# Nutrient and Dissolved Oxygen TMDLs for Lake Hoskins in McIntosh County, North Dakota

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## 1.0 INTRODUCTION AND DESCRIPTION OF THE LAKE AND WATERSHED

Lake Hoskins is located in McIntosh County, North Dakota, approximately three miles west of Ashley, North Dakota, along North Dakota Highway 11 (Figure 1). Lake Hoskins is a natural freshwater lake found in the Missouri Coteau physiographic region of North Dakota. Two small unnamed tributaries provide the main routes for the watershed runoff to be transported to the main lake (Figure 2). Although McIntosh County is in the Missouri River drainage basin, most of the drainage is internal. Table 1 summarizes some of the geographical, hydrological, and physical characteristics of Lake Hoskins.

**Table 1. General Characteristics of Lake Hoskins and the Lake Hoskins Watershed.**

| | |
|---|---|
| **Legal Name** | Lake Hoskins |
| **ADB Assessment Unit ID #** | ND-10130106-003-L-00 |
| **Major Drainage Basin** | Missouri River - Lake Oahe |
| **Nearest Municipality** | Ashley, ND |
| **8-Digit HUC** | 10130106 |
| **County** | McIntosh County, ND |
| **Latitude** | N 46º 2.416' |
| **Longitude** | W 99º 27.136' |
| **Surface Area** | 556.6 acres |
| **Watershed Area** | 38.63 square miles |
| **Average Depth** | 9.0 feet |
| **Maximum Depth** | 11.6 feet |
| **Volume** | 5,025.7 acre-feet |
| **Tributaries** | 2 small unnamed tributaries |
| **Outlet** | Concrete spillway |
| **Type of Waterbody** | Natural |
| **Dam Type** | Rolled earthen |
| **Fishery Type** | Northern Pike, Walleye, Perch, Bullhead |
| **Classified Beneficial Uses** | Recreation, Cool-Water Fishing, Agriculture |


**Figure 1. General Location of Lake Hoskins.**

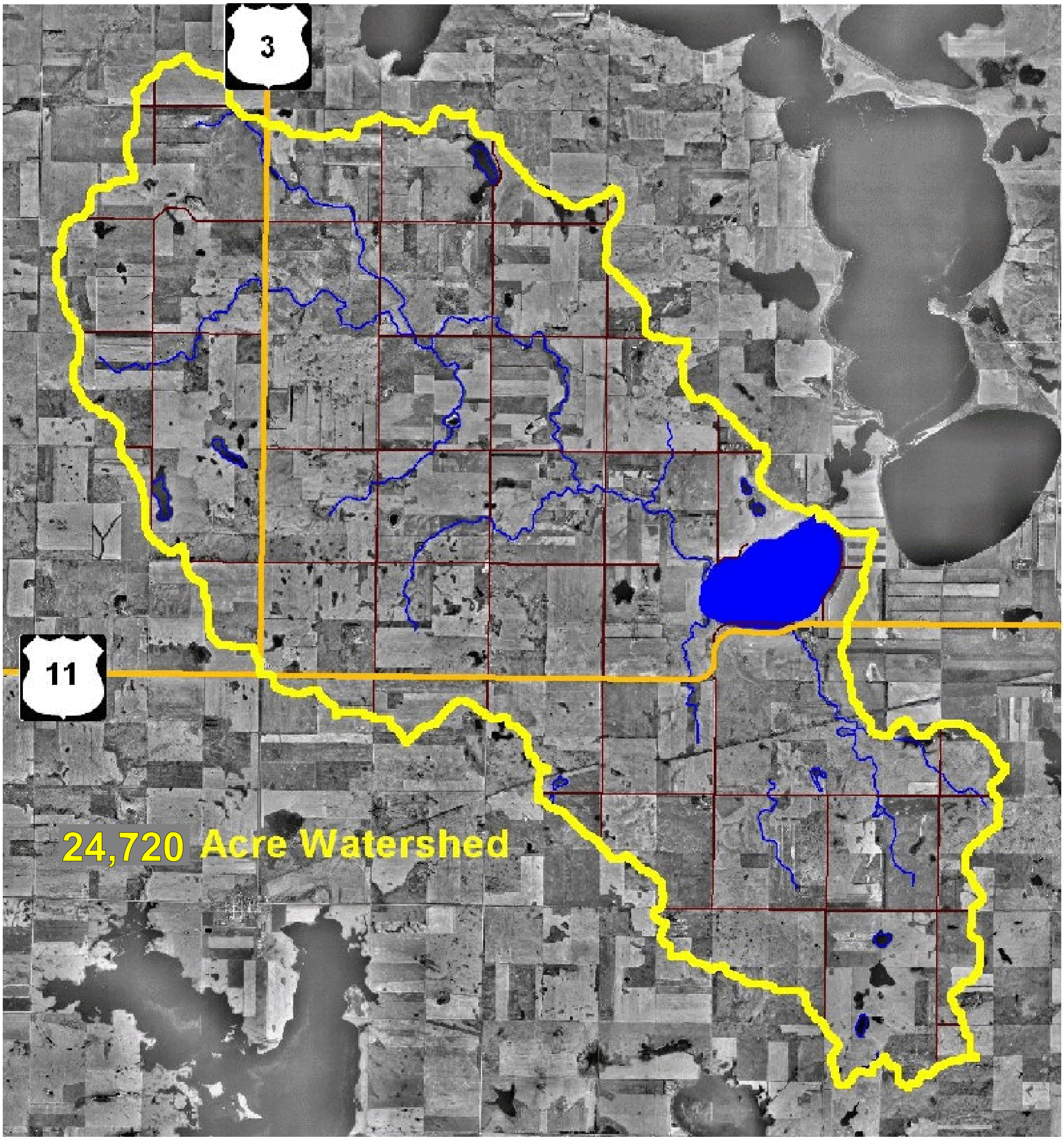


**Figure 2. Lake Hoskins Watershed.**

### 1.1 Clean Water Act Section 303(d) Listing Information

As part of the Clean Water Act Section 303(d) listing process, the North Dakota Department of Health (NDDoH) has identified Lake Hoskins as an impaired waterbody (Table 2). Fish and other aquatic biota and recreational uses of Lake Hoskins are fully supporting, but threatened. The identified cause of impairment to these designated uses are nutrient eutrophication related to the lake. The lake is categorized as a priority 1A TMDL. In the Water Quality Standards for North Dakota (NDDoH, 2001), Lake Hoskins is classified as a Class 2, cool water fishery. These waters are capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmonid fishes and associated aquatic biota.

**Table 2. Lake Hoskins Section 303(d) Listing Information (NDDoH, 2004).**

| | |
|---|---|
| **Assessment Unit ID** | ND-10130106-003-L_00 |
| **Waterbody Name** | Lake Hoskins |
| **Designated Use** | Fish and Other Aquatic Biota, Recreation |
| **Use Support** | Fully Supporting, but Threatened |
| **Pollutants of Concern** | Nutrients/eutrophication/low dissolved oxygen |
| **TMDL Priority** | 1A |

### 1.2 Topography and Elevation

Lake Hoskins is located on the Missouri Plateau in the Great Plains Province, which is a major subdivision of the Interior Plains. It is on the Coteau Slope, which is the glaciated section of the Missouri Plateau. Numerous lakes and prairie potholes are present and most of them are intermittently wet and dry.

The elevations immediately adjacent to Lake Hoskins range from 1,985 to 2,020 feet above sea level. The majority of the existing watershed ranges from 2,020 to 2,080 feet (msl). The sharpest rises in elevation were noted in the northwest portion of the watershed, where elevations were noted above 2,230 feet (msl) and the majority ranged from 2,150 to 2,190 feet (msl) (Figure 3).

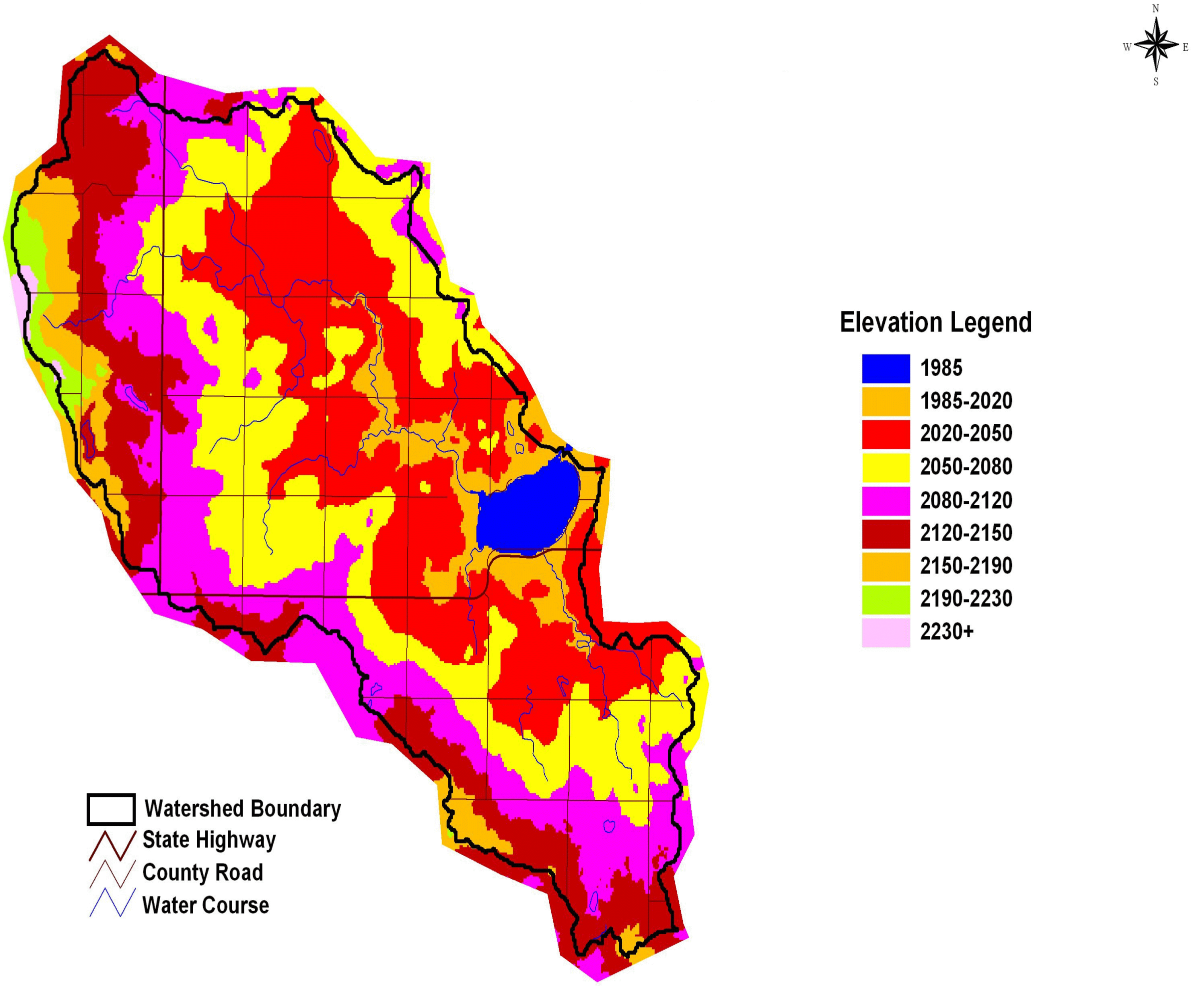


**Figure 3. Elevation of the Lake Hoskins Watershed.**

### 1.3 Land Use/Land Cover

Land use in the Lake Hoskins watershed is primarily cropland. Fifty-four percent of the watershed's land cover was classified as cropland (Figure 4, Table 3). Permanent herbaceous cover was noted on 36 percent of the land, which included rangeland, trees, and farmsteads. Conservation Reserve Program (CRP) acres accounted for 10 percent of the land use in the watershed. CRP lands are classified by the United States Department of Agriculture (USDA) as cropland, and described as a 10-15 year cover type. The majority of the non-cropland and CRP area were noted in the south and east portions of the Lake Hoskins watershed. The major cropped areas, based on the 2003 crop year, were located approximately two miles northwest of the lake, near the major tributary.

**Table 3. Land Use in the Lake Hoskins Watershed.**

| Land Use | Acres | Percent |
|---|---|---|
| CRP | 2,472 | 10% |
| Rangeland, Trees, Farmsteads | 8,899 | 36% |
| Cropland | 13,349 | 54% |
| Total Watershed Acres | 24,720 | 100% |

Figure 4 also compares the CRP and non-cropland land cover type with land slope. Twenty-five percent of the cells (40-acre tracts within the watershed) evaluated in the Lake Hoskins watershed with CRP or cropland had slopes ranging from 5 to 15 percent, while twenty-one percent of the cells with CRP or cropland had slopes greater than 15 percent.

The variety of land-uses decreases with the increase in land slope. Seventy-nine percent of the cells with slopes of 15 percent or greater were CRP or pasture/hayland with the remaining areas covered with wheat or soybeans. Fifty-nine percent of cells with slopes ranging from 9 to 15 percent slope cells were covered with CRP or pasture that was in good condition. The remaining cells were primarily covered with wheat, sunflowers and soybeans. Cells with 5 to 9 percent slopes were again primarily covered with pasture or CRP (58 percent). Twenty-one percent of the cells with slopes of 5-9 percent were in row crops. The remaining areas were covered with wheat and flax.

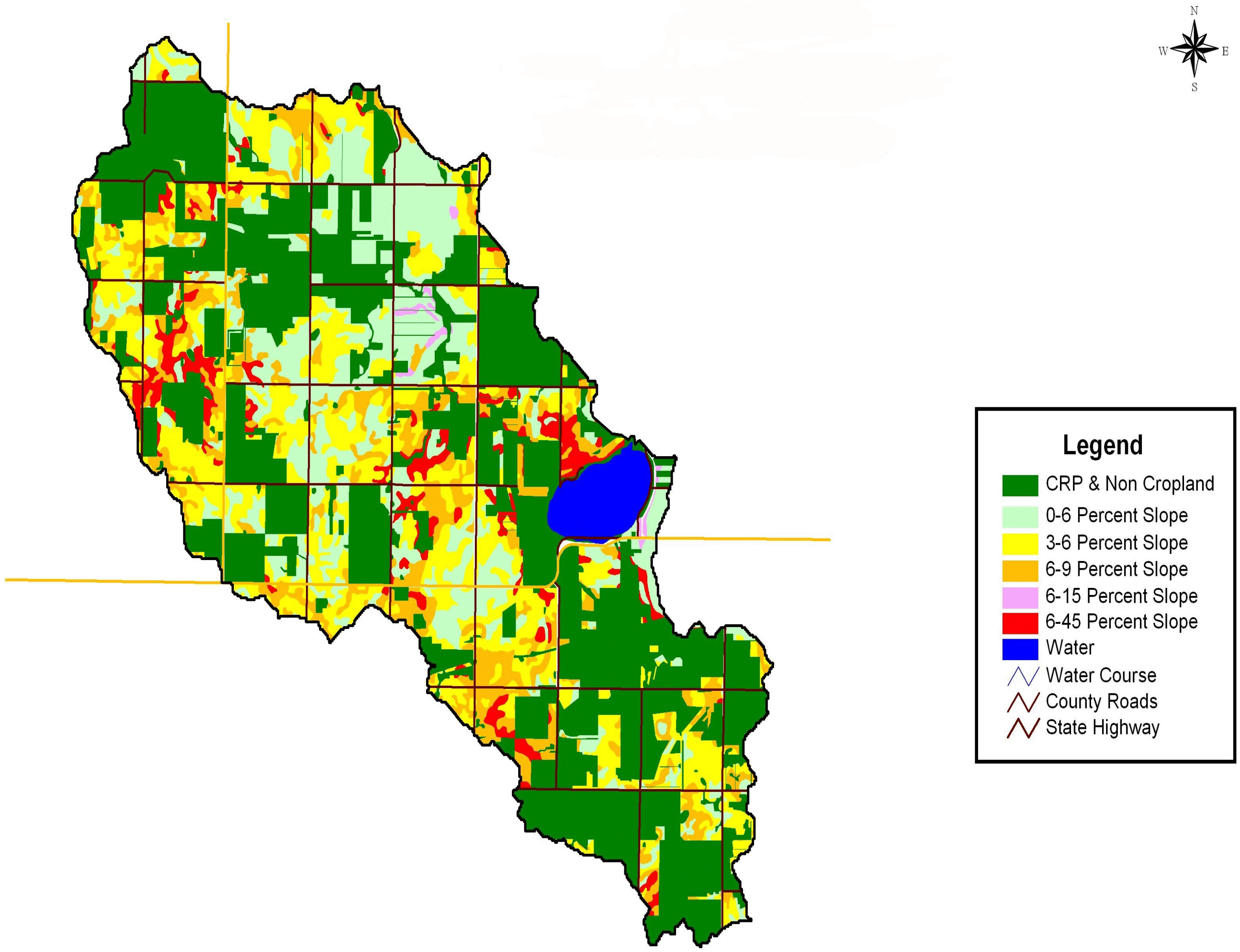


**Figure 4. Land Use in the Lake Hoskins Watershed.**

### 1.4 Climate and Precipitation

Climate data is based on the National Oceanic and Atmospheric Administration (NOAA) records for Wishek, North Dakota, located approximately 20-miles northwest of Lake Hoskins. The climate of McIntosh County is semiarid. Records show that average annual precipitation is 17.96 inches. Most of the precipitation (75 to 80 percent) occurs from April through September (Figure 5). Much of the summer precipitation is derived from local thunderstorms, consequently, the amount of precipitation received in one year varies considerably throughout the county. During 2003, the area received approximately 11.70 inches of annual precipitation which was approximately 65 percent of normal (Figure 6).

Based on NOAA records for Wishek, North Dakota, mean annual temperature is 40.5ºF. June, July, and August are the warmest months with mean temperature ranges from 66ºF to 68.9ºF (Figure 7). January is the coldest month with mean temperatures of 8.2ºF at Wishek (Figure 7).

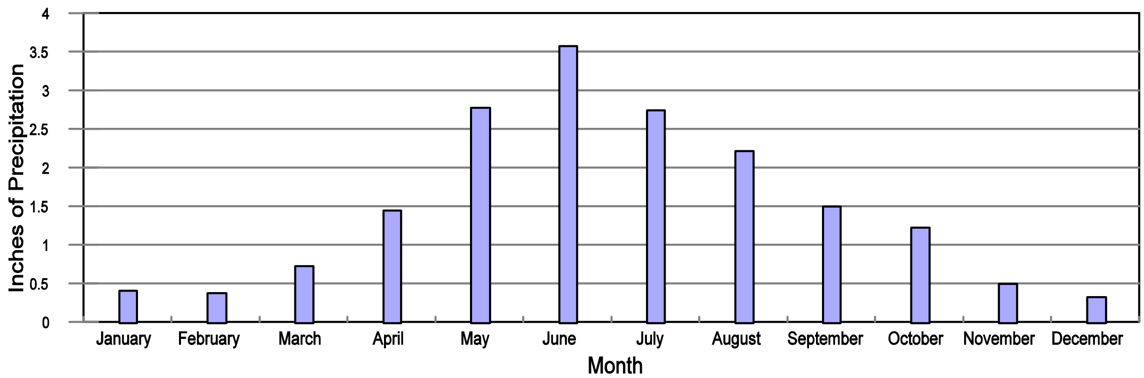


**Figure 6. Annual Precipitation for Wishek, North Dakota.**

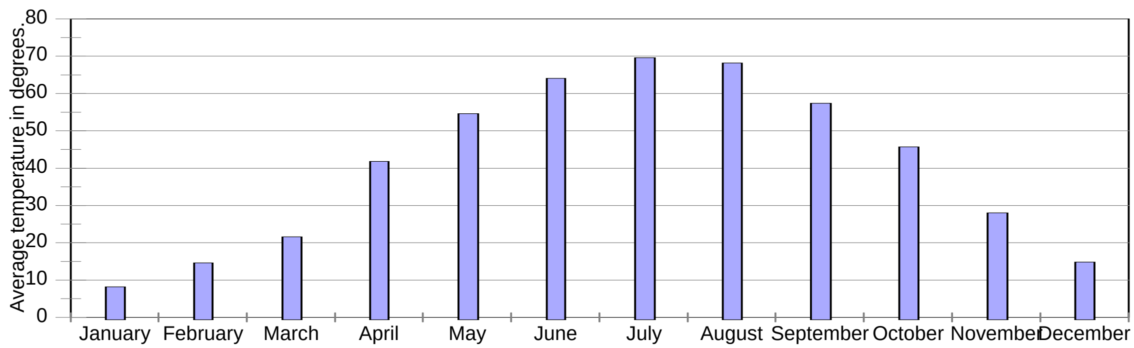


**Figure 7. Average Monthly Temperature for Wishek, North Dakota.**

## 1.5 Water Quality Data

Water quality data were collected by members of the Lake Hoskins Improvement Association (LHIA) under the supervision of High Plains Consortium, Inc. between February 2003 and February 2004. Water quality samples were collected twice per month. In addition, event-based precipitation samples were collected from the inlet sites when a 0.02 foot increase was noted in the stream gauges. Sampling parameters are shown in Table 4.

Additional data, such as meteorological data, an aquatic vegetation survey, and a shoreline reconnaissance, were collected in addition to the in-lake and tributary chemical data that were collected.

**Table 4. Water Quality Sampling Parameters**.

| Physical Parameters | Chemical Parameters |
|---|---|
| Stage | pH |
| Flow, Velocity | Major Anions & Cations |
| Temperature | Phosphorus (Total and Dissolved) |
| Conductivity | Total Nitrogen |
| | Total Kjeldahl Nitrogen |
| | Nitrogen |
| | Nitrate - nitrite |
| | Ammonia |

At the same time the water samples were collected from the lake, secchi disk transparency measurements and temperature/dissolved oxygen profiles were completed. Chlorophyll-a samples were collected during the warmer open water portion of the sampling year.

A detailed description of the water quality monitoring plan for the Lake Hoskins TMDL study is provided in the "QAPP for the Lake Hoskins TMDL Development Project" (NDDoH 2002).

### 1.5.1 Inlet Tributary Data

Three tributary inlet sites were established on the major inflow portions of the watershed to optimize collection of data and to ensure a representative cross-section of water flowing into Lake Hoskins. A summary of the site locations is included in Table 5 and Figure 8.

Sampling occurred from February 2003 and continued through February 2004. Eleven samples were collected from each of the two inlet tributaries. Samples were analyzed for total phosphorous, total nitrogen, total suspended solids, and selected cations and anions. While selected cations and anions were monitored the results are not presented in this document because the reported results do not affect this TMDL nor result in any new TMDL requirements. Each sampling event also included measurements for stream stage, flow, temperature, pH, specific conductance and dissolved oxygen. Average concentrations for the nutrient variables and total suspended solids for the three inlet sites sampled during the 2003-2004 sampling year are shown in Tables 6, 7 and 8.

**Table 5. Summary of the Lake Hoskins Monitoring Stations.**

| Station Location | Storet ID | No. of Samples Collected | Drainage Area | Percent of Total Watershed |
|---|---|---|---|---|
| Northwest Inlet | 385276 | 11 | 15,580 acres | 68% |
| Southwest Inlet | 385277 | 2 | 1,920 acres | 8% |
| Southeast Inlet | 385278 | 5 | 5,440 acres | 24% |

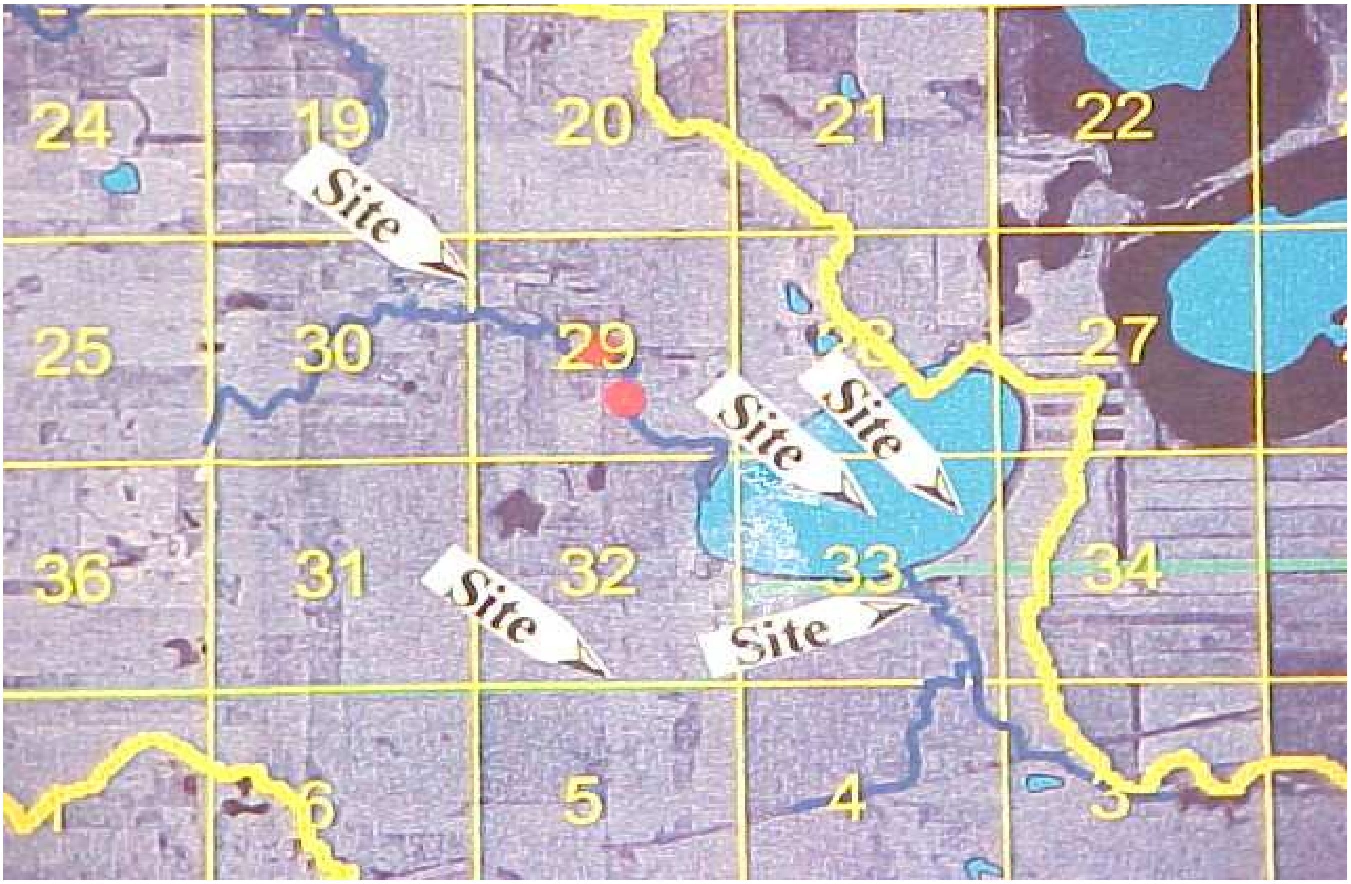


**Figure 8. Sampling Locations**

**Table 6. Summary of Nutrient Concentrations at the Northwest Inlet Monitoring Station (385276).**

| | Total Phosphorus (mg/L) | Dissolved Phosphorus (mg/L) | Total Kjeldahl Nitrogen (mg/L) | Nitrate/ Nitrite (mg/L) | Ammonia (mg/L) | Total Suspended Solids (mg/L) |
|---|---|---|---|---|---|---|
| n | 11 | 11 | 11 | 11 | 11 | 11 |
| Min | 0.157 | 0.117 | 1.760 | 0.010 | 0.010 | 5.000 |
| Max | 1.260 | 0.991 | 2.710 | 1.130 | 0.291 | 12.000 |
| Media | 0.419 | 0.368 | 2.215 | 0.020 | 0.795 | 5.000 |
| Mean | 0.555 | 0.480 | 2.190 | 0.241 | 0.114 | 6.500 |

**Table 7. Summary of Nutrient Concentrations at the Southwest Inlet Monitoring Station (385277).**

| | Total Phosphorus (mg/L) | Dissolved Phosphorus (mg/L) | Total Kjeldahl Nitrogen (mg/L) | Nitrate/ Nitrite (mg/L) | Ammonia (mg/L) | Total Suspended Solids (mg/L) |
|---|---|---|---|---|---|---|
| n | 2 | 2 | 2 | 2 | 2 | 2 |
| Min | 0.317 | 0.224 | 1.940 | 2.410 | 0.028 | 5.000 |
| Max | 0.385 | 0.260 | 2.020 | 3.540 | 0.059 | 15.000 |
| Mean | 0.352 | 0.242 | 1.980 | 2.975 | 0.044 | 10.000 |

**Table 8. Summary of Nutrient Concentrations at the Southeast Inlet Monitoring Station (385278).**

| | Total Phosphorus (mg/L) | Dissolved Phosphorus (mg/L) | Total Kjeldahl Nitrogen (mg/L) | Nitrate/ Nitrite (mg/L) | Ammonia (mg/L) | Total Suspended Solids (mg/L) |
|---|---|---|---|---|---|---|
| n | 5 | 5 | 5 | 5 | 5 | 5 |
| Min | 0.268 | 0.198 | 1.930 | 0.030 | 0.046 | 5.000 |
| Max | 1.170 | 0.923 | 3.440 | 0.650 | 0.506 | 15.000 |
| Media | 0.712 | 0.658 | 2.820 | 0.160 | 0.192 | 5.000 |
| Mean | 0.677 | 0.550 | 2.704 | 0.290 | 0.243 | 7.200 |

### 1.5.2 Lake Data

Lake Hoskins was sampled at two locations during 2003 and 2004 as part of the Lake Hoskins TMDL development project (Figure 8). Sampling included Secchi Disk transparency, chlorophyll-a, and water chemistry. Samples were collected from a littoral zone site located near the east shoreline, and from the deepest portion of the lake. The deepest site location corresponded approximately to the north edge of the winter aeration opening in the ice.

**Water Quality Data**

Average values for selected water chemistry variables collected from 2003 to 2004 for Lake Hoskins (Tables 9 - 10) were compared to data collected by NDDoH in 1992 as part of the Lake Water Quality Assessment Project (Ell et al., 1993) (Table 11). Total dissolved solids concentrations reported for Lake Hoskins during 2003-04 increased when compared to 1992 data. Recently, the Lake Hoskins watershed has experienced a period of drought with evaporation exceeding inflows, thus a lowering of the lake surface level and concentrating dissolved materials. Total phosphorus concentrations reported for 2003-04 have shown dramatic decreases when compared to 1992 data. In-lake Total Kjeldahl Nitrogen (TKN) concentrations were also lower in 2003-04 than in 1992.

**Table 9. Summary of 2003-2004 TDS and Nutrient Concentrations for the Deepest In-lake Site (380760).**

| | Total Dissolved Solids (mg/L) | Total Phosphorus (mg/L) | Dissolved Phosphorus (mg/L) | Total Nitrogen mg/L | Total Kjeldahl Nitrogen (mg/L) | Nitrate/ Nitrite (mg/L) | Ammonia (mg/L) |
|---|---|---|---|---|---|---|---|
| Min | 1060.000 | 0.515 | 0.464 | 1.013 | 0.942 | 0.020 | 0.010 |
| Max | 1650.000 | 1.531 | 1.476 | 2.118 | 1.640 | 0.785 | 0.763 |
| Media | 1160.000 | 0.784 | 0.715 | 1.178 | 1.120 | 0.020 | 0.037 |
| Mean | 1243.333 | 0.790 | 0.733 | 1.238 | 1.169 | 0.063 | 0..082 |

**Table 10. Summary of 2003-2004 TDS and Nutrient Concentrations for the Littoral In-lake Site (380761).**

| | Total Dissolved Solids (mg/L) | Total Phosphorus (mg/L) | Dissolved Phosphorus (mg/L) | Total Nitrogen (mg/L) | Total Kjeldahl Nitrogen (mg/L) | Nitrate/ Nitrite (mg/L) | Ammonia (mg/L) |
|---|---|---|---|---|---|---|---|
| Min | 1070.000 | 0.506 | 0.453 | 1.010 | 1.930 | 0.010 | 0.005 |
| Max | 1710.000 | 1.260 | 1.200 | 1.480 | 3.440 | 0.040 | 0.149 |
| Media | 1140.000 | 0.675 | 0.627 | 1.120 | 2.820 | 0.010 | 0.005 |
| Mean | 1225.294 | 0.732 | 0.678 | 1.178 | 2.704 | 0.016 | 0.044 |

**Table 11. Volume-Weighted Mean Concentrations for Selected Water Quality Variables - July 1991-February 1992 (Ell et al., 1993).**

| Water Quality Variable | Volume Weighted Mean Concentration |
|---|---|
| Total Dissolved Solids | 961 mg/L |
| Conductivity | 1438 umhos/cm |
| Hardness as Calcium | 416 mg/L |
| Sulfates | 310 mg/L |
| Chloride | 42.08 mg/L |
| Total Phosphate as P | 1.66 mg/L |
| Nitrate + Nitrite as N | 0.008 mg/L |
| Total Alkalinity | 443 mg/L |
| Ammonia | 0.041 mg/L |
| Total Kjeldahl Nitrogen | 2.26 mg/L |
| Bicarbonate | 448 mg/L |

**Secchi Disk Transparency**

Secchi disk transparency was measured at both in-lake stations (380760 and 380761) by the LHIA. These readings are provided in Table 12. The deepest portion of Lake Hoskins had Secchi Disk readings ranging from 0.75 to 3.0-meters. The water clarity peaked during late May to early June (Table 12). No data were collected during early winter because of ice conditions limiting access. At the littoral sampling station the most turbid conditions occurred during sampling in March and September. The March levels would be affected by inflows, while the September readings could be attributed to the build up of large amounts of aquatic vegetation. In addition, sediment, total dissolved solids, and debris can affect secchi depths.

**Table 12. In-Lake Secchi Disk Transparency Results (meters)**.

| Date | Deepest Site (380760) | Littoral Site (380761) |
|---|---|---|
| 2/27/03 | 0.98 | 0 .26 |
| 3/7/03 | 2.3 | 0.63 |
| 4/21/03 | 0.75 | 0.60 |
| 4/30/03 | 1.3 | 1.3 |
| 5/4/03 | 2 | 1.33 |
| 5/8/03 | – | -- |
| 5/12/03 | 2.5 | 1.8 |
| 5/15/03 | 2.5 | 2 |
| 5/19/03 | – | -- |
| 6/8/03 | 3 | 2 |
| 6/22/03 | 2.5 | 1.7 |
| 7/6/03 | 1.5 | 1.6 |
| 7/27/03 | 1.25 | 1.5 |
| 8/11/03 | 1.5 | 1.5 |
| 9/11/03 | 0.9 | 1.4 |
| 9/14/03 | – | -- |
| 10/5/03 | 2. 0 | 1.25 |
| 1/11/04 | 2.13 | 1.33 |
| Average | 1.81 | 1.35 |

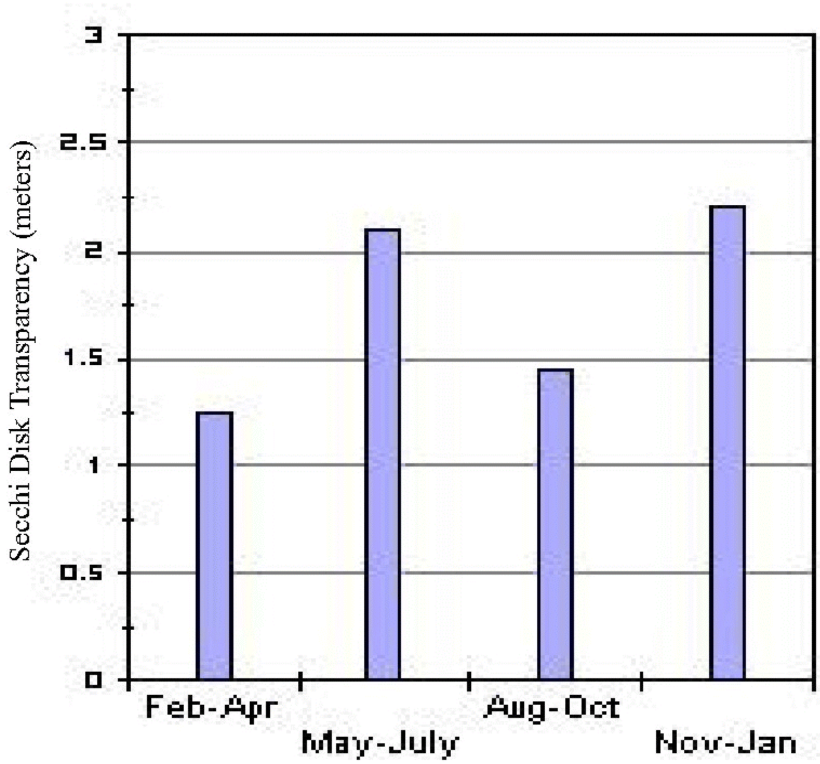


**Figure 9. Average Seasonal Secchi Disk Transparency for the Lake Hoskins Deepest Site (380760).**

**Dissolved Oxygen and Temperature**

Dissolved oxygen and temperature data for the deepest site on Lake Hoskins and littoral site along the east shoreline are presented in Figures 10 and 11**.** Significant temperature increases were noted during July - August 2003. In addition, the dissolved oxygen levels increased during the early part of the summer and decreased during the latter portion. Increases in dissolved oxygen levels were noted throughout the winter months, which was attributed to the operation of an in-lake aeration system. Open water areas, resulting from the aeration process, were noted throughout the winter months near the deepest portion of Lake Hoskins.

The dissolved oxygen and temperature data for the deep and littoral sites were comparable. The littoral portion of Lake Hoskins that was sampled demonstrated a more rapid response to the aeration system being operated with the dissolved oxygen levels rising from 8.0 mg/L to 15.0 mg/L. The dissolved oxygen levels ranged from 7.78 mg/L in August, to 16.06 mg/L in February. The temperatures of Lake Hoskins ranged from 1.2° C in February to 24.6° C in August.

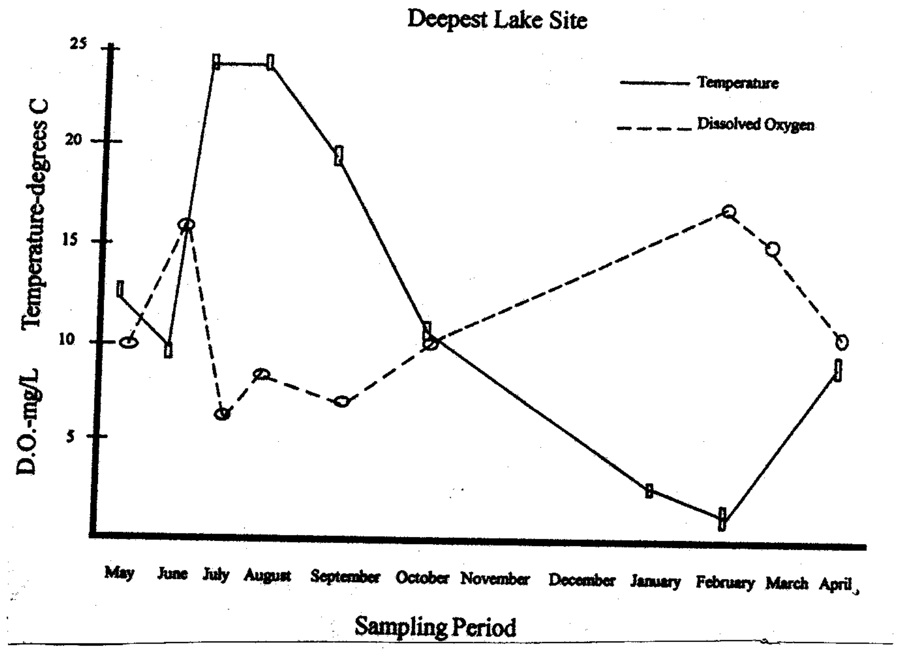


**Figure 10. Dissolved Oxygen and Temperature Data for the Deepest In-Lake Site (380760).**

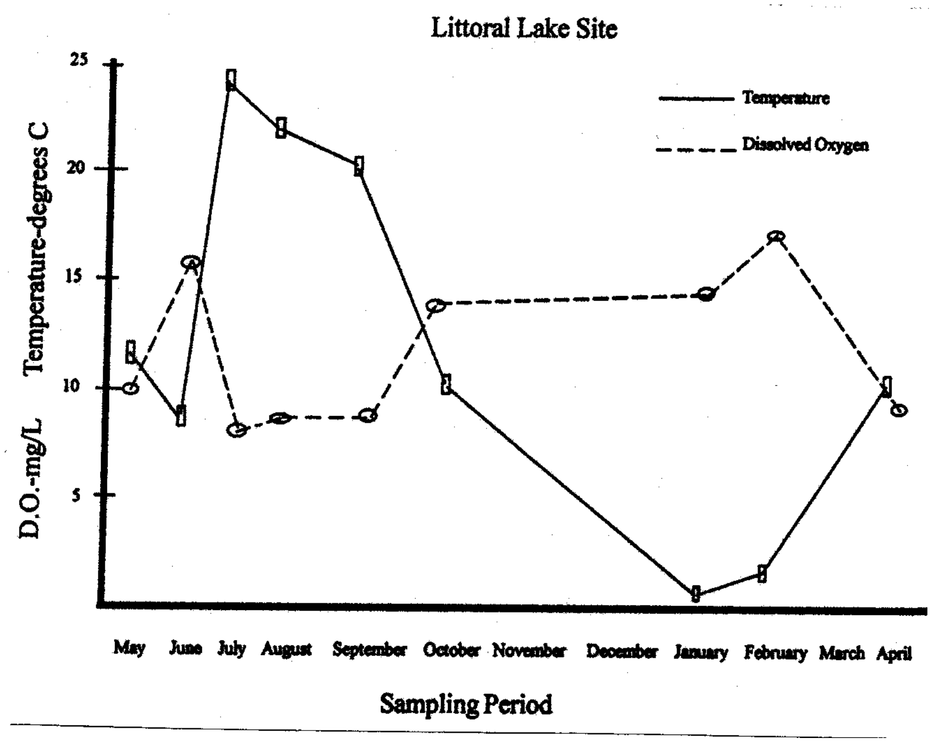


**Figure 11. Dissolved Oxygen and Temperature Data for the Littoral In-Lake Site (380761).**

# 2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on a state's Section 303(d) list. A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain or maintain water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis.

## 2.1 Narrative Water Quality Standards

The NDDoH has set narrative water quality standards that apply to all surface waters in the state (NDDoH, 2001). The narrative standards pertaining to nutrient impairments include:

- All waters of the state shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations that are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutant, which alone or in combination with other substances, shall:
  a. Cause a public health hazardous injury to environmental resources;
  b. Impair existing or reasonable beneficial uses of receiving waters; or
  c. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDH has set a biological goal for all surface waters in the state. The goal states that "The biological condition of surface waters shall be similar to that of sites or water bodies determined by the department to be regional reference sites" (NDDH, 2001).

## 2.2 Numeric Water Quality Standards

Lake Hoskins has been classified as a Class 2 cool water fishery. Class 2 lakes are "waters capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmonid fishes and associated aquatic biota" (NDDH, 2001). All classified lakes in North Dakota are assigned aquatic life, recreation, irrigation, livestock watering, and wildlife beneficial uses. State Water Quality Standards (NDDoH, 2001) states that lakes shall use the same numeric criteria as Class 1 streams. However, different nitrogen and phosphorus guidelines have been established for lakes (Table 13).

**Table 13. North Dakota Nutrient Guidelines for Classified Lakes.**

| Parameter | Criteria/Guideline | Limit |
|---|---|---|
| $NO_3$ as N | 0.25 mg/L | Maximum Allowable Limit |
| $PO_4$ as P | 0.02 mg/L | Maximum Allowable Limit |

**Nutrients**

Lake use attainment determinations are often made using Carlson's Trophic State Index (TSI), which is further discussed in Section 3.0 (Carlson, 1977). The average nitrate/nitrite concentration in Lake Hoskins (0.018 mg/L) was significantly lower than the North Dakota lake nitrate guidelines of 0.25 mg/L. Most of the nitrogen in Lake Hoskins was organic in nature (TKN). High TKN concentrations generally indicate pollution resulting from septic systems, human wastes, animal wastes, and agricultural runoff.

The ratio of dissolved phosphorus to total phosphorus was determined to be very high at most monitoring sites. Phosphorus loadings may be attributed to agricultural sources and aquatic vegetation decay. Lake Hoskins phosphorous levels at the Deepest Site (380760) ranged from 0.515 mg/L to 1.531 mg/L which exceeds the North Dakota nutrient guideline for phosphorous of 0.02 mg/L. This can partially be attributed to reduced runoff and increased residence time of the water in the lake during the 2003-2004 season.

**Dissolved Oxygen**

The numeric limit for surface waters is a dissolved oxygen level of not less than 5mg/L.

## 3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets must be based on state water quality standards, but can also include site-specific values when no numeric criteria are specified in the standard. Based on public informational meetings, lake users want to use Lake Hoskins for swimming and boating, while at the same time maintaining a viable fishery. The lake must also be aesthetically pleasing. The following sections summarize the water quality targets applicable to Lake Hoskins based on these desired beneficial uses.

### 3.1 Trophic State Index

North Dakota's 2004 Integrated 305(b) and 303(d) Report states, "one of the most useful measures of lake water quality is trophic condition." (NDDoH, 2004). Trophic status is a measure of the productivity of a lake or reservoir and is directly related to the level of nutrients (phosphorus and nitrogen) within the lake or reservoir. Lakes tend to become eutrophic (more productive) with higher nitrogen and phosphorus inputs. Eutrophic lakes often have nuisance aquatic vegetation, limited clarity, and low dissolved oxygen concentrations that can result in impaired aquatic life (e.g., winter and summer kills) and recreational uses. Carlson's Trophic State Index (TSI) attempts to measure the trophic state of a lake using three indicators: phosphorus, chlorophyll-a and Secchi Disk transparency measurements (Carlson, 1977).

Data from the deepest sampling point in Lake Hoskins were averaged to develop the TSI Indexes for each indicator (Table 10 and Figure 18). Littoral data was not used due to its highly variable nature. According to Carlson's TSI and water quality data collected between February 2003 and January 2004, Lake Hoskins would be considered a hypereutrophic lake (Table 14). Hypereutrophic lakes (most productive) are characterized by excessive growths of vegetation, blue green algal blooms, and low dissolved oxygen concentrations. These lakes experience frequent fish kills and are generally characterized as having excessive rough fish populations (carp, bullhead, sucker) and poor sport fisheries. Because of frequent algal blooms and excessive vegetation growth, these lakes are also undesirable for recreational uses such as swimming and boating.

**Table 14. Carlson's Trophic State Indexes and Lake Hoskins' TSI Values.**

| Parameter | Measured Value[1] | TSI Relationship | TSI Value[2] |
|---|---|---|---|
| Chlorophyll-a | 7.6 ug/L | TSI C = 30.60 + ln (7.6) (9.81) | 50.50 |
| Total Phosphorus | 789.6 ug/L | TSI P = 4.15 + ln (789.6) (14.42) | 100.35 |
| Secchi Depth (SD) | 1.7 m | TSIS = 60 - ln (1.7) (14.41) | 52.35 |

[1] Values for each indicator were averaged from the monitoring site located in the deepest area of Lake Hoskins (380760).
[2] TSI < 40 = Oligotrophic (least productive) TSI > 60 = Hypertrophic

### 3.2 Nutrient Target

The following TMDL target for nitrogen and phosphorus has been established for Lake Hoskins to restore and maintain its designated beneficial uses for aquatic life (i.e. fish) and recreation. This target was chosen based on the desire of the Lake Hoskins Improvement Association to maintain the recreational use of the lake and to maintain a viable fishery . According to the BATHTUB model, a reduction in the external phosphorus and nitrogen loading of fifty percent will decrease the chlorophyll-a concentrations and increase the Secchi disk transparency depth.

It is likely that this improvement would result in a noticeable change in trophic state to the average lake user. However, a TSI target of 45.4 for chlorophyll and 51.6 for Secchi depth are chosen based on the predicted response with a 50 percent reduction in phosphorus loading (Table 15). While this will not bring concentrations of total phosphorus to the NDDoH State Water Quality Standard guideline for lakes (0.02 mg/L), it should result in a change of trophic status for the lake from hypereutrophic down to eutrophic. Given the size of the lake, the probable amount of phosphorus in bottom sediments, nearly constant wind in North Dakota causing a mixing effect, and few cost efficient ways to reduce in-lake nutrient cycling, this was determined to be the best possible outcome for the reservoir.

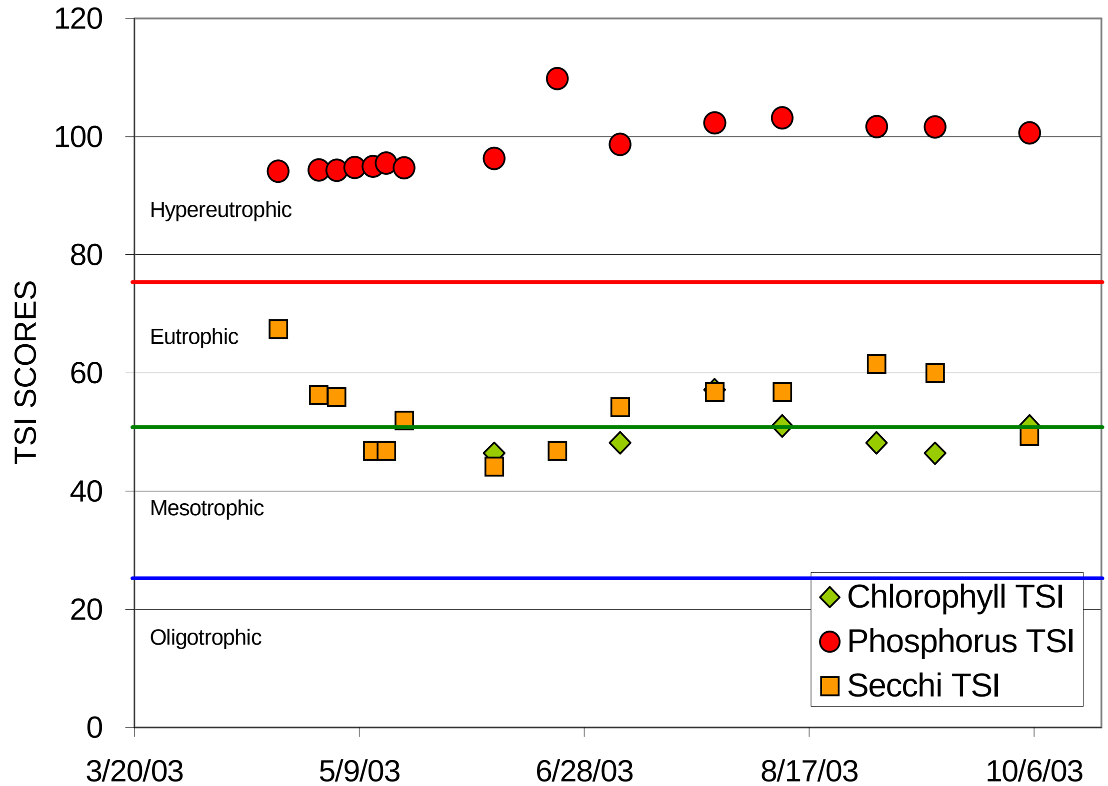


**Figure 12. Temporal Distribution of Carlson's Trophic Status Index Scores for Lake Hoskins.**

**Table 15. Observed and Predicted TSI Scores Assuming a 50 Percent Reduction in External Phosphorus and Nitrogen Loading.**

| Parameter | Observed TSI Value | Predicted response with 50% Reduction |
|---|---|---|
| Carlson's TSI for Chlorophyll-a | 50.46 | 45.41 |
| Carlson's TSI for Total Phosphorus | 100.36 | 90.74 |
| Carlson's TSI for Secchi Depth | 52.27 | 51.56 |

### 3.3 Dissolved Oxygen Target

Lake Hoskins is listed as fully supporting but threatened, fish and aquatic biota uses because of dissolved oxygen levels observed below the North Dakota water quality standard. The North Dakota water quality standard for dissolved oxygen is "not less than 5.0 mg/ L". For Lake Hoskins, low dissolved oxygen levels appear to be related to excessive nutrient loadings.

## 4.0 SIGNIFICANT SOURCES

There are no point sources of pollution located in the Lake Hoskins watershed. The pollutants of concern originate from non-point sources. During the watershed study four Animal Feeding Operations (AFOs) were noted. The Agricultural Non-Point Source Pollution (AgNPS) model analysis of the four feedlots indicated ratings ranging from 37 to 58, with an average rating of 49. A rating of zero indicates that there is a zero possibility of pollution and 100 indicates the worst possible pollution scenario. The average mass of phosphorus introduced annually from these areas was calculated at 72.84 pounds per feedlot. These loads are due in part to operations that allow livestock direct access to the lake and associated tributaries. Also, the high observed TKN and dissolved phosphorus concentrations are supported by the fact that the majority of the cabins around Lake Hoskins have septic systems. Nutrient loadings may be originating through runoff from the watershed and/or groundwater flow from failing systems.

Since there was little outflow from the lake, most of the nutrient load from the 2003-2004 season can be presumed to be stored in the lake.

## 5.0 MODELING ANALYSIS

Establishing the relationship between in-stream and in-lake water quality targets and source loading is a critical component of TMDL development. Identifying the cause-and-effect relationship between pollutant loads and the water quality response is necessary to evaluate the loading capacity of the receiving water body. The loading capacity is the amount of pollutant that can be assimilated by the waterbody while still attaining and maintaining water quality standards. This section discusses the estimation of the loading capacity and existing loading in Lake Hoskins and the inlet tributaries to the lake. It should be noted that no discharge was noted at the spillway from Lake Hoskins during the 2003-2004 sampling season.

### 5.1 Tributary Load Analysis

To facilitate the analysis and reduction of tributary inflow and outflow water quality and flow data the FLUX program was employed. The FLUX program, also developed by the US Corps of Engineers Waterways Experiment Station (Walker, 1996), uses six calculation techniques to estimate the average mass discharge or loading that passes a given river or stream site. FLUX estimates loadings based on grab sample chemical concentrations and the continuous daily flow record. Load is therefore defined as the mass of a pollutant during a given time period (e.g., hour, day, month, season, year). The FLUX program allows the user, through various iterations, to select the most appropriate load calculation technique and data stratification scheme, either by flow or date, which will give a load estimate with the smallest statistical error, as represented by the coefficient of variation. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model. For a complete description of the FLUX program the reader is referred to Walker (1996).

Tributary flow data for the project period were reduced by HPC and the corresponding tributary and in-lake water quality data were reduced utilizing Microsoft Excel. Nutrient loads were calculated from the data collected during 2003-2004 for the Lake Hoskins' project. These data indicate that 2,223 kg of total phosphorus entered Lake Hoskins between March 2003 and February 2004 (Table 16) with 183 kg retained in the lake. An estimated 9,721 kg of nitrogen entered Lake Hoskins during the study period with 6,195 kg retained in the lake. The residence time for TN was 1.29 years.

**Table 16. Total Annual Loading of Total Nitrogen and Phosphorus to Lake Hoskins for the Period February 2003 - February 2004.**

| Load Sources | Total P | Total N |
|---|---|---|
| Surface Runoff | 2,155 kg | 7,481 kg |
| Precipitation | 67 kg | 2,240 kg |
| Amount Retained | 183 kg | 6,195 kg |

### 5.2 BATHTUB Model

For purposes of this project, the BATHTUB program was used to predict changes in trophic status based on changes in nutrient loading. The BATHTUB program, developed by the US Army Corps of Engineers Waterways Experiment Station (Walker 1996), applies an empirically derived eutrophication model to reservoirs. The model is developed in three phases. The first two phases involve the analysis and reduction of the tributary and in-lake water quality data. The third phase involves model calibration. In the data reduction phase, the in-lake and tributary monitoring data collected as part of the project are summarized, or reduced, in a format that can serve as inputs to the model. The following is a brief explanation of the computer software, methods, and procedures used to complete each of these phases. A more complete discussion may be found in Appendix A of this document.

The trophic response model, BATHTUB, has been calibrated to match Lake Hoskins' trophic response for the project period between February, 2003 and February, 2004 (Table 17). This is accomplished by combining tributary loading estimates for the hydrologic year February 2003 through February 2004 (see Section 5.1) with in-lake water quality. Tributary flow data for the project period were reduced by HPC and the corresponding tributary and in-lake water quality data were reduced utilizing Microsoft Excel. The outputs from these two sources were then provided as input to the BATHTUB model. The model is calibrated through several iterations, first by selecting appropriate empirical relationships for model coefficients (e.g., nitrogen and phosphorus sedimentation, nitrogen and phosphorus decay, oxygen depletion, and algal/chlorophyll growth), and second by adjusting model calibration factors for those coefficients. The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates made from project monitoring data.

The two most important nutrients controlling trophic response in Lake Hoskins are nitrogen and phosphorus. After calibration the observed average annual concentration of total nitrogen and total phosphorus compare well with those of the BATHTUB model. Other measures of trophic response predicted by the model are average annual chlorophyll-a concentration and average Secchi disk transparency. The calibrated model was equally efficient at predicting average chlorophyll-a concentration and Secchi disk transparency within the reservoir as total phosphorus and total nitrogen (Table 17).

Predicted changes in trophic response to Lake Hoskins were evaluated by reducing externally derived phosphorus loads by 25, 50, 75, and 90 percent (Table 18). These reductions were simulated in the model by reducing the phosphorus concentrations in the contributing tributary and other external delivery sources by 25, 50, 75, and 90 percent. Since there is no reliable means of estimating how much hydraulic discharge would be reduced through the implementation of BMPs, flow was held constant.

The model results indicate that if it were possible to reduce external phosphorus loading to Lake Hoskins the average annual total phosphorus and chlorophyll-a concentrations in the lake would decrease as well and secchi disk transparency depth would increase. However it is unlikely that the change would be noticeable until a 50 or probably 75 percent reduction in external phosphorus and nitrogen load is achieved. The model predicts a reduction in Carlsons TSI score from for chlorophyll-a, and secchi disk transparency corresponding to trophic state of mesotrophic and eutrophic, respectively with a 50 percent reduction and mesotrophic for both with a 75 percent reduction.

**Table 17. Observed and Predicted Average Annual Values for Trophic Response Variables and TSI Scores for Lake Hoskins (2003-2004) Based on the Calibrated BATHTUB Model.**

| Variable | Units | Observed Value | Predicted Value |
|---|---|---|---|
| Total Phosphorus as P | mg/L | 0.790 | 0.790 |
| Total Dissolved Phosphorus | mg/L | 0.057 | 0.057 |
| Total Nitrogen as N | mg/L | 1.238 | 1.238 |
| Organic Nitrogen as N | mg/L | 1.093 | 1.092 |
| Chlorophyll-a | ug/L | 7.57 | 7.43 |
| Secchi Disk Transparency | meters | 1.71 | 1.69 |
| Carlson TSI-P | | 100.36 | 100.37 |
| Carlson TSI-Chl-a | | 50.46 | 50.27 |
| Carlson TSI-Secchi | | 52.27 | 52.47 |

### 5.3 AGNPS Watershed Model

In order to identify significant NPS pollutant sources in the Lake Hoskins watershed and to assess the relative reductions in nutrient (nitrogen and phosphorus) and sediment loading that can be expected from the implementation of BMPs in the watershed, an AGNPS Version 3.65 model analysis was employed. The AGNPS Version 3.65 model was used to analyze data collected by USDA-NRCS.

The primary objectives for using the AGNPS 3.65 model were to: 1) evaluate NPS contributions within the watershed(s); 2) identify critical pollutant source areas within the watershed; and 3) evaluate potential pollutant (nitrogen, phosphorus, and sediment) reduction estimates that can be achieved through the implementation of various BMP implementation scenarios.

The AGNPS 3.65 model is a single event model that has twenty input parameters. Sixteen parameters were used to calculate nutrient/sediment output, surface runoff and erosion. The parameters used were receiving cell, aspect, SCS curve, percent slope, slope shape, slope length,

Manning's roughness coefficient, K-factor, C-factor, P-factor, surface conditions constant, soil texture, fertilizer inputs, point source indicators, COD factor and channel indicator.
Annual run-off and annual nutrient yields were calculated for the watershed using the AgNPS model (Table 19). The initial Lake Hoskins watershed summary data is listed in Table 20. Additional modeling comparisons were made by changing crop rotations on selected portions of the watershed. The watershed was divided into 618 40-acre cells for evaluation. Each cell was evaluated based on soil characteristics, slope and land-use characteristics.

**Table 18. Observed and Predicted Values for Selected Trophic Response Variables, Assuming a 25, 50, 75 and 90 Percent Reduction in External Annual Total Phosphorus and Nitrogen Loading to Lake Hoskins**.

| | | Predicted | | | |
|---|---|---|---|---|---|
| **Variable** | **Observed** | **25%** | **50%** | **75%** | **90%** |
| Total Phosphorus as P | 0.790 | 0.598 | 0.405 | 0.212 | 0.097 |
| Total Dissolved Phosphorus | 0.057 | 0.053 | 0.047 | 0.042 | 0.038 |
| Total Nitrogen as N | 1.238 | 0.993 | 0.750 | 0.508 | 0.361 |
| Chlorophyll-a | 7.57 | 6.06 | 4.53 | 2.67 | 1.46 |
| Secchi Disk Transparency | 1.71 | 1.74 | 1.80 | 1.87 | 1.93 |
| Carlson TSI-P | 100.36 | 96.35 | 90.74 | 81.45 | 70.09 |
| Carlson TSI-Chl-a | 50.46 | 48.27 | 45.41 | 40.25 | 34.33 |
| Carlson TSI-Secchi | 52.27 | 52.04 | 51.56 | 50.94 | 50.53 |

**Table 19. AGNPS Watershed Model Input Parameters and Results for the Lake Hoskins Watershed.**

| Input Parameters | Values |
|---|---|
| Watershed Area | 24,723 acres |
| Cell Area | 40.00 acres |
| Number of Cells | 618 |
| Characteristic Storm Precipitation | 4.00 inches |
| Storm Energy Intensity Value | 98.49 |
| **Runoff Values at the Watershed Outlet** | |
| Runoff Volume (Precipitation Equivilent) | 1.64 inches |
| Peak Runoff Rate | 4187.01 cfs |
| Total Particulate Nitrogen Yield | 0.58 lbs/acre |
| Total Soluble Nitrogen Yieldf | 1.04 lbs/acre |
| Soluble Nitrogen Concentration | 2.80 mg/L |
| Total Particulate Phosphorus Yield | 0.29 lbs/acre |
| Total Soluble Phosphorus Yield | 0.19 lbs/acre |
| Total Soluble Chemical Oxygen Demand Yield | 33.79 lbs/acre |
| Soluble Chemical Oxygen Demand Concentration | 90.77 mg/L |
| Total Sediment Load | 1958.45 tons |
| Mean Total Sediment Concentration | 425.62 mg/L |
| Area Weighted Erosion Rate | 2.05 lbs/acre |

**Table 20. AGNPS Predicted Total Phosphous and Nitrogen Yield Estimates Based on Land Use Changes to Cells with Greater Than 8 Percent Slopes in the Lake Hoskins Watershed.**

| Runoff Values at the Watershed Outlet | 2003-04 Estimated Yield | Cells with Cropland and >8% Slopes Converted to Minimum Tillage | Cells with Cropland and >8% Slopes Converted to Grass | Cells Currently in CRP to Converted to Soybeans |
|---|---|---|---|---|
| Total Particulate Nitrogen | 0.48 lbs/acre | 0.45 | 0.41 | 0.58 |
| Total Particulate Phosphorus | 0.24 lbs/acre | 0.23 | 0.2 | 0.029 |
| Total Soluble Phosphorus in Runoff | 0.19 lbs/acre | | 0.2 | |

The AGNPS model predicted that based on the existing 2003-04 farming practices that were implemented in the Lake Hoskins watershed (i.e., a mixture of cropland, CRP and rangeland), the total particulate nitrogen (i.e., nitrogen in sediment) yield resulting from a 4.00 inch rainfall event was 0.48 pounds per acre and the total particulate phosphorus (i.e., total phosphorus in sediment) yield was 0.24 pounds per acre (Table 19 and 20). Cover-management factors (C-Factors) were determined for each cell within the Lake Hoskins watershed. The C-factor is used to reflect the cropping and management practices on erosion rates. This factor indicates how the cropping management practices will affect the annual soil loss and how that soil-loss potential will be distributed. By changing the land management practices in only those cells with slopes of greater than 8 % to a cropland C-factor equivalent to that for minimum tillage, the AGNPS model predicts that the total nitrogen and total phosphorus in sediment yields would be reduced to 0.45 and 0.23 lbs/acre, respectively. If these C-factors were converted to numbers for grass-like vegetation in the AGNPS model, a reduction was noted of 15% for total nitrogen and 16% for total phosphorus. The potential effects of converting lands currently in CRP to cropland was also evaluated with the AGNPS model. Cells in the watershed currently in CRP were converted to cropland planted to soybeans. The AGNPS model estimated that total nitrogen and total phosphorus yield would increase approximately 120 % and 121 %, respectively.

## 6.0 MARGIN OF SAFETY AND SEASONALITY

### 6.1 Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations require that TMDLs shall be established at levels necessary to attain and maintain applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. The margin of safety can be either incorporated into conservative assumptions used to develop the TMDL or added as a separate component of the TMDL.

In order to meet the TMDL target of 0.405 mg/L total phosphorus (TSI Score = 90.74), the BATHTUB model estimates that a 50% reduction in total phosphorus loading is necessary. Based on data collected for this assessment, the current annual total phosphorus load is 2,223 kg/yr. Assuming BMPs are implemented on the critical areas within the watershed, then total phosphorus loading from the watershed should be reduced by 50% or 1,111.5 kg. Assuming a 10% explicit margin of safety, then 111.15 kg will be set aside as a margin of safety resulting in the remaining 1000.35 kg allocated to the load allocation and waste load allocations in the TMDL.

Through conservative assumptions in the AgNPS and BATHTUB modeling procedures an implicit MOS is being provided. The most conservative of the assumptions is that all external nutrients were kept in the lake because of the lack of outflow. Through the implementation of best management practices on the four AFOs an additional margin of safety should be achieved in accordance with the TMDL.

Post-implementation monitoring related to the effectiveness of the BMPs can also be used to assure attainment of the TMDL targets, through the use of adaptive management during the implementation phase.

### 6.2 Seasonality

Section 303(d) (1) of the Clean Water Act and the U. S. Environmental Protection Agency (US EPA) regulations require that a TMDL be established with seasonal variations. The Lake Hoskins TMDLs address seasonality because the BATHTUB Model incorporates seasonal differences in its prediction of annual average total phosphorus concentrations by evaluating existing and allowable loads over a full range of flows that in turn reflect seasonal differences.

## 7.0 TMDL

The TMDL can be generally described by the following equation:

**TMDL = LC = WLA + LA + MOS**

where

**LC** loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;

**WLA** wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;

**LA** load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources;

**MOS** margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a priority loading capacity**.**

### 7.1 Nutrient TMDL

Table 23 summarizes the nutrient TMDL for Lake Hoskins in terms of loading capacity, waste load allocations, load allocations, and a margin of safety.

**Table 21. Summary of the Nutrient TMDL for Lake Hoskins.**

| Category | Total Phosphorus (kg/yr) | Explanation |
|---|---|---|
| **Existing Loading** | 2,223 | From Observed Data |
| **Loading Capacity** | 1,111.50 | 50% Reduction<br>Based on BATHTUB Modeling |
| **Waste Load Allocation** | 0 | There are no point sources in the watershed. |
| **Load Allocation** | 1,000.35 | Allocation to nonpoint sources minus MOS |
| **MOS** | 111.15 | Explicit ten percent (10%) MOS set aside, in addition an implicit MOS is provided through conservative modeling assumptions. |

Based on data collected in 2003 and 2004, the existing load to Lake Hoskins is estimated at 2,223.0 kg. Assuming a 50 percent reduction based on BATHTUB and AGNPS modeling results in Lake Hoskins reaching a TMDL target total phosphorus concentration of 0.405 mg L-1, then the TMDL or Loading Capacity is 1,111.5 kg. Assuming 10 percent of the loading capacity (111.15 kg/yr) is assigned to the MOS and there are no point sources in the watershed all of the remaining loading capacity (1000.35 kg/yr) is assigned to the load allocation.

### 7.2 Dissolved Oxygen TMDL

AGNPS and BATHTUB models indicate that excessive nutrient loading is responsible for the low dissolved oxygen levels in Lake Hoskins. Wetzel (1983) summarized, "The loading of organic matter to the hypolimnion and sediments of productive eutrophic lakes increases the consumption of dissolved oxygen. As a result, the oxygen content of the hypolimnion is reduced progressively during the period of summer stratification."

Carpenter et al. (1998), has shown that nonpoint sources of phosphorous has lead to eutrophic conditions for many lake/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of designated beneficial uses. However, the rates of recovery are variable among lakes/reservoirs. This supports the Department of Health's viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process takes a significant amount of time (5-15 years).

In Lake Erie, heavy loadings of phosphorous have impacted the lake severely. Monitoring and research from the 1960's has shown that depressed hypolimnetic dissolved oxygen levels were responsible for large fish kills and large mats of decaying algae. Binational programs to reduce nutrients into the lake have resulted in a downward trend of the oxygen depletion rate since monitoring began in the 1970's. The trend of oxygen depletion has lagged behind that of phosphorous reduction, but this was expected (See: http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nürnberg (1995, 1995a, 1997, 1998), developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual total phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nürnberg (1996), developed several regression models that show nutrients control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. NDDoH has calculated the morphometric parameters such as surface area (Ao = 553.5 acres; 2.24 km2), mean depth (z = 8.0 feet; 2.44 meters), and the ratio of mean depth to the surface area ($z/Ao^{0.5} = 0.43x10^{-3}$) for Lake Hoskins, which show that these parameters are within the range of lakes used by Nürnberg. Based on this information, NDDoH is confident that Nürnberg's empirical nutrient-oxygen relationship holds true for North Dakota lakes and reservoirs. NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to the Dam which will reduce algae blooms and therefore increase oxygen levels over time.

Best professional judgment concludes that as levels of phosphorus are reduced by the implementation of best management practices, dissolved oxygen levels will improve. This is supported by the research of Thornton, et al (1990). They state that, "... as organic deposits were exhausted, oxygen conditions improved." To insure that the implementation of BMPs will reduce phosphorus levels and result in a corresponding increase in dissolved oxygen, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan.

## 8.0 ALLOCATION

This TMDL will be implemented by several parties on a volunteer basis. Phosphorus loads into the reservoir will be reduced by 50 % by treating of the AGNPS identified “high nutrient runoff” areas (Figure 13). High nutrient runoff areas were determined using the AgNPS model which identified those 40 acre cells with a sediment nitrogen factor of greater than 3.0 lbs per acre, a sediment phosphorus factor of greater than 1.5lbs per acre, and a soluble phosphorus factor of greater than 0.4 lbs per acre.

There are 159 cells within the Lake Hoskins watershed identified as "high nutrient runoff areas" by AGNPS modeling. These cells represent a total area of 6,360 acres of cropland acres, or 26% of the watershed. If 100% of the critical watershed areas can be treated with appropriate BMPs and Livestock Waste Management systems installed on three of the four AFOs, then the specified reduction is possible.

Cover-management factors (C-Factors) were determined for each cell within the Lake Hoskins watershed. The C-factor is used to reflect the cropping and management practices on erosion rates. This factor indicates how the cropping management practices will affect the annual soil loss and how that soil-loss potential will be distributed. By changing the land management practices in cells with slopes of greater than 8% and a cropland C-factor, the total nitrogen (TN) and total phosphorus (TP) in sediment levels would be reduced for the watershed. If these C-factors were converted to numbers for grass-like vegetation in the AgNPS model, a further reduction was noted of 15% for TN and 16% for TP.

Further reductions in total phosphorus loads will be achieved through drafting of ordinances relating to future developments and existing developments around Lake Hoskins that will further reduce phosphorus loading.

The Lake Hoskins Improvement Association, in cooperation with the North Dakota State Game and Fish Department’s Save Our Lakes Program, local and State NRCS Offices and local volunteer groups (Boy Scouts) have implemented several improvement ideas within the Lake Hoskins watershed. Areas of shoreline have been stabilized to reduce erosion and sediment loads. Numerous trees have been planted along shorelines. The groups also worked with local landowners to address the feedlot operations and the impacts to Lake Hoskins. Two sedimentation dams, one in the northwest portion of the watershed and one in the southern portion of the watershed, were installed in an attempt to further reduce loadings during periods of heavy run-off within those portions of the watershed. In addition, areas were re-fenced and alternative water sources were added to restrict direct access to the shoreline by livestock.

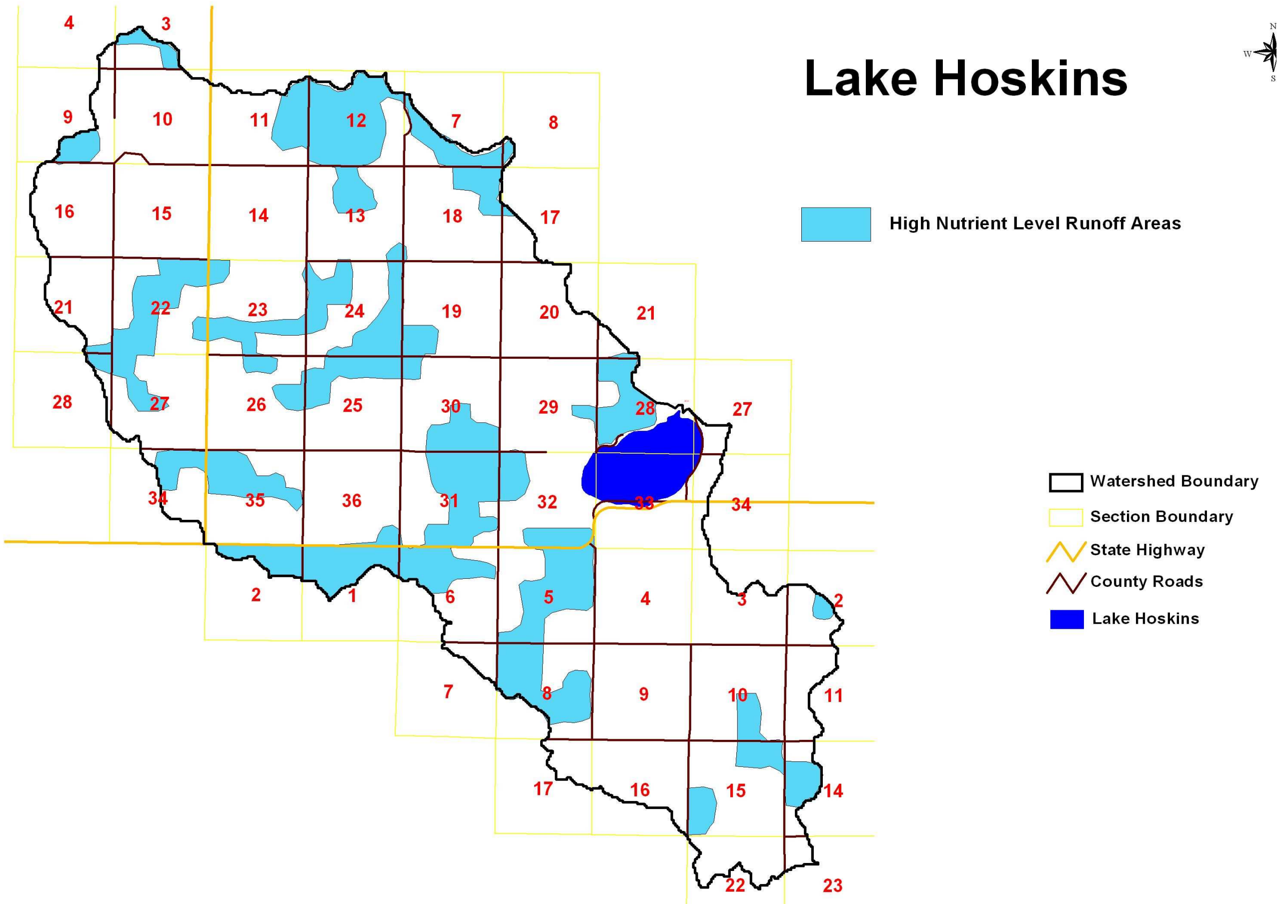


**Figure 13. High Nutrient Run-off Areas in the Lake Hoskins Watershed.**

## 9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Lake Hoskins and a request for public comment was mailed to participating agencies, partners, and to those who request a copy. Those included in the mailing of a hard copy are as follows:

US EPA - Region VIII
USDA-NRCS State Office
US Fish & Wildlife Service
North Dakota State Game and Fish Department
McIntosh County Soil Conservation District
McIntosh County Water Resource Board
Lake Hoskins Improvement Association

In addition to the mailed hard copies, the TMDL for Lake Hoskins was posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.health.state.nd.us/wq. A 30-day public notice soliciting comment and participation was also published in the Ashley Tribune and the Bismarck Tribune.

The 30-day comment period was held from May 25, 2006 through June 23, 2006. Comments were received from the North Dakota Game and Fish Department and the U.S. EPA. A summary of the comments received and the North Dakota Department of Health's response to those comments are provided in Appendix D.

Significant public involvement also occurred during the development of the Lake Hoskins TMDL. Table 24 summarizes the efforts taken to gain public education, review, and comment during the development of the TMDL.

**Table 22. Summary of Public Involvement During the Lake Hoskins TMDL Development Project.**

| Public Meetings/Contacts | Articles/Reports | Comments |
|---|---|---|
| Monthly LHIA meetings | Ashley Tribune–shoreline and tree planting | Public concern for lake and recreation potential |
| Data Review by NRCS/HPC | Ashley Tribune– sedimentation dam project | Public concern for water quality improvement |
| Meetings with NDGF/Save Our Lakes Program | Ashley Tribune– water sampling | Public involvement in project implementation |
| Cooperative efforts on projects with Boy Scout troop | Ashley Tribune– June 2004 Public Meeting | Public attendance at open discussion meeting |
| Cooperative efforts with watershed landowners/sediment | Bismarck Tribune–June 2004 Public Meeting | Public follow-up with ideas for planned improvements |

## 10.0 MONITORING STRATEGY

In the fall of 2004 the McIntosh County Soil Conservation District applied for, and received, FY 2004 Section 319 NPS watershed restoration funding. These funds will be used to work with producers in the Lake Hoskins watershed to implement BMPs that will result in achieving the TMDL targets set forth in this report. To ensure these TMDL targets are met and the goals of the Section 319 project are achieved, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan (QAPP).

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. These include, but are not limited to nutrients (i.e., nitrogen and phosphorus) and dissolved oxygen. Monitoring will be conducted in the lake beginning two years after implementation and extending 5 years after the implementation project is complete.

## 11.0 TMDL IMPLEMENTATION STRATEGY

As stated in the previous section, the McIntosh County SCD has received Section 319 NPS watershed restoration funding to implement BMPs necessary to achieve the TMDL targets set forth in this report. It should be remembered, however, that the implementation of the best management practices contained in the NPS pollution management project implementation plan (PIP) is voluntary. Therefore, the success of this project is ultimately dependent on the ability of the local project sponsor to find cooperating producers.

Monitoring is also an important and required component of any PIP. As a part of the PIP, data are collected to monitor and track the effects of BMP implementation as well as to judge overall project success. The Quality Assurance Project Plans (QAPPs) for the Lake Hoskins Section 319 PIP details the strategy of how, when and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data are gathered and analyzed, watershed restoration tasks will be adapted, if necessary, to place BMPs where they will have the greatest benefit to water quality.

## 12.0 ENDANGERED SPECIES

States are encouraged to participate with the U.S. Fish and Wildlife Service and EPA in the Endangered Species Act consultation process to document, adversely or beneficially, the potential effects of the TMDL on threatened or endangered species. To assist with this process, the U.S. Fish and Wildlife Service’s Ecological Services Division in Bismarck, North Dakota was contacted (Ellsworth 2006, personnel communication) regarding potential endangered or threatened species in the Lake Hoskins watershed area. The U.S. Fish and Wildlife Service identified two federally listed species as endangered, the Whooping Crane (*Grus americana*) and the Gray wolf (*Canis lupis*), and two federally listed threatened species, the Bald eagle (*Haliaeetus leucocephalus*) and the Piping plover (*Charadrius melodus*), as potentially found in the area. There were no critical habitats identified by the U.S. Fish and Wildlife Service in the watershed area.

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# Appendix A

## A Calibrated Trophic Response Model (BATHTUB) for Lake Hoskins

**A Calibrated Trophic Response Model (BATHTUB) for Lake Hoskins
As a Tool to Evaluate Various Nutrient Reduction Alternatives
Based on Data Collected by the Lake Hoskins Lake Improvement Association from
February 2003 through February, 2004**

Prepared by
Peter Wax
October 17, 2005

## Introduction

In order to meet the project goals, as set forth by the project sponsors of identifying possible options to improve the trophic condition of Lake Hoskins to levels capable of maintaining the reservoirs beneficial uses (e.g., fishing, recreation, and drinking water supply), and the objectives of this project, which are to: (1) develop a nutrient and sediment budget for the reservoir; (2) identify the primary sources and causes of nutrients and sediments to the reservoir; and (3) examine and make recommendations for reservoir restoration measures which will reduce documented nutrient and sediment loadings to the reservoir, a calibrated trophic response model was developed for Lake Hoskins. The model enables investigations into various nutrient reduction alternatives relative to the project goal of improving Lake Hoskins's trophic status. The model will allow resource managers and the public to relate changes in nutrient loadings to the trophic condition of the reservoir and to set realistic lake restoration goals that are scientifically defensible, achievable and socially acceptable.

## Methods

For purposes of this project, the BATHTUB program was used to predict changes in trophic status based on changes in nutrient loading. The BATHTUB program, developed by the US Army Corps of Engineers Waterways Experiment Station (Walker, 1996), applies an empirically derived eutrophication model to reservoirs. The model is developed in three phases. The first two phases involve the analysis and reduction of the tributary and in-lake water quality data. The third phase involves model calibration. In the data reduction phase, the in-lake and tributary monitoring data collected as part of the project are summarized, or reduced, in a format which can serve as inputs to the model. The following is a brief explanation of the computer software, methods, and procedures used to complete each of these phases.

## Tributary Data

To facilitate the analysis and reduction of tributary inflow and outflow water quality the program Microsoft Excel was employed. Water volume was calculated by the environmental consulting firm High Plains Consortium (HPC). The total inflow water volume calculated was then divided between each sub-watershed based on the percentage of land area each occupied within the total watershed area. Water quality concentrations used in the final analysis were the mean concentrations for each sub-watershed as collected by the Lake Hoskins Lake Improvement Association. The average concentrations and calculated flow volumes were used as inputs to calibrate the BATHTUB eutrophication response model.

## Lake Data

Lake Hoskins's in-lake water quality data was reduced using Microsoft Excel. The data was reduced in excel to provide three computational functions, including: (1) the ability to display constitute concentrations as a function of depth, location, and/or date; (2) calculate summary statistics (e.g., mean, median and standard error in the mixed layer of the lake or reservoir); and (3) track the temporal trophic status. As is the case with tributary data, output from the Excel program is used as input to calibrate the BATHTUB model.

## BATHTUB Model Calibration

As stated previously, the BATHTUB eutrophication model was selected for this project as a means of evaluating the effects of various nutrient reduction alternatives on the predicted trophic status of Lake Hoskins. BATHTUB performs water and nutrient balance calculations in a steady-state. The BATHTUB model also allows the user to spatially segment the reservoir. Eutrophication related water quality variables (e.g., total phosphorus, total nitrogen, chlorophyll-a, Secchi Disk transparency, organic nitrogen, orthophosphorous, and hypolimnetic oxygen depletion rate) are predicted using empirical relationships previously developed and tested for reservoir systems (Walker, 1985).

Within the BATHTUB program the user can select from six schemes based on reservoir morphometry and the needs of the resource manager. Using BATHTUB the user can view the reservoir as a single spatially averaged reservoir or as a single segmented reservoir. The user can also model parts of the reservoir, such as an embayment, or model a collection of reservoirs. For purposes of this project, Lake Hoskins was modeled as a single, spatially averaged, reservoir.

Once input is provided to the model from FLUX and Excel the user can compare predicted conditions (i.e., model output) to actual conditions. Since BATHTUB uses a set of generalized rates and factors, predicted vs. actual conditions may differ by a factor of 2 or more using the initial, un-calibrated, model. These differences reflect a combination of measurement errors in the inflow and outflow data, as well as unique features of the reservoir being modeled.

In order to closely match an actual in-lake condition with the predicted condition, BATHTUB allows the user to modify a set of calibration factors (Table 1). For a complete description of the BATHTUB model the reader is referred to Walker (1996).

**Table 1. Selected model parameters, number and name of model, and where appropriate the calibration factor used for Lake Hoskins BATHTUB Model.**

| Model Option | Model Selection | Calibration Factor |
|---|---|---|
| Conservative Substance | 1 Computed | 1.00 |
| Phosphorus Balance | 7 Settling Velocity | 0.547 |
| Phosphorus - Ortho P | 7 | 1.730 |
| Nitrogen Balance | 6 First Order Settling Velocity | 0.830 |
| Organic Nitrogen | 6 | 1.760 |
| Chlorophyll-a | 1 P, N, Light, T | 0.250 |
| Secchi Depth | 1 Vs. Chla & Turbidity | 2.000 |
| Phosphorus Calibration | 1 Decay Rate | NA |
| Nitrogen Calibration | 1 Decay Rate | NA |
| Availability Factors | 2 All Models Except 2 | NA |
| Mass-Balance Tables | 0 Use Observed Concentrations | NA |

## Results

The trophic response model, BATHTUB, has been calibrated to match Lake Hoskins's trophic response for the project period between February, 2003 and February, 2004. This is accomplished by combining tributary loading estimates for the hydrologic year February, 2003 and February, 2004 with in-lake water quality. Tributary flow data for the project period are reduced by HPC and the corresponding tributary and in-lake water quality data are reduced utilizing Microsoft Excel. The outputs from these two sources are then provided as input to the BATHTUB model. The model is calibrated through several iterations, first by selecting appropriate empirical relationships for model coefficients (e.g., nitrogen and phosphorus sedimentation, nitrogen and phosphorus decay, oxygen depletion, and algal/chlorophyll growth), and second by adjusting model calibration factors for those coefficients (Table 1). The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates made from project monitoring data.

The two most important nutrients controlling trophic response in Lake Hoskins are nitrogen and phosphorus. After calibration the observed average annual concentration of total nitrogen and total phosphorus compare well with those of the BATHTUB model. The model predicts that the reservoir has an annual volume weighted average total phosphorus concentration of 0.79 mg/ L and an annual average volume weighted total nitrogen concentration of 1.235 mg/L compared to observed values for total phosphorus and total nitrogen of 0.79 mg/ L and 1.235 mg/L, respectively (Table 2).

Other measures of trophic response predicted by the model are average annual chlorophyll-a concentration and average secchi disk transparency. The calibrated model was equally effective at predicting average chlorophyll-a concentration and secchi disk transparency within the reservoir as total phosphorus and total nitrogen (Table 2).

**Table 2. Observed and Predicted Values for Selected Trophic Response Variables for the Calibrated BATHTUB Model.**

| Variable | Observed | Predicted |
|---|---|---|
| Total Phosphorus as P (mg/L) | 0.790 | 0.790 |
| Total Dissolved Phosphorus (mg/L) | 0.057 | 0.057 |
| Total Nitrogen as N (mg/L) | 1.238 | 1.238 |
| Organic Nitrogen as N (mg/L) | 1.093 | 1.092 |
| Chlorophyll-a ($\mu$g/L) | 7.57 | 7.43 |
| Secchi Disk Transparency (meters) | 1.71 | 1.69 |
| Carlson's TSI for Phosphorus | 100.36 | 100.37 |
| Carlson's TSI for Chlorophyll-a | 50.46 | 50.27 |
| Carlson's TSI for Secchi Disk | 52.27 | 52.47 |

Once predictions of total phosphorus, chlorophyll-a, and secchi disk transparency are made, the model calculates Carlson's Trophic Status Index (TSI) (Carlson, 1977) as a means of expressing predicted trophic response (Table 2). Carlson's TSI is an index that can be used to measure the relative trophic state of a lake or reservoir. Simply stated, trophic state is how much production (i.e., algal and weed growth) occurs in the waterbody. The lower the nutrient concentrations are within the waterbody the lower the production and the lower the trophic state or level. In contrast, increased nutrient concentrations in a lake or reservoir increase the production of algae and weeds which make the lake or reservoir more eutrophic or of a higher trophic state. Oligotrophic is the term which describes the least productive lakes and hypereutrophic is the term used to describe lakes and reservoirs with excessive nutrients and primary production.

Figure 1 provides a graphic summary of the TSI range for each trophic level compared to values for each of the trophic response variables. The calibrated model provided predictions of trophic status which are similar to the observed TSI values for the project period (Table 2). Overall, the predicted and observed TSI values for phosphorus, chlorophyll-a and secchi disk suggest Lake Hoskins is eutrophic. Figure 2 is a graphic that shows the annual temporal distribution of Lake Hoskins's trophic state based on the three parameters - total phosphorus as phosphate, chlorophyll-a and secchi disk depth transparency.

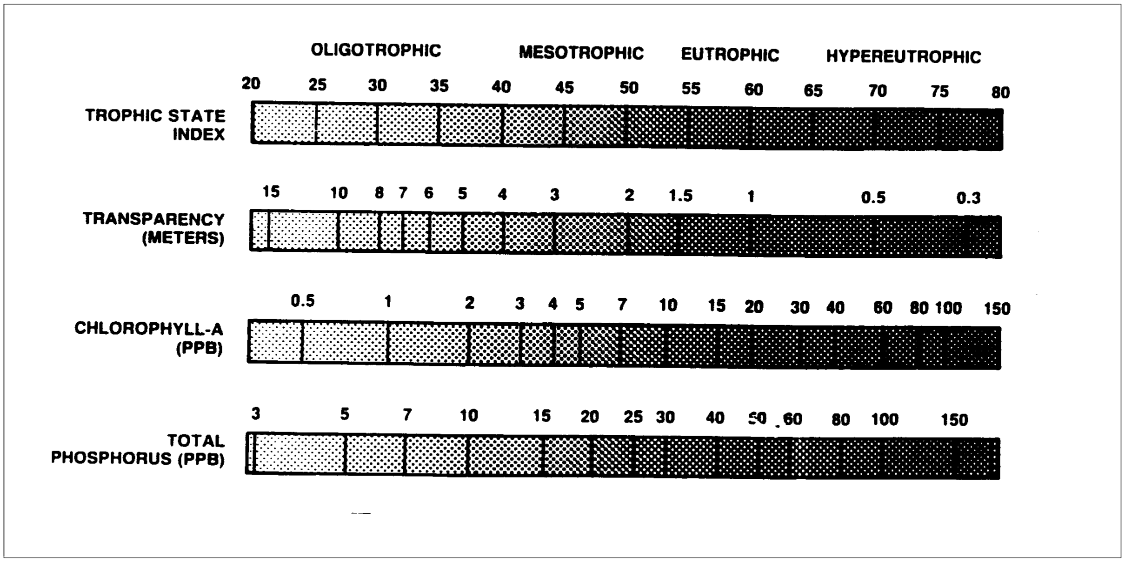


**Figure 1. Graphic depiction of Carlson's Trophic Status Index**

## Model Predictions

Once the model is calibrated to existing conditions, the model can be used to evaluate the effectiveness of any number of nutrient reduction or lake restoration alternatives. This evaluation is accomplished comparing predicted trophic state, as reflected by Carlson's TSI, with currently observed TSI values. Modeled nutrient reduction alternatives are presented in three basic categories: (1) reducing externally derived nutrient loads; (2) reducing internally available nutrients; and (3) reducing both external and internal nutrient loads. For Lake Hoskins only external nutrient loads were addressed. External nutrient loads were addressed because they are known to cause eutrophication and because they are controllable through the implementation of watershed Best Management Practices (BMPs).

Predicted changes in trophic response to Lake Hoskins were evaluated by reducing externally derived phosphorus loads by 25, 50, 75, and 90 percent. These reductions were simulated in the model by reducing the phosphorus concentrations in the contributing tributary and other external delivery sources by 25, 50, 75, and 90 percent. Since there is no reliable means of estimating how much hydraulic discharge would be reduced through the implementation of BMPs, flow was held constant.

The model results indicate that if it were possible to reduce external phosphorus loading to Lake Hoskins the average annual total phosphorus and chlorophyll-a concentrations in the lake would decrease as well and secchi disk transparency depth would increase (Table 3, Figure 3). However it is unlikely that the change would be noticeable until a 50 or even 75 percent reduction in external phosphorus and nitrogen load is achieved. The model predicts a reduction in Carlson's TSI score from for chlorophyll-a, and secchi disk transparency corresponding to trophic state of mesotrophic and eutrophic, respectively with a 50 percent reduction and mesotrophic for both with a 75 percent reduction.

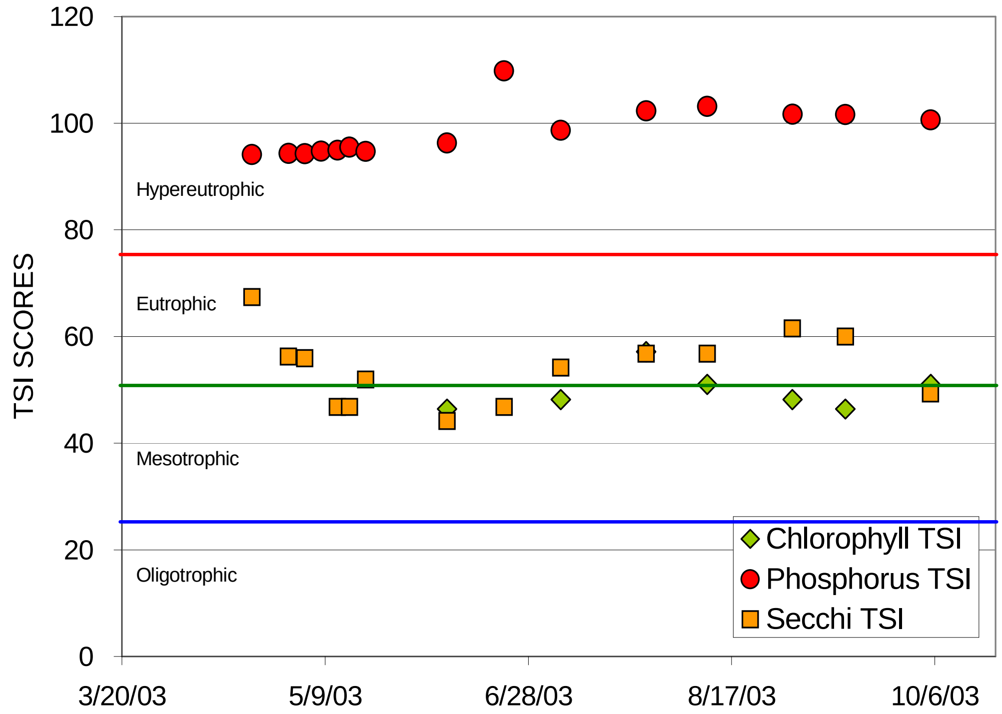


**Figure 2. Temporal distribution of Carlson's Trophic Status Index scores for Lake Hoskins (February 2003 to February 2004).**

**Table 3. Observed and Predicted Values for Selected Trophic Response Variables Assuming a 25, 50, 75 and 90 Percent Reduction in External Phosphorus and Nitrogen Loading.**

| | | Predicted | | | |
|---|---|---|---|---|---|
| **Variable** | **Observed** | **25 %** | **50 %** | **75 %** | **90 %** |
| Total Phosphorus as P (mg/L) | 0.790 | 0.598 | 0.405 | 0.212 | 0.097 |
| Total Dissolved Phosphorus (mg/L) | 0.057 | 0.053 | 0.047 | 0.042 | 0.038 |
| Total Nitrogen as N (mg/L) | 1.238 | 0.993 | 0.750 | 0.508 | 0.361 |
| Chlorophyll-a ($\mu$g/L) | 7.57 | 6.06 | 4.53 | 2.67 | 1.46 |
| Secchi Disk Transparency (meters) | 1.71 | 1.74 | 1.80 | 1.87 | 1.93 |
| Carlson’s TSI for Phosphorus | 100.36 | 96.35 | 90.74 | 81.45 | 70.09 |
| Carlson’s TSI for Chlorophyll-a | 50.46 | 48.27 | 45.41 | 40.25 | 34.33 |
| Carlson’s TSI for Secchi Disk | 52.27 | 52.04 | 51.56 | 50.94 | 50.5 |

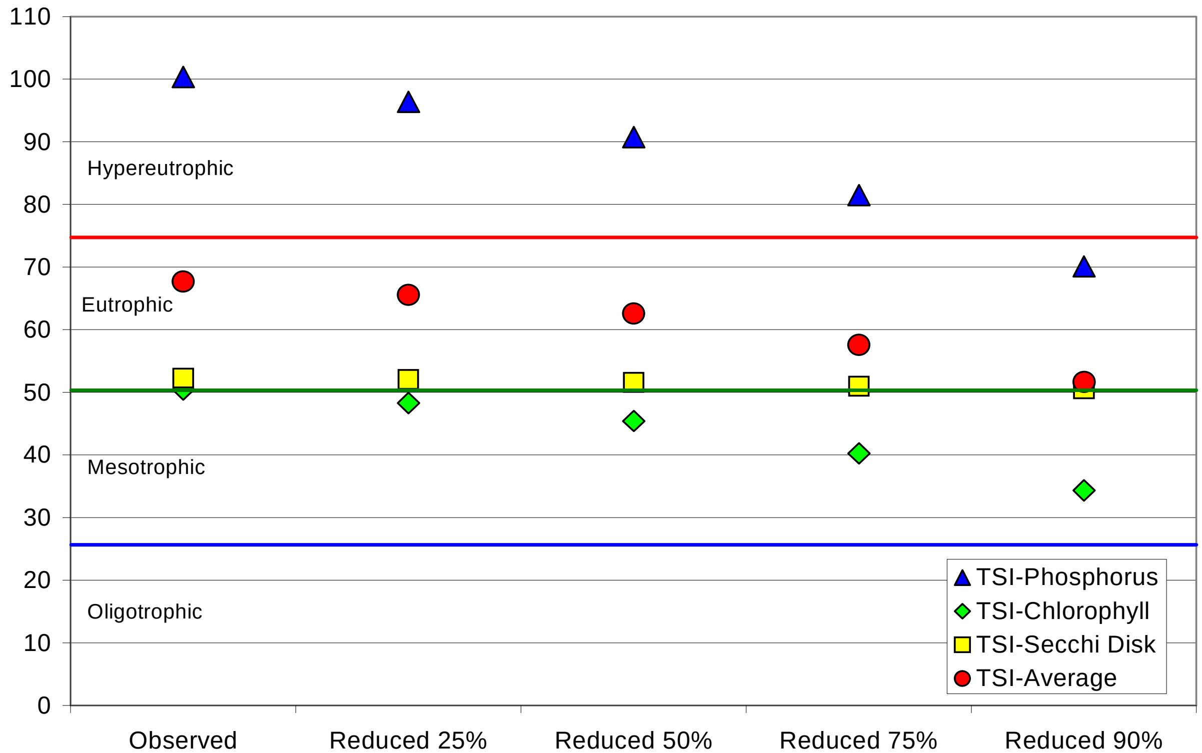


**Figure 3. Predicted trophic response to phosphorus load reductions to Lake Hoskins of 25, 50, 75, and 90 percent.**

## Appendix B

## Public Comments on the Draft Lake Hoskins Dissolved Oxygen and Nutrient TMDL Report and the North Dakota Department of Health's Response to Comments

During the 30-day public notice soliciting comment on the draft report entitled “Nutrient and Dissolved Oxygen TMDLs for Lake Hoskins in McIntosh County, North Dakota”, the NDDoH only received comments from Scott Elstad with the North Dakota Game and Fish Department and from Vern Berry with the US EPA Region 8. Mr. Elstad’s comments were submitted as hand written comments submitted in the margins of the draft report. Mr. Berry’s comments were submitted to the NDDoH via email dated June 30, 2006. The following are their comments and the NDDoH’s reponse to those comments.

**NDGF Comment:** In Section 1.5.2 Water Quality Data, page 12, does the term “significant increase” mean “statistically significant increase”?

**NDDoH Response:** No, the term “significant” was removed from the sentence.

**NDGF Comment:** In Section 1.5.2 Secchi Disk Transparency, page 13, the paragraph states “The water clarity peaked during late May to early June” and references Figure 15. In Figure 9 it looks like Secchi Disk transparency was highest in November-January at the deepest site. Is this simply the difference between “peak” and “average”?

**NDDoH Response:** Table 12 provides a summary of daily Secchi Disk transparency measurements, while Figure 9 presents seasonal means. The sentence in this section was changed to reference Table 12.

**NDGF Comment:** In Section 3.1 Trophic State Index, page 19, Mr. Elstad suggested changing “weeds” to “vegetation” and “large” to “excessive”.

**NDDoH Response:** Suggested changes made.

**NDGF Comment:** In Section 8.0, page 29, the report states that”sedimentation dams were installed in the NW Portion of the (Lake Hoskins) watershed”. Two sediment dams were installed in the Lake Hoskins watershed through funding provided by the NDGF’s Save Our Lakes Program, one in the NW portion of the watershed and one in the southern portion of the watershed. Alternate livestock watering sources were also installed in the watershed through the SOL program.

**NDDoH Response:** This section of the report was re-written to reflect this information.

**EPA Region 8 Comment:** In Section 3.2, Nutrient Target, page 19, the text says that the TMDL nutrient target(s) are TSI of 50 for chlorophyll and Secchi depth, whereas the values shown in Table 15 (with a 50% reduction in external nutrient loading) for Chl-a and SD are 45.4 and 51.6 respectively. We recommend that the Nutrient TMDL target be stated clearly in the fist or second paragraph of this section, and it be consistent with predictions derived from the modeling performed for the watershed. We assume that the nutrient targets are TSI Chl-a = 45.4 and TSI SD = 51.6. We recommend that this section be revised accordingly.

**NDDoH Response:** The text in Section 3.2, Nutrient Target, was changed to reflect EPA’s comment. The Trophic Status Index TMDL targets for chlorophyll-a and Secchi disk transparency were change to 45.4 and 51.6, respectively.

**EPA Region 8 Comment:** In Section 7.1, Nutrient TMDL, page 27, the explanation for the MOS in Table 21 says the TMDL includes a 10% "implicit" margin of safety, whereas Section 6.1 explains how an "explicit" MOS is included. We recommend that the MOS explanation in Table 21 be revised similar to:
"10% explicit MOS is being set aside, in addition, an implicit MOS is provided through conservative modeling assumptions."

**NDDoH Response:** The explaination provided for the Margin of Safety (MOS) in Table 21 was re-worded as suggested. It reads an "Explicit ten percent (10%) MOS set aside, in addition an implicit MOS is provided through conservative modeling assumptions".