Total Maximum Daily Loads
for
Big Indian Lake – Gage County, Nebraska

Parameters of Concern: Total Phosphorus And Sedimentation

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Planning Unit, Water Quality Division

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Executive Summary

Big Indian Lake was included as a Category 5 waterbody in the 2006 Nebraska Surface Water Quality Integrated Report (NDEQ 2006) due to excessive total phosphorus and on the 2008 Water Quality Integrated Report as impaired by excessive sediment. As such, total maximum daily loads must be developed in accordance with the Clean Water Act. This document presents TMDLs, for phosphorus and sediment to address these impairments. The information contained herein should be considered two (2) TMDLs.

These TMDLs have been prepared to comply with the current (1992) regulations found at 40 CFR Part 130.7.

1. Name and geographic location of the impaired waterbody for which the TMDL is being developed.

Big Indian Lake, Section 12, T 1 North, R 6 East, Gage County, Nebraska. Lat. 40° 03' 45", Long. 96° 41' 40"

2. Identification of the pollutant and applicable water quality standard

The parameters causing the impairment(s) of the water quality criteria, water quality targets, designated beneficial uses and for which these TMDLs are being developed are total phosphorus and sediment. Designated uses assigned to Big Indian Lake include: primary contact recreation, aquatic life Warmwater Class A, agriculture water supply class A and aesthetics (NDEQ 2006b). Excessive total phosphorus and sediment have been determined to be impairing the aquatic life and aesthetics beneficial uses.

3. Quantification of the pollutant load that may be present in the waterbody and still allows attainment and maintenance of the water quality standards.

Bathymetric survey data, empirical data and the CNET water quality (eutrophication) model were employed to determine the current and target total phosphorus and sediment loads. The loading capacities, that if achieved will result in beneficial use attainment were based upon water quality criteria and assessment guidelines. These values are 573 lbs/year (1,163 kg/year) and 5,426 tons/year for phosphorus and sediment, respectively

4. Quantification of the amount or degree by which the current pollutant load in the waterbody, including upstream sources that is being accounted for as background loading deviates from the pollutant load needed to attain and maintain water quality standards.

The average annual total phosphorus load delivered to Big Indian Lake is estimated to be 4,423 lbs/year (2,010 kg/year). To meet the water quality goals, the average annual loading capacity is 573 lbs/year and approximately an 87.5% reduction is needed.

Empirical data indicates approximately 8,050 tons/year of sediment is delivered to Big Indian Lake. To achieve the sedimentation goal, a 32.6% reduction from the current average annual load is needed.

5. Identification of the pollution source categories.

Nonpoint and natural sources of total phosphorus and nonpoint sources of sediment have been identified as the cause of impairments to Big Indian Lake.

6. Wasteload allocations for pollutants from point sources.

No point sources discharge in the watershed and therefore the wasteload allocations for both phosphorus and sediment will be set at zero (0).

7. Load allocations for pollutants from nonpoint sources.

For the phosphorus TMDL the load allocation was set at 551lbs/year (250 kg/year). This allocation was developed using models and empirical data. Natural background was determined using rainfall concentration and measurements and is 22 lbs/year (10 kg/year).

For sediment, natural background was not separated out allowed by 40 CFR Part 130.7a and the load allocation was set at 5,426 tons/year

8. A margin of safety.

This TMDL contains an implicit margin of safety. Pollutants are discharged from the system via the reservoir's outlet. The TMDL will assume all pollutants delivered to the waterbody remain, again reflecting a worst-case condition.

9. Consideration for seasonal variation.

The pollutants of concern are delivered on a year round basis and the assessment of the data considers annual average conditions. However, in-lake and watershed model inputs require that seasonal changes (e.g. vegetative cover, precipitation) be accounted for. Because nonpoint sources have been identified as the largest contributor, management practices and implementation will be targeted at those times when the nonpoint source influence is the greatest. This usually revolves around the precipitation events of mid to late spring when there is a high potential for run-off of sediment, phosphorus (attached to sediment), and nitrogen. The effects of the excess pollutant loadings are: large quantities of algae growth occurring during the growing season, potential for future dissolved oxygen impairments and sediment reducing the volume of the lake.

10. Allowances for reasonably foreseeable increases in pollutant loads.

There was no allowance for future growth included in these TMDLs.

11. Implementation Plan

A general implementation plan has been developed and included. In the near future, the Lower Big Blue Natural Resource will initiate a community-based watershed planning process that will focus on water quality improvements.

The TMDL included in the following text can be considered a "phased TMDL" and as such is an iterative approach to managing water quality based on the feedback mechanism of implementing a required monitoring plan that will determine the adequacy of load reductions to meet water quality standards and revision of the TMDL in the future if necessary. A description of the future monitoring (Section +4.0) that is planned has been included.

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining status quo;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected should be used to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairments. As well the data and information can be used to determine if the TMDLs have accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in lake response to pollutant loads, etc.) and if revisions are appropriate.

1.0 Introduction

Big Indian Lake was included in Category 5 (Section 303(d) list) of the 2006 Nebraska Surface Water Quality Integrated Report (Integrated Report) (NDEQ 2006a) as not supporting the aquatic life and aesthetics beneficial uses with the parameter of concern being excess phosphorus.

Along with the phosphorus impairment, bathymetric information collected in 1995 and 2003 indicate the waterbody has shown a volume loss of 45.4 acre/feet or approximately 1% per year. Based upon NDEQ assessment methodology, this information would also yield an impairment assessment for excessive sediment. Rather than delay the TMDL until the 2008 IR, the TMDL will be completed.

Therefore, based on the above and as required by Section 303(d) of the Clean Water Act and 40 CFR Part 130.7, TMDLs will be developed for phosphorus and sediment to address the aquatic life and aesthetics impairments. The information contained herein should be considered two (2) TMDLs.

1.1 Background Information

Big Indian Lake is located in Gage County, Nebraska (Figure 1) and was one of thirty-five structures planned and constructed as past of the Big Indian Watershed Project (LBBNRD 1996). The lake and associated area are owned and operated by the Lower Big Blue Natural Resource District (LBBNRD). Big Indian Lake was designed as a flood control structure and became a recreational focal point. A description of the physical information is provided in Table 1.1. The Nebraska Game and Parks Commission (NGPC) manage the fishery and the LBBNRD manages the immediate surrounding 223 acres as a recreation facility. No towns exist within the watershed boundary however, Wymore/Blue Springs (population 2,039) lie approximately four miles to the northeast and Odell (population 345) lies approximately six miles to the southwest.

1.1.1 Waterbody Description

1.1.1.1 Waterbody Name: Big Indian Lake

Lake Identification Number: BB1-L0030 (Tile 117 – Nebraska Surface Water Quality Standards)

1.1.1.2 Major River Basin: Kansas River

1.1.1.3 Minor River Basin: Big Blue

1.1.1.4 Hydrologic Unit Code: 10270202

1.1.1.5 Assigned Beneficial Uses: Primary contact recreation, Aquatic Life Warmwater Class A, Agricultural Water Supply Class A and Aesthetics (Title 117 – Nebraska Surface Water Quality Standards) (NDEQ 2006b).

1.1.1.6 Major Tributary: Undesignated Tributary to BB1-10810: Squaw Creek

1.1.2 Watershed Characterization

1.1.2.1 Physical Features: Big Indian Lake has a watershed of approximately 3,381 acres and is located in the Western Corn Belt Plains (Level III) ecoregion as defined by Chapman, et al. (2001). The recreation area was completed in 1974 by the LBBNRD who retains ownership however; the lake's fishery is managed by the NGPC. The watershed is rural with general agriculture (e.g. row crops, pasture) dominating the land use with lesser amounts of homesteads and wooded areas.

Figure 1.1 Locations of Big Indian Lake and Watershed in Gage County, Nebraska

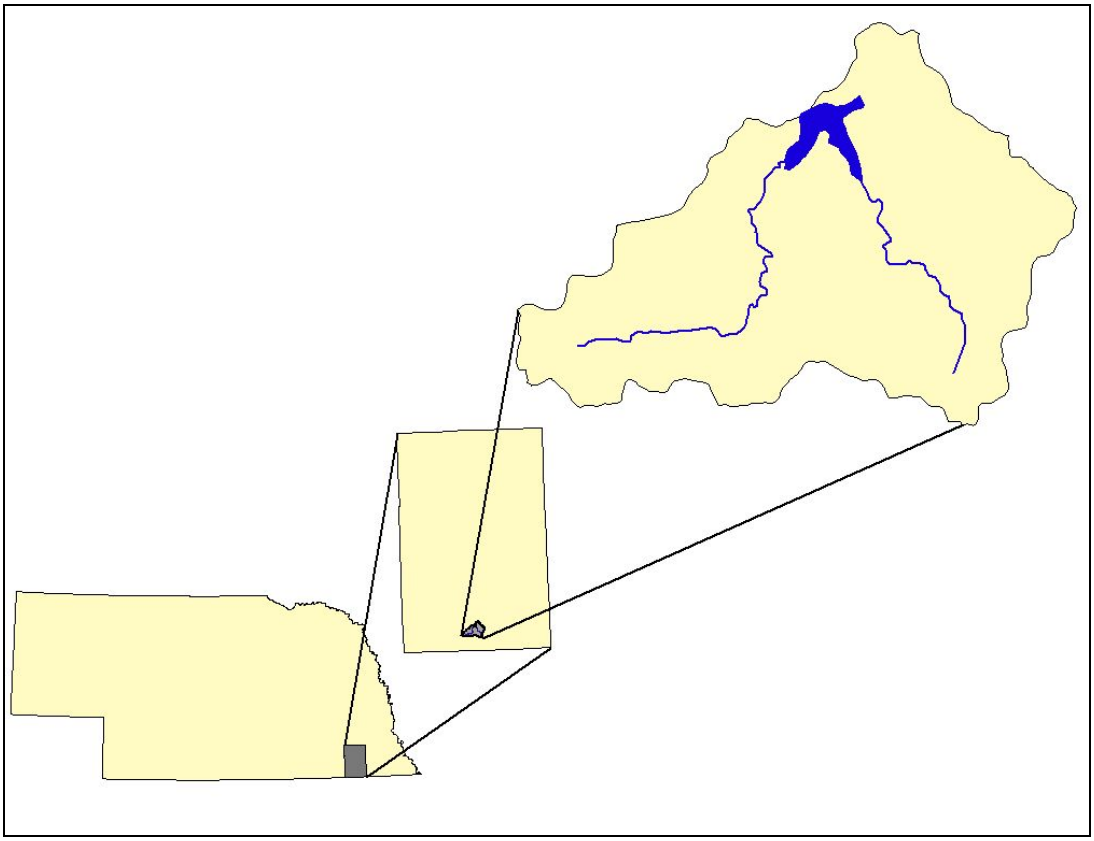


Table 1.1 Physical Description of Big Indian Lake

Parameter	Big Indian Lake
State	Nebraska
County	Gage
Latitude (center of dam)	40° 03’ 45”
Longitude (center of dam)	96° 41’ 40”
Section, Township, Range (dam)	Section 12, T 1 North, R 6 East
Surface Area – 1995	72 acres
Surface Area – 2003	71 acres
Shoreline length (approximate)	2.5 miles
Mean Depth – 1995	7.9 feet (2.4 meters)
Mean Depth – 2003	7.4 feet (2.25 meters)
Conservation Pool Volume – 1995	570 acre-feet
Conservation Pool Volume – 2003	524 acre-feet
Number of Inlets	2
Watershed Area	3,381 acres
Lake to Watershed Area Ratio	1:48

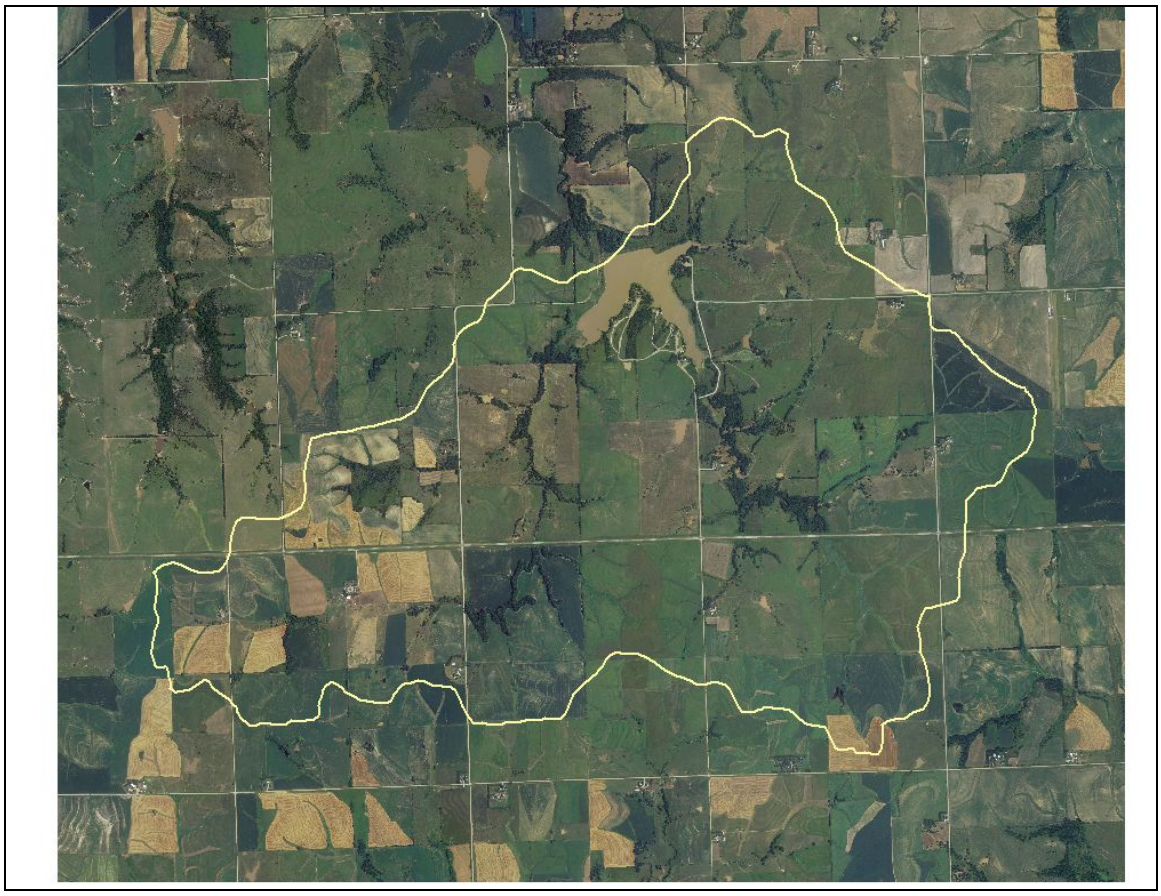
Two undesignated stream segments are tributaries to the lake and enter from the southeast and southwest. The watershed is located in the Loess-Drift Hills part of the glaciated area of the Great Plains physiographic province. Relief in the watershed ranges from level to steep with the southwestern portion having the highest elevation. Soils in the watershed are in the Crete-Pawnee-Adair association and are deep and generally well drained (LBBNRD 1996).

1.1.2.2 Climate: Winters in the watershed are cold with precipitation mainly occurring as snowfall. Summers can be hot but with occasional cool spells. Annual precipitation in the area is approximately 31 inches (DNR Data bank). The majority of the precipitation occurs during the growing season.

1.1.2.3 Demographics: While no municipality lies in the watershed, the Cities of Wymore/Blue Springs s – population 2039 and the Village of Odell – population 345 – lie approximately four miles to the northeast and six miles to the southwest, respectfully. Odell has seen an approximate 17% population increase from 1990 to 2000 while Wymore/Blue Springs has seen a two percent decrease during the same period.

1.1.2.4 Land Uses: Agriculture dominates the land use in the watershed with the 1995 estimates being 40% being devoted to pasture, 35% cropland, 20% enrolled in the Conservation Reserve Program and the remaining 5% being homesteads, water and NRD land (LBBNRD 1996). An aerial photograph of the watershed is provided in Figure 1.1.2

Figure 1.1.2 Aerial Photograph of Big Indian Lake and Watershed



2.0 Water Quality Conditions

2.1 Problem Identification

Big Indian Lake was included as a Category 5 waterbody on the 2006 Integrated Report, as being impaired by excessive phosphorus. As well bathymetric information obtained in 1995 and 2003 indicate the sedimentation rate exceeds the threshold for impairment. The following sections detail the extent and nature of the water quality impairments related to phosphorus and sediment in Big Indian Lake and the contributing watershed.

2.2 Water Quality Impairments

Big Indian Lake's assigned beneficial uses for Warmwater A (WWA) Aquatic Life and Aesthetics were identified as impaired due to excessive phosphorus and sediment.

2.3 Data Sources

The LBBNRD and NDEQ have collected various water quality data and information on a semi-regular basis mainly from 1995 through 2001. During 2002 the University of Nebraska-Lincoln monitored Big Indian Lake as part of a statewide lake classification project.

Sediment loading and volume loss estimates for Big Indian Lake were determined from GPS based storage volume (bathymetric) surveys conducted by the LBBNRD during the Phase I Diagnostic-Feasibility Study in 1995 and by the United States Geologic Survey under contract with NDEQ in 2003.

2.4 Water Quality Assessment

In the management of lakes and reservoirs, the concern associated with excessive phosphorus lies not with the direct toxicity impacts. Rather the concern is the impact to the biomass of the waterbody. Phosphorus loading can lead to extensive algal growth that impact recreation during blooms and can cause a dissolved oxygen deficit when die-off occurs.

A commonly used biomass related idiocies is that developed by Carlson and is referred to the Trophic State Index (TSI) (Carlson 1996). The index provides a numeric comparison of interrelated eutrophication parameters of total phosphorus (TSI(TP)), chlorophyll *a* concentration (TSI(Chl-a)) and secchi depth (transparency) (TSI(SD)).

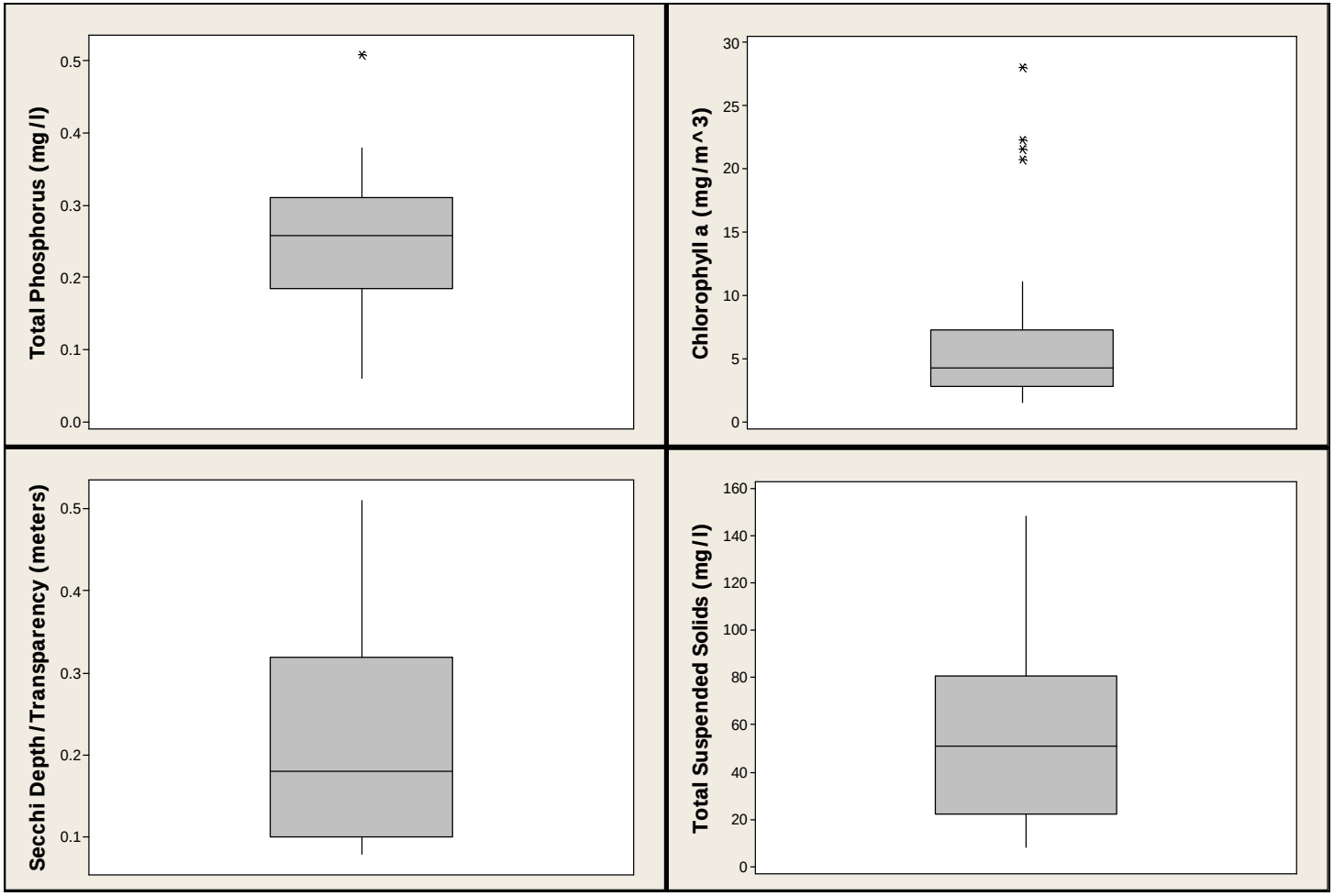
While not directly comparable, total suspended solids (TSS) information is used as the surrogate for sediment concentrations and sedimentation.

The parameters of concern for this waterbody assessment and TMDL are: total phosphorus, chlorophyll *a*, Secchi depth (transparency) and total suspended solids. Boxplots of the data are shown in Figure 2.4a and Table 2.4 provides the long-term average values.

Table 2.4 Big Indian Lake Data Summary

Parameter	Period of Record	Number of Samples	Value
Total Phosphorus	1995, 1997-998, 2001-2002	22	0.246 mg/l
Chlorophyll *a*	1995-1998, 2001-2002	27	7.3 mg/m^3
Secchi Depth	1995-1998, 2001-2002	27	0.23 meters (9 inches)
Total Suspended Solids	1995, 1997-98, 2001	17	56 mg/l

Figure 2.4a Boxplots of Big Indian Lake Data

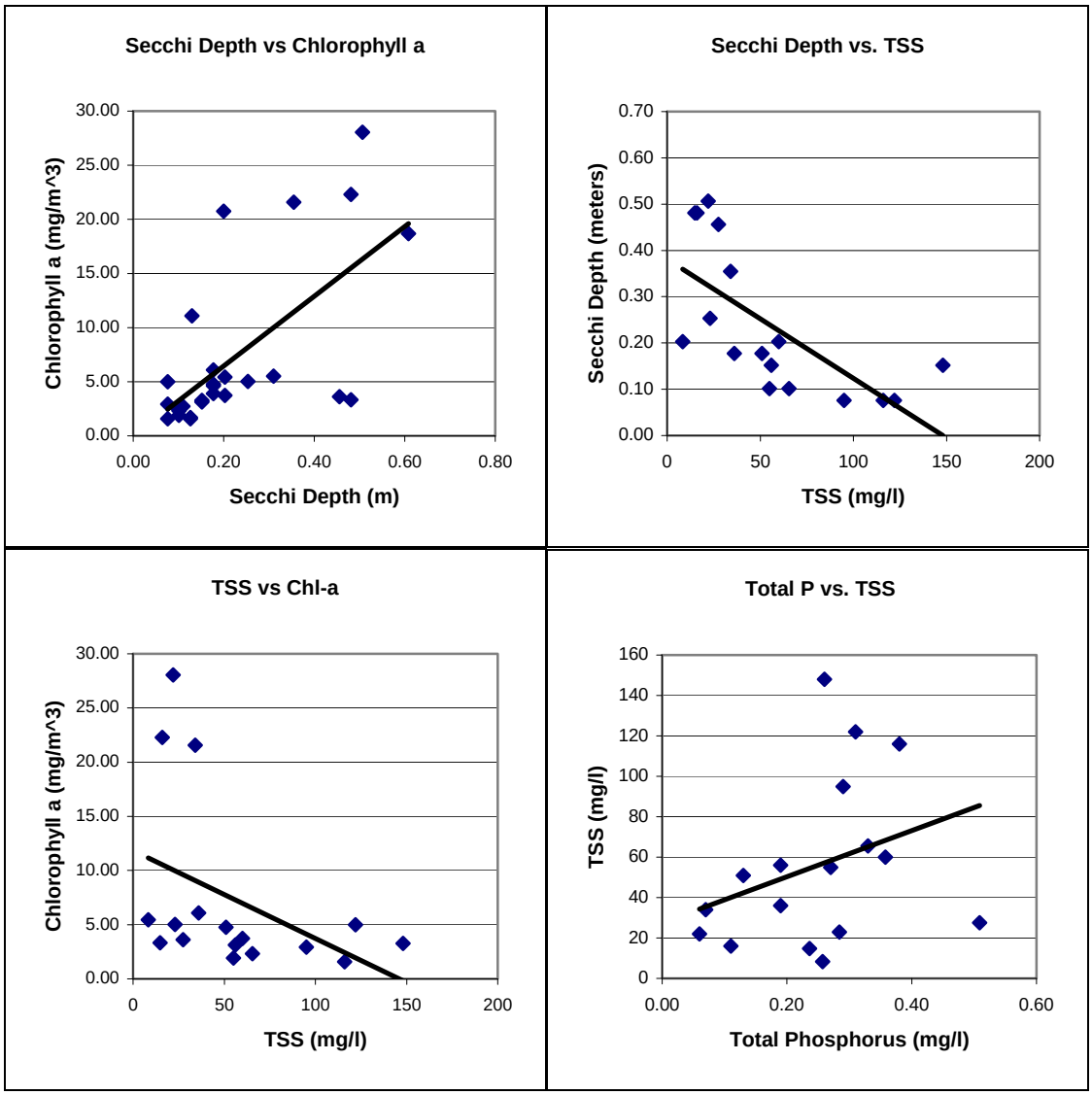


As stated, one of the major concerns with abundant phosphorus in a waterbody is the impact to the algal community. Chlorophyll *a* (Chl-a) is a commonly used parameter to describe algae densities. For Big Indian Lake the long-term average Chl-a value is 7.3 mg/m^3 which when translated into TSI units is 50.5. When this value is then used to assess the measured condition to an accepted condition the waterbody would be in the mesotrophic to the lower end of eutrophic attribute (Carlson 1996). Although the value is at the lower end of the eutrophic range, the 50.5 TSI(Chl-a) is low in comparison to other southeast Nebraska Lakes with TSI(Chl-a) scores generally in the 60s.

The average secchi depth/transparency for the period of record was low (0.22 meters) and based on the above described situation involving low Chl-a values, it is likely not due to algal production. Non-algal turbidity may be caused inorganic or other particles and are also likely limiting algae production.

The water quality patterns observed in Big Indian Lake are shown in Figure 2.4b.

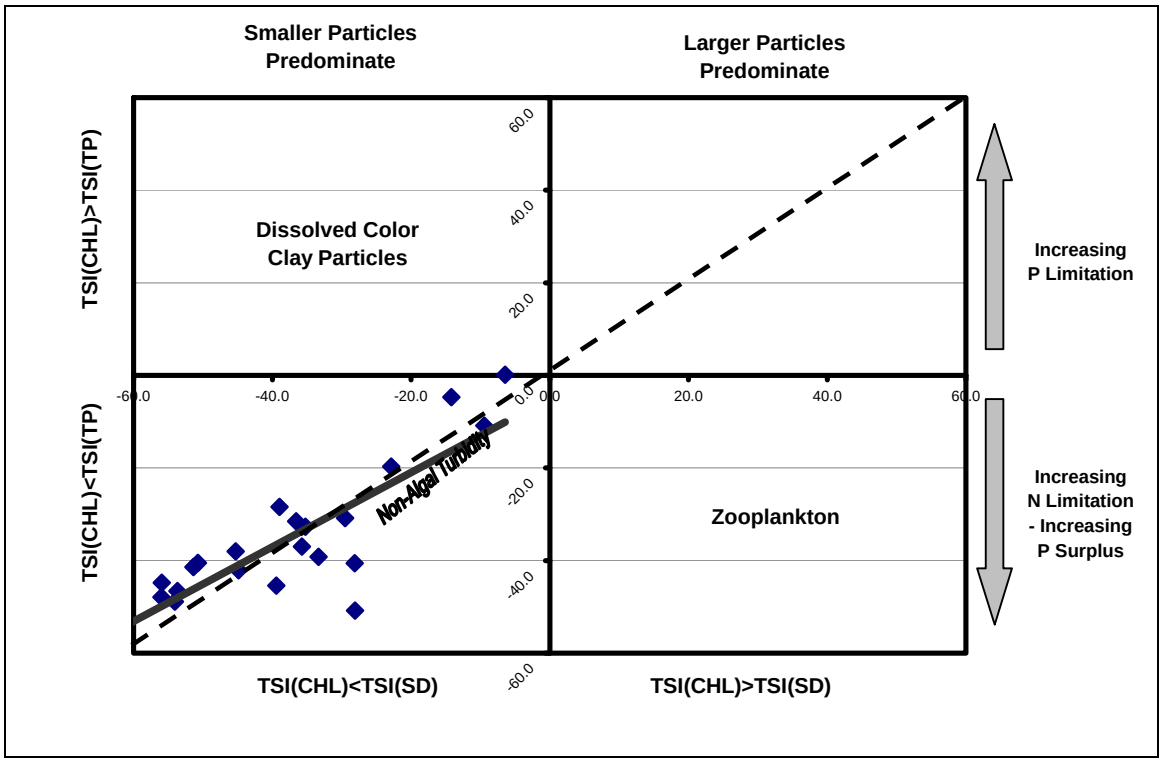
Figure 2.4b Water Quality Patterns Monitored at Big Indian Lake



The data shows a relationship of decreasing secchi and Chl-a with an increase of TSS further indicating the non-algal turbidity is causing low water clarity. Also shown in the figure is the role that TSS plays with the phosphorus concentrations, in that the relationship is positive. Not only does TSS factor in decreasing water clarity and production, the positive relationship indicates the delivery or resuspension of solids increases the water column phosphorus.

Another procedure for looking at deviations is a multivariate comparison that has been presented by Carlson (1992). If the deviations of TSI(Chl-a) - TSI(TP) and TSI(Chl-a) – TSI(SD) are simultaneously plotted the possible identifications of the deviations can be made (Figure 2.4c).

Figure 2.4c Multivariate Comparison of TSI Parameters



The zero line is related to a total nitrogen (TN) to total phosphorus (TP) rations greater than 33:1. Phosphorus has been generally thought to become limiting at a TN/TP ration of 10:1. An interpretation would be the greater the negative deviation, the greater probability of something other than phosphorus limits algae growth (Carlson 1996).

Points lying diagonally to the left of the origin indicate situations where phosphorus and transparency are correlated but chlorophyll *a* is not. Points on or near this (zero) line would be found in turbid situations where phosphorus is bound to clay particles and therefore phosphorus and turbidity are related but chlorophyll is not (Carlson 1996).

The plotted points for Big Indian Lake fall in the area described in the preceding paragraph and the conclusion that can be drawn is non-algal turbidity (such as TSS) is responsible for the low transparency and limits algae growth.

The situation then indicates the control or reduction of sediment and or solids is necessary to increase the transparency of the lake. Should this action occur, the phosphorus supply is sufficient to spur algae growth and transform the brown lake into a green or blue-green lake. It then becomes important to reduce the total phosphorus load.

2.5 Determination of Existing Nutrient Load

Determination of the existing nutrient load was completed using the CNET spreadsheet model and empirical data. The initial model run was completed using empirical tributary inflow total phosphorus concentration. The result was an annual total load of 2,383 lbs/yr (1,074 kg/yr) and a predicted in-lake concentration of 0.133 mg/l (Appendix A).

The predicted in-lake concentration of 0.133 mg/l is much lower that the observed 0.246 mg/l. To obtain the in-lake concentration of 0.246 mg/l the modeled load must be increased on 4,423 lbs/year (2,010 kg/yr) (Appendix B).

Resuspension of sediments from power boating, wind action and bottom feeding fish lead to nutrient cycling that is often referred to as internal loading. It is important to recognize the role that internal cycling/loading plays in the eutrophication process. That is, much effort can be placed in reducing the watershed load with no apparent improvements in lake water quality conditions due to the role of the internal loading component.

Finally, precipitation does provide a phosphorus input directly to the waterbody. The calculated precipitation load is 22 lbs/year (10 kg/year)

Therefore the two model outputs will be used to define the existing nutrient load for Big Indian Lake of 4,423 lbs/yr with table 2.5 providing the breakdown.

Table 2.5 Big Indian Lake Total Phosphorus Load

External Load	Internal Load	Precipitation Load	Total Existing Load
2,383 lbs/yr	2,048 lbs/yr	22 lbs	4,423 lb/yr
1,074 kg/yr	929 kg/yr	10 kg	2,013* kg/yr

*Values are rounded.

2.6 Determination of Existing Sediment Load

Based on the 1995 and 2003 bathymetric evaluations, Big Indian Lake's conservation pool has been reduced by 46 acre/feet. Using a sediment density value of 1,400 the acre-feet measurement was converted to tons and the total load is 64,400 tons with an average annual load of 8,050 tons/yr.

3.0 Total Phosphorus TMDL

3.1 Water Quality Goals

Nebraska does not have approved water quality criteria for total phosphorus. EPA has developed recommendations for criteria based on an ecoregion division. Rather than delay the preparation of TMDLs, the information will be applied as numeric translators of the aesthetics beneficial use. The aesthetics beneficial use is deemed impaired due to excessive phosphorus.

The criteria can be found in the EPA 2001 document entitled *Ambient Water Quality Criteria Recommendations- Information Supporting the Development of State and Tribal Nutrient Criteria - Lakes and Reservoirs in Nutrient Ecoregion V*

From this document, the aggregate ecoregion reference (25th percentile) value and the TMDL target is 0.033 mg/l.

3.2 Selection of Critical Environmental Conditions

The "critical condition" for which this nutrient TMDL applies is the entire year. An annual loading period was utilized in modeling Big Indian Lake's assimilative capacity and for estimating loading reductions necessary to meet in-lake water quality targets. This approach also takes into consideration that nutrients being lost from the water column and trapped in the bottom sediments have the potential to re-enter the water column at a later time. However, according to Title 117 the assessment of water quality information and application of the criteria are based on seasonal averages from April 1 through September 30.

3.3 Waterbody Pollutant Loading Capacity

The loading capacity for this nutrient TMDL is defined as the amount of phosphorus Big Indian Lake can receive on an annual basis and still meet the applicable water quality criteria and assigned beneficial use criteria. Utilizing the CNET model to meet the in-lake phosphorus water quality criteria, the loading capacity for phosphorus is 573 lbs/year (260 kg/year).

3.4 Deviation From Pollutant Loading Capacity

The targeted waterbody loading capacity for phosphorus, to meet the in-lake goals is 573 lbs/year and the modeled average annual load is 4,423 lbs/year. The loading capacity is being exceeded by 3,850 lbs/year and to achieve the loading capacity, an 87.5% reduction from the internal and external sources is needed.

3.5 Identification of Pollutant Sources

No point sources have been identified in the Big Indian Lake watershed so the pollutant load (excluding precipitation) is believed to originate from nonpoint sources. Typically, areas with high sediment yields also produce significant phosphorus loads.

3.6 Pollutant Allocation

A TMDL is defined as:

$$\text{TMDL} = \text{Loading Capacity} = \text{WLA} + \text{LA} + \text{Background} + \text{MOS}$$

As stated above, the phosphorus loading capacity for Big Indian Lake is 573 lbs/year (260 kg/year). To achieve the defined phosphorus loading capacity the required allocations are contained in the following sections.

3.6.1 Wasteload Allocation

No point sources of phosphorus discharge in the Big Indian Lake watershed therefore the wasteload allocation (WLA) will be "zero" (0).

3.6.2 Load Allocation

The phosphorus load allocation distributed among the nonpoint sources within the watershed will be 551 lbs/year (250 kg/year).

3.6.3 Natural Background

Utilizing annual precipitation, waterbody surface area and precipitation concentration the natural background load of phosphorus was determined to be approximately 22 lbs/year (10 kg/year).

3.6.4 Margin of Safety

The margin of safety for the nutrient TMDL will be: phosphorus can be discharged from the Big Indian Lake/Reservoir outlet without being utilized. While this reduction is realized in the system, the TMDL will not account for this and assume the phosphorus load delivered to the lake remains available for algae production.

3.6.5 Phosphorus TMDL Summary

TMDL/Waterbody Loading Capacity = 0 lbs/year (WLA) + 551 lbs/year (LA) + 22 lbs/year (Natural Background) + Implicit Margin of Safety

3.6.6 Conversion to Daily Load

The TMDL has established an annual average phosphorus load that if achieved should meet the water quality targets. A recent court decision often referred to as Anacostia decision have dictated that TMDLs include a "daily" load (*Friends of the Earth, Inc. v. EPA, et al.)*

Expressing this TMDL in daily time steps could mislead the reader by implying a daily response to a daily load. It is important to recognize that the growing season mean is affected by many factors such as the following: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

As stated, the TMDL does set a total phosphorus allocation of 573 lbs/year. To translate the long term average to maximum daily values EPA Region 7 has suggested the approach described in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001) (TSD). The maximum daily load (MDL) equals the long term average (LTA) * exp(z*sigma-0.5*sigma^2). The data used in the TMDL has a coefficient of variation (CV) of 0.429. From the TSD, the 99th percentile occurrence probability for a CV of 0.429 is 2.39. Using these assumptions, the MDL = LTA*2.39. Therefore, the total phosphorus would be:

573 lbs/year ÷365 days/year * 2.39 = 3.75 lbs/day (1.7 kg/day)

3.7 Internal vs. External Loading Reductions

The goal of the TMDL is to reduce the total phosphorus load by 87.5% to achieve the desired water quality criteria. Section 2.5 provides estimates of the contributing internal and external loads based on CNET modeling. Of the total existing nutrient load, 54% was estimated to be external and 46% was estimated to be internal.

The overall loading reduction requirement cannot be achieved solely through external source reductions. Therefore it is necessary to also reduce internal sources. As well, the reduction of internal sources and attainment of the goals may be obtained more quickly (e.g. dredging, alum treatments). However, long-term protection of the waterbody must also be considered and obtained through external source reductions.

For the purposes of this TMDL, the 87.5% reductions will be applied to each of the modeled loads – excluding precipitation. Adjustments may be appropriate in the future based on the desired or recommended implementation practices. The target loads are found in table 3.6.

Table 3.6 Target Loading Reductions

Loading Source	Existing Annual Load	87.5% Reduction
Internal Load	2,048 lbs/year	256 lbs/year
External Load	2,383 lbs/year	295 lbs/year
Precipitation Load	22 lbs/year	None Targeted
Total		**573 lbs/year**

4.0 Sediment TMDL

4.1 Water Quality Criteria and/or Goals

Nebraska does not have numeric water quality criteria for sediment or total suspended solids within Title 117.

4.1.1 Quantification of Narrative Water Quality Standards/Criteria: The Warmwater Class A *Aquatic Life* beneficial use is protected through the overall reservoir volume loss and the annual reservoir sedimentation rate utilized by NDEQ during waterbody assessments. In support of the sedimentation assessment criteria, the narrative criteria for the *Aesthetics* beneficial use found in Title 117 state in part "To be aesthetically acceptable, waters shall be free from human induced pollution which causes floating, suspended, colloidal or settleable materials that produce objectionable films, colors, turbidity or deposits" (NDEQ 2006b).

Assessment procedures in *Methodologies for Waterbody Assessments and Development of the 2006 Integrated Report for Nebraska* (NDEQ 2006c) will identify a waterbody as impaired when either the overall volume loss of a reservoir is loss ≥25% or annual sedimentation rate >0.75% per year.

Therefore, the quantification of the narrative criteria will be a target of <0.75% annual sedimentation rate.

4.2 Selection of Environmental Conditions

There are no "specific environmental or critical conditions" associated with this sediment TMDL because once the pollutant settles in a reservoir, it is assumed the have an infinite residence time and is present on a year round basis.

4.3 Waterbody Pollutant Loading Capacity

The loading capacity for this sediment TMDL is defined as the amount of sediment Big Indian Lake can receive on an annual basis and still meet the applicable water quality criteria and assigned beneficial use. Utilizing the 2003 bathymetric information and the assessment goal of <0.75% (0.74%) annual volume loss, the loading capacity for Big Indian Lake is 5,429 tons/year.

4.4 Deviation From Pollutant Loading Capacity

The targeted waterbody loading capacity for sediment, to meet the in-lake goals is 5,429 tons/year and the measured average annual load is 8,050 tons/year. The loading capacity is being exceeded by 2,621 tons/year and to achieve the loading capacity, a 32.6% reduction is needed.

4.5 Identification of Pollutant Sources

No point sources have been identified in the Big Indian Lake watershed so the pollutant load is believed to originate from nonpoint sources. For the TMDL the natural background will not be separated from the nonpoint sources or load allocation.

4.6 Pollutant Allocation

A TMDL is defined as:

TMDL = Loading Capacity = WLA + LA + Background + MOS

As stated above, the sediment loading capacity for Big Indian Lake is 5,429 tons/year. To achieve the defined sediment loading capacity the required allocations are contained in the following sections.

4.6.1 Wasteload Allocation

No point sources of sediment exist in the watershed therefore the wasteload allocation (WLA) will be "zero" (0 tons/year).

4.6.2 Load Allocation

The sediment load allocation distributed among nonpoint sources will be 5,426 tons/year. Base flows carry indiscernible amounts of sediment and thus natural background will not be separated from the load allocation.

4.6.3 Margin of Safety

The effects of sedimentation are most greatly realized when deposition occurs in the multi-purpose pool. Losses through the outlet and deposition in the flood storage zone will not be separated out. This assumes then that all the sediment delivered is deposited in the multi-purpose pool.

4.6.4 Sediment TMDL Summary

TMDL/Waterbody Loading Capacity = 0 lbs/year (WLA) + 5,426 tons/year (LA and Natural Background) + Implicit Margin of Safety

4.6.5 Conversion to Daily Load

The TMDL has established an annual average sediment load that if achieves should meet the water quality targets. A recent court decision often referred to as Anacostia decision have dictated that TMDLs include a "daily" load (*Friends of the Earth, Inc. v. EPA, et al.)*

Expressing this TMDL in daily time steps could mislead the reader by implying a daily response to a daily load. It is important to recognize that the annual load is affected by many factors including rainfall duration, intensity and frequency, vegetative cover and stream bank stability.

As stated, the TMDL does set an annual sediment allocation of 5,426 tons/year. To translate the long term average to maximum daily values EPA Region 7 has suggested the approach described in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001) (TSD). The maximum daily load (MDL) equals the long term average (LTA) * exp (z*sigma-0.5*sigma^2).

In order to calculate the MDL a coefficient of variation is needed. The data set does not contain true sediment measurements therefore the TSS data will be used as a surrogate. The TSS data used in the TMDL has a coefficient of variation (CV) of 0.743. From the TSD, the 99th percentile

occurrence probability for a CV of 0.743 is 3.75. Using these assumptions, the MDL = LTA*3.75. Therefore, the sediment would be:

$$5{,}426 \text{ tons/year} \div 365 \text{ days/year} * 3.75 = 55.8 \text{ tons/day}$$

5.0 Implementation Plan

The implementation plan for this TMDL will be fairly simple and straightforward. Several layers of control are necessary to achieve the total phosphorus and sediment reduction goals. Because phosphorus readily attaches to sediment particles, nonpoint source reduction activities that target sediment will be pursued. These include:

Overland and Gully Erosion: Desired implementation activities will be targeted at the areas identified as being the largest contributors of sediment to the lake. These areas typically correspond to crop areas on steeper slopes that do not have best management practices in place.

- Implement management practices that will increase crop residue such as no-till farming,
- Construct terraces and grassed waterways.
- Install buffer strips along stream corridors.
- Construct grade stabilization structures to reduce head cutting and gully expansion.

Stream bank Erosion: Desired implementation activities will be targeted at the areas identified as being that largest contributor of sediment from eroding stream banks.

- Install check dams on smaller tributaries to reduce peak flows during runoff events.
- Install stream bank protection using vegetation and graded rock.

Also, the LBBNRD has expressed interest in developing a water quality/watershed management plan for Big Indian Lake. In developing watershed management plans the sponsor (LBBNRD) brings stakeholders to develop a community based plan that includes goals and management strategies. At a minimum the plan will establish reduction and management activities that are consistent with those established by the TMDLs.

5.1 Reasonable Assurances

Effective management of nonpoint source pollution in Nebraska necessarily requires a cooperative and coordinated effort by many agencies and organizations, both public and private. Each organization is uniquely equipped to deliver specific services and assistance to the citizens of Nebraska to help reduce the effects of nonpoint source pollution on the State's water resources. Appendix C lists those entities that may be included in the implementation process. These agencies have been identified as being responsible for program oversight or fund allocation that may be useful in addressing and reducing sedimentation and nutrient delivery to Big Indian Lake. Participation will depend on the agency/organization's program capabilities.

To address the impairments, the Lower Big Blue Natural Resource District has committed to undertake a watershed planning and treatment installation process. Applications for funding have been made to the Nebraska Environmental Trust Fund, EPA Section 319 and NRCS-Environmental Quality Incentives Program.

6.0 Future Monitoring

Monitoring of Big Indian Lake will be conducted in the future to determine if the water quality is improving, degrading or remaining status quo. As well, monitoring will be conducted to evaluate the effectiveness of implemented best management practices (BMPs). A formal monitoring plan will be prepared in conjunction with the watershed management plan. Monitoring typically will be planned for ten years following project implementation and completion. The data will be collected once monthly during the growing season (May-September).

7.0 Public Participation

The public was invited to review and comment on the draft TMDLs with an announcement being published in the Beatrice Daily Sun and the Wymore Arbor State. The review and comment period ran from approximately May 19, 2009 to June 30, 2009. These TMDLs were also made available to the public on the NDEQ's Internet site and announcements were emailed to identified stakeholders. No comments were received as a result of this public notice.

8.0 References

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Appendix A – CNET Model Prediction of External Load

RESERVOIR EUTROPHICATION MODELING WORKSHEET			TITLE	**Big Indian - External**				Based on CNET.WK1 VERSION 1.0			
VARIABLE	UNITS	Current	LC	VARIABLE	UNITS	Current	LC	VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS		Latitude	40	AVAILABLE P BALANCE				RESPONSE CALCULATIONS			
Drainage Area	km2	14.2	14.2	Precipitation Load	kg/yr	5	5	Reservoir Volume	hm3	0.678	0.678
Precipitation	m/yr	0.79	0.79	NonPoint Load	kg/yr	247	58	Residence Time	yrs	0.4264	0.4264
Evaporation	m/yr	1.17	1.17	Point Load	kg/yr	0	0	Overflow Rate	m/yr	5.3	5.3
Unit Runoff	m/yr	0.12	0.12	Total Load	kg/yr	252	63	Total P Availability Factor		1	1
Stream Total P Conc.	ppb	630	147	Sedimentation	kg/yr	40	10	Ortho P Availability Factor		0	0
Stream Ortho P Conc.	ppb	0	0	Outflow	kg/yr	212	53	Inflow Ortho P/Total P		0.000	0.000
Atmospheric Total P Load	kg/km2-yr	32.95	32.95	PREDICTION SUMMARY				Inflow P Conc	ppb	158.4	39.3
Atmospheric Ortho P Load	kg/km2-yr	0	0	P Retention Coefficient	-	0.159	0.159	P Reaction Rate - Mods 1 & 8		3.3	0.8
POINT SOURCE CHARACTERISTICS				Mean Phosphorus	ppb	133.3	33.1	P Reaction Rate - Model 2		#DIV/0!	#DIV/0!
Flow	hm3/yr	0	0.0	Mean Chlorophyll-a	ppb	1.3	7.0	P Reaction Rate - Model 3		6.8	1.7
Total P Conc	ppb	0	0.0	Algal Nuisance Frequency	%	0.0	3.7	1-Rp Model 1 - Avail P		0.421	0.653
Ortho P Conc	ppb	0	0	Mean Secchi Depth	meters	0.20	0.46	1-Rp Model 2 - Decay Rate		#DIV/0!	#DIV/0!
RESERVOIR CHARACTERISTICS				Hypol. Oxygen Depletion A	mg/m2-d	269.5	633.5	1-Rp Model 3 - 2nd Order Fixed		0.318	0.530
Surface Area	km2	0.3	0.3	Hypol. Oxygen Depletion V	mg/m3-d	359.4	844.7	1-Rp Model 4-Canfield-Bachman		0.394	0.596
Max Depth	m	4.88	4.88	Organic Nitrogen	ppb	499.8	428.8	1-Rp Model 5- Vollenweider 76		0.605	0.605
Mean Depth	m	2.26	2.26	Non Ortho Phosphorus	ppb	97.0	43.9	1-Rp Model 6 - First Order Decay		0.701	0.701
Non-Algal Turbidity	1/m	4.17	1.5	Chl-a x Secchi	mg/m2	0.3	3.2	1-Rp Model 7 - First Order Setting		0.841	0.841
Mean Depth of Mixed Layer	m	2.26	2.26	Principal Component 1	-	2.41	2.55	1-Rp Model 8 - 2nd Order Tp Only		0.421	0.653
Mean Depth of Hypolimnion	m	0.75	0.75	Principal Component 2	-	-0.33	0.43	1-Rp – Used		0.841	0.841
Observed Phosphorus	ppb	246	40.0		Observed	Pred	Target	Reservoir P Conc	ppb	133.3	33.1
Observed Chl-a	ppb	7.3	20.0	Carlson TSI P	83.6	74.7	54.7	Gp		0.452	0.452
Observed Secchi	meters	0.23	0.50	Carlson TSI Chl-a	50.1	32.9	49.7	Bp	ppb	166.9	24.8
MODEL PARAMETERS				Carlson TSI Secchi	81.2	83.0	71.3	Chla vs.P, Turb, Flushing	2	1.3	7.0
BATHTUB Total P Model #	(1-8)	7	7	OBSERVED / PREDICTED RATIOS				Chla vs. P Linear	4	37.3	9.3
BATHTUB Total P Model Name		SETTLING		Phosphorus		1.85	1.21	Chla vs. P 1.46	5	102.5	13.4
BATHTUB Chl-a Model Number	(2,4,5)	2	2	Chlorophyll-a		5.79	2.87	Chla Used	ppb	1.3	7.0
BATHTUB Chl-a Model Name		P L Q		Secchi		1.13	1.10	ml - Nuisance Freq Calc.		0.1	1.8
Beta = 1/S vs. C Slope	m2/mg	0.595593	0.1	OBSERVED/PREDICTED T-STATISTICS				z		4.894	1.787
P Decay Calibration (normally =1)		1	1	Phosphorus		2.26	0.70	v		0.000	0.081
Chlorophyll-a Calib normally = 1)		1	1	Chlorophyll-a		6.46	3.88	w		0.380	0.627
Chla Temporal Coef. of Var.		0.55	0.55	Secchi		0.46	0.35	x		0.000	0.037
Chla Nuisance Criterion	ppb	16	16	ORTHO P LOADS				TOTAL P LOADS			
WATER BALANCE								BAF Override (KS)	OrP %		
Precipitation Flow	hm3/yr	0.24	0.24	Precipitation	kg/yr	0	0	0.5	0%	10	10
NonPoint Flow	hm3/yr	1.70	1.70	NonPoint	kg/yr	0	0	0.23	0%	1074	250
Point Flow	hm3/yr	0.00	0.00	Point	kg/yr	0	0	0.8	0%	0	0
Total Inflow	hm3/yr	1.94	1.94	Total	kg/yr	0	0			1083	260
Evaporation	hm3/yr	0.35	0.35	Total	lbs/year	0	0			2383	573
Outflow	hm3/yr	1.59	1.59								

Appendix B – CNET Model Prediction of Total Load to Meet In-Lake Concentration and Loading Capacity

RESERVOIR EUTROPHICATION MODELING WORKSHEET			TITLE	Big Indian - Total Load				Based on CNET.WK1 VERSION 1.0			
VARIABLE	UNITS	Current	LC	VARIABLE	UNITS	Current	LC	VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS		Latitude	40	AVAILABLE P BALANCE				RESPONSE CALCULATIONS			
Drainage Area	km2	14.2	14.2	Precipitation Load	kg/yr	5	5	Reservoir Volume	hm3	0.678	0.678
Precipitation	m/yr	0.79	0.79	NonPoint Load	kg/yr	460	58	Residence Time	yrs	0.4264	0.4264
Evaporation	m/yr	1.17	1.17	Point Load	kg/yr	0	0	Overflow Rate	m/yr	5.3	5.3
Unit Runoff	m/yr	0.12	0.12	Total Load	kg/yr	465	63	Total P Availability Factor		1	1
Stream Total P Conc.	ppb	1174	147	Sedimentation	kg/yr	74	10	Ortho P Availability Factor		0	0
Stream Ortho P Conc.	ppb	0	0	Outflow	kg/yr	391	53	Inflow Ortho P/Total P		0.000	0.000
Atmospheric Total P Load	kg/km2-yr	32.95	32.95	PREDICTION SUMMARY				Inflow P Conc	ppb	292.5	39.3
Atmospheric Ortho P Load	kg/km2-yr	0	0	P Retention Coefficient	-	0.159	0.159	P Reaction Rate - Mods 1 & 8		6.0	0.8
POINT SOURCE CHARACTERISTICS				Mean Phosphorus	ppb	246.1	33.1	P Reaction Rate - Model 2		#DIV/0!	#DIV/0!
Flow	hm3/yr	0	0.0	Mean Chlorophyll-a	ppb	1.3	7.0	P Reaction Rate - Model 3		12.5	1.7
Total P Conc	ppb	0	0.0	Algal Nuisance Frequency	%	0.0	3.7	1-Rp Model 1 - Avail P		0.332	0.653
Ortho P Conc	ppb	0	0	Mean Secchi Depth	meters	0.20	0.46	1-Rp Model 2 - Decay Rate		#DIV/0!	#DIV/0!
RESERVOIR CHARACTERISTICS				Hypol. Oxygen Depletion A	mg/m2-d	271.2	633.5	1-Rp Model 3 - 2nd Order Fixed		0.246	0.530
Surface Area	km2	0.3	0.3	Hypol. Oxygen Depletion V	mg/m3-d	361.6	844.7	1-Rp Model 4 - Canfield & Bachman		0.311	0.596
Max Depth	m	4.88	4.88	Organic Nitrogen	ppb	500.1	428.8	1-Rp Model 5 - Vollenweider 1976		0.605	0.605
Mean Depth	m	2.26	2.26	Non Ortho Phosphorus	ppb	97.0	43.9	1-Rp Model 6 - First Order Decay		0.701	0.701
Non-Algal Turbidity	1/m	4.17	1.5	Chl-a x Secchi	mg/m2	0.3	3.2	1-Rp Model 7 - First Order Setting		0.841	0.841
Mean Depth of Mixed Layer	m	2.26	2.26	Principal Component 1	-	2.41	2.55	1-Rp Model 8 - 2nd Order Tp Only		0.332	0.653
Mean Depth of Hypolimnion	m	0.75	0.75	Principal Component 2	-	-0.33	0.43	1-Rp - Used		0.841	0.841
Observed Phosphorus	ppb	246	40.0		Observed	Pred	Target	Reservoir P Conc	ppb	246.1	33.1
Observed Chl-a	ppb	7.3	20.0	Carlson TSI P	83.6	83.6	54.7	Gp		0.452	0.452
Observed Secchi	meters	0.23	0.50	Carlson TSI Chl-a	50.1	33.0	49.7	Bp	ppb	386.6	24.8
MODEL PARAMETERS				Carlson TSI Secchi	81.2	83.0	71.3	Chla vs. P, Turb, Flushing	2	1.3	7.0
BATHTUB Total P Model Number	(1-8)	7	7	OBSERVED / PREDICTED RATIOS				Chla vs. P Linear	4	68.9	9.3
BATHTUB Total P Model Name		SETTLING		Phosphorus		1.00	1.21	Chla vs. P 1.46	5	250.8	13.4
BATHTUB Chl-a Model Number	(2,4,5)	2	2	Chlorophyll-a		5.72	2.87	Chla Used	ppb	1.3	7.0
BATHTUB Chl-a Model Name		P L Q		Secchi		1.13	1.10	ml - Nuisance Freq Calc.		0.1	1.8
Beta = 1/S vs. C Slope	m2/mg	0.595593	0.1	OBSERVED / PREDICTED T-STATISTICS				z		4.872	1.787
P Decay Calibration (normally =1)		1	1	Phosphorus		0.00	0.70	v		0.000	0.081
Chlorophyll-a Calib (normally = 1)		1	1	Chlorophyll-a		6.42	3.88	w		0.382	0.627
Chla Temporal Coef. of Var.		0.55	0.55	Secchi		0.46	0.35	x		0.000	0.037
Chla Nuisance Criterion	ppb	16	16	ORTHO P LOADS				TOTAL P LOADS			
WATER BALANCE								BAF Override (KS)	OrP %		
Precipitation Flow	hm3/yr	0.24	0.24	Precipitation	kg/yr	0	0	0.5	0%	10	10
NonPoint Flow	hm3/yr	1.70	1.70	NonPoint	kg/yr	0	0	0.23	0%	2000	250
Point Flow	hm3/yr	0.00	0.00	Point	kg/yr	0	0	0.8	0%	0	0
Total Inflow	hm3/yr	1.94	1.94	Total	kg/yr	0	0			2010	260
Evaporation	hm3/yr	0.35	0.35	Total	lbs/year	0	0			4423	573
Outflow	hm3/yr	1.59	1.59								

Appendix C – Federal, State and Local Agency and Private Organizations Included in TMDL Implementation

FEDERAL

- Bureau of Reclamation
- Environmental Protection Agency
- Fish and Wildlife Service
- Geological Survey
- Department of Agriculture - Farm Services Agency
- Department of Agriculture - Natural Resources Conservation Service

STATE

- Association of Resources Districts
- Department of Agriculture
- Department of Environmental Quality
- Department of Roads
- Department of Water Resources
- Department of Health and Human Services
- Environmental Trust
- Game and Parks Commission
- Natural Resources Commission
- University of Nebraska Institute of Agriculture and Natural Resources (IANR)
- UN-IANR: Agricultural Research Division
- UN-IANR: Cooperative Extension Division
- UN-IANR: Conservation and Survey Division
- UN-IANR: Nebraska Forest Service
- UN-IANR: Water Center and Environmental Programs

LOCAL

- Natural Resources Districts
- County Governments (Zoning Board)
- City/Village Governments

NON-GOVERNMENTAL ORGANIZATIONS

- Nebraska Wildlife Federation
- Pheasants Forever
- Nebraska Water Environment Association
- Nebraska Corn Growers Association, Wheat Growers, etc.
- Nebraska Cattlemen's Association, Pork Producers, etc
- Other specialty interest groups
- Local Associations (i.e. homeowners associations)