to 105 degrees Celsius.

Turbidity:	A term used to indicate water transparency (or lack thereof). Turbidity is the degree to which light is scattered or absorbed by a fluid. In practical terms, highly turbid waters have a high degree of cloudiness or murkiness caused by suspended particles.
UAA:	Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)
USDA:	United States Department of Agriculture
USGS:	United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's waterbodies.
Watershed:	The land area that drains water (usually surface water) to a particular waterbody or outlet.
WLA:	Wasteload Allocation. The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities).
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.
WWTF:	Wastewater Treatment Facility. General term for a facility that treats municipal, industrial, or agricultural wastewater for discharge to public waters according to the conditions of the facility's NPDES permit. Used interchangeably with wastewater treatment plant (WWTP).
Zooplankton:	Collective term for all animal plankton suspended in the water column which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term).

Here are some examples of scientific notation.

10,000 = 1E+4	24,327 = 2.4327E+4
1,000 = 1E+3	7,354 = 7.354E+3
100 = 1E+2	482 = 4.82E+2
1/100 = 0.01 = 1E-2	0.053 = 5.3E-2
1/1,000 = 0.001 = 1E-3	0.0078 = 7.8E-3
1/10,000 = 0.0001 = 1E-4	0.00044 = 4.4E-4

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

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 by which waterbodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of waterbody (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the waterbody that is being dealt with. This appendix is intended to provide information about how Iowa's waterbodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the waterbody.

General Use Segments

A general use segment waterbody is one that does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins that consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use waterbody, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are waterbodies that maintain flow throughout the year, or at least hold pools of water that are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are thirteen different designated use classes (Table B-1) that may apply, and a waterbody may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

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

Designated use classes are determined based on a Use Attainability Analysis, or UAA. This is a procedure in which the waterbody is thoroughly scrutinized, using existing knowledge, historical documents, and visual evidence of existing uses, in order to determine what its designated use(s) should be. This can be a challenging endeavor, and as such, conservative judgment is applied to ensure that any potential uses of a waterbody are allowed for. Changes to a waterbody's designated uses may only occur based on a new UAA, which depending on resources and personnel, can be quite time consuming.

It is relevant to note that on March 22, 2006, a revised edition of Iowa's water quality standards became effective which significantly changed the use designations of the state's surface waters. Essentially, the changes that were made consisted of implementing a "top down" approach to use designations, meaning that all waterbodies should receive the highest degree of protection applicable until a UAA could be performed to ensure that a particular waterbody did not warrant elevated protection. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C. Water Quality Data

The following is a summary of the sampling data from the Iowa State University (ISU) Iowa Lakes Information System and University of Iowa State Hygienic Laboratory (SHL) monitoring efforts.

C.1. Individual Sample Results

Table C-1. ISU and SHL Water Quality Sampling Data (Ambient Location(1)).

Source	Date (2)	Secchi (m)	Chl-a (µg/L)	TP (µg/L)	TN (mg/L)	pH	Secchi TSI	Chl-a TSI	TP TSI
ISU	5/29/2002	1.15	7.9	36.4	1.01	9.1	58.0	50.9	55.9
ISU	6/26/2002	0.55	68.1	77.8	1.07	8.0	68.6	72.0	66.9
ISU	7/30/2002	0.40	101.3	96.4	1.43	9.0	73.2	75.9	70.0
ISU	5/29/2003	1.85	6.8	35.1	2.11	8.5	51.1	49.4	55.4
ISU	6/25/2003	0.95	34.6	79.6	1.79	8.9	60.7	65.4	67.2
ISU	7/30/2003	0.63	23.0	76.5	1.07	8.6	66.8	61.4	66.6
ISU	5/26/2004	0.15	4.5	291.7	4.04	8.1	87.3	45.3	85.9
ISU	6/23/2004	0.73	50.8	61.5	4.98	8.5	64.6	69.1	63.5
ISU	7/28/2004	0.75	32.4	56.6	3.08	8.2	64.1	64.7	62.3
ISU	6/2/2005	1.65	26.3	45.4	1.68	8.5	52.8	62.7	59.1
ISU	6/29/2005	0.65	65.6	84.8	1.04	8.9	66.2	71.6	68.1
UHL	7/5/2005	0.50	42.0	120.0	1.10	9.0	70.0	67.3	73.1
ISU	7/28/2005	0.35	151.8	216.2	2.34	9.0	75.1	79.9	81.6
UHL	8/17/2005	0.20	320.0	200.0	2.60	9.6	83.2	87.2	80.5
UHL	10/18/2005	0.90	3.0	60.0	2.43	7.6	61.5	41.4	63.1
UHL	5/1/2006	0.55	5.0	70.0	1.59	7.9	68.6	46.4	65.4
UHL	5/30/2006	0.61	20.0	80.0	1.29	8.2	67.1	60.0	67.3
ISU	6/1/2006	1.00	32.2	44.2	1.73	9.2	60.0	64.7	58.7
ISU	6/28/2006	0.85	23.0	59.0	1.24	8.8	62.3	61.4	62.9
UHL	7/10/2006	0.85	17.0	80.0	0.90	8.1	62.3	58.4	67.3
ISU	8/2/2006	0.52	92.6	78.5	1.49	9.3	69.3	75.0	67.0
UHL	8/14/2006	0.76	38.0	90.0	1.40	8.2	64.0	66.3	69.0
UHL	9/26/2006	0.58	22.0	120.0	1.40	8.2	67.8	60.9	73.1
UHL	4/23/2007	0.90	4.0	70.0	3.30	8.1	61.5	44.2	65.4
ISU	5/31/2007	0.70	19.6	51.0	6.74	8.1	65.1	59.8	60.8
ISU	6/27/2007	0.73	47.6	56.1	5.97	8.3	64.6	68.5	62.2
UHL	7/9/2007	0.30	120.0	80.0	5.70	8.9	77.3	77.6	67.3
ISU	7/30/2007	0.35	160.3	150.6	0.69	9.8	75.1	80.4	76.4
UHL	9/10/2007	1.00	37.0	140.0	1.90	9.0	60.0	66.0	75.4
UHL	5/12/2008	0.90	10.0	120.0	4.00	8.2	61.5	53.2	73.1
UHL	7/7/2008	1.10	24.0	50.0	4.00	8.2	58.6	61.8	60.5
ISU	6/10/2009	0.60	30.0	61.7	2.33	8.1	67.4	64.0	63.6

Source	Date (2)	Secchi (m)	Chl-a (µg/L)	TP (µg/L)	TN (mg/L)	pH	Secchi TSI	Chl-a TSI	TP TSI
ISU	7/14/2009	0.90	37.0	59.1	2.04	8.4	61.5	66.0	62.9
ISU	8/11/2009	0.60	65.0	82.1	1.63	8.4	67.4	71.6	67.7
ISULL	6/15/2010	0.60	29.8	50.2	---	8.5	67.4	63.9	60.6
ISULL	8/3/2010	0.30	87.4	116.7	---	8.3	77.3	74.5	72.7
ISULL	9/18/2010	0.50	46.4	76.9	---	8.2	70.0	68.2	66.7
ISU	6/15/2011	0.55	38.1	70.4	---	8.0	68.6	66.3	65.5
ISU	6/12/2013	4.18	1.0	141.9	3.71	7.6	39.4	30.6	75.5
ISU	7/31/2013	1.15	21.1	41.3	1.56	7.7	58.0	60.5	57.8
ISU	9/11/2013	1.77	11.2	82.1	0.77	7.7	51.8	54.3	67.7
ISU	6/18/2014	0.55	118.0	227.5	1.82	8.7	68.6	77.4	82.4
ISU	8/6/2014	0.60	63.6	62.6	2.07	9.0	67.4	71.3	63.8
ISU	9/17/2014	1.45	23.4	129.5	2.23	7.9	54.6	61.5	74.2
ISU	6/17/2015	3.18	8.9	22.4	2.23	8.3	43.3	52.1	49.0
ISU	8/4/2015	1.03	49.3	48.8	1.14	9.3	59.6	68.8	60.2
ISU	9/15/2015	0.63	36.3	83.5	1.08	8.1	66.7	65.8	67.9

(1) Ambient monitoring location = STORET ID 22830002

(2) Data between 2012 – 2015 were used for the 2018 Water Quality Assessment Period.

C.2. Supplemental Sample Results

Table C-2.SHL Supplemental Water Quality Sampling Data

Source	Date (2)	Secchi (m)	Chl-a (µg/L)	TP (µg/L)	TN (mg/L)	Secchi TSI	Chl-a TSI	TP TSI
SHL	4/13/2016	0.68	59	70.0	3.6	65.6	70.6	65.4
SHL	4/28/2016	1.25	22	---	2.2	56.8	60.9	--
SHL	5/12/2016	1.70	22	40.0	2.6	52.4	60.9	57.3
SHL	5/26/2016	2.90	10	220.0	2.8	44.7	53.2	81.9
SHL	6/8/2016	2.40	9	30.0	3.4	47.4	52.2	53.2
SHL	6/22/2016	---	19	40.0	2.5	--	59.5	57.3
SHL	7/8/2016	0.80	72	60.0	2.01	63.2	72.6	63.1
SHL	7/20/2016	0.54	100	110.0	0.95	68.9	75.8	71.9
SHL	7/27/2016	---	76	90.0	1.45	--	73.1	69.0
SHL	8/10/2016	0.60	88	70.0	1.45	67.4	74.5	65.4
SHL	8/26/2016	0.60	68	140.0	0.65	67.4	72.0	75.4
SHL	9/1/2016	0.60	91	140.0	1.05	67.4	74.9	75.4
SHL	9/21/2016	0.45	97	100.0	1.35	71.5	75.5	70.5
SHL	10/5/2016	0.75	52	110.0	1.53	64.1	69.4	71.9
SHL	10/19/2016	---	43	120.0	1.44	--	67.5	73.1
SHL	4/18/2017	3.7	10	100.0	0.98	41.1	53.2	70.5
SHL	5/2/2017	1.24	8	80.0	1.14	56.9	51.0	67.3
SHL	5/23/2017	2.03	34	140.0	1.18	49.8	65.2	75.4
SHL	5/30/2017	2.74	13	40.0	1.72	45.5	55.8	57.3
SHL	6/14/2017	---	52	60.0	1.9	--	69.4	63.1
SHL	6/30/2017	1.22	36	70.0	1.25	57.1	65.8	65.4
SHL	7/13/2017	1.04	29	140.0	0.75	59.4	63.6	75.4
SHL	8/2/2017	0.35	120	190.0	0.45	75.1	77.6	79.8
SHL	8/16/2017	0.43	75	130.0	1.45	72.2	73.0	74.3
SHL	8/30/2017	0.41	140	160.0	1.95	72.8	79.1	77.3
SHL	9/13/2017	0.44	83	210.0	1.05	71.8	73.9	81.2
SHL	9/27/2017	1.15	9	140.0	1.92	58.0	52.2	75.4
SHL	10/11/2017	1.27	---	190.0	1.58	56.6	--	79.8
SHL	10/25/2017	3.7	10	100.0	0.98	56.8	69.5	74.1

C.3. Annual Mean Data

Table C-3. Precipitation and Annual Mean TSI Values (^{1}Ambient Location).

Date	Annual Precipitation (in)	Apr-Sep Precipitation (in)	Secchi TSI	Chl-a TSI	TP TSI
2002	26.30	20.57	65.1	70.6	65.4
2003	25.99	17.33	58.1	60.7	64.0
2004	36.90	22.91	68.8	63.7	75.0
2005	25.45	16.96	65.0	75.9	73.3
2006	33.83	25.55	64.8	64.4	66.9
2007	45.10	30.49	65.9	71.5	69.2
2008	38.67	29.04	60.0	58.4	68.2
2009	35.86	24.58	65.1	67.7	64.9
2010	44.47	36.89	71.0	69.8	67.5
2011	33.24	27.60	68.6	66.3	65.5
2012	27.56	16.91	*	*	*
2013	31.83	24.97	47.6	54.2	68.7
2014	46.50	39.33	62.1	72.0	75.3
2015	45.84	32.96	53.1	64.4	61.0
Average	**40.7**	**30.3**	**67.3**	**70.1**	**71.4**

(1) Ambient monitoring location = STORET 22830002
* Lake temporarily dewatered, no in-lake data available

Appendix D. Watershed Model Development

Watershed and in-lake modeling were used in conjunction with analysis of observed water quality data to develop the Total Maximum Daily Load (TMDL) for the algae and turbidity impairment to Prairie Rose Lake in Shelby County, Iowa. This TMDL targets an allowable phosphorus load that will satisfy the primary contact recreation impairment (see Section 3 of this document for details). Reduction of phosphorus is expected to reduce algal blooms and non-algal turbidity, which decrease water clarity and impair the ability of the public to enjoy the recreational benefits of the lake.

The Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.3, was utilized to simulate watershed hydrology and pollutant loading. In-lake water quality simulations were performed using BATHTUB 6.1, an empirical lake and reservoir eutrophication model. The integrated watershed and in-lake modeling approach allows the holistic analysis of hydrology and water quality in Prairie Rose Lake and its watershed. This section of the Water Quality Improvement Plan (WQIP) discusses the modeling approach and development of the STEPL watershed and BATHTUB lake models.

D.1. Modeling Approach

Data from a fourteen year period of record, 2002-2015, were analyzed and used to develop watershed and lake models for the simulation and prediction of phosphorus loads and in-lake response. Models representing a variety of conditions (e.g., wet, dry) and various years were developed. This process was instructive in understanding watershed and in-lake processes, and in the validation of model inputs and calibration. This simulation period is supplemental to the water quality assessment period (2012-2015) upon which the 2018 Integrated Report and 303(d) list were generated.

D.2. STEPL Model Description

STEPL is a watershed-scale hydrology and water quality model developed for the U.S. Environmental Protection Agency (EPA) by Tetra Tech, Incorporated. STEPL is a long-term average annual model used to assess the impacts of land use and best management practices on hydrology and pollutant loads. STEPL is capable of simulating a variety of pollutants, including sediment, nutrients (nitrogen and phosphorus), and 5-day biochemical oxygen demand (BOD5). Required input data is minimal if the use of model default county-wide soils and coarse precipitation information is acceptable to the user. If available, the user can modify soil and precipitation inputs with higher resolution and local soil and precipitation data. Precipitation inputs include average annual rainfall and rainfall correction factors that describe the intensity (i.e., runoff producing) characteristics of long-term precipitation. Characteristics that affect STEPL estimates of hydrology and pollutant loading include land cover types, population of agricultural livestock, wildlife populations, population served by septic systems, and urban land uses. STEPL also quantifies the impacts of manure application and best management practices (BMPs). Almost all STEPL inputs can be customized if site-specific data is available and more detail is desired.

The watershed was divided into five subbasins to help quantify the relative pollutant loads stemming from different areas of the watershed and to assist with targeting potential BMP locations. These basins were created to coincide with the natural drainage network and topography as shown in Figure D-1. Hydrology and pollutant loadings are summarized for each subbasin and also aggregated as watershed totals.

D.3. Meteorological Input

Precipitation Data

The STEPL model includes a pre-defined set of weather stations from which the user may obtain precipitation-related model inputs. Unfortunately, none of the NWS COOP stations within a reasonable distance of Prairie Rose Lake are included in the STEPL model. Therefore, rainfall data from the Iowa Environmental Mesonet network were used for modeling purposes. Weather station information and rainfall data were reported in Section 2.1 (see Table 2.2 and Figures 2.2 and 2.3.) Annual rainfall used in the STEPL model was the 2002-2015 average of 35.5 inches/year.

The STEPL precipitation correlation and rain day correction factors were calculated outside of STEPL and entered directly in the STEPL "Input" worksheet to override the default rainfall data. Precipitation data from the modeling period of 2002-2015 were utilized in parameterization. The rain day correction factor of 0.344 was calculated by dividing the number of days that it rained at least 5 mm by the number of days with at least 1 mm of rainfall. This ratio is intended to estimate the number of days that could potentially generate surface runoff. Precipitation inputs are reported in Table D-1, as entered in the "Input" worksheet of the 2002-2015 Prairie Rose Lake STEPL model.

Table D-1. STEPL Rainfall Inputs (2002-2015 Average Annual Data).

Rain correction factors			
[1]0.897	[2]0.344		
[3]Annual Rainfall	**[4]Rain Days**	**[5]Avg. Rain/Event**	**Input Notes/Descriptions**
35.5	131	0.707	(1) The percent of rainfall that exceeds 5 mm per event
			(2) The percent of rain events that generate runoff
			(3) Annual average precipitation for modeling period (in)
			(4) Average days of precipitation per year (days)
			(5) Average precipitation per event (in)

D.4. Watershed Characteristics

Topography

The Prairie Rose Lake watershed was delineated into five subbasins. The natural topography and drainage network was chosen as basin boundaries as shown in Figure D-1. This was chosen with future analysis in mind in being able to determine the effectiveness future renovations within the park. These will aide in identifying areas to implement best management practice strategies in water quality improvement programs in the future.

Land Use

Tablet and windshield assessments done in 2004 and 2007 were initially done to categorize landuse, tillage, and other existing BMPs. These data were then cross referenced with newer GIS landuse information described below.

The Geographic Information System (GIS) coverage of land used to validate the windshield assessments was developed using a 2015 aerial photography and the 2015 Cropland Data Layer (CDL), which was obtained from the United States Department of Agriculture – National Agricultural Statistics Service (USDA-NASS, 2016). The CDL land cover data is summarized by Common Land Units (CLUs). According to the USDA – Farm Service Agency, CLUs are the smallest units of land that have a permanent, contiguous boundary, common land cover, common owner, and common producer (USDA-FSA, 2016). Because land cover pixels are much smaller than CLU field boundaries, many CLUs have one primary land cover, but small isolated pixels with several minor land cover types. In those cases, the dominant land cover within each CLU boundary was determined using a zonal statistic command within Spatial Analyst. This step served as a land cover "filter" to simplify the data and eliminate small isolated pixels of various land uses within a single field boundary. In addition, 2015 aerial photography was used to further refine the GIS land use coverage. STEPL land cover classifications are reported in Table D-2, with land use distribution previously illustrated in the map (Figure 2-4) and table (Table 2-3) in Section 2.

Table D-2. STEPL Land Use Inputs.

Watershed	¹Urban	Cropland	Pastureland	Forest	²User Defined	³Total
W1	20.82	425.59	1.51	18.35	8.16	474.43
W2	63.25	952.25	0.00	0.00	58.88	1074.38
W3	44.32	894.54	0.00	0.00	51.45	990.31
W4	49.27	704.00	5.81	3.54	48.68	811.30
W5	39.33	685.34	6.46	359.12	13.97	1104.22
³Total	216.99	3661.72	13.78	381.01	181.14	4454.64

(1) Urban includes all developed areas, including roads and farmsteads.
(2) Includes hay / alfalfa, non-pasture grassland and conservation reserve programs.
(3) Totals exclude open water in STEPL land use inputs.

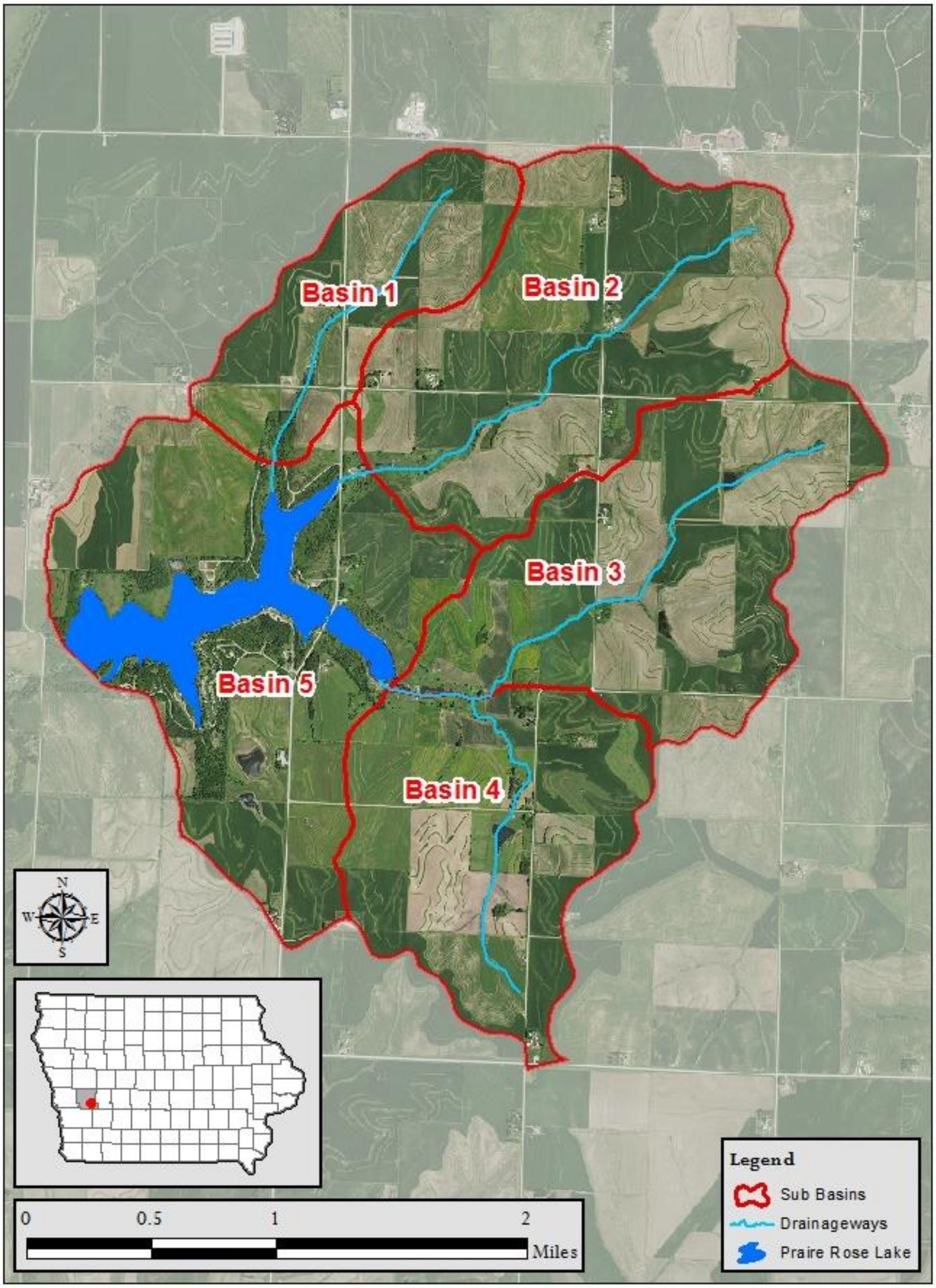

Figure D-1. STEPL Subbasin Map.

Land use type was assigned a specific USLE C-factor and P-factor (Table D-3), based on NRCS publications. C-factors were established strictly on land use based on the NRCS Field office Technical Guide. (NRCS, 2002). P-factor, support practice factor, was determined based on default values in the STEPL model for Shelby County, Iowa.

Table D-3. C and P Factors for each Land Use.

Land Use Description	C-Factor	P-Factor
Alfalfa/Hay	0.20	1.0
Corn	0.31	0.902
Farmstead	0.013	1.0
Forest	0.003	1.0
Grassland	0.004	1.0
Pasture	0.013	1.0
Roads	0.00	1.0
Soybeans	0.28	0.902

Soils

Soils are discussed in detail in Section 2.2. The hydrologic soil group (HSG) and the USLE K-factor are the critical soil parameters in the STEPL model. Watershed soils are predominantly HSG type C soils, with some C/D, B and D soils interspersed. HSG values were set at group C curve numbers values (CNs) in STEPL as a conservative measure. USLE K-factors are specific to each soil type, and were area-weighted and entered into the “Input” worksheet in the STEPL model.

Slopes

Slopes are described in more detail in Section 2.2. USLE land slope (LS) factors were obtained from previous RASCAL surveys and cross checked with the subroutine Ls-factor, field based, in Quantum GIS (QGIS). Resulting LS-factors entered into the “Input” worksheet in the STEPL model vary between 0.13 in user defined ungrazed grassland areas to 3.31 in forest. Slopes are heavily influenced by the Loess formations and dissected terrain. Slopes for each land use in each basin are listed below in Table D-4, land uses with no area in a sub basin are marked “N/A”.

Table D-4. STEPL Slopes for Land Use.

Watershed	Cropland	Pastureland	Forest	^{1}User Defined
W1	1.06	0.84	1.08	0.49
W2	0.98	N/A	N/A	0.13
W3	0.96	N/A	N/A	0.63
W4	1.08	1.17	3.31	0.77
W5	1.18	1.00	1.70	1.06

(1) Includes hay / alfalfa, non-pasture grassland, and conservation reserve programs

Curve Numbers

The STEPL model includes default curve numbers (CNs) selected automatically based on HSG and land use. In Iowa, watershed modeling professionals across multiple agencies have found that standard NRCS curve numbers result in overestimation of surface runoff and flow (IDNR and ISU, unpublished data). Therefore, HSG type C curve numbers were modified to better reflect conditions in the watershed.

Urban land use curve numbers were developed within STEPL based on percent land use of the urban subcategories. Adjusted CNs were entered in the “Input” worksheet of STEPL, and are reported in Table D-5.

Table D-5. STEPL Curve Numbers.

Subwatershed	[1]Urban	Cropland	Forest	Pastureland	[2]User Defined
W1	92	85	73	79	67
W2	92	85	73	79	67
W3	92	85	73	79	67
W4	92	85	73	79	67
W5	92	85	73	79	67

(1) Urban includes all developed areas, including transportation and farmstead areas.
(2) User defined Includes hay / alfalfa, non-pasture grassland, and conservation reserve programs.

Sediment Delivery Ratio

The sediment load to Prairie Lake will be dependent upon watershed morphology, water velocity, residence time, best management practices and other factors. The sediment load to the lake is smaller than total sheet and rill erosion because some of the eroded material is deposited in depressions, ditches, or streams before it reaches the watershed outlet (i.e., the lake). The sediment delivery ratio (SDR) is the portion of sheet and rill erosion that is transported to the watershed outlet. STEPL calculates the SDR for each subbasin using a simple empirical formula based on drainage area (i.e., subbasin area). The resulting SDR values are 0.194 for all basins. This is lower than sub basins with similar landuse, soil, and slope characteristics; but due to the prevalence of terraces in cropland areas sediment is trapped with greater efficiency.

Best Management Practices

STEPL is able to simulate load reduction efficiencies for a variety of urban and agricultural BMPs in each sub basin. Reductions are dependent on the overall efficiency of each practice and the area of the BMP to which it is applied. The main practices modeled in the Prairie Rose Lake watershed are settling basin, contour farming, and terrace farming – with terraces occurring on up to 93% of cropland in certain sub basins. Table D-6 shows, the nitrogen, phosphorus, and sediment removal efficiency for terraced cropland, the percent land use applies to each BMP, and the efficiency of the practice compared to ideal conditions. With the frequency of terraces and the lack of significant areas of other BMPs, terraces were the only practice applied to each basin. Due to the age of the installation of the terraces, an effectiveness factor of (2/3 * total area) was applied to each practice to reflect the conditions of the terraces on the ground.

Table D-6. BMP Reduction Efficiencies for Nitrogen, Phosphorus, and Sediment.

Basin	Efficiency(1)	Area Applied, %	N removal factor	P removal factor	Sed removal factor
W1	0.66	80	0.107	0.373	0.453
W2	0.66	90	0.120	0.420	0.510
W3	0.66	93	0.124	0.434	0.527
W4	0.66	90	0.120	0.420	0.510
W5	0.66	90	0.120	0.420	0.510

(1) This is the practice efficiency for the given BMP due to age and condition.

D.5. Animals

Agricultural Animals and Manure Application

The STEPL model utilizes livestock population data and the duration (in months) that manure is applied to account for nutrient loading from livestock manure application. There is one main pastureland with two small pastures within the Prairie Rose Lake watershed. Based on available information there are several animal feeding operations within 3 miles. Inspection of manure management plans (MMP) showed that these facilities may directly contribute to manure application within the Prairie Rose Lake watershed. It is therefore assumed that manure will be applied to cropland for two weeks twice a year in the Prairie Rose Lake watershed. The number of confined animals producing manure applied within the watershed was then a calculation based on the area of fields within the watershed compared to the total area of fields the confinement spread manure. For example, if a confinement had 1,000 AU of swine and spread manure on 500 acres, of which 100 acres are in the Prairie Rose Lake watershed, the value of 200 AU (100 acres / 500 total acres * 1000 AU) would be listed on the table below. Table D-6 lists the number and type of animals, the animal equivalent units (AEU) normalized per acre, and number of months manure is applied.

Table D-7. Agricultural Animals and Manure Application.

Watershed	Beef Cattle	Swine (Hog)	AEU (1000lb/ac)	# of months manure applied
W1	10	232	0.13	1
W2	100	0	0.11	1
W3	0	0	0.00	1
W4	10	295	0.10	1
W5	10	0	0.01	1
Total	130	527	0.06	1

Livestock Grazing

There are two small cattle grazing areas in the Prairie Rose Lake watershed. Erosion and nutrient loss from pastureland in the STEPL model, which likely results in an over-estimate of TP loads from this source. Erosion from pasture (and other grassland that may be in poor condition) carries sediment-bound phosphorus, which is accounted for by using a sediment nutrient enrichment ratio. The STEPL default enrichment ratio is 2.0. STEPL simulates nutrient loss in pasture and grassland runoff by assuming a phosphorus concentration of 0.3 mg/L in the runoff. Similarly, a phosphorus concentration of 0.063 was used to simulate phosphorus loads from shallow groundwater in grazed areas.

Open Feedlots

There are no open feedlots in the Prairie Rose Lake watershed in the IDNR Animal Feeding Operations Database, however, there is a 900 head beef lot directly north of the watershed boundary. Feedlot operators are not required to report open feedlot information to IDNR for feedlots with less than 1000 animal units (AUs). Values for AEU and months of manure spread were calculated for this lot similar to the confinements and are listed in Table D-7.

Wildlife

The estimated county-wide average deer density is approximately 5 deer per square mile, but an average of 10 deer per square mile was entered in the “Animals” worksheet of the STEPL model for Prairie Rose Lake watershed to account for increased density of deer around the lake. Population densities of 120 geese, 10 raccoons, 10 beavers, and 10 other per square mile were used to account for other wildlife (e.g., furbearers, upland birds, etc.) for which data is lacking.

Septic Systems

A GIS coverage of rural residences with private onsite wastewater treatment systems (e.g., septic systems) was developed using aerial images. This procedure resulted in the identification of 24 septic systems in this sparsely populated watershed. It is estimated that 10 percent of these systems are not functioning adequately (i.e., are ponding or leaching). This is a fairly common occurrence in some rural parts of the state. This information is included in the “Inputs” worksheet of the STEPL model for Prairie Rose Lake.

D.6. References

U.S. Department of Agriculture – Natural Resources Conservation Service 2002, https://efotg.sc.egov.usda.gov/references/public/IA/Universal_Soil_Loss_Equation1.pdf

U.S. Department of Agriculture – Farm Service Agency (USDA-FSA). 2016. http://www.fsa.usda.gov/Internet/FSA_File/clu_2007_infosheetpdf.pdf.

U.S. Department of Agriculture – National Agricultural Statistical Summary (USDA-NASS). 2016. http://nassgeodata.gmu.edu/CropScape/.

Appendix E. Water Quality Model Development

Two models were used to develop the Total Maximum Daily Load (TMDL) for Prairie Rose Lake. Watershed hydrology and pollutant loading was simulated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.3. STEPL model development was described in detail in Appendix D.

In-lake water quality simulations were performed using BATHTUB 6.14, an empirical lake and reservoir eutrophication model. The BATHTUB model developed for Prairie Rose Lake does not simulate dynamic conditions associated with storm events or individual growing seasons. Rather, the model predicts average water quality in the modeling period of 2002-2015, which includes the 2018 Integrated Report (2012-2015). This appendix discusses development of the BATHTUB model. The integrated watershed and in-lake modeling approach allows the holistic analysis of hydrology and water quality in Prairie Rose Lake and its watershed.

E.1. BATHTUB Model Description

BATHTUB is a steady-state water quality model developed by the U.S. Army Corps of Engineers that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). Eutrophication-related parameters are expressed in terms of total phosphorus (TP), total nitrogen (TN), chlorophyll-a (chl-a), and transparency. The model can distinguish between organic and inorganic forms of phosphorus and nitrogen, and simulates hypolimnetic oxygen depletion rates. Water quality predictions are based on empirical models that have been calibrated and tested for lake and reservoir applications (Walker, 1985). Control pathways for nutrient levels and water quality response are illustrated in Figure E-1.

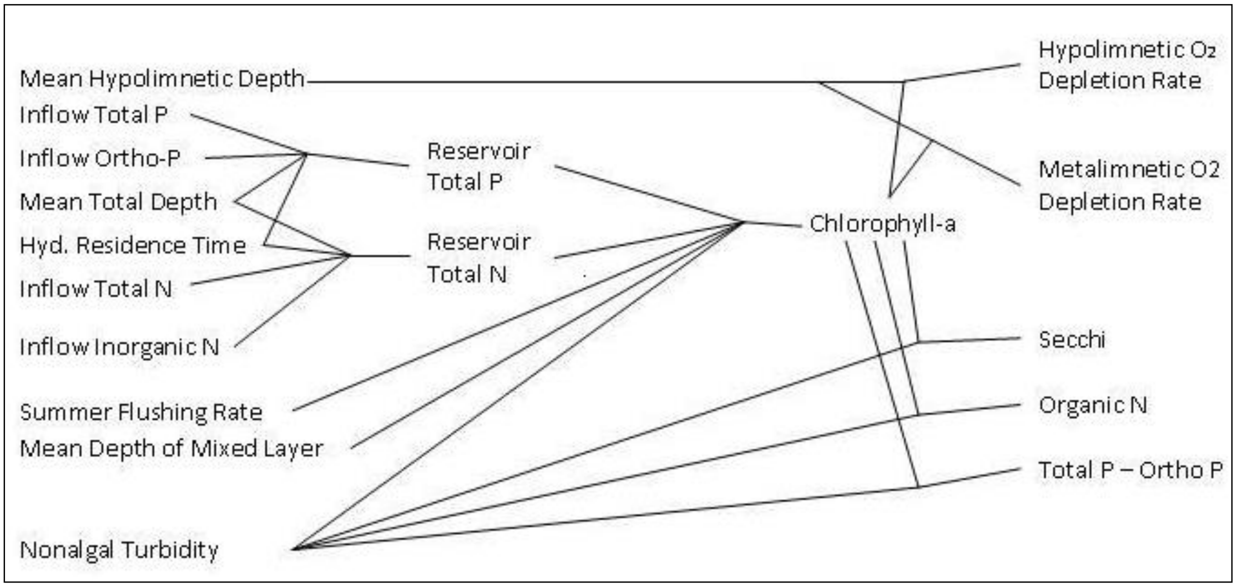

Figure E-1. Eutrophication control pathways in BATHTUB (Walker, 1999)

E.2. Model Parameterization

BATHTUB includes several data input menus and modules to describe lake characteristics, simulation equations, and external (i.e., watershed) inputs. Data menus utilized to develop the BATHTUB model for Prairie Rose Lake include: model selections, global variables, segment data, and tributary data. The model selections menu allows the user to specify which modeling equations (i.e., empirical relationships) are used in the simulation of in-lake nitrogen, phosphorus, chl-a, transparency, and other parameters. The global variables menu describes parameters consistent throughout the lake such as precipitation, evaporation, and atmospheric deposition. The segment data menu is used to describe lake morphometry, observed water quality, calibration factors, and internal loads in each segment of the lake or reservoir. The tributary data menu specifies nutrient loads to each segment using mean flow and concentration in the averaging period. The following sub-sections describe the development of the Prairie Rose Lake BATHTUB model and report input parameters for each menu.

Model Selections
BATHTUB includes several models and empirical relationships for simulating in-lake nutrients and eutrophication response. For TP, TN, chl-a, and transparency, Models 1 and 2 are the most general formulations, based upon model testing results (Walker, 1999). Alternative models are provided in BATHTUB to allow use of other eutrophication models, evaluate sensitivity of each model, and facilitate water quality simulation in light of data constraints.

Table E-1 reports the models selected for each parameter used to simulate eutrophication response in Prairie Rose Lake. Preference was given to Models 1 and 2 during evaluation of model performance and calibration of the Prairie Rose Lake model, but final selection of model type was based on applicability to lake characteristics, availability of data, and agreement between predicted and observed data. The default models were left to predict in-lake phosphorus and transparency levels because it provided the best agreement with observed data, and because Prairie Rose Lake is a manmade impoundment and representative of aquatic systems for which these specific models were developed. Chlorophyll model selection was based on observed data agreement and applicability based on BATHTUB user manual IR-W-96 table 4.2. Model performance is discussed in more detail in Appendix F.

Table E-1. Model selections for Prairie Rose Lake.

Parameter	Model No.	Model Description
Total Phosphorus	*01	2nd order, Avail. P
Total Nitrogen	01	2nd order, Avail. N
Chlorophyll-a	03	P. N. Low Turbidity
Transparency	*01	vs CHLA & Turbidity
Longitudinal Dispersion	*01	Fischer-Numeric
Phosphorus Calibration	02	Concentrations
Nitrogen Calibration	02	Concentrations
Availability Factors	*00	Ignore

* Asterisks indicate BATHTUB defaults

Global Variables
Global input data for Prairie Rose Lake are reported in Table E-2. Global variables are independent of watershed hydrology or lake morphometry, but affect the water balance and nutrient cycling of the lake. The first global input is the averaging period. Both seasonal and annual averaging periods are appropriate, depending on site-specific conditions. An annual averaging period was utilized to quantify existing loads and in-lake water quality, and to develop TMDL targets for Prairie Rose Lake.

Table E-2. Global Variables Data for Simulation Period.[1]

Parameter	Observed Data	BATHTUB Input
Averaging Period	Annual	1.0 years
[1]Precipitation	35.5 in	0.902 m
[1]Evaporation	38.6 in	0.980 m
[2]Increase in Storage	0	0
[3]Atmospheric Loads:		
TP	0.3 kg/ha-yr	30 mg/m^2-yr
TN	7.7 kg/ha-yr	770 mg/m^2-yr

[1]Precip and evaporation data are from 2002 - 2015 in order to provide accurate long term data

[2]Change in lake volume from beginning to end of simulation period.

[3]From Anderson and Downing, 2006.

Precipitation was summarized for the fourteen year assessment period of 2002-2015 from the Iowa Mesonet network collected and discussed in Chapter 2. Potential evapotranspiration data for the same period was obtained from the Lewis, Iowa weather station via the ISU Ag Climate database (IEM, 2016b). Net change in reservoir storage was assumed to be zero. This fourteen year period was chosen in order to reflect the climate during the assessment period when water quality data was collected and analyzed to show the algal and non-algal impairments at Prairie Rose Lake. It was shown in Section 3.1 (Figures 3-10 to 3-12) that precipitation is not highly correlated with total phosphorus and the impairment seen at Prairie Rose Lake. These data were summarized and converted to BATHTUB units and entered in the global data menu. Atmospheric deposition rates were obtained from a regional study (Anderson and Downing, 2006). Nutrient deposition rates are assumed constant from year to year.

Segment Data

Lake morphometry, observed water quality, calibration factors, and internal loads are all included in the segment data menu of the BATHTUB model. Separate inputs can be made for each segment of the lake or reservoir system that the user wishes to simulate. In lakes with simple morphometry and one primary tributary, simulation of the entire lake as one segment is often acceptable. If evaluation of individual segments of the lake (or inflowing tributaries) is desirable, the lake can be split into multiple segments. Each segment may have a distinct tributary.

The Prairie Rose Lake BATHTUB model includes two segments to facilitate simulation of diffusion, dispersion, and sedimentation that occur. The relationship between watershed basins and the BATHTUB segments is shown in Table E-5. The ambient monitoring location is used for listing and delisting purposes, the TMDL target applies at the ambient monitoring location in that segment.

Segment morphometry was calculated in the model. Bathymetric survey data and ESRI GIS software was used to estimate segment surface area, mean depth, and segment length. Segment physical parameters input into BATHTUB for the lake system area shown in Table E-3.

Table E-3. Segment Morphometry for the Prairie Rose Lake.

Segment	Outflow Segment	Segment Group	Surface Area (km^2)	Mean Depth (m)	Length (km)
Upper Segment	Lower Segment	1	0.271	1.74	1.12
Lower Segment	Out of Reservoir	2	0.418	3.35	1.11

Mean water quality parameters observed for the modeling period (2002-2015) are reported in Table E-4. These data were compared to output in the main segment of the BATHTUB lake model to evaluate model performance and calibrate the BATHUB and STEPL models for each scenario. The TMDL and future water quality assessment and listing / delisting will be based solely on water quality data from the ambient monitoring location in 'Lower Segment.'

Table E-4. Ambient Water Quality (2002-2015 Annual Means).

Parameter	Measured Data	[1]BATHTUB Input
Total Phosphorus	86.5 µg/L	86.5 ppb
Total Nitrogen	2,300 mg/L	2,300 ppb
Chlorophyll-a	43.7 µg/L	43.7 ppb
Secchi Depth	0.95 m	0.95 m

[1] Measured or monitored data converted to units required by BATHTUB
ppb = parts per billion = micrograms per liter (ug/L)

Tributary Data

The empirical eutrophication relationships in the BATHTUB model are influenced by the global and segment parameters previously described, but are heavily driven by flow and nutrient loads from the contributing drainage area (watershed). Flow and nutrient loads can be input to the BATHTUB model in a number of ways. Flow and nutrient loads used in the development of the Prairie Rose Lake BATHTUB model utilize watershed hydrology and nutrient loads predicted using the STEPL model described in Appendix D. Output from STEPL includes annual average flow and nutrient loads. Table E-5 summarizes the physical parameters and monitored inputs for Prairie Rose Lake. Note in the table that Basin 5 area excludes the surface area of Prairie Rose Lake.

Table E-5. Tributary Data for the Prairie Rose Lake.

Tributary Name	BATHTUB Receiving Segment	Total Watershed Area (km^2)	Avg Period Flow Rate (hm^3/yr)	STEPL Total P concentration (ppb)
Basin 1	Upper Segment	1.92	0.538	379.7
Basin 2	Upper Segment	4.35	1.240	335.2
Basin 3	Upper Segment	4.03	1.250	347.7
Basin 4	Upper Segment	3.29	0.935	350.9
Basin 5	Lower Segment	4.56	1.095	409.9

E.3. References

Anderson, K., and J. Downing. 2006. Dry and wet atmospheric deposition of nitrogen, phosphorus, and silicon in an agricultural region. Water, Air, and Soil Pollution, 176:351-374.

Iowa Environmental Mesonet (IEM). 2016a. Iowa State University Department of Agronomy. Iowa Ag Climate Network. Download available at http://mesonet.agron.iastate.edu/request/coop/fe.phtml Accessed in March 2018.

Iowa Environmental Mesonet (IEM). 2016b. Iowa State University Department of Agronomy. Iowa Ag Climate Network. Download available at
http://mesonet.agron.iastate.edu/agclimate/hist/dailyRequest.php.
Accessed in March 2018.

Appendix F. Model Performance and Calibration

The Prairie Rose Lake watershed and water quality models were calibrated by comparing simulated and observed local and regional data. The primary source of calibration data is the ambient lake monitoring data collected by Iowa State University (ISU) and the University of Iowa State Hygienic Laboratory (SHL) between 2002 and 2015. Literature values and results from regional studies regarding sediment and phosphorus exports in similar watersheds were also utilized to evaluate model performance. Calibration was an iterative process that involved running both the watershed model (STEPL) and in-lake model (BATHTUB), and refining model parameters to (1) produce simulated values that were within reasonable ranges according to similar studies, and (2) provide good agreement with observed water quality in Prairie Rose Lake.

F.1. STEPL Performance and Calibration

The STEPL model is a long-term average annual simulation model, and is incapable of simulating storm events or short-term fluctuations in hydrology and nutrient loads. There is no long-term monitoring data for tributaries in the Prairie Rose Lake watershed, therefore model calibration relied heavily upon sediment and phosphorus exports reported in similar watersheds in the region. Table F-1 reports estimated sheet and rill erosion rates found in several Iowa watersheds that are similar composition or proximate in location. Values for Prairie Rose Lake watershed are before BMP reductions.

Table F-1. Sheet and Rill Erosion in Western Iowa Watersheds.

Watershed	County	Proximity (miles)	Erosion (tons/ac/yr)
Meadow Lake	Adair	43	0.97
Thayer Lake	Union	72	1.6
Green Valley Lake	Union	55	2.1
[1]Prairie Rose Lake	**Shelby**	**--**	**1.05**

(1) Annual sheet/rill erosion estimated for this TMDL using STEPL (2002-2015).

The Prairie Rose Lake STEPL model predicts sheet and rill erosion rates that are consistent with those predicted by DNR for other watersheds in the area. The 2002-2015 simulated annual average sheet and rill erosion rate was 1.05 tons/acre, compared with average estimated rates between 1.0 to 5.0 tons/acre/year estimated in other watersheds in the Loess Hills and Southern Iowa Drift Plain. Note that erosion rates in Table F-1 reflect sheet and rill erosion, not sediment delivered to the lake. Sheet and rill erosion rates in the Prairie Rose Lake watershed include erosion from grassland and pasture areas. The extreme slopes in the watershed create conditions which highly favor excessive erosion rates in the watershed. Terraces throughout the watershed have placed the erosion rates on the lower end of the scale for similar watersheds.

Table F-2 compares the annual average TP export simulated by the Prairie Lake STEPL model with past study results in other watersheds in Iowa with an emphasis on the Loess Hills and Southern Iowa Drift Plain. TP exports in the Prairie Rose Lake watershed are 0.89 pounds per acre per year. However, this reduced rate takes BMPs throughout the watershed into account when calculating load reductions which may not occur in other watershed studies. Because the STEPL model predicted sediment and phosphorus loads similar in magnitude to estimates developed for other local and regional watersheds, IDNR has determined the STEPL model to be adequate for estimation of phosphorus loads to Prairie Rose Lake for development of TMDLs and implementation planning.

Table F-2. Comparison of TP Exports in Loess Hills and Southern Iowa Drift Plain Watersheds.

Watershed Location	Source	TP Export (lb/ac)
Lake Iowa, Iowa County	IDNR (Previous TMDL)	1.09
Windmill Lake, Taylor County	IDNR (Previous TMDL)	1.5
Meadow Lake, Adair County	IDNR (Previous TMDL)	0.97
Green Valley Lake, Adair County	IDNR (Previous TMDL)	1.6
Thayer Lake, Union County	IDNR (Previous TMDL)	2.1
Prairie Rose Lake, Shelby County	**STEPL Model (Current TMDL)**	**0.89**

F.2. BATHTUB Model Performance

Performance of the BATHTUB model was assessed by comparing predicted water quality with observed data collected in Prairie Rose Lake. Simulation of TP concentration and Secchi depth / chl-a (algae) were critical for TMDL development, and were the focus of calibration efforts.

Calibration

Table F-3 reports observed and predicted annual average TP, chl-a, and Secchi depths in the open water area of Prairie Rose Lake, along with the dispersion model and calibration coefficients for each parameter of interest. More comprehensive observed data is reported in Appendix C. Predicted water quality is based on BATHTUB simulations, and the calibration coefficients were iteratively adjusted in order to obtain the best possible agreement between observed and predicted water quality, while minimizing changes in the default coefficients. The calibration period was 2002-2015, the assessment period.

Calibration coefficients listed alongside the simulated values in Table F-3 were entered in the "Segments" menu of the BATHTUB model, and apply to the ambient monitoring segment of Prairie Rose Lake. Calibration coefficients for Prairie Rose Lake are within the recommended range according to the BATHTUB user guidance (Walker, 1999).

Initial testing showed phosphorus levels from watershed loading were adequate for meeting observed water quality data in Prairie Rose Lake. Internal loading levels were not required and due to lake morphology not appropriate for Prairie Rose Lake (Filstrup 2016). Once simulated phosphorus levels were calibrated to observed phosphorus levels, other water quality measurements were calibrated by increasing or decreasing model coefficients within the BATHTUB model.

Table F-3. Observed and Simulated Water Quality with Calibration Factors.

Parameter	[1]Observed	[2]Predicted	Calibration Coefficient
Modeling period conditions (2002-2015)			
Dispersion coefficient	--	--	--
Total Phosphorus (ug/L)	86.5	86.5	0.891
Total Nitrogen (ug/L)	2300	2300	1.820
Chlorophyll-a (ug/L)	43.7	43.7	0.944
Secchi depth (m)	0.9	0.9	1.00

(1) Average concentration observed at ambient monitoring location
(2) Average annual concentration predicted modeled segment of BATHTUB lake model

F.3. References

U.S. Geological Survey (USGS), 2001. Water Quality Assessment of the Eastern Iowa Basins – Nitrogen, Phosphorus, Suspended Sediment, and Organic Carbon in Surface

Walker, W. 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

Appendix G. Expressing Average Loads as Daily Maximums

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increments. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

Per the EPA requirements, the loading capacity of Prairie Rose Lake for TP is expressed as both a maximum annual average and a daily maximum load. The annual average load is more applicable to the assessment of in-lake water quality and water quality improvement actions, whereas the daily maximum load expression satisfies the legal uncertainty addressed in the EPA memorandum. The allowable annual average was derived using the BATHTUB model described in Appendix E, and is 2,076 lbs/year.

The maximum daily load was estimated from the allowable growing season average using a statistical approach. The methodology for this approach is taken directly from the follow-up guidance document titled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), which was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control*.

The *Options for Expressing Daily Loads in TMDLs* document presents a similar case study in which a statistical approach is considered the best option for identifying a maximum daily load (MDL) that corresponds to the allowable average load. The method calculates the daily maximum based on a long-term average and considers variation. This method is represented by the equation:

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

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

The allowable annual average of 2,076 lbs/year is equivalent to a long-term average (LTA) daily of 5.68 lbs/day. The LTA is the allowable annual load divided by the 365-day averaging period. The average annual allowable load must be converted to a MDL. The 365-day averaging period equates to a recurrence interval of 99.7 percent and corresponding z statistic of 2.326, as reported in Table G-1. The coefficient of variation (CV) is the ratio of the standard deviation to the mean. However, there is insufficient data to calculate a CV as it relates to TP loads to the lake, because the models are based on annual averages over several years. In cases where data necessary for calculating a CV is lacking, EPA recommends using a CV of 0.6 (EPA, 1991). The resulting σ^2 value is 0.31. This yields a TMDL of 17.7 lbs/day. The TMDL calculation is summarized in Table G-2. An explicit MOS of 10 percent (1.8 lbs) was applied, resulting in a daily LA of 15.9 lbs/day to the daily equation daily TMDL equations. The resulting TMDL, expressed as a daily maximum, is:

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (15.9 lbs-TP/day) + MOS (1.8 lbs-TP/day) = **17.7 lbs-TP/day**

Table G-1. Multipliers Used to Convert a LTA to an MDL.

Parameter	TMDL	Σ WLA	Σ LA	MOS
LTA (lbs/day)	5.68	0.00	5.12	0.56
Z Statistic	2.326	2.326	2.326	2.326
CV	0.6	0.6	0.6	0.6
σ^2	0.31	0.31	0.31	0.31
MDL (lbs/day)	**17.7**	**0.00**	**15.9**	**1.7**

Table G-2. Summary of LTA to MDL Calculation for the TMDL.

Parameter	Value	Description
LTA	5.68 lbs/day	Annual TMDL (205 lbs) divided by 365 days
Z Statistic	2.326	Based on 180-day averaging period
CV	0.6	Used CV from annual GWLF TP loads
σ^2	0.31	ln (CV^2 + 1)
MDL	**17.7 lbs/day**	**TMDL expressed as daily load**

Appendix H. 2018 305(b) Water Quality Assessment

Segment Summary
Prairie Rose Lake
Waterbody ID Code: IA 05-NSH-1462
Location: Shelby County, S36, T79N, R38W, 6 miles SE of Harlan

Assessment Cycle	2018	**Overall IR Category**	5 – Water is impaired or threatened and a TMDL is needed.
Release Status	Final	**Trophic**	Eutrophic
Result Period	2012 - 2016	**Trend**	Unknown
Created	10/16/2018 11:14:47 PM	**Last Updated**	4/22/2019 2:35:16 PM

Class	Support	Causes of Impairment
Class A1 Recreation Primary Contact	Partially Supporting	Impairment Code 5a – Pollutant-caused impairment. TMDL needed. Cause Algal Growth / Turbidity: Chlorophyll a and Sediment Cause Magnitude Moderate Status Continuing Source Agriculture Source confidence Moderate Cycle Added 2004 Impairment Rationale Narrative criteria violation: aesthetically objectionable conditions Data Source Ambient monitoring: Iowa DNR-lakes TMDL Priority Tier I
Class B(LW) Aquatic Life – Lakes and Wetlands	Partially Supporting	Impairment Code 3b – Use potentially impaired based on an evaluated assessment. Cause Algal Growth: Cyanobacteria Cause Magnitude Slight Status New Source Source Unknown Source Confidence Low Cycle Added 2016 Impairment Rationale Adverse impacts on plat/animal communities Data Source Ambient monitoring: Iowa DNR-lakes
Class C - Drinking Water	Not Assessed	
Class HH - Human Health	Fully Supporting	
General Use - General Use water	Not Assessed	

Assessment Summary
The Class A1 (primary contact recreation) uses are assessed (monitored) as “partially supported” due to poor water transparency caused by algae blooms and (ww turbidity. In addition, violation's of the state's water quality standard for indicator bacteria also suggest an impairment at Prairie Rose Lake: this is a new impairment for this lake. The Class B(LW) (aquatic life) uses are assessed (monitored) as “fully supported.” The Class C (drinking water) uses are “not assessed” due to a lack of information upon which to base an assessment. Fish consumption uses are assessed (monitored) as “fully supported” based on fish tissue monitoring in 2003 and 2007. Sources of data for this assessment include (1) results of IDNR/UHL beach monitoring from 2014 through 2016, (2) results of the TMDL monitoring conducted in 2016 by Iowa Department of Natural resources (IDNR), (3) results of the statewide survey of Iowa lakes conducted from 2012 through 2016 by Iowa State University (ISU), (4) information from the IDNR Fisheries Bureau, and (5) results of U.S. EPA/IDNR fish contaminant (RAFT) monitoring in 2003 and 2007.

Assessment Explanation
Results of DNR beach monitoring from 2014 through 2016 suggest that the Class A1 uses are "partially supported." Levels of indicator bacteria at Prairie Rose Beach were monitored once per week during the primary contact recreation seasons (May through September) of 2014 (16 samples), 2015 (19 samples) and 2016 (16 samples), as part of the DNR beach monitoring program. According to DNR’s assessment methodology two conditions need to be met for results of beach monitoring to indicate “full support” of the Class A1 (primary contact recreation) uses: (1) the geometric mean of the samples from each recreation season of the three-year assessment period are less than the state's geometric mean criterion of 126 E. coli orgs/100 ml and (2) not more than 10% of the samples during any one recreation season exceeds the state's single-sample maximum value of 235 E. coli orgs/100 ml. If a sampling season geometric mean exceeds the state criterion of 1000 orgs/100 ml during the three-year assessment period, the Class A1 uses should be assessed as “not supported.” Also, if a sampling season geometric mean exceeds the state criterion of 126 orgs/100 ml during the three-year assessment period and/or if significantly more than 10% of the samples in any one of the three recreation seasons exceed Iowa's single-sample maximum value of 235 E. coli orgs/100 ml, the Class A1 uses should be assessed as “partially supported.” This assessment approach is based on U.S. EPA guidelines (see pgs 3-33 to 3-35 of U.S. EPA 1997b).

At Prairie Rose Beach, the geometric mean from 2015 was below the Iowa water quality standard of 126 E. coli orgs/100 ml. The geometric means from 2014 and 2016, however, were greater than the Iowa water quality standard of 126 E. coli orgs/100ml and therefore suggests impairment of the Class A1 uses. The geometric mean was 215 E. coli orgs/100 ml in 2014, 54 E. coli orgs/100 ml in 2015 and 343 E. coli orgs/100 ml in 2016. The percentage of samples exceeding Iowa's single-sample maximum criterion (235 E. coli orgs/100 ml) was 50% in 2014, 21% in 2015 and 56% in 2016. The number of samples exceeding the single-sample maximum criterion was significantly greater than 10% in 2014 and 2016. According to DNR's assessment methodology and U.S. EPA guidelines, these results suggest "partially supported" of the Class A1 uses.

For the 2018 assessment/listing cycle, the Class A1 (primary contact recreation) uses of Prairie Rose Lake are assessed (monitored) as "partially supported" due to aesthetically objectionable conditions caused by algae blooms based on information from the ISU lake survey and DNR TMDL monitoring. Using the median values from these surveys from 2013-2016 (approximately 12 samples), Carlson's (1977) trophic state indices for Secchi depth, chlorophyll a, and total phosphorus were 58, 69, and 68 respectively for Prairie Rose Lake. According to Carlson (1977) the Secchi depth, chlorophyll a, and total phosphorus values all place Prairie Rose Lake in the Eutrophic category. These values suggest high levels of chlorophyll a and suspended algae in the water, relatively good water transparency, and high levels of phosphorus in the water column. The data show 2 violations of the Class A1 criterion for pH in 11 samples (18%).Although the index value for Secchi is below the impairment trigger of 65 for this assessment cycle, Prairie Rose Lake was listed as partially supporting its Class A1 uses due to aesthetically objectionable conditions. Based on DNR's methodology, the median TSI value for Secchi must be 63 or less for two consecutive assessment/listing cycles before a lake can be removed from the state's Section 303(d) list (IR Category 5). Therefore, Prairie Rose Lake will remain listed as "not supported" for the 2018 assessment/listing cycle.

The level of inorganic suspended solids was low at Prairie Rose Lake, and does not suggest water quality problems due to non-algal turbidity. The median level of inorganic suspended solids in Prairie Rose Lake (1.6 mg/L) was ranked 9th among the 138 lakes by the ISU lake survey.

Data from the 2013-2016 ISU lake survey suggest a moderate population of cyanobacteria exists at Prairie Rose Lake. These data show that cyanobacteria comprised 50% of the phytoplankton wet mass at this lake. The median cyanobacteria wet mass (11.2 mg/L) was ranked 54th of the 138 lakes sampled. The Class B(LW) (aquatic life) uses are assessed (monitored) as "fully supported." Results of the ISU lake survey from 2013-2016 show there were no violations of the criterion for ammonia in 11 samples(0%), one violation of the criterion for dissolved oxygen in 12 samples(8%), and 2 violations of the criterion for pH in 11 samples(18%). Based on DNR's assessment methodology these violations are not significantly greater than 10% of the samples and therefore suggest (fully supported/monitored) of the Class B(LW) uses of Prairie Rose Lake.

The Class C (drinking water) uses are not assessed due to the lack of recent information upon which to base an assessment. The only parameter collected as part of the ISU lake surveys relevant to support of Class C (drinking water) uses is nitrate. While the results of the ISU surveys from 2013-2016 show that nitrate levels are low at this lake (maximum value = 3.1 mg/l; median = 0.2 mg/l), these data are not sufficient for developing a valid assessment of support of the Class C uses.

Fish consumption uses were assessed (monitored) as “fully supported” based on results of U.S.EPA/DNR fish contaminant (RAFT) monitoring at Prairie Rose Lake in 2003 and 2007. The composite samples of fillets from channel catfish and largemouth bass had very low levels of contaminants. Levels of primary contaminants in the composite sample of channel catfish fillets were as follows: mercury: <0.0181 ppm; total PCBs: 0.09 ppm; and technical chlordane: <0.03 ppm. Levels of primary contaminants in the composite sample of largemouth bass fillets were as follows: mercury: <0.0181 ppm; total PCBs: 0.09 ppm; and technical chlordane: <0.03 ppm. Follow up sampling in 2007 also showed low levels of primary contaminants. Data from 2007 show the composite samples of fillets from channel catfish and largemouth bass had low levels of contaminants. Levels of primary contaminants in the composite sample of channel catfish fillets were as follows: mercury: 0.0273 ppm; total PCBs: 0.09 ppm; and technical chlordane: <0.03 ppm. Levels of primary contaminants in the composite sample of largemouth bass fillets were as follows: mercury: 0.091 ppm. The existence of, or potential for, a fish consumption advisory is the basis for Section 305(b) assessments of the degree to which Iowa’s lakes and rivers support their fish consumption uses. The fish contaminant data generated from the 2003 and 2007 RAFT sampling conducted at Prairie Rose Lake show that the levels of contaminants do not exceed any of the advisory trigger levels, thus indicating no justification for issuance of a consumption advisory for this waterbody.

Note: Prairie Rose Lake was drawn down in July of 2011 and refilled in September of 2012 for restoration purposes. As a result, no samples were collected during that time. While the lake was drawn down, Stabilization of the eroding shoreline and removal of 60,000 cubic yards of sediment was completed and undesirable fish species (e.g. common carp)were removed from the lake and watershed. The lake was restocked starting in April of 2013. In lake dredging started in mid-July. Approximately 185,000 CY of sediment were to be removed from Prairie Rose Lake. The project was completed in 2015. This assessment does not include post-restoration data.

Monitoring and Methods

Assessment Key Dates

6/15/2010	Fixed Monitoring Start Date
9/17/2014	Fixed Monitoring End Date
9/1/2003	Fish Tissue Monitoring
8/21/2007	Fish Tissue Monitoring
8/24/2007	Fish Tissue Monitoring

Methods

- Surveys of fish and game biologists/other professionals
- Non-fixed-station monitoring (conventional during key seasons and flows)
- Fish tissue analysis
- Primary producer surveys (phytoplankton / periphyton / macrophyton)
- Water column surveys (e. g. fecal coliform)

Appendix I. DNR Project Files and Locations

This appendix is primarily for future reference by DNR staff that may wish to access the original spreadsheets, models, maps, figures, and other files utilized in the development of the TMDL.

Table I-1. Project Files and Locations.

Directory\folder path	File name	Description
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Data\Raw	Various files	All raw data received from others
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Data\Reduced	WQ_Data_PRL.xlsx	Summary of in-lake WQ data
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Data\Reduced	Rainfall_ET_Data_PRL.xlsx	Summary of precipitation and PET data
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Documents, Presentations\Draft TMDL	Draft TMDL reports	Includes review comments
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Documents, Presentations\Final TMDL	Final report	Report for submittal to EPA
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Documents, Presentations\References	Various .pdf and .doc files	References cited in the WQIP and/or utilized to develop model input parameters
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\GIS\GIS_Data	Various shapefiles (.shp) and raster files (.grd)	Used to develop models and maps
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\GIS\Projects	ArcGIS project files	Used to develop models and maps
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\GIS\Exports	Various .pdf and .jpg files	Maps/figures used in the WQIP document
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Modeling\Bathtub	TMDL_Equation_Calcs_PRL.xlsx	Calculation of the TMDL; Used to develop the TMDL equation (LA, WLA, and MOS) Load response curve calcs
\\iowa.gov.state.ia.us...\Prairie_Rose_Lake\Modeling\STEPL	Prairie_Rose_STEPL.xlsm	Used to simulated/predict existing watershed loads
	Various .xls files	Used to develop/calculate STEPL model inputs
\\iowa.gov.state.ia.us\...\Prairie_Rose_Lake\Modeling\BATHTUB	STEPL_Conversion_PRL.xlsx	Calculated/converted STEPL outputs to BATHTUB inputs for existing conditions
	Various .btb files	BATHTUB input files for various scenarios

Appendix J. Public Comments

Public Comment:

The Iowa Department of Natural Resources received no public comments on the Prairie Rose Lake TMDL.