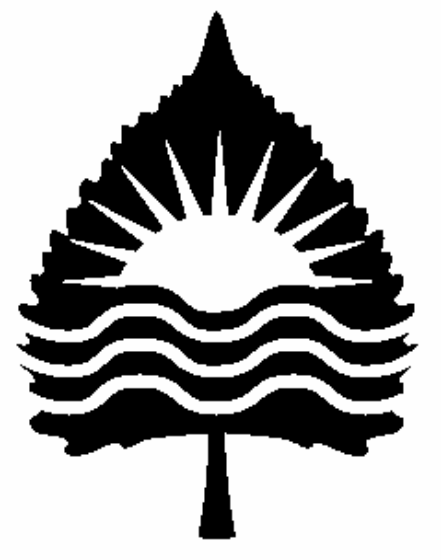

Total Maximum Daily Load
for
Fremont Lake #20E
Dodge County, Nebraska

Parameters of Concern: Algal Toxins
Pollutant Addressed: Phosphorus

Nebraska Department of Environmental Quality
Planning Unit, Water Quality Division

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List of Figures and Tables

Executive Summary

Fremont Lake #20E was included as a Category 5 waterbody in the 2006 Nebraska Surface Water Quality Integrated Report (NDEQ 2006) due to impairment by algal toxins. As such, a total maximum daily load must be developed in accordance with the Clean Water Act. This document presents the TMDL, for phosphorus this impairment. The information contained herein should be considered one TMDL.

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.**
   Fremont Lake #20E, Section 17, T 17 North, R 8 East, Dodge County, Nebraska. Lat. 41° 26' 14", Long. 96° 32' 58"

2. **Identification of the pollutant and applicable water quality standard**
   The parameter causing the impairment(s) of the water quality target, designated beneficial uses and for which these TMDLs are being developed is algal toxins with the targeted pollutant being phosphorus. Designated uses assigned Fremont Lake #20E include: primary contact recreation, aquatic life Warmwater Class A, agriculture water supply class A and aesthetics (NDEQ 2006). Excessive algal toxins have been determined to be impairing the primary contact recreation beneficial use.

3. **Quantification of the pollutant load that may be present in the waterbody and still allows attainment and maintenance of the water quality standards.**
   Empirical data and the Canfield-Bachmann natural lake water quality model were employed to determine the current and maximum phosphorus load that if achieved should result in beneficial use attainment. This value is 120 lbs/year (54.4 kg/year) for phosphorus.

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 Fremont Lake 20E is estimated to be 839 lbs/year (381 kg/year). To meet the water quality goals, the average annual loading capacity is 120 lbs/year and approximately an 86% reduction is needed.

5. **Identification of the pollution source categories.**
   Nonpoint and natural sources of nutrients have been identified as the cause of impairment to Fremont Lake #20E.

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 this TMDL the phosphorus load allocation (including natural background) was set at 108 lbs/year (49 kg/yr). This allocation was developed using models and empirical data.

8 **A margin of safety.**
   This TMDL contain an explicit margin of safety of 10% or 12 lbs/year (5.4 kg/year).

9. **Consideration for seasonal variation.**
   The pollutant of concern is delivered on a year round basis and the assessment of the data considers recreation season and annual average conditions.

10. Allowances for reasonably foreseeable increases in pollutant loads.
There was no allowance for future growth included in these TMDLs.

11. Implementation Plan

An implementation plan has been developed and will be utilized to reduce water column total phosphorus. Implementation includes the removal of "rough fish" and treatment of the lake with aluminum.

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

Fremont Lake #20E was included in Category 5 (Section 303(d) list) of the 2006 Nebraska Surface Water Quality Integrated Report (IR) (NDEQ 2006) as not supporting the primary contact recreation beneficial uses with the parameter of concern being algal toxins.

During the summers of 2004-06 following concerns raised by recreational users of Nebraska waters, the Department and other entities began weekly sampling and analysis for microcystin. Microcystin is a toxin produced by some types of cyanobacteria also referred to as blue green algae. The toxin can produce rashes, lesions and blisters on humans, pets and livestock from external contact and may be fatal if ingested. Currently, there are no water quality criteria for the assessment of microcystin data. The Department in conjunction with the Nebraska Department of Health and Human Services, the Nebraska Game and Parks Commission and the University of Nebraska has developed a process for issuing a "Health Alert" based on frequent monitoring to warn users of the potential dangers associated with primary contact recreation in the affected waterbodies.

The warning levels used to issue health alerts were established based on literature review and other available information from the World Health Organization. As stated, Title 117 – Nebraska Surface Water Quality Standards (Title 117) does not currently include water quality criteria for microcystin for the protection of the primary contact recreation beneficial use. Although blue-green algae have been an issue for some time in Nebraska waters, the concerns were mainly focused on aesthetics rather than primary contact recreation. The Department is in the process of collecting and reviewing additional information from Nebraska waterbodies as well as tracking the problem and solutions in other areas. During the 2008 triennial review of Title 117, the parameters will be examined for potential inclusion with two of the options being a numeric value(s) or narrative statements.

Data collected by the University of Nebraska during 2005 indicated the annual growing season total phosphorus mean concentration exceeds the recently adopted phosphorus criteria for sandpits. The impaired assessment will likely be included in the 2008 IR.

While no criterion for algal toxins exists, the role of nutrients in accelerating eutrophication is clear (EPA 1999), thus it is appropriate to develop a TMDL for the pollutant (phosphorus) rather than the response variable. Therefore, based on the above and as required by Section 303(d) of the Clean Water Act and 40 CFR Part 130.7, a TMDL will be developed for phosphorus to address the microcystin/algal toxin impairment.

1.1 Background Information

Fremont Lake #20E (Fremont #20) located in Dodge County, Nebraska (Figure 1) and is part of the Fremont Lakes State Recreation Area (SRA). The SRA includes 20 sandpit lakes with approximately 300 surface acres of water that lie adjacent to the Platte River. The lake and associated area are owned by the State of Nebraska and operated by the Nebraska Game and Parks Commission who manages the recreational facilities as well as the fishery. Fremont #20 has a limited watershed and no towns exist within the boundary however, Fremont (population 25,314) lies approximately three miles to the east.

1.1.1 Waterbody Description

1.1.1.1 Waterbody Name: Fremont Lake #20E

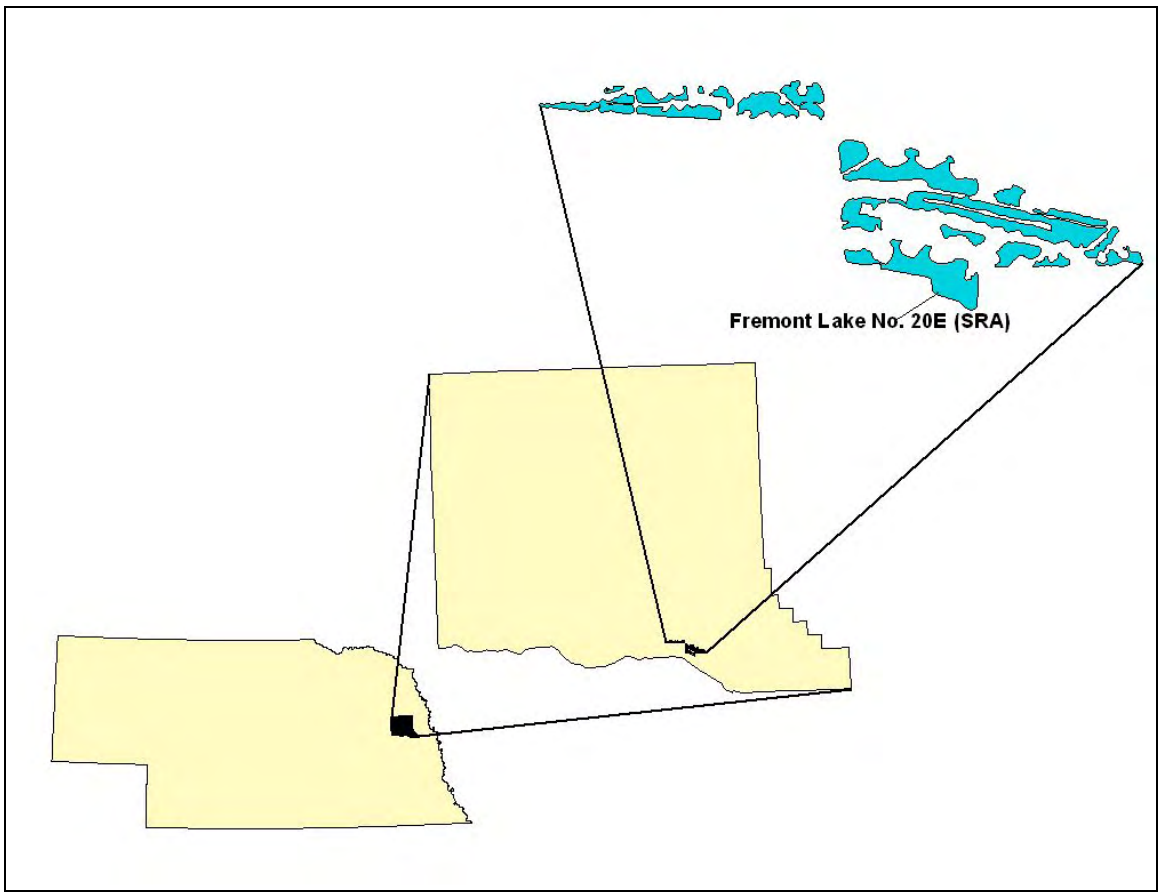
Lake Identification Number: LP1-L0250 (Tile 117 – Nebraska Surface Water Quality Standards)

1.1.1.2 Major River Basin: Missouri River

1.1.1.3 Minor River Basin: Lower Platte

1.1.1.4 Hydrologic Unit Code: 10200202

Figure 1.1 Fremont Lake#20E, Dodge County, NE



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 2006).

1.1.1.6 Major Tributary: None

1.1.2 Watershed Characterization

1.1.2.1 Physical Features: Fremont #20 is a sandpit lake with a limited watershed and is located in the Western Corn Belt Plains (Level III) ecoregion as defined by Chapman, et al. (2001). The lake is part of the Fremont Lake State Recreation Area that is managed by the NGPC. The area directly surrounding the lake consists of the recreation area and deciduous forest areas.

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 28 inches (National Climate Data Center). The majority of the precipitation occurs during the growing season.

1.1.2.3 Demographics: While no municipality lies in the limited watershed, the City of Fremont – populations 25,164 lies approximately 3 miles to the east. As well, the City of Omaha and Lincoln are approximately 24 miles to the southeast and 41 miles to the south, respectively.

1.1.2.4 Land Uses: The limited watershed consists of a state recreation area and deciduous forest.

Table 1.1 Physical Description of Fremont Lake #20E

Parameter	Fremont Lake #20E
State	Nebraska
County	Dodge
Latitude (center of dam)	41° 26' 14"
Longitude (center of dam)	96° 32' 58"
Section, Township, Range (dam)	Section 17, T 17 North, R 8 East
Surface Area – 1985	50 acres
Shoreline length (approximate)	2.0 miles
Mean Depth – 1986	11.0 feet (3.36 meters)
Conservation Pool Volume – 2001	552 acre-feet
Number of Major Inlets	0

2.0 Phosphorus TMDL to Address Algal Toxin Impairment

2.1 Problem Identification

Fremont #20 was included as a Category 5 waterbody on the 2006 Nebraska Surface Water Quality Integrated Report (Integrated Report), as being impaired by algal toxins. Toxin levels have been observed to increase as algae density increases and often spikes when "blooms" occur. While some species of green algae are beneficial to fish and other aquatic life, some species of blue-green algae are known to be toxic to animal and humans (Brakhage 2004). Nutrient concentrations, particularly phosphorus, play a role in the quantity of algae produced. Most Nebraska lakes have ample supply of phosphorus to produce significant algae blooms (Brakhage 2004).

Algae toxins are the result of increased algae densities. Algae densities are the response to the nutrients available within the waterbody. To address the impairment, algae densities must be controlled, which is best accomplished through the reduction of nutrients. Therefore, this TMDL will focus on phosphorus as the pollutant of concern to address the algal toxin impairment.

2.1.1 Water Quality Impairments

Fremont #20 assigned beneficial use for primary contact recreation was assessed to be impaired due to excessive algal toxins.

2.1.2 Data Sources

The Lower Platte North Natural Resource District and NDEQ collected microcystin samples starting in 2004 and continuing through the 2006 recreation season (May 1 – September 30). In the preparation of the 2006 Integrated Report, only data from 2004-05 was utilized.

2.1.3 Water Quality Data Assessment

Title 117 does not include criteria for algal toxins however; the NDEQ, Nebraska Game and Parks Commission and the Nebraska Health and Human Services System collaborated to establish conditions where a waterbody would be considered unsafe for primary contact recreation. When these conditions were observed, the management agencies would post information advising the public to exercise caution when boating or potentially coming into contact with the water and the affected beaches were closed.

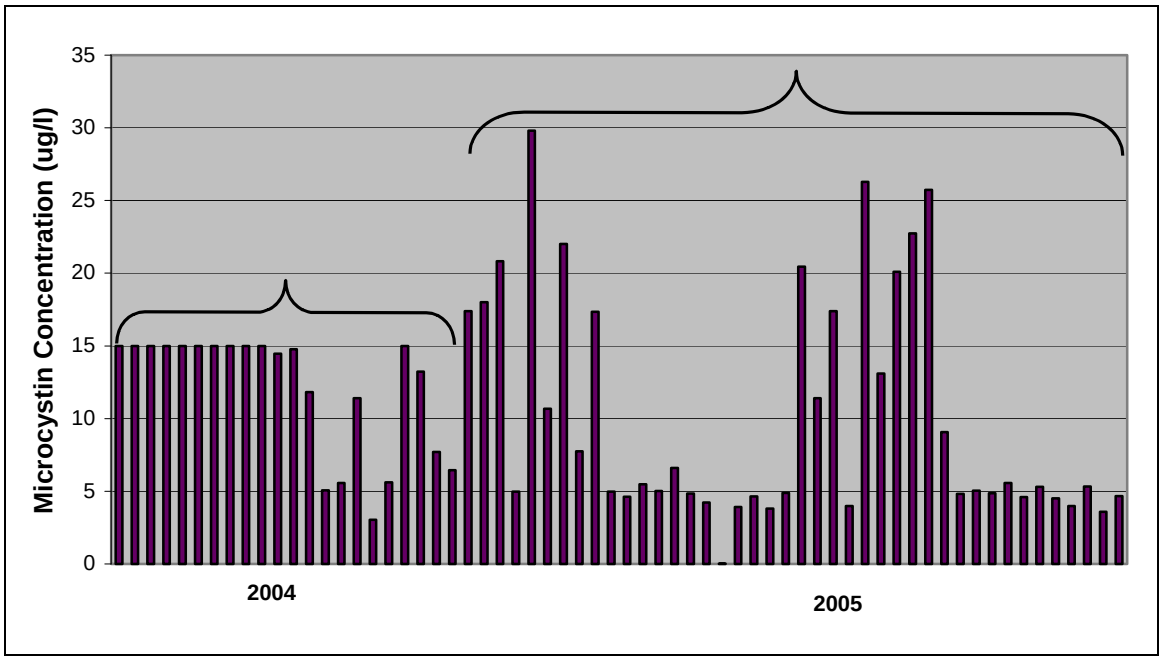
The posting and closing of beaches was initiated in 2004. Based on the information available at the time a microcystin level of 15 μg/l was the basis for the action. Further review of data and information during the winter of 2004-2005 led to a value of 20 μg/l as the action value, which was continued during 2006.

Assessment of the 2004 data was based on a comparison to 15 μg/l and for subsequent years was based on 20 μg/l.

Impairment will be defined as an exceedance rate of more than 10 percent. The number of exceedances was selected to maintain a *Type I error* probability below 10 percent (i.e., $\alpha < 0.1$). All waters assessed to have an impaired beneficial use and meeting the 90% confidence interval shall be included in either Category 4 or 5 of the State of Nebraska Integrated Report (NDEQ 2006).

2.1.3.1 Water Quality Conditions: For the assessment period 2004-2005, 64 microcystin samples were obtained during the recreation season. Nineteen samples exceeded the applicable action level. The data is illustrated in Figure 2.1.3.1. Is should be noted, analytical techniques applied in 2004 had maximum reporting value of 15 μg/l.

Figure 2.1.3.1 Fremont #20 Microcystin Data 2004-2005



Phosphorus water quality data collected in 2005 was not available when the assessments for the 2006 IR were completed. As well, NDEQ was in the process of modifying Title 117 to include criteria for total phosphorus, total nitrogen and chlorophyll a, applicable to lakes and impounded waters.

The data was assesses during the TMDL preparation and yielded a total phosphorus growing season average of 0.163 mg/l.

2.1.4 Potential Pollutant Sources

2.1.4.1 Point Source: No point sources, permitted under the National Pollutant Discharge Elimination System (NPDES) program has been identified in the Fremont #20 watershed

2.1.4.2 Nonpoint Sources: Nonpoint phosphorus sources identified in the Fremont #20 watershed include: bank erosion, groundwater inflow and deposition and decomposition of vegetative material from the surrounding landscape.

2.1.4.3 Natural Sources: Natural background phosphorus can be contributed from precipitation events however; natural source will not be separated from the nonpoint source contribution.

2.2 TMDL Endpoint

There will be two endpoints for this TMDL. The first endpoint will be to maintain the water quality within the recreation season based on the NDEQ action levels and the second will be to maintain an in-lake phosphorus value consistent with criteria in Title 117.

2.2.1 Targeted Beneficial Use

As previously outlined in Section 2.1.3, Nebraska does not have numeric water quality standards for nutrients or algal toxins. However, Nebraska's water quality standards for "Aesthetics" states 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 2006).

2.2.1.1 Linkage of a Numeric Water Quality Target to Impaired Beneficial Use: Algal toxins (microcystin) were deemed the parameter impairing the beneficial use. Phosphorus was selected as the parameter of concern as algal growth is mainly controlled by phosphorus (NALMS 2001). Past monitoring has shown Nebraska waterbodies to be phosphorus limited.

The nuisance growth of algae is on aspect of eutrophication that is recognized as a water quality problem. While there are species of algae that are beneficial to fish and other aquatic life, the occurrence of scums, odors and toxins are attributed to blue-green algae (Brakhage 2004). Lakes with excessive algal scums and where blue-green algae are often deemed hypereutrophic.

Carlson developed a biomass trophic state index (TSI) (Carlson 1977; Carlson and Simpson 1996) that can be used as a metric for evaluating this source/stressor and to provide numeric goals for the various stages of eutrophication. TSI's can calculated from transparency (secchi depth), chlorophyll *a*, and total phosphorus concentration data (USEPA 1999) as shown below.

Trophic State Index Score	Trophic Status
<40	Oligotrophic
>35 but <45	Mesotrophic
>45	Eutrophic
>60	Hypereutrophic

For this TMDL the goal will be to achieve a TSI value for phosphorus that is not considered hypereutrophic (TSI <60). To achieve the numeric target, the in-lake total phosphorus must be 0.047 mg/l.

2.2.2 Selection of Critical Environmental Conditions

The "critical condition" for which the nutrient portion of this TMDL applies is the entire year. Although the April-October growing season data is utilized, the loading to meet the conditions is an annual load. This approach 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.

The critical condition for algal toxins is the recreation season of May 1 through September 30.

2.2.3 Waterbody Pollutant Loading Capacity

The loading capacity for this nutrient TMDL is defined as the amount of phosphorus Fremont #20 can receive on an average annual basis and still meet the applicable in-lake water quality targets. Utilizing the Canfield-Bachman (Canfield and Bachman 1980) prediction model for natural lakes, to meet the water quality goal of 0.047 mg/l the phosphorus average annual loading capacity is 120 lbs/year (54 kg/year) (Appendix A).

2.3 Pollutant Assessment

For this TMDL, the pollutant assessment is based upon the water quality information collected from Fremont #20.

2.3.1 Existing Pollutant Concentration and Load

As stated in section 2.1.3.1 the 2005 growing season average in-lake phosphorus concentration is 0.163 mg/l (169 μg/l). The calculated average annual phosphorus load delivered to Fremont #20 is 839 lbs/year (381 kg/year) as predicted by the Canfield-Bachman natural lake model (Appendix A).

2.3.2 Deviance From Desired In-lake Pollutant Concentration and Loading Capacity

In order to meet the in-lake total phosphorus quality target and ultimately the algal toxin water quality target, the average annual total phosphorus concentration must be reduced from 0.163 mg/l (163 μg/l) to 0.047 mg/l (47 μg/l). To accomplish this the existing load must be reduced by approximately 86%.

2.3.3 Identification of Pollutant Sources

Because no point sources have been identified in the Fremont #20 watershed, the pollutant load is believed to originate from nonpoint and natural sources.

2.4 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 Fremont #20 is 120 lbs/year (54.4 kg/year). To achieve the defined phosphorus loading capacity the required allocations are contained in the following sections.

2.4.1 Wasteload Allocation

The wasteload allocation for this TMDL will be "zero" – 0 lbs/year (0 kg/year).

2.4.2 Load Allocation/Natural Background

The phosphorus load allocation distributed among the nonpoint and natural sources will be 108 lbs/year (49 kg/year).

2.4.3 Margin of Safety

Ax explicit 10% margin of safety will be defined for this TMDL. Therefore the margin of safety is 12 lbs/year (5.4 kg/year)

2.4.4 Conversion to Daily Loads

The TMDL has established an annual average phosphorus load that if achieves should meet the water quality targets. A recent court decision often referred to as Anacostia decision have dictated that TMDL 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 120 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 0.3. From the TSD, the 99th percentile occurrence probability for a CV of 0.3 is 1.9. Using these assumptions, the MDL = LTA*1.9. Therefore, the total phosphorus would be:

120 lbs/year ÷ 365 days/year * 1.9 = 0.662 lbs/day

2.4.5 Phosphorus TMDL Summary

TMDL/Waterbody Loading Capacity = 0 lbs/year (WLA) + 108 lbs/year (LA) + 12 lbs/year (Natural Background) + Implicit Margin of Safety

3.0 Implementation Plan

The development of an implementation plan is an integral part of the overall waterbody/watershed management process and one of the key pieces of information necessary for the process is the level of reduction needed for beneficial use attainment. As a result of the limited watershed options for addressing the pollutant load are also limited. Removal of the nutrients via hydraulic or mechanical dredging has been ruled out not being cost effective.

Phosphorus precipitation/inactivation is being targeted as the primary treatment reduction. This procedure targets the removal of phosphorus from the water column by the used of aluminum salts, a technique that has been long used in advanced wastewater treatment.

3.1 Reasonable Assurance

Effective management of nonpoint source pollution in Nebraska necessarily requires a cooperative and coordinated effort by many agencies and organizations. To address the phosphorus and algal toxin impairments in Fremont #20 the NDEQ has partnered with the Nebraska Game and Parks Commission and the University of Nebraska-Lincoln to collectively prepare an implementation plan.

As well, the Department has identified the Fremont #20 project as a high priority for receipt of CWA Section 319 grant monies.

4.0 Future Monitoring

Monitoring of Fremont #20 will be conducted in the future to determine if the water quality is improving, degrading or remaining status quo. Specifically, the NDEQ will coordinate weekly monitoring of the swimming beach for algal toxins (microcystin) concentration. In-lake monitoring will also be conducted to determine if the alum treatment was successful at reducing and maintaining the in-lake, growing season total phosphorus at a level below the applicable water quality criteria.

5.0 Public Participation

The availability of the TMDL in draft form was published in the Fremont Tribune with the public comment period running from May 14, 2007 to June 18, 2007. These TMDLs were also made available to the public on the NDEQ's Internet site and interested stakeholders were informed via email of the availability of the draft TMDL. No comments on the TMDL were received.

6.0 References

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Appendix A – Canfield-Bachmann Total Phosphorus Model for Natural Lakes

Fremont Lake 20E is considered a sand pit, which is a lake that lies in sandy ground and was formed as the result of sand mining. Sand pit lakes are primarily ground water fed and have very limited watersheds and outlet water through overland flow. These waterbodies more closely resemble "natural lakes" that typically are defined by smaller watershed area: lake surface ratio, longer hydraulic residence times, simple shapes and a surface outlet (NALMS 2001).

Canfield and Bachman developed models to predict total phosphorus concentrations using data from natural and artificial lakes. The research did produce statistically significant regression equations for natural and artificial waterbodies. For this TMDL the natural lake model was chosen based on the attributes of Fremont 20E in comparison to NALMS definition of a natural lake.

The equation for the Canfield-Bachmann Natural Lake model is:

$$P = \frac{L}{z[0.162(L/z)^{0.458} + p]}$$

where,

P = predicted in-lake total phosphorus concentration (µg/L)

L = areal total phosphorus load (mg/m^2 of lake area per year)

z = lake mean depth (meters)

p = lake flushing rate (yr^{-1})

In-lake total phosphorus for both the current and target conditions are known. Therefore the equation is used to solve for *L*. The following inputs were used for Fremont #20

P = current in-lake conditions

z = 3.36 meters (11 feet)

p = 0.5 (detention time = 5 years).

Therefore:

$$P(163) = \frac{1880}{3.36\left[0.162(1880/3.36)^{0.458} + 0.5\right]}$$

The areal total phosphorus load to meet an in-lake total phosphorus concentration of 163 µg/l is 1880 mg/m^2. The annual total phosphorus load is then obtained by multiplying the areal load (L in mg/m^2) by the lake area (in square meters) and converting the resulting value to pounds.

The model is similarly used to solve for the water quality target of 47 µg/l (P47).