Nutrient and Dissolved Oxygen TMDLs for McGregor Dam in Williams County, North Dakota

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**Includes De-listing Justification for Sediment Impairment

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TABLE OF CONTENTS

Table of Contents ii
List of Tables iii
List of Figures iv
Appendices iv

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED 1
- 1.1 Clean Water Act Section 303(d) Listing Information 4
- 1.2 Topography 4
- 1.3 Land Use/Land Cover 5
- 1.4 Climate and Precipitation 7
- 1.5 Water Quality Data 8

2.0 WATER QUALITY STANDARDS 14
- 2.1 Narrative Water Quality Standards 14
- 2.2 Numeric Water Quality Standards 15

3.0 TMDL TARGETS 16
- 3.1 Nutrient Target 16
- 3.2 Dissolved Oxygen Target 18

4.0 SIGNIFICANT SOURCES 18

5.0 TECHNICAL ANALYSIS 18
- 5.1 Tributary Load Analysis 18
- 5.2 BATHTUB Trophic Response Model 18
- 5.3 AGNPS Watershed Model 21
- 5.4 Dissolved Oxygen 22
- 5.5 Sediment 24

6.0 MARGIN OF SAFETY AND SEASONALITY 25
- 6.1 Margin of Safety 25
- 6.2 Seasonality 26

7.0 TMDL 26
- 7.1 Nutrient TMDL 26
- 7.2 Dissolved Oxygen TMDL 27
- 7.3 Sediment TMDL 27

8.0 ALLOCATION 27

9.0 PUBLIC PARTICIPATION 29

10.0 MONITORING 29

11.0 TMDL IMPLEMENTATION STRATEGY 29

12.0 REFERENCES 30

List of Tables

1. General Characteristics of McGregor Dam and its Watershed. 1

2. McGregor Dam Section 303(d) Listing Information (NDDoH, 2008). 4

3. Description of Land Use (NASS, 2004). 6

4. General Description of Monitoring Sites. 8

5. Summary Statistics for Water Quality Variables Sampled at Tributary Monitoring Station 385242 (Inlet). 10

6. Summary Statistics for Water Quality Variables Sampled at Tributary Monitoring Station 385243 (SW Tributary Inlet). 10

7. Summary Statistics for Water Quality Variables Sampled at Tributary Monitoring Station 385244 (Outlet). 10

8. Summary Statistics for Water Quality Variables Measured in McGregor Dam Deepest Site (380820). 11

9. Average Total Suspended Solids Concentrations for McGregor Dam Inlet and Outlet Sites (2003-2004). 14

10. Numeric Guidelines for Classified Lakes and Reservoirs (NDDoH, 2006). 15

11. Carlson's Trophic State Indices for McGregor Dam. 16

12. Relationships between TSI Variables and Conditions. 17

13. Observed and Predicted Values for Selected Trophic Response Variables Assuming a 25, 50, and 75 Percent Reduction in External Phosphorus and Nitrogen Loading. 20

14. Event-Based Yield Summary for the McGregor Dam Watershed. 22

15. McGregor Dam Watershed AGNPS Summary. 22

16. Sediment Balance for McGregor Dam (2003-2004). 24

17. Summary of the Phosphorus TMDL for McGregor Dam 27

List of Figures

1. Location of McGregor Dam in North Dakota. 2

2. Location of McGregor Dam. 2

3. North Dakota Game and Fish contour Map of McGregor Dam. 3

4. General Location of McGregor Dam Watershed. 5

5. Land Use in the McGregor Dam Watershed. 6

6. Normal Monthly Precipitation from 1971-2000 at the North Dakota Agricultural Weather Station Network (NDAWN),Williston, ND Station. 7

7. Normal Monthly Temperature from 1971-2000 at the North Dakota Agricultural Weather Station Network (NDAWN),Williston, ND Station. 8

8. Monitoring Site Locations for McGregor Dam and Its Tributaries. 9

9. Summary of Temperature Data for the McGregor Dam Deepest Area Site (380820) in 2003. 12

10. Summary of Dissolved Oxygen Concentrations for the McGregor Dam Deepest Area Site (380820) in 2003. 12

11. Summary of Temperature Data for the McGregor Dam Deepest Area Site (380820) in 2004. 13

12. Summary of Dissolved Oxygen Concentrations for the McGregor Dam Deepest Area Site (380820) in 2004. 13

13. Temporal Distribution of Carlson's Trophic Status Index Scores for McGregor Dam. 17

14. Predicted Trophic Response in McGregor Dam to 25, 50, and 75 Percent Phosphorus Load Reduction. 20

15. AGNPS Identification of Critical Areas for BMP Implementation 28

Appendices

A. A Calibrated Trophic Response Model (BATHTUB) for McGregor Dam and Model Output

B. Flux Data and Analysis

C. Stream Visual Assessment Results

D. Review Comments Provided by US EPA Region 8

E. NDDoH Response to Public Comments

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

McGregor Dam is located in the northeast corner of Williams County, one mile south of McGregor, ND (Figures 1 and 2). Completed in 1969 for the purpose of recreation and wildlife enhancement, the reservoir covers 57.5 acres with a maximum depth of 34.1 feet. The shoreline of McGregor Dam is publically owned, surrounded by a State Wildlife Management Area. It is a popular recreational area and receives heavy use from the surrounding communities. The contributing watershed of McGregor Dam is 5,492 acres. Approximately a quarter mile upstream from the reservoir, the two major unnamed tributaries converge into one before entering the reservoir. Table 1 summarizes some of the geographical, hydrological, and physical characteristics of McGregor Dam and its watershed.

Table 1. General Characteristics of McGregor Dam and its Watershed.

Legal Name	McGregor Dam
Major Drainage Basin	Missouri River
Nearest Municipality	Williston, ND
Assessment Unit ID	ND-10110101-019-L_00
County Location	Williams County, ND
Physiographic Region	Glaciated Dark Brown Prairie
Latitude	48˚25'47"
Longitude	-103˚43'58"
Surface Area	57.5 acres
Watershed Area	5,492 acres
Average Depth	13.5 feet
Maximum Depth	34.1 feet
Volume	785.1 acre-feet
Tributaries	Unnamed Tributaries
Type of Waterbody	Constructed Reservoir
Fishery Type	Walleye, Rainbow Trout, BrownTrout

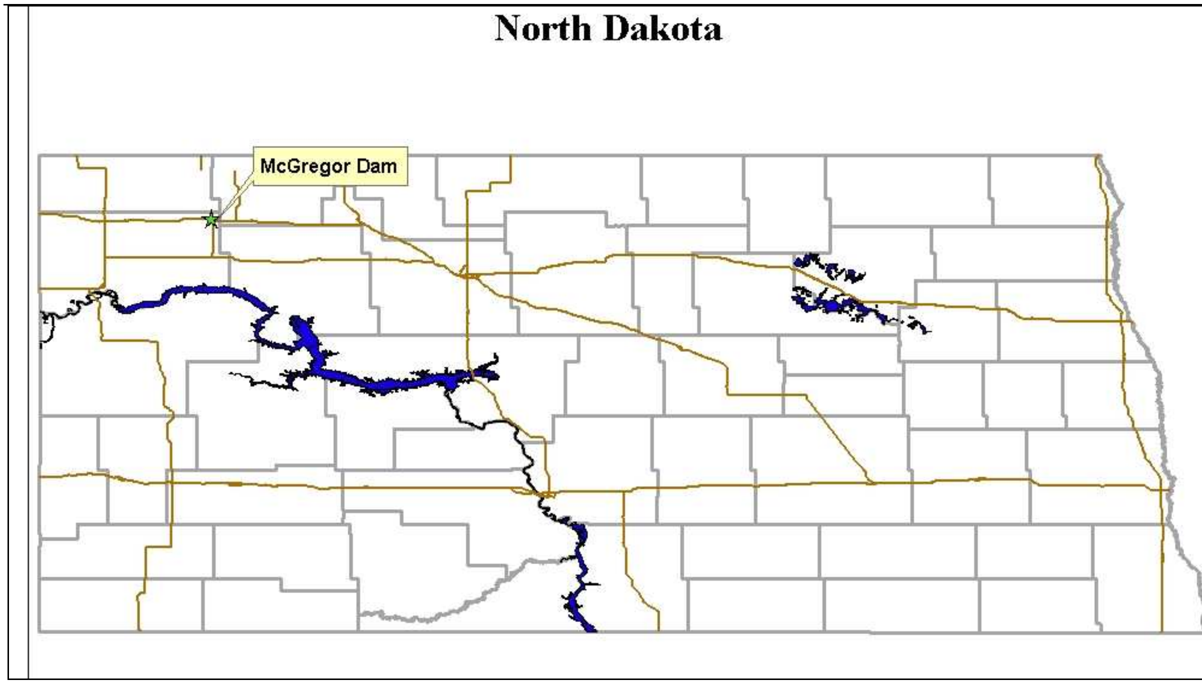

Figure 1. Location of McGregor Dam in North Dakota.

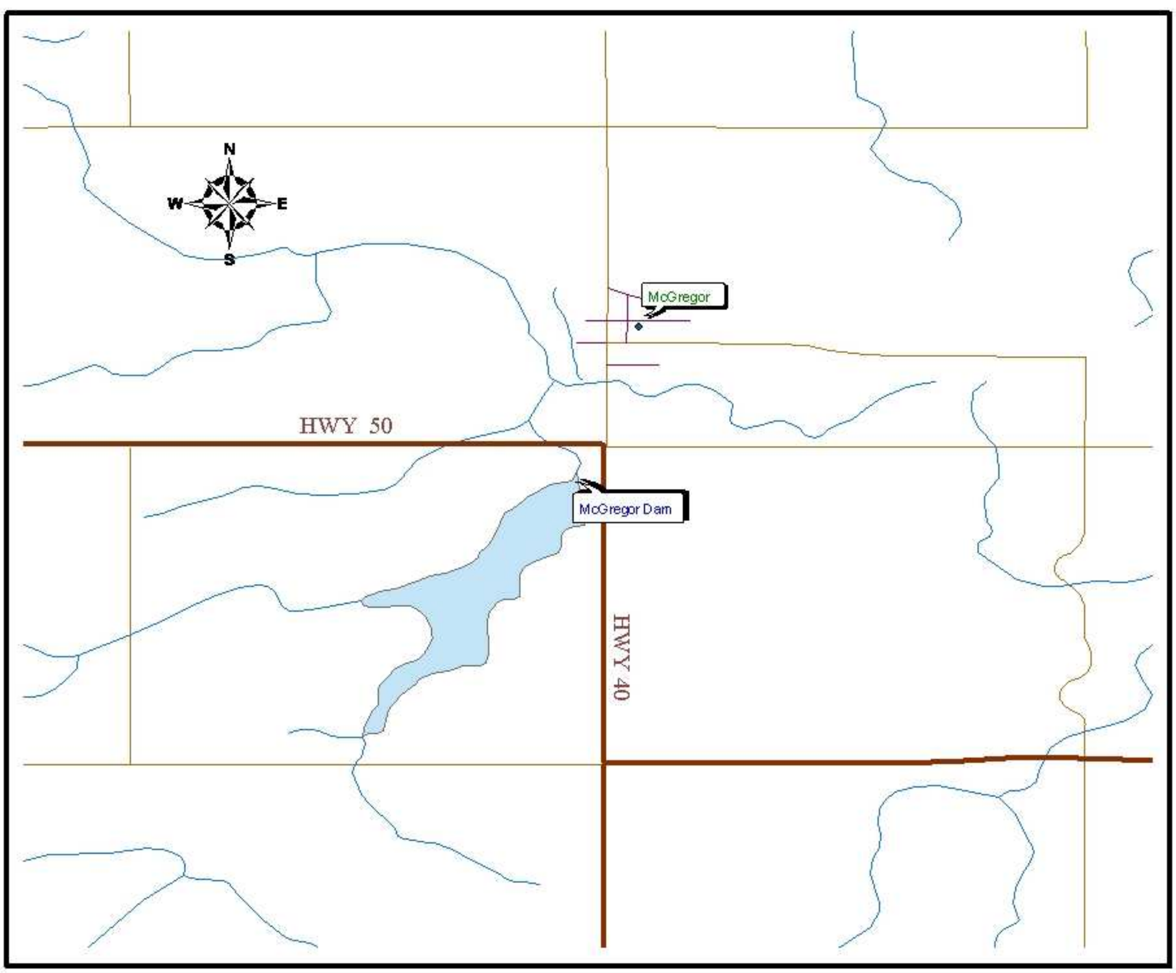

Figure 2. Location of McGregor Dam.

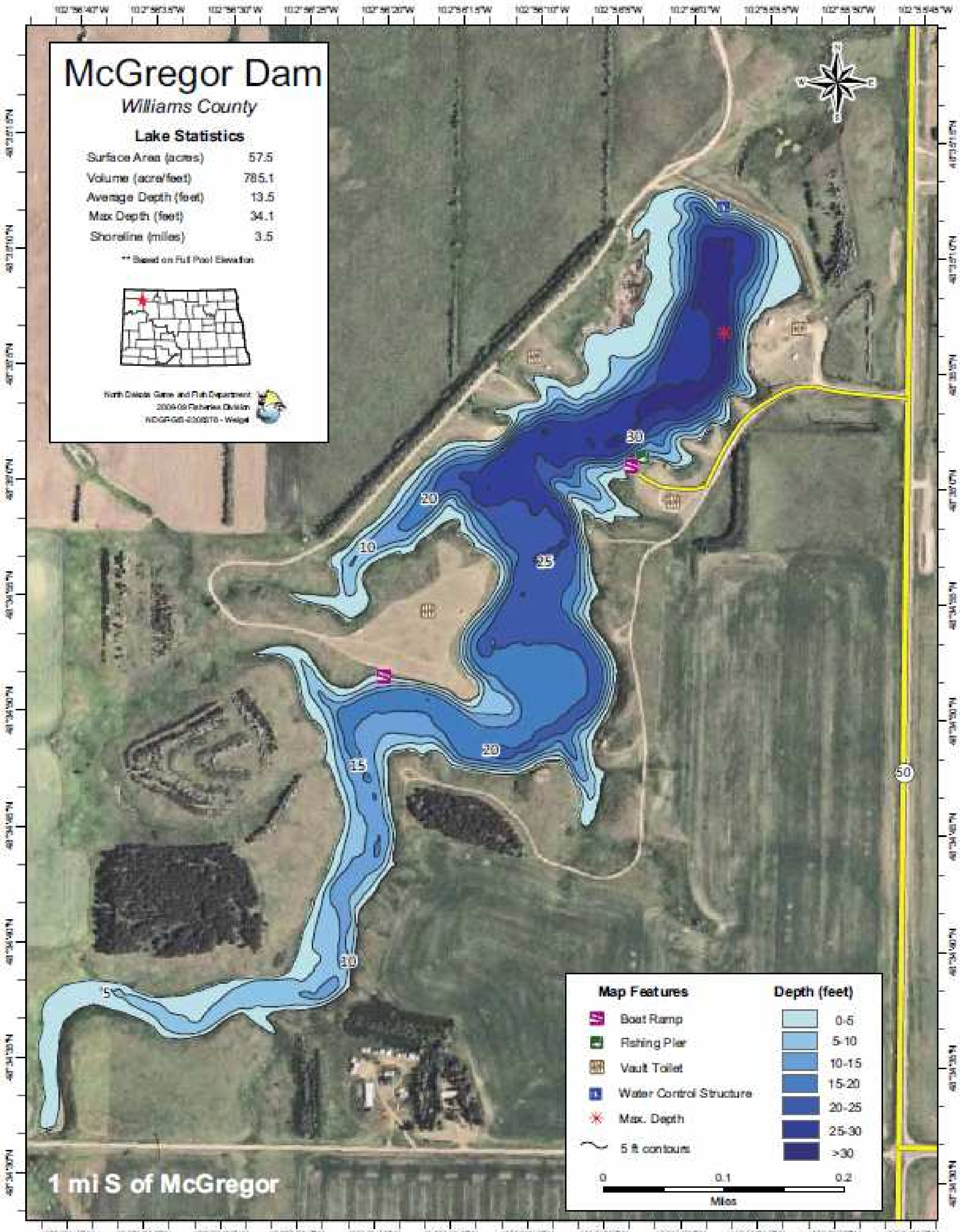

Figure 3. North Dakota Game and Fish Contour Map of McGregor Dam.

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2008 Section 303(d) list of impaired waters needing TMDLs, the North Dakota Department of Health (NDDoH) has identified McGregor Dam as fully supporting but threatened for recreation beneficial use due to nutrient enrichment/eutrophication and biological indicators, and fully supporting but threatened for aquatic life beneficial uses due to sediment, nutrient enrichment/eutrophication and biological indicators (Table 2). Fish and other aquatic biota inhabiting the reservoir are threatened because accelerated eutrophication as a result of nutrient enrichment from the contributing watershed. In addition, sedimentation is threatening aquatic life and the longevity of the reservoir. The recreational uses of the reservoir are being threatened by eutrophication from nutrient enrichment. While not originally listed as impaired for dissolved oxygen, the assessment conducted showed that dissolved oxygen levels fell consistently below the State standard, so a TMDL was developed for that impairment as well.

Table 2. McGregor Dam Section 303(d) Listing Information (NDDoH, 2008).

Waterbody Name	McGregor Dam
Assessment Unit ID	ND-10110101-019-L_00
Class	Class 1, Capable of Supporting a Cold Water Fishery
Impaired Uses	Recreation, Fish and Other Aquatic Biota (fully supporting but threatened)
Causes	Nutrients, Sedimentation/Siltation, Biological Indicators
Priority	High

1.2 Topography

McGregor Dam and its watershed lie within the Glaciated Dark Brown Prairie level IV ecoregion (42i). This ecoregion has a well defined drainage system and fewer wetlands compared to the Missouri Coteau Slope which lies to the east of McGregor Dam and the Dark Brown Prairie ecoregion. The Northwestern Glaciated Plains level III ecoregion, in which McGregor Dam resides, marks the western most extent of continental glaciation. Much of the land in the area is transitional between the dry land farming that dominates the land to the east (ecoregion 46i), and prevalent cattle ranching practices to the west (ecoregion 43). As a result, ecoregion 42i represents a mosaic of cropland and rangeland. The established drainage pattern present in the ecoregion consists of gently rolling plains sloping toward the Missouri River. Elevation of the area ranges between 1,950-3,000-feet (MSL), with McGregor Dam situated at approximately 2,077-feet (MSL). Local relief is between 50 and 200 feet. Figure 4 shows the general location, shape, and size of the McGregor Dam watershed in Williams County, North Dakota.

Figure 4. General Location of McGregor Dam Watershed.

1.3 Land Use/Land Cover

Land use in the watershed is primarily agricultural (94.4 percent), with 77 percent of the agricultural land actively farmed. The land is tilled mainly for durum, spring wheat, and other small grains (Table 3, Figure 5). The remaining three percent of land consists of farmsteads, hay land, and pastureland. There is one animal feeding operation in the watershed. The United States Department of Agriculture's Stream Visual Assessment Protocol was used to assess the riparian area of tributaries to McGregor Dam (Appendix C). Although 20 sites were selected for the assessment, only 11 were evaluated due to lack of stream flow. Of the 11, eight were ranked as poor and three were ranked as fair. Priority resource issues listed as impacting the riparian area include nutrient management and riparian health.

The geology of the ecoregion is comprised of glacial till over tertiary sandstone and shale. Soil series include Williams, Zahl, and Bowbells. Potential native vegetation in the watershed may include blue grama, needle-and-thread, western wheatgrass, green needlegrass, and little bluestem.

Table 3. Description of Land Use (NASS 2004).

Description	Acres	Percent of Total
Canola	274	4.99
Sunflowers	76	1.39
Lentels/Peas	373	6.79
Grains	3,508	63.87
CRP/Pasture	956	17.41
Water	249	4.53
Urban/Roads/Farmsteads	56	1.02
Total	**5492**	**100**

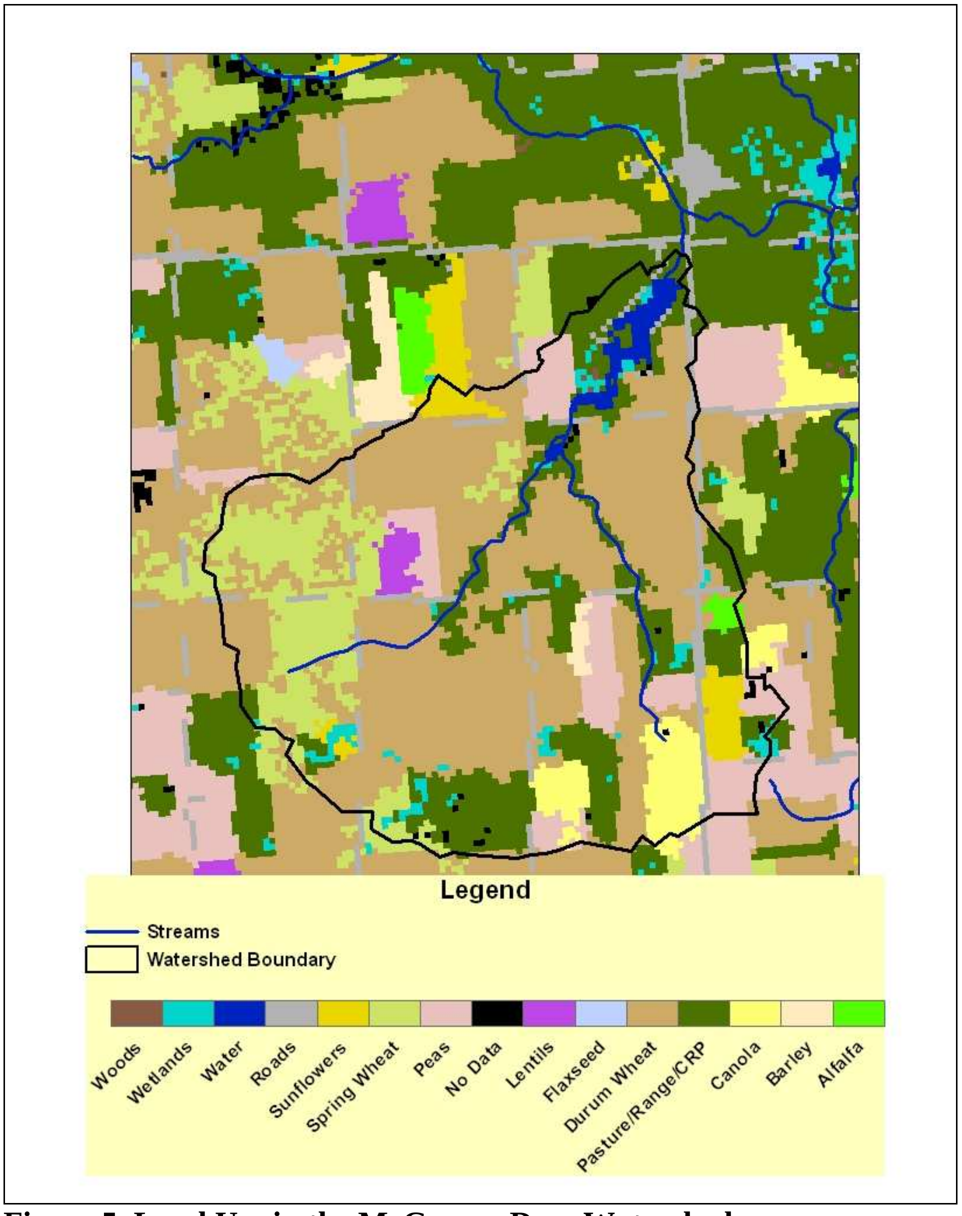

Figure 5. Land Use in the McGregor Dam Watershed.

1.4 Climate and Precipitation

The climate of northwestern North Dakota and the area encompassing McGregor Dam is semiarid to sub-humid and continental. Precipitation events are sporadic occurring primarily as rainfall in May through July where monthly rainfall is greater than two inches (Figure 6). The average snowfall is 37 inches and average rainfall is 14 inches annually. Sunshine occurs 62 percent of the time annually (Soil Survey of Williams County, USDA Soil Conservation Service, 2000). Summers are warm with frequent bouts of hot weather and sporadic cool days. On average there are between 110-130 frost free days per year in the ecoregion. Winters are cold, especially when arctic air from Canada surges over the area. The normal temperature in January is 9°F while the normal temperature in July is 70°F (NDAWN, 2005) (Figure 7). Since North Dakota Agricultural Weather Network (NDAWN) period of record data was too short to accurately calculate normal air temperatures alone, NDAWN normal air temperatures were calculated through interpolation of monthly normal air temperature measurements from nearby National Weather Service (NWS) Cooperative Stations data (1971-2000).

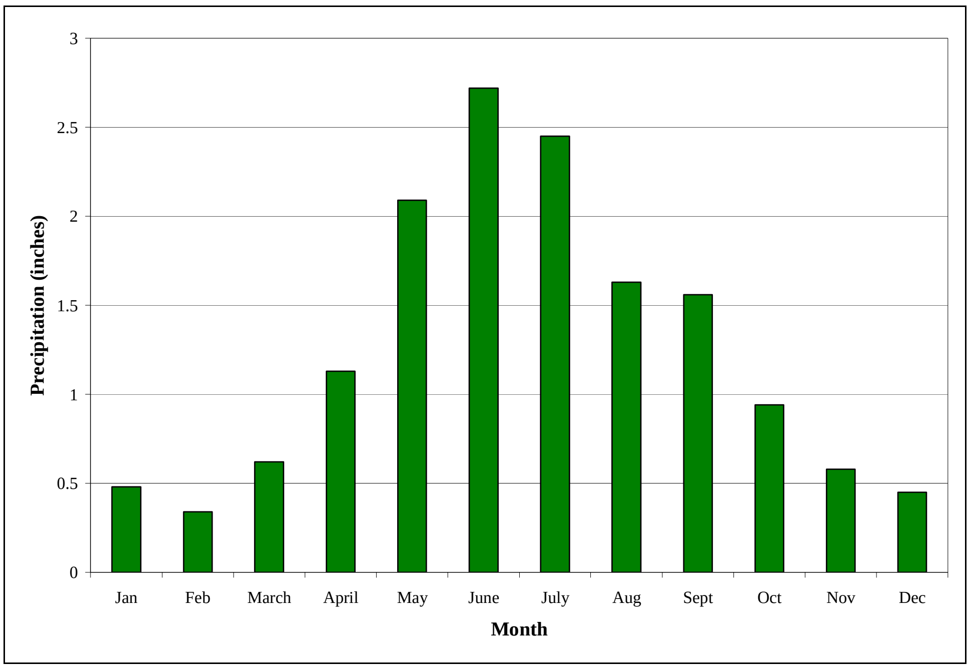

Figure 6. Normal Monthly Precipitation from 1971-2000 at the North Dakota Agriculture Weather Network (NDAWN), Williston, ND Weather Station.

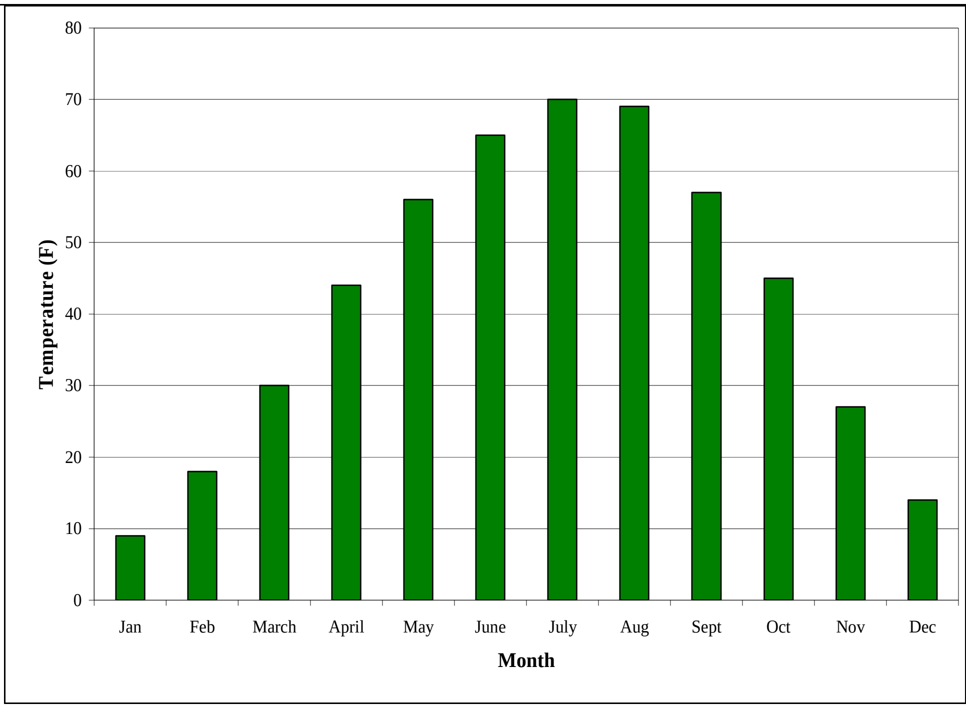

Figure 7. Normal Monthly Temperature from 1971-2000 at NDAWN, Williston, ND Weather Station.

1.5 Water Quality Data

Recognizing the need to improve water quality conditions in McGregor Dam, a TMDL development project was initiated with sponsorship by the Williams County Soil Conservation District. Data for the TMDL development project was collected between June 2003 and October 2004. Water quality samples were collected at two tributary sites, one in-lake site, and one site at the outlet of the reservoir (Table 4, Figure 8).

Table 4. General Description of Monitoring Sites.

Station ID	Station Description	Samples Collected	Latitude	Longitude
385243	Southwest Tributary 2 miles S. & 1 mile W. of McGregor	28	48.42741	-103.74836
385242	Inlet 2 miles S. & ¾ mile W. of McGregor	29	48.43866	-103.75173
380820	Near Dam at deepest point	25	48.42984	-103.7331
385244	Outlet 1 mile S. of McGregor	17	48.42989	-103.73062

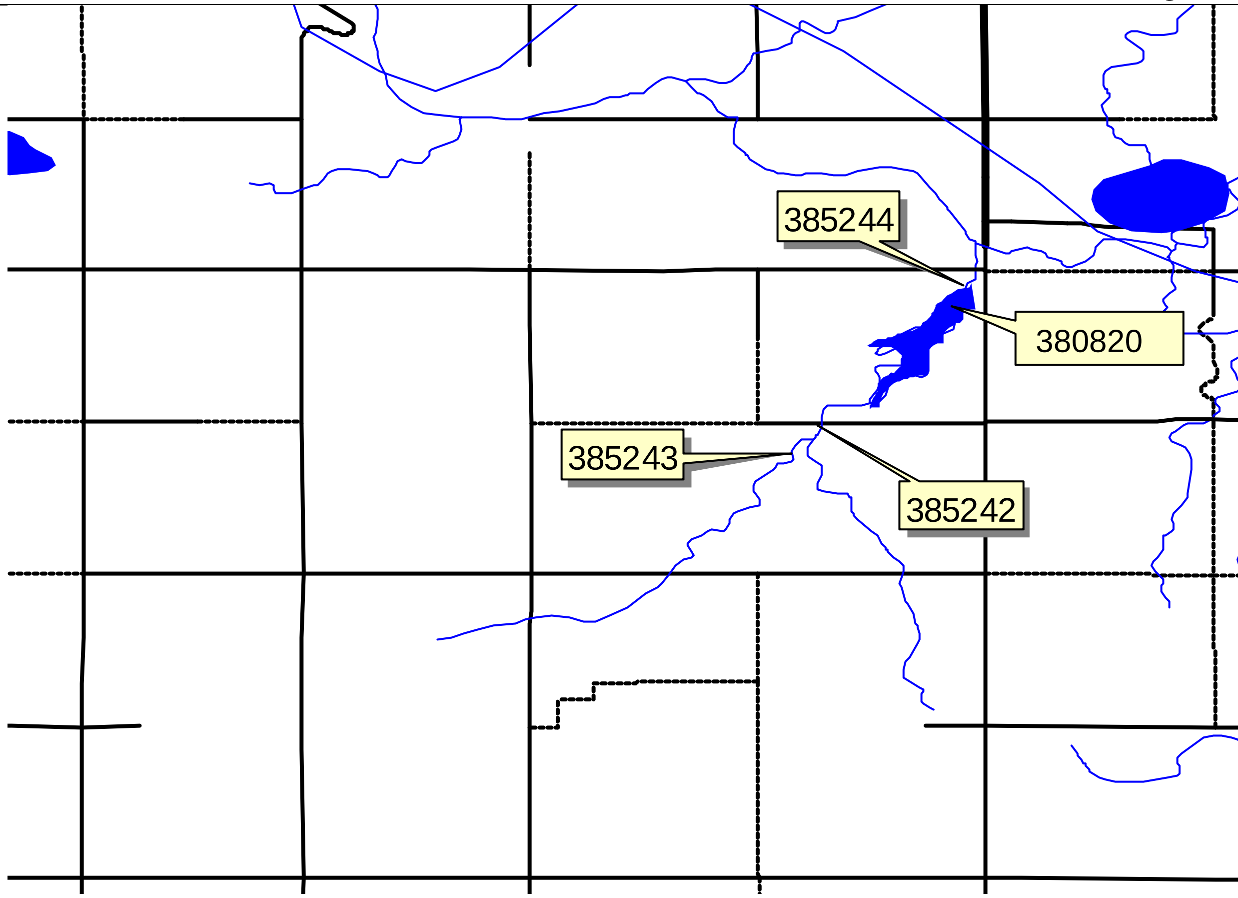

Figure 8. Monitoring Site Locations for McGregor Dam and Its Tributaries.

Stream Monitoring

Sampling frequency for the stream sampling sites was stratified to coincide with the typical hydrograph for the region. This sampling design results in more frequent samples during spring and early summer when stream discharge was typically greatest. Less frequent samples were taken during late summer and fall. Sampling efforts were discontinued during winter ice cover conditions, and terminated when the stream stopped flowing. If the stream began flowing again, water quality sampling was reinitiated.

Reservoir Monitoring

In order to accurately account for temporal variation in lake water quality, the lake was sampled twice per month during the spring and early summer season and monthly during fall and ice cover conditions. Reservoir monitoring was conducted at depths of 0.5 meters below the surface, mid-depth, and 0.5 meters from the reservoir bottom.

Nutrient Data

Water quality parameters were monitored in the McGregor Dam watershed at three sampling stations between June 2003 and October 2004. Water quality data were collected on two tributaries upstream of McGregor Dam (385242 and 385243) and at the dam's outlet (385244). A suite of nutrients and total suspended solids (TSS) were collected for analysis. Tables 5, 6, and 7 highlight general water quality statistics for the stream sites. In addition to water quality, stream stage and discharge were measured, and used in the loading calculations (Appendix B). An automated stage recorder and staff gauge were installed at each site and discharge was measured during each water quality sampling trip.

Table 5. Summary Statistics for Water Quality Variables Sampled at Tributary Monitoring Station 385242 (Inlet).

Variable	Number of Samples Collected	Maximum (mg/L)	Minimum (mg/L)	Mean (mg/L)	Median (mg/L)
Total Phosphorus	12	0.423	0.181	0.336	0.369
Total Nitrogen	12	5.18	1.31	2.211	1.890
Total Kjeldahl Nitrogen	12	2.18	1.08	1.490	1.350
Nitrate + Nitrite	12	3.40	0.01	0.720	0.375
Ammonia	12	0.376	0.005	0.119	0.061

Table 6. Summary Statistics for Water Quality Variables Sampled at Tributary Monitoring Station 385243 (SW Tributary Inlet).

Variable	Number of Samples Collected	Maximum (mg/L)	Minimum (mg/L)	Mean (mg/L)	Median (mg/L)
Total Phosphorus	10	0.460	0.209	0.369	0.398
Total Nitrogen	10	5.02	1.32	2.444	2.095
Total Kjeldahl Nitrogen	10	2.11	1.02	1.370	1.310
Nitrate + Nitrite	10	3.51	0.01	1.073	0.795
Ammonia	10	0.338	0.005	0.145	0.127

Table 7. Summary Statistics for Water Quality Variables Sampled in Tributary Monitoring Station 385244 (Outlet).

Variable	Number of Samples Collected	Maximum (mg/L)	Minimum (mg/L)	Mean (mg/L)	Median (mg/L)
Total Phosphorus	12	1.31	0.09	0.612	0.447
Total Nitrogen	12	6.94	1.51	3.745	3.275
Total Kjeldahl Nitrogen	12	6.92	1.39	3.703	3.255
Nitrate + Nitrite	12	0.14	0.01	0.383	0.020
Ammonia	12	4.64	0.005	1.91	1.51

Reservoir water quality samples were collected at one monitoring site (380820) located at the deepest point near the dam itself (Figure 8). Twenty-two samples were collected between June 2003 and September 2004 during the open water season and under ice cover. Parameters sampled and measured include: chlorophyll a, total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, and Secchi disk transparency. A summary of the water quality data is provided in Table 8. These data indicate that the reservoir is phosphorus limited with an average total nitrogen (TN) to total phosphorus (TP) ratio of 17:1. For both reservoir and stream samples, where results were below detection limits, one half detection limit was used in calculations.

Table 8. Summary Statistics for Water Quality Variables Sampled in McGregor Dam, Deepest Site (380820).

Variable	Units	Maximum	Minimum	Mean	Median
Total Phosphorus	mg/L	1.35	0.025	0.163	0.136
Total Nitrogen	mg/L	7.93	1.02	2.769	2.105
Total Kjeldahl Nitrogen	mg/L	6.55	0.90	2.235	2.045
Nitrate+Nitrite as N	mg/L	2.80	0.01	0.108	0.020
Ammonia as N	mg/L	4.69	0.005	0.689	0.340
Chlorophyll-a	µg/L	70.8	0.75	23.0	17.0
Secchi Disk Transparency	Meters	6.3	1.1	1.6	2.3

Dissolved Oxygen and Temperature

Dissolved oxygen and temperature were monitored at the deepest site of McGregor Dam from June 2003 through October 2004. Measurements were taken at 1-meter depth intervals during ice cover and open water periods each time a water quality sample was collected. Figures 9 through 12 illustrate the results of the temperature and dissolved oxygen data for the in-lake monitoring site for each year. During the sampling of 2003, McGregor Dam was thermally stratified June through September. Dissolved oxygen concentrations were below the State water quality standard of 5.0 mg/L in a portion of the water column for every sample taken except for October. Samples were only taken once during the months of August and September 2003 due to equipment malfunctions. Stratification also occurred in 2004 from May through September. Severe dissolved oxygen deficits occurred throughout 2004 with the exception of four sampling events in April (2), May, and October. The bottom depths were primarily affected throughout the year, but at times the entire water column was less than 2.0 mg/L.

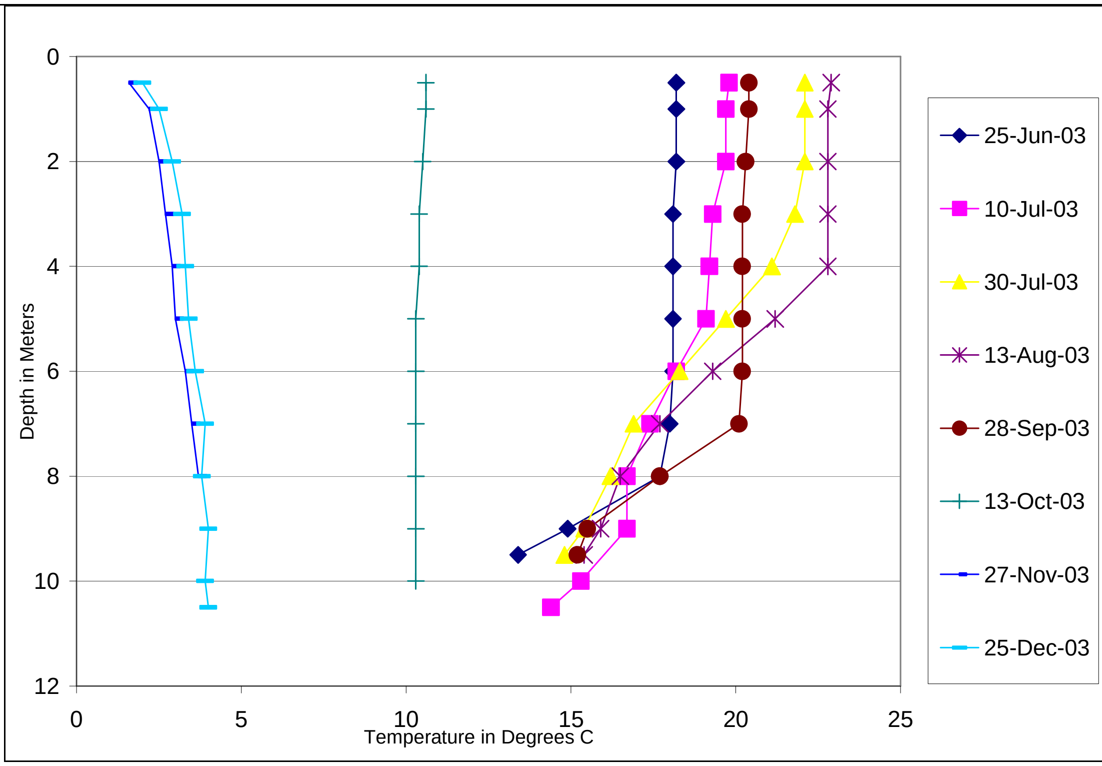

Figure 9. Summary of Temperature Data for the McGregor Dam Deepest Area Site (380820) in 2003.

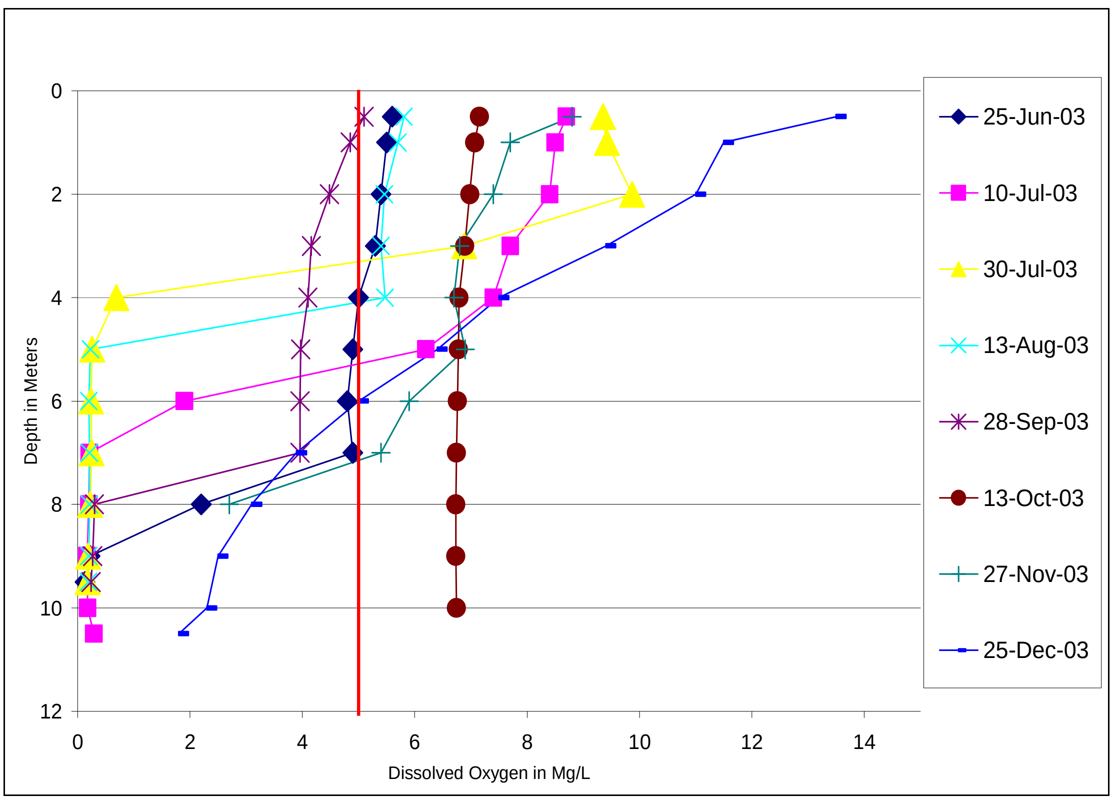

Figure 10. Summary of Dissolved Oxygen Concentrations for the McGregor Dam Deepest Area Site (380820) in 2003.

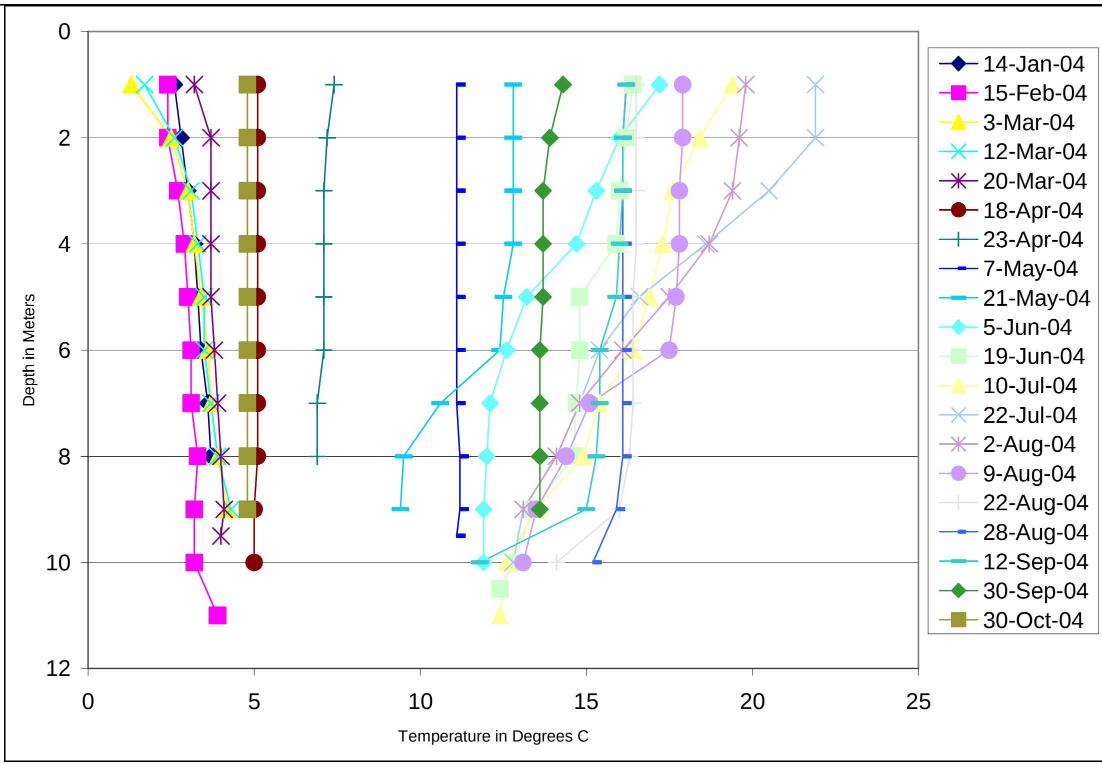

Figure 11. Summary of Temperature Data for the McGregor Dam Deepest Area Site (380820) in 2004.

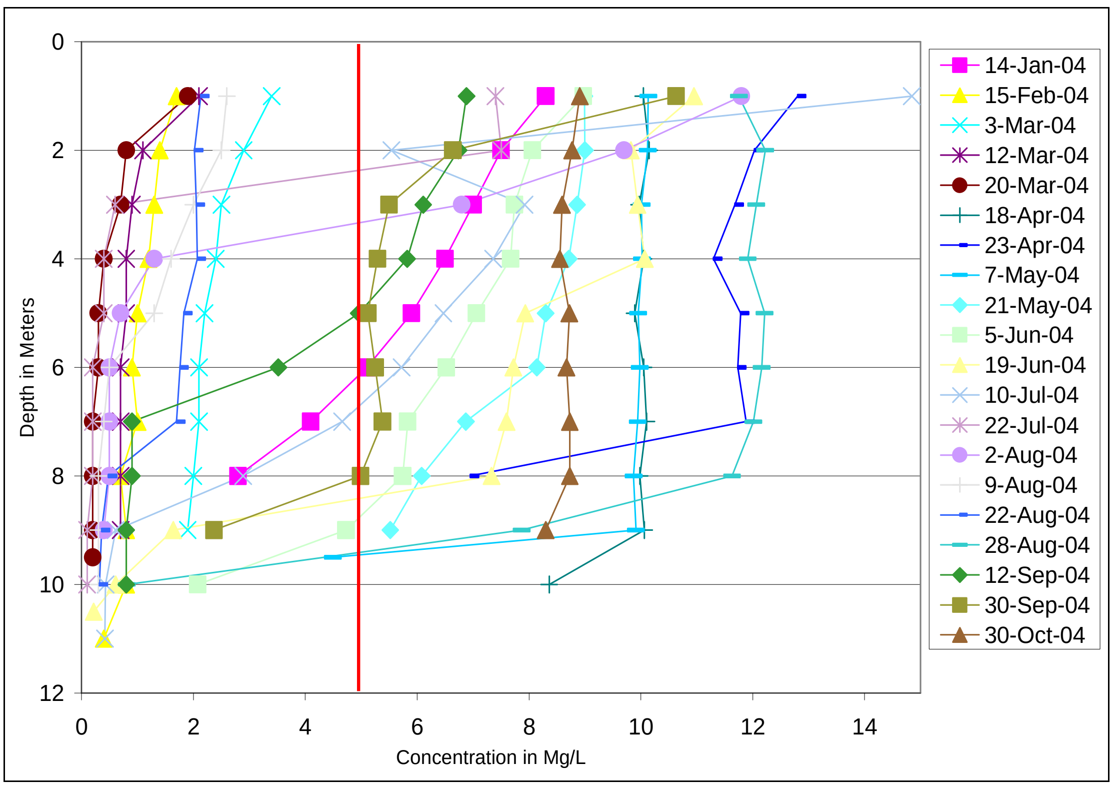

Figure 12. Summary of Dissolved Oxygen Concentrations for the McGregor Dam Deepest Area Site (380820) in 2004.

Secchi Disk Transparency and In-Lake Total Suspended Solids

Throughout the course of the sampling effort, McGregor Dam yielded an average Secchi disk transparency of 1.6 meters. Of the 17 Secchi disk measurements, 6.3 meters was the maximum depth and 1.1 meters was the minimum depth recorded.

Water clarity in a reservoir can be affected by many factors. Algal biomass, total suspended solids, and other debris can all affect Secchi disk transparency. Monthly total suspended solid (TSS) data indicate that algal biomass is the main factor limiting water clarity in McGregor Dam. Data shows that during the time of year when sediment loading is typically greatest (spring and early summer), Secchi disk transparency was also the greatest. During mid to late summer, when algal biomass and plant matter are typically at a maximum, Secchi disk transparency was lowest. It can therefore be assumed that water clarity, as represented by Secchi disk transparency, is due primarily to algal blooms. Due to this fact, a reduction in nutrient loading into the reservoir should decrease algal biomass and increase water clarity.

Tributary Total Suspended Solids

Total suspended solids (TSS) samples were collected by the Williams County Soil Conservation District between June 2003 and October 2004. TSS samples were collected from two inlet sites (385242) and (385243) and one outlet site (385244) of McGregor Dam. Average TSS concentrations at the inlet sites were 19.75 and 16.7 mg/L, respectively. The average concentration at the outlet site was 3.75 mg/L (Table 9). These data indicate that suspended solids are being retained within the reservoir when comparing the mean concentration of the two inlet sites to the outlet site.

Table 9. Average Total Suspended Solid Concentrations for McGregor Dam Inlet and Outlet Sites (2003-2004).

Site ID	Site Description	Max TSS (mg/L)	Min TSS (mg/L)[1]	Average TSS (mg/L)
385243	Southwest Inlet	74	2.5	16.7
385242	Composite Inlet	126	2.5	19.75
385244	Outlet	14	2.5	3.75

[1] Below detection limits. One half of detection limit used.

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as “the sum of the individual waste load 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 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. Separate TMDLs are required to address each pollutant or cause of impairment (i.e., nutrients, dissolved oxygen).

2.1 Narrative Water Quality Standards

The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters in the state. The narrative standards pertaining to nutrient and sediment impairments are listed below (NDDoH, 2006).

- 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 pollutants, which alone or in combination with other substances, shall:
  - Cause a public health hazard or injury to environmental resources;
  - Impair existing or reasonable beneficial uses of the receiving water; or
  - Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH 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 waterbodies determined by the department to be regional reference sites" (NDDoH, 2006).

2.2 Numeric Water Quality Standards

McGregor Dam is classified as a Class 1 cold water fishery. Class 1 fisheries are "waters capable of supporting growth of cold water fish species (e.g., salmonids) and associated aquatic biota" (NDDoH, 2006). Some cool water species may also be present. All classified North Dakota lakes are assigned recreation, aquatic life, irrigation, livestock watering, and wildlife beneficial uses. Those beneficial uses threatened in McGregor Dam include recreation and fish and other aquatic biota. McGregor Dam's beneficial uses have been assessed as fully supporting, but threatened as a result of nutrient enrichment, low dissolved oxygen, and sedimentation. Based on dissolved oxygen profile data collected in 2003 and 2004 as a part of the TMDL development project, dissolved oxygen has also been identified as a cause of aquatic life impairment. The State Water Quality Standards state that lakes shall use the same numeric criteria as Class 1 streams. This includes the State standard for dissolved oxygen of 5.0 mg/L as a daily minimum (with up to 10% of representative samples collected during any three year period less than this value provided that lethal conditions are avoided). State standards for lakes and reservoirs also specify guidelines for nitrogen 1.0 mg/L as nitrate (up to 10% of samples may exceed) (Table 10).

Table 10. Numeric Guidelines for Classified Lakes and Reservoirs (NDDoH, 2006).

Parameter	Guidelines	Limit
Guidelines or Standards for Classified Lakes:		
Nitrates (dissolved)	1.0 mg/L	Maximum allowed[1]
Dissolved Oxygen	5.0 mg/L	Daily Minimum
Guidelines for goals in a lake improvement or maintenance program:		
NO_3 as N	0.25 mg/L	Goal
PO_4 as P	0.02 mg/L	Goal

[1] "Up to 10% of samples may exceed"
[2] "Up to 10% of representative samples collected during any three year period may be less than this value provided that lethal conditions are avoided."

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. The following sections summarize water quality targets for McGregor Dam based on its beneficial uses. If the specific target is met, it is assumed the reservoir will meet the applicable water quality standards, including its designated beneficial uses.

3.1 Nutrient Target

North Dakota's 2008 Integrated Section 305(b) Water Quality Assessment Report indicates that Carlson's Trophic State Index (TSI) is the primary indicator used to assess beneficial uses of the State's lakes and reservoirs (NDDoH, 2008). Trophic state is the measure of productivity of a lake or reservoir and is directly related to the level of nutrients (phosphorus and nitrogen) entering the lake or reservoir from its watershed. Lakes tend to become eutrophic (more productive) with higher nitrogen and phosphorus inputs. Eutrophic lakes often have nuisance algal blooms, limited water clarity, and low dissolved oxygen concentrations that can result in impaired aquatic life and recreational uses. Carlson's TSI attempts to measure the trophic state of a lake using nitrogen, phosphorus, chlorophyll-a, and Secchi disk depth measurements (Carlson, 1977).

Based on Carlson's TSI and water quality data collected between June 2003 and October 2004, McGregor Dam was generally assessed as a eutrophic to hypereutrophic lake (Table 11). Hypereutrophic lakes are characterized by large growths of weeds, bluegreen 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 the frequent algal blooms and excessive weed growth, these lakes are also undesirable for recreational uses such as swimming and boating.

Table 11. Carlson's Trophic State Indices for McGregor Dam.

TSI Parameter	Relationship	TSI Value[1]
Secchi Disk (SD)	TSI (SD) = 60 – 14.41[ln(SD)]	53.23
Chlorophyll-*a* (CHL)	TSI (CHL) = 30.6 + 9.81[ln(CHL)]	61.36
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[ln(TP)]	77.60

TSI < 25 - Oligotrophic (least productive) TSI 25-50 Mesotrophic
TSI 50-75 Eutrophic TSI > 75 - Hypereutrophic (most productive)

The reasons for the different TSI values estimated for McGregor Dam are varied. According to the phosphorus TSI value, McGregor Dam is an extremely productive lake (eutrophic to hypereutrophic) (Table 11, Figure 13). Carlson and Simpson (1996) suggest that if the phosphorus and Secchi depth TSI values are relatively similar and higher than the chlorophyll-*a* TSI value, then dissolved color or nonalgal particulates dominate light attenuation. It follows that, if the Secchi depth and chlorophyll-*a* TSI values are similar (as is the case for McGregor Dam), then chlorophyll-*a* is dominating light attenuation (Table 12). Carlson and Simpson (1996) also state that a nitrogen index value might be more universally applicable than a phosphorus index, but it also means that a correspondence of the nitrogen index with the chlorophyll-*a* index cannot be used to indicate nitrogen limitation.

Table 12. Relationships Between TSI Variables and Conditions.

Relationship Between TSI Variables	Conditions
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as *Aphanizomenon* flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

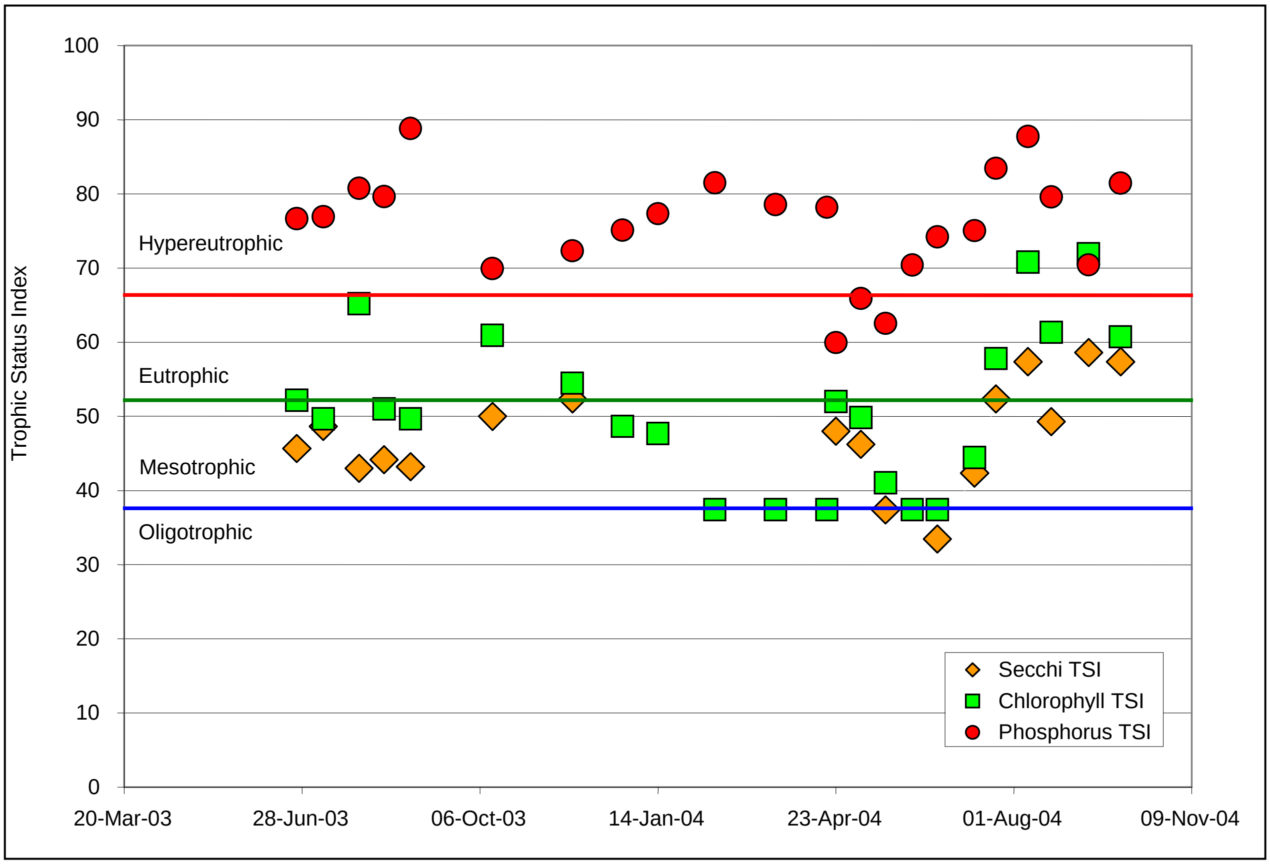

Figure 13. Temporal Distribution of Calrson's Trophic Status Index Scores for McGregor Dam.

A Carlson's TSI target of 68.36 based on total phosphorus was chosen for the McGregor Dam TMDL endpoint. This relates to a phosphorus load reduction of 50 percent (see Section 5.0 for technical analysis). While this TSI value will not correspond to the concentration of total phosphorus in the State Water Quality Standard guideline for in-lake improvement (0.02 mg/L), it should result in a change of trophic status for the lake from hypereutrophic to eutrophic during all times of the year. Based on the BATHTUB model, the 50 percent reduction in phosphorus is also predicted to reduce chlorophyll-a and Secchi disk TSI values down to 54.99 and 46.08 respectively, almost to a mesotrophic range. 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 effective ways to reduce in-lake nutrient cycling, this was determined to be the best possible outcome for the reservoir. If the specified TMDL TSI target of 68.35 based on total P is met, the reservoir can be expected to meet the applicable water quality standards for aquatic life and recreational beneficial uses.

3.2 Dissolved Oxygen Target

The North Dakota State Water Quality Standard for dissolved oxygen is "5.0 mg/L as a daily minimum (up to 10% of the representative samples collected during any 3-year period may be less than this value provided that lethal conditions are avoided)" and will be the dissolved oxygen target for McGregor Dam.

4.0 SIGNIFICANT SOURCES

There are no known point sources in the McGregor Dam watershed. Nutrients impairing the reservoir's beneficial uses are from non-point sources. There is one animal feeding operation in the watershed which is considered part of the nonpoint source load.

5.0 TECHNICAL ANALYSIS

Establishing a relationship between in-stream water quality targets and pollutant 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 waterbody. The loading capacity is the amount of a pollutant that can be assimilated by the waterbody while still attaining and maintaining water quality standards. This section discusses the technical analysis used to estimate existing loads to McGregor Dam and the predicted trophic response of the reservoir to reductions in loading capacity.

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, 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 (Appendix B) 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).

5.2 BATHTUB Trophic Response Model

The BATHTUB model (Walker, 1996) was used to predict and evaluate the effects of various nutrient load reduction scenarios on McGregor Dam. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network. The model accounts for advective and diffusive transport and nutrient sedimentation. Eutrophication related water quality conditions are predicted using empirical relationships previously developed and tested for reservoir applications.

The BATHTUB 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 were summarized in a format which can serve as inputs to the model.

The tributary data were analyzed and reduced by the FLUX program. FLUX uses tributary inflow and outflow water quality and flow data to estimate the average mass discharge or loading that passes a river or stream site using six calculation techniques. Load is therefore defined as the mass of pollutant during a given unit of time. The FLUX model then allows the user to pick the most appropriate load calculation technique with the smallest statistical error. Output from the FLUX program is then used to calibrate the BATHTUB model.

The reservoir data were reduced in Excel using three computational functions. These include: 1) the ability to display concentrations as a function of depth, location, or date; 2) summary statistics (mean, median, etc.); and 3) evaluation of trophic status. The output data from the Excel program were then used to calibrate the BATHTUB model.

When the input data from the FLUX and Excel programs are entered into the BATHTUB model the user has the ability to compare predicted conditions (model output) to actual conditions using general rates and factors. The BATHTUB model is then calibrated by combining tributary load estimates for the project period with in-lake water quality estimates. The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates from the project monitoring data. BATHTUB then has the ability to predict total phosphorus concentration, chlorophyll-a concentration, and Secchi disk transparency and the associated TSI scores as a means of expressing trophic response.

As stated above, BATHTUB can compare predicted vs. actual conditions. After calibration, the model was run based on observed concentrations of phosphorus and nitrogen to derive an estimated annual average total phosphorus load of 119.4 kg. The model was then run to evaluate the effectiveness of a number of nutrient reduction alternatives including: 1) reducing externally derived nutrient loads; 2) reducing internally available nutrients; and 3) reducing both external and internal nutrient loads. (See Appendix A for more detail).

In the case of McGregor Dam, BATHTUB modeled externally derived phosphorus. Phosphorus was used in the simulation model based on its known relationship to eutrophication and that it is controllable with the implementation of watershed Best Management Practices (BMPs). Changes in trophic response were evaluated by reducing externally derived phosphorus loading by 25, 50, and 75 percent. Simulated reductions were achieved by reducing phosphorus concentrations in contributing tributaries and other externally delivered sources. Flow was held constant due to uncertainty in estimating changes in hydraulic discharge with the implementation of BMPs.

With a 50 percent reduction in external phosphorus load, the model also predicts a reduction in Carlson's TSI score from 61.53 to 54.99 for chlorophyll-a, and 53.23 to 46.08 for Secchi disk transparency, corresponding to a trophic state of nearly mesotrophic. More important for the long term health of the lake, is the predicted reduction in the total phosphorus TSI score of 77.60 to 68.36 which is a change from hypertrophic to a middle eutrophic TSI score (Table 13, Figure 14).

Table 13. Observed and Predicted Values for Selected Trophic Response Variables, Metalimnetic Oxygen Demand, and Hypolimnetic Oxygen Demand Assuming a 25, 50, and 75 Percent Reduction in External Phosphorus and Nitrogen Loading.

Variable	Observed Value	Predicted Value		
		25% Reduction	50% Reduction	75% Reduction
Total Phosphorus (mg/L)	0.163	0.124	0.086	0.047
Chlorophyll-a (ug/L)	23.00	17.35	12.02	8.26
Secchi Disk Transparency (meters)	1.6	1.95	2.63	2.44
Carlson's TSI for Phosphorus	77.60	73.65	68.36	59.71
Carlson's TSI for Chlorophyll-a	61.53	58.59	54.99	49.31
Carlson's TSI for Secchi Disk	53.23	50.40	46.08	40.16
Metalimnetic Oxygen Demand	119.70[1]	104.57	87.04	64.68
Hypolemnetic Oxygen Demand	131.52[1]	114.90	95.64	71.07

[1] Based on the calibrated BATHTUB model predicted rate.

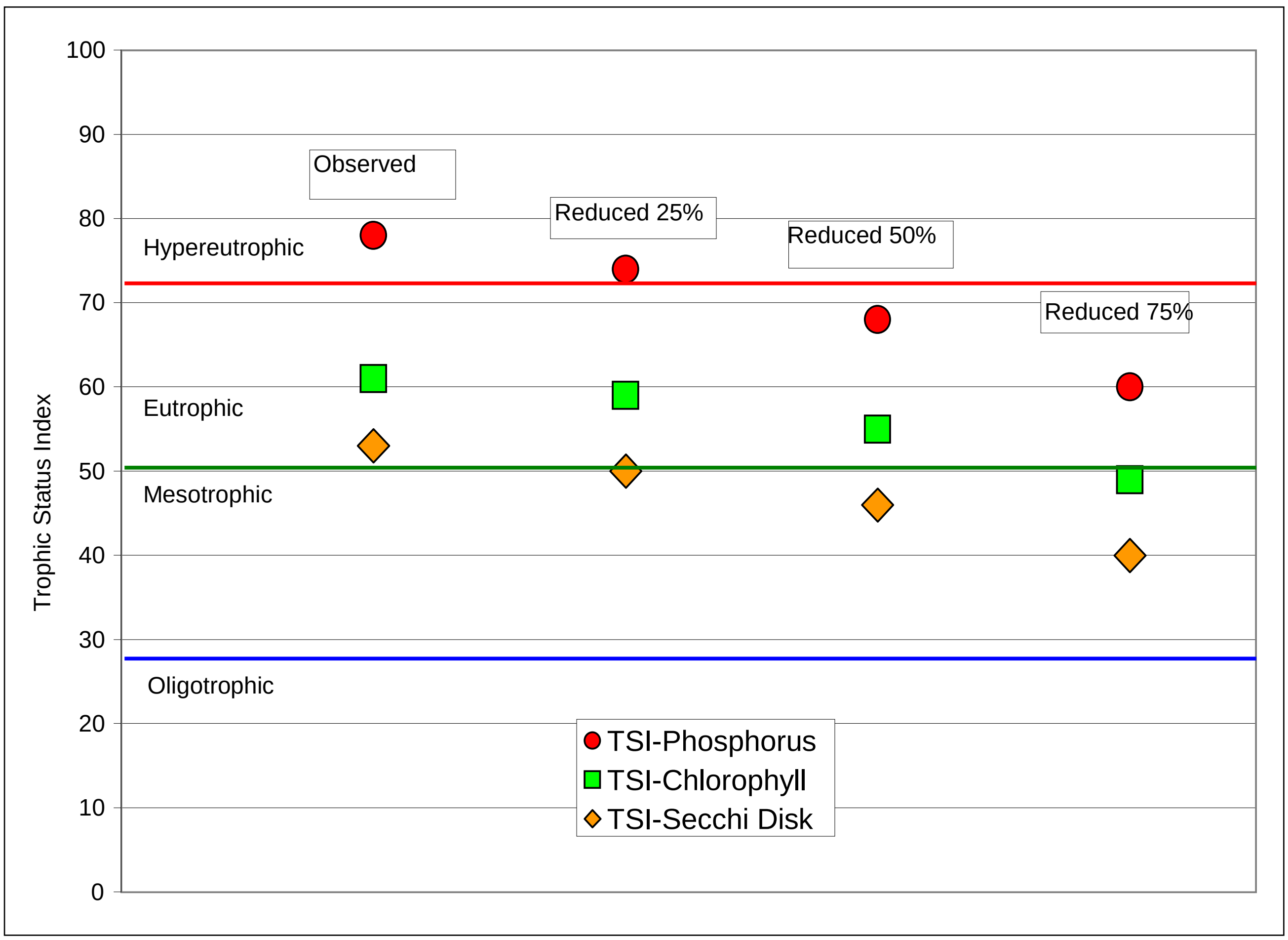

Figure 14. Predicted Trophic Response in McGregor Dam to a 25, 50, and 75 Percent Phosphorus Load Reduction.

5.3 AGNPS Watershed Model

In order to identify significant NPS pollutant sources in the McGregor Dam 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 3.65 model analysis was employed.

The primary objectives for using the AGNPS 3.65 model were to: 1) evaluate NPS contributions within the watershed; 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 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 where receiving cell, aspect, SCS curve number, 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.

The AGNPS 3.65 model was used in conjunction with an intensive land use survey to determine critical areas within the McGregor Dam watershed. Criteria used during the land-use assessment include percent cover on cropland and pasture/range conditions. These criteria were used to determine the C factor for each cell. The model was run using current conditions determined during the land-use assessment. Other than the low density urban development around McGregor Dam, the land use survey required for AGNPS data input files identified that 100 percent of the watershed is in agricultural production or in support of agricultural production such as farmsteads and farm-to-market roads.

Based on land use and watershed characteristics during the TMDL study (2003-2004), current event-based runoff and nutrient yields were calculated for the watershed using the AGNPS model (Table 14).

Additional modeling comparisons were made by changing land-use practices on selected portions of the watershed. The watershed was divided into 134 40-acre cells for evaluation. Each cell was evaluated for soil characteristics, terrain, and land-use characteristics.

The AGNPS model predicted that with the 2003-04 farming practices being utilized in the McGregor Dam watershed, composed of a mixture of cropland, CRP and rangeland, the total phosphorus in sediment yield would be 0.29 pounds per acre (Table 15). However, by altering some of the land management practices in the watershed, a reduction in total phosphorus (TP) can be expected. The following changes were input into the AGNPS model. Land practices in cells with a land slope greater than 5% were converted to CRP, no or zero till cultivation was applied to all row crop or small grain crops, and total containment of waste from the one concentrated livestock feeding operations in the watershed was input into the model as well. All alfalfa and pasture land in the watershed was left unchanged. A reduction in runoff yield of 0.17 lbs/acre (TP) is estimated to result from these practices (Table 15).

Table 14. Event-Based Yield Summary for the McGregor Dam Watershed.

Watershed studied is	McGregor Dam
The Area of the Watershed is	5,360.00 acres
The Area of Each Cell is	40.00 acres
The Characteristic Storm Precipitation is	4.00 inches
The Storm Energy-intensity Value is	98.49
Values at the Watershed Outlet	
Runoff Volume	1.9 Inches
Peak Runoff Rate	2,647 cfs
Total Nitrogen in Sediment	0.57 lbs/acre
Total Soluble Nitrogen in Runoff	0.39 lbs/acre
Soluble Nitrogen Concentration in Runoff	0.92 ppm
Total Phosphorus in Sediment	0.29 lbs/acre
Soluble Phosphorus Concentration in Runoff	0.06 ppm
Total Soluble Chemical Oxygen Demand in Runoff	1694.3 lbs/acre
Soluble Chemical Oxygen Demand Concentration in Runoff	1125.0 ppm

Table 15. McGregor Dam Watershed AGNPS Summary.

Watershed Studied			
Area of Watershed	5,360 acres		
Area of Each Cell	40 acres		
Characteristic Storm Precipitation	4 inches		
Storm Energy-Intensity Value	98.49 inches		
Values at the Watershed Outlet			
Original	**2003-2004 Conditions**	**No till/ total containment**	**>5%slope to CRP**
Number of Cells	134		
Runoff Volume	1.9 inches		
Peak Run-off Rate	2,647 cfs		
Total Phosphorus in Sediment Yield	0.29 lbs/acre	0.25 lbs/acre	0.12 lbs/acre

5.4 Dissolved Oxygen

McGregor Dam is considered impaired due to dissolved oxygen levels observed below the North Dakota water quality standard of 5.0 mg/L as a daily minimum. This assessment is based on the dissolved oxygen profile data collected in the 2003- 2004 TMDL assessment. For McGregor Dam, low dissolved oxygen levels appear to be related to excessive nutrient loading.

The cycling of nutrients in aquatic ecosystems is largely determined by oxidation-reduction (redox) potential and the distribution of dissolved oxygen and oxygen-demanding particles (Dodds, 2002). Dissolved oxygen gas has a strong affinity for electrons, and thus influences biogeochemical cycling and the biological availability of nutrients to primary producers such as algae. High levels of nutrients can lead to eutrophication, which is defined as the undesirable growth of algae and other aquatic plants. In turn, eutrophication can lead to increased biological oxygen demand and oxygen depletion due to the respiration of microbes that decompose the dead algae and other organic material.

AGNPS and BATHTUB models indicated that excessive nutrient loading is responsible for the low dissolved oxygen levels in McGregor Dam. 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 lakes/reservoirs across the U.S. One consequence of eutrophication is oxygen depletion 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 NDDoH's viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process may take 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. Bi-national 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, 1996, 1997), developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that the 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 and reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. NDDoH has obtained from the North Dakota Game and Fish Department the morphometric parameters such as surface area (A_o = 147 acres; 0.59 km^2), mean depth (z = 16.0 feet; 4.88 meters), and the ratio of mean depth to the surface area ($z/A_o^{0.5} = 8.59$) for McGregor Dam which show that these parameters are within the range of lakes used by Nürnberg. Based on this information, the NDDoH is confident that Nürnberg's empirical nutrient-oxygen relationship holds true for North Dakota lakes and reservoirs. The NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to McGregor Dam which will reduce algae blooms, thereby reducing hypolimnetic oxygen depletion rates resulting in increased 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), where they state that, "... as organic deposits were exhausted, oxygen conditions improved."

This conclusion is also supported by BATHTUB model predictions of both metalimnetic and hypolimnetic oxygen demand. The calibrated model predicts that metalimnetic and hypolimnetic oxygen demand in McGregor Dam is currently 119.70 and 131.72 mg/m^3-day, respectively (Table 13). With a 50% reduction in total phosphorus loading, the metalimnetic and hypolimnetic oxygen demand rate is predicted to decrease by 27.3 percent to 87.04 and 95.64 mg/m^3-day, respectively (Table 13).

5.5 Sediment

A sediment balance was calculated for McGregor Dam (Table 16). The time period over which this amount of sediment transport occurred was 0.997 years, therefore, sediment accumulated within the reservoir at a rate of 5,111.5 kg/yr.

Table 16. Sediment Balance for McGregor Dam (2003-2004).

	Inflow (kg)	Outflow (kg)	Storage (kg)
Total Suspended Solids	6,470.4	1376.4	5094.0

Mulholland and Elwood (1982) state that the acceptable average accumulation rate of sediment within reservoirs is 2 cm/yr. Based on a conversion from mass of sediment storage to depth of sediment storage, it can be assumed that McGregor Dam is accumulating sediment at a current rate that is considered acceptable for reservoirs.

In order to perform the conversion from mass to depth, the particle density of soil is needed. In most mineral soils the average density of particles is in the range of 2.6 to 2.7 g/cm^3. This narrow range reflects the predominance of quartz and clay minerals in the soil matrix. An average particle density of 2.65 g/cm^3 (the density of quartz), is often applied to soils comprised principally of silicate materials. Since soils in the McGregor Dam watershed are mineral soils, the particle density of silicate minerals can be used to calculate a depth of sediment accumulation within the reservoir. However, for the sake of providing an implicit margin of safety, the low end of the range (2.6 g/cm^3) will be used to calculate the equivalent depth of 5,111.5 kg of sediment transported in one year into McGregor Dam.

Based on a sediment loading rate of 5,111,500 g/yr times a sediment density of 2.60 g/cm^3, the sediment volume deposited in McGregor Dam is 1,965,962 cm^3 each year.

$$(5{,}111{,}500 \text{ g/yr}) / (2.60 \text{ g/cm}^3) = 1{,}965{,}962 \text{ cm}^3\text{/yr}$$

Based on a surface area of 57.5-acres (2,326,942,443 cm^2), the annual sedimentation rate is 0.000845 cm/year.

$$(1{,}965{,}962 \text{ cm}^3\text{/yr}) / (2{,}326{,}942{,}443 \text{ cm}^2) = 0.000845 \text{ cm/yr}$$

This estimated annual sediment accumulation rate is well below the average sedimentation rate of typical reservoirs.

Further support for the removal of TSS as a pollutant of concern can also be found in literature. Waters (1995) states that suspended sediment concentrations less than 25 mg/L are not harmful to fisheries; between 25 and 80 mg/L reduces fish yield; between 80 and 400 mg/L is unlikely to display a good fishery; and suspended sediment concentration greater than 400 mg/L will exhibit a poor fishery. Therefore, research by Waters (1995) supports the view that the mean TSS concentration entering McGregor Dam of 19.75 mg/L is not considered harmful to fisheries. Two samples out of twenty-four exceeded the 25 mg/L concentration stated by Waters (1995) as capable of reducing fish yield, only one sample exceeded the 80 mg/L deemed unlikely to display a good fishery. Therefore, it is the recommendation of this TMDL report, that in the next North Dakota Section 303(d) list cycle, McGregor Dam should be de-listed for sediment impairments.

Justification for delisting is also based on the Natural Resource Conservation Service (NRCS) Sedimentation Rate Standard for reservoirs. This standard is set at 1/8 inch of sediment eroded from the watershed drainage area delivered and detained in the sediment pool over the 50-year expected life of the project. Therefore:

Assuming Watershed Area = 5,492 acres = $2.39231\ ^{8}\ ft^2$
and,
NRCS Sedimentation Rate Standard equals 1/8 inch = 0.125 inch = 0.01041667 ft over 50 years
then,
NRCS Sediment Standard Volume =

$$2.39231 \times 10^{8}\ ft^2 * 0.01041667\ ft = 2,491,996\ ft^3$$
$$\text{where: } 2,491,996\ ft^3 = 7.0565468 \times 10^{10}\ cm^3$$

Compare this to the calculated annual sedimentation rate from observed data entering McGregor Dam over 50 years:

Calculated sediment volume from data = 1,965,962 cm^3/yr * 50 years = $9.8298100 \times 10^{7}\ cm^3$.

Using the NRCS Sedimentation Rate Standard of 1/8 inch over 50 years, McGregor Dam's predicted sedimentation accumulation rate would be $7.0565468 \times 10^{10}\ cm^3$. When compared with the current sedimentation rate over 50 years entering the reservoir, $9.8298100 \times 10^{7}\ cm^3$ appears to be well under the predicted sedimentation rate standard.

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 should be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can either be incorporated into conservative assumptions used to develop the TMDL (implicit) or added as a separate component of the TMDL (explicit). For the purposes of this nutrient TMDL, a MOS of 10 percent of the loading capacity will be used as an explicit MOS.

Assuming the combined "normal" year load to McGregor Dam is 119.4 kg of total phosphorus and the TMDL reduction goal is a 50 percent reduction in total phosphorus loading, then this would result in a TMDL target total phosphorus loading capacity of 59.7 kg of total phosphorus per year. Based on a 10 percent explicit margin of safety, the MOS for the McGregor Dam TMDL would be 5.97 kg of phosphorus per year.

Monitoring and adaptive management during the implementation phase, along with post-implementation monitoring related to the effectiveness of the TMDL controls, will be used to ensure the attainment of the targets.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and the EPA's regulations require that a TMDL be established with seasonal variations. McGregor Dam's TMDL addresses seasonality because the FLUX analysis and BATHTUB model incorporates seasonal differences in its prediction of annual total phosphorus and nitrogen loadings.

7.0 TMDL

Table 17 summarizes the nutrient TMDL for McGregor Dam in terms of loading capacity (LC), wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS). The TMDL can be generically 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 non-point sources;

MOS = margin of safety, or an accounting of the 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 portion of the loading capacity as a MOS.

7.1 Nutrient TMDL

Based on data collected in 2003 and 2004, the existing load to McGregor Dam is estimated at 119.4 kg/yr. Based on the BATHTUB and AGNPS modeling results, a 50 percent reduction in the existing total phosphorus loading to McGregor Dam will result in a predicted TMDL target total phosphorus concentration of 0.086 mg/L, therefore the TMDL or Loading Capacity is 59.7 kg/yr. Assuming that 10 percent of the loading capacity is explicitly assigned to the MOS (5.97 kg) and there are no point sources in the watershed, then all of the remaining loading capacity is then assigned to the load allocation (53.76 kg/yr).

In November of 2006, EPA issued a memorandum "Establishing TMDL 'Daily' Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et. Al., No. 05-5015 (April 25, 2006) and Implications for NPDES Permits," which recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment in conjunction with other appropriate temporal expressions that may be necessary to implement the relevant water quality standard. While the Department believes that the appropriate temporal expression for phosphorus loading to lakes and reservoirs is as an annual load, the phosphorus TMDL has also been expressed as a daily load. In order to express this phosphorus TMDL as a daily load the annual loading capacity of 59.7 kg/yr was divided by 365 days. Based on this analysis, the phosphorus TMDL, expressed as an average daily load, is 0.1636 kg/day with the load allocation equal to 0.1472 kg/day and the MOS equal to 0.0164 kg/day.

Table 17. Summary of the Phosphorus TMDL for McGregor Dam.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load	119.4	Determined through the BATHTUB model
Loading Capacity	59.7	50 percent total reduction based on BATHTUB modeling
Wasteload Allocation	0.0	No point sources
Load Allocation	53.73	Entire loading capacity minus MOS is allocated to non-point sources
MOS	5.97	10% of the loading capacity (59.7 kg/yr) is reserved as an explicit margin of safety

7.2 Dissolved Oxygen TMDL

While not originally listed on the state's Section 303(d) list of impaired waters needing TMDLs, monitoring data collected to develop this TMDL showed dissolved oxygen concentrations in the reservoir consistently below the state's water quality standard of 5 mg/L in the hypolimnion, during summer stratification, and throughout the water column, during winter under ice cover conditions (Figures 10 and 12). It is expected that by attaining the phosphorus load reduction target established for McGregor Dam, the dissolved oxygen impairment will be addressed. A reduction in total phosphorus loading to McGregor Dam is expected to lower algal biomass levels in the water column, thereby reducing both metalimnetic and hypolimnetic oxygen demand exerted by the decomposition of these primary producers (see Section 5.4 for additional justification). The predicted reduction in metalimnetic and hypolimnetic oxygen demand is therefore assumed to result in attainment of the dissolved oxygen standard.

7.3 Sediment TMDL

No reduction necessary. This report provides justification for de-listing for sediment (see Section 5.5).

8.0 ALLOCATION

A 50 percent phosphorus load reduction target was established for the McGregor Dam watershed. This reduction was set based on the BATHTUB model, which predicted that under similar hydraulic conditions, an external phosphorus load reduction of 50 percent would lower Carlson's phosphorus TSI from 77.60 to 68.36 (Figure 14).

McGregor Dam's watershed is small and supports extensive agriculture where cropland constitutes a majority of the land use. Sub-dividing it into smaller units, based on hydrology or type of conservation practice implemented, would not be practical. This TMDL will be implemented by several parties on a volunteer basis. Phosphorus loads into the reservoir will be reduced by treating the AGNPS identified critical cells (Figure 15). There are sixty-nine 40-acre cells within the McGregor Dam watershed identified as "critical" by the AGNPS model. Critical cells are those with fallow, small grains, or land chiseled multiple times; as well as feedlots (one identified in the watershed), and all land with a slope greater than five percent. These cells represent a total area of 2,746 acres or 50 percent of the watershed. If these critical areas in the watershed are targeted for treatment with BMPs (e.g., no till, nutrient management, grazing systems, native/tame grass seeding on steep slopes), then the specified phosphorus load reduction of 65.67 kg (LC + MOS) is possible.

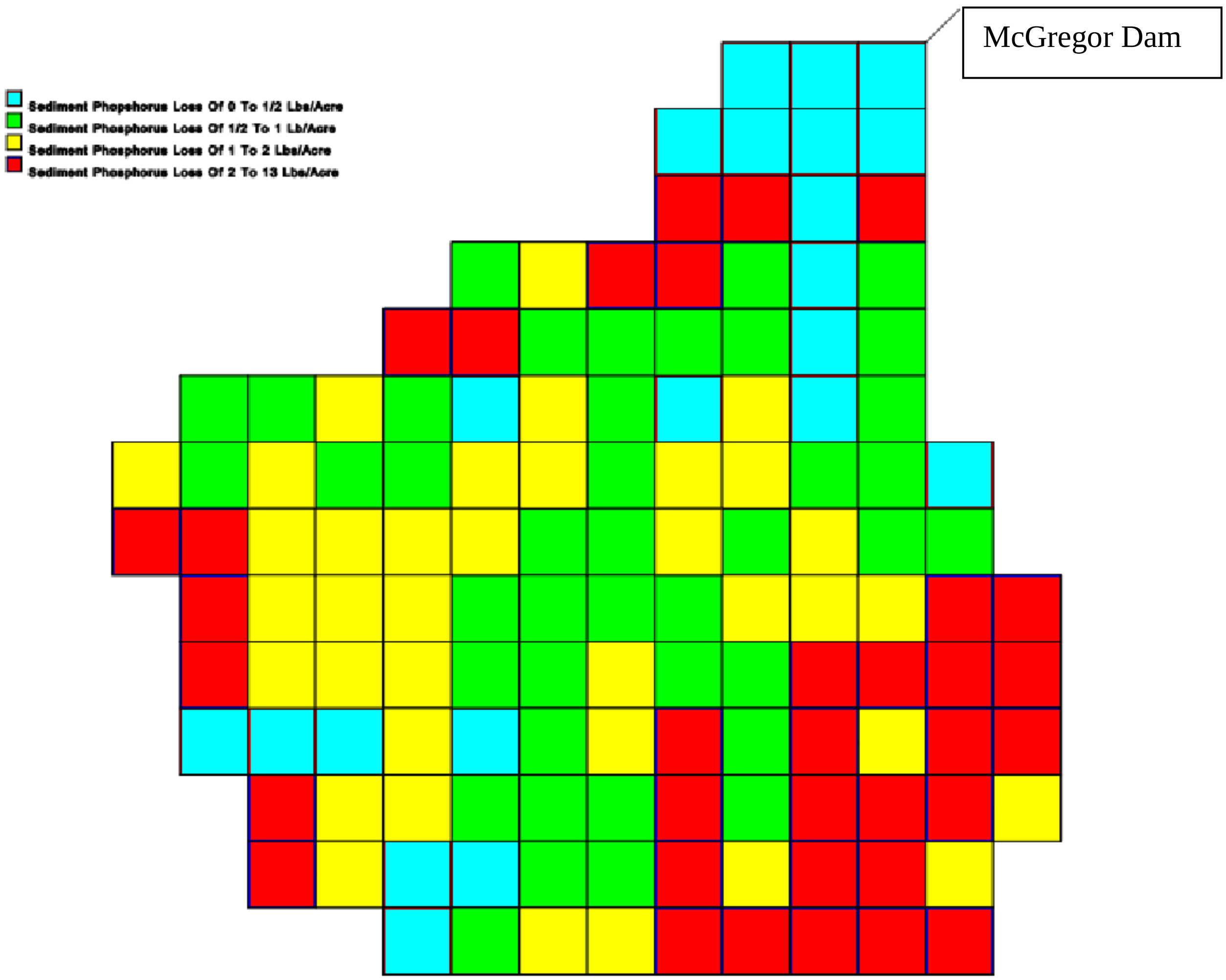

Figure 15. AGNPS Identification of Critical Areas for BMP Implementation.

The TMDLs in this report are a plan to improve water quality by implementing BMPs through a volunteer, incentive-based approach. This TMDL plan is put forth as a recommendation of what must be accomplished for McGregor Dam and its watershed to meet and protect its beneficial uses. Water quality monitoring should continue to assess the effects of the recommendations made in this TMDL. Monitoring may indicate that the loading capacity recommendations should be adjusted.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for McGregor Dam and request for comment was mailed to participating agencies, partners, and to those requesting a copy. Those included in the hard copy mailing were:

- Williams County Soil Conservation District;
- Williams County Water Resource Board;
- Williams County Park Board;
- Natural Resources Conservation Service (State and Williams County Field Offices);
- North Dakota Game and Fish Department – Williston District and
  Save Our Lakes Program; and
- U.S. Environmental Protection Agency, Region VIII.

In addition to the mailed copies, the TMDL for McGregor Dam was posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.health.state.nd.us/WQ/sw/Z2_TMDL/TMDLs_Under_PublicComment/B_Under_Public_Comment.htm . A 30 day public notice, ending June 5th, 2009, soliciting comment and participation was also published in the following newspapers:

- Williston Daily Herald; and
- The Bismarck Tribune.

No comments were received from the public. Review comments were received from EPA Region 8 (Appendix D). The NDDoH's response to EPA's comments are provided in Appendix E.

10.0 MONITORING

To insure that BMPs implemented as part of any watershed restoration plan 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 (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. Once a watershed restoration plan (e.g. Section 319 Project Implementation Plan) is implemented, monitoring will be conducted in the reservoir beginning two years after implementation and extending five years after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA EQIP), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the ND Nonpoint Source Pollution Task Force and the US EPA for approval. The implementation of the best management practices contained in the NPS pollution management project implementation plan (PIP) is voluntary. Therefore, success of any TMDL implementation project is ultimately dependent on the ability of the local project sponsor to find cooperating producers.

Monitoring is 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. Quality Assurance Project Plans (QAPPs) detail 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 are adapted to place BMPs where they will have the greatest benefit to water quality.

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Appendix A
A Calibrated Trophic Response Model (BATHTUB) for McGregor Dam and Model Output

A Calibrated Trophic Response Model (Bathtub) for McGregor Dam
As a Tool to Evaluate Various Nutrient Reduction Alternatives
Based on Data Collected by the Williams County Soil Conservation District from
June 20, 2003 through October 31, 2004 Prepared by
Peter Wax
November 6, 2004
June 23, 2006

Introduction

In order to meet the project goals, as set forth by the project sponsors of identifying possible improvements to the trophic condition of McGregor Dam 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 McGregor Dam. The model enables investigations into various nutrient reduction alternatives relative to the project goal of improving McGregor Dam'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 use 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 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 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).

Lake Data

McGregor Dam'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 FLUX, 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 McGregor Dam. 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 depth, 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 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, McGregor Dam 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 McGregor Dam Bathtub Model.

Model Option	Model Selection	Calibration Factor
Conservative Substance	1 Computed	1.00
Phosphorus Balance	5 Vollenweider	1.15
Phosphorus – Ortho P	5 Vollenweider	1.30
Nitrogen Balance	7 Settling Velocity	1.01
Organic Nitrogen	7 Settling Velocity	3.25
Chlorophyll-a	4 P, Linear	0.50
Secchi Depth	1 Vs. Chla & Turbidity	1.00
Phosphorus Calibration	1 Concentrations	NA
Nitrogen Calibration	1 Concentrations	NA
Availability Factors	0 Ignore	NA
Mass-Balance Tables	0 Use Observed Concentrations	NA

Results

The trophic response model, BATHTUB, has been calibrated to match McGregor Dam's trophic response for the project period between June 20, 2003 through October 31, 2004. This is accomplished by combining tributary loading estimates for the hydrologic year October 31, 2003 through October 31, 2004 with in-lake water quality. Tributary flow and concentration data for the project period are reduced by the FLUX program and the corresponding in-lake water quality data are reduced utilizing Excel. The output from these two programs is 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 McGregor Dam 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 0.1624 mg L^{-1} and an annual average volume weighted total nitrogen concentration of 2.768 mg L^{-1} compared to observed values for total phosphorus and total nitrogen of 0.163 mg L^{-1} and 2.769 mg L^{-1}, 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 did just as good a job of predicting average chlorophyll-a concentration and secchi disk transparency within the reservoir as total phosphorus and total nitrogen (Table 2).

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.

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

	Value	
Variable	Observed	Predicted
Total Phosphorus as P (mg/L)	0.163	0.162
Total Dissolved Phosphorus (mg/L)	0.051	0.050
Total Nitrogen as N (mg/L)	2.769	2.768
Organic Nitrogen as N (mg/L)	2.235	2.214
Chlorophyll-a (μg/L)	23.00	22.73
Secchi Disk Transparency (meters)	1.60	1.54
Carlson's TSI for Phosphorus	77.60	77.55
Carlson's TSI for Chlorophyll-a	61.36	61.24
Carlson's TSI for Secchi Disk	53.23	53.75

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). Over all the predicted and observed TSI values for phosphorus, chlorophyll and secchi disk suggest McGregor Dam is eutrophic. Figure 2 is a graphic that shows the annual temporal distribution of McGregor Dam's trophic state based on the three parameters total phosphorus as phosphate, and chlorophyll-a concentrations and secchi disk depth transparency.

<u>Model Predictions</u>

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 McGregor Dam 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).

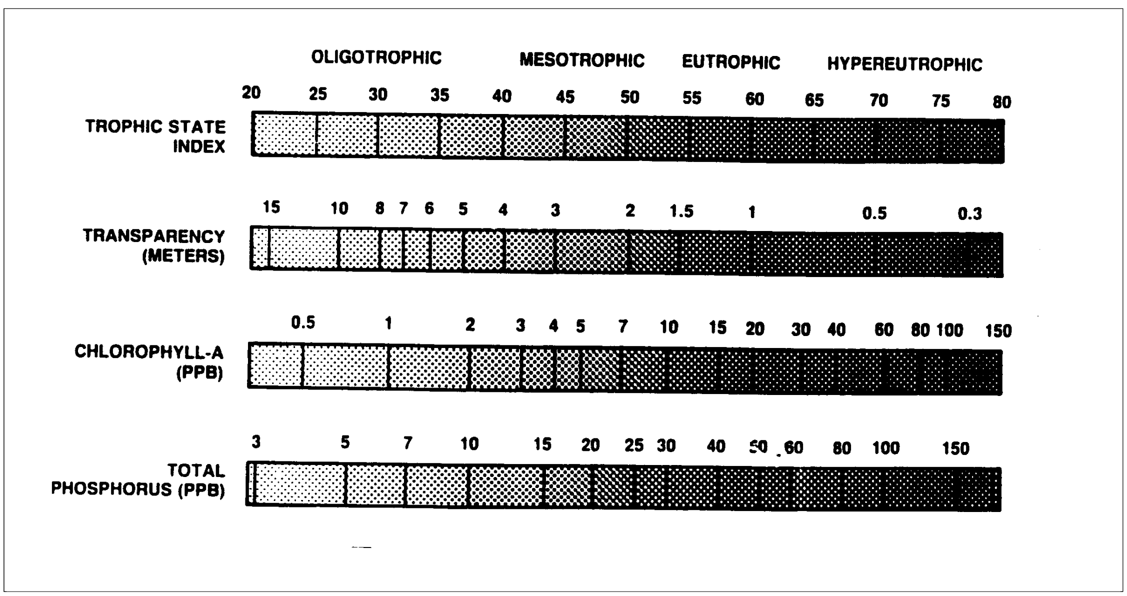

Figure 1. Graphic depiction of Carlson's Trophic Status Index

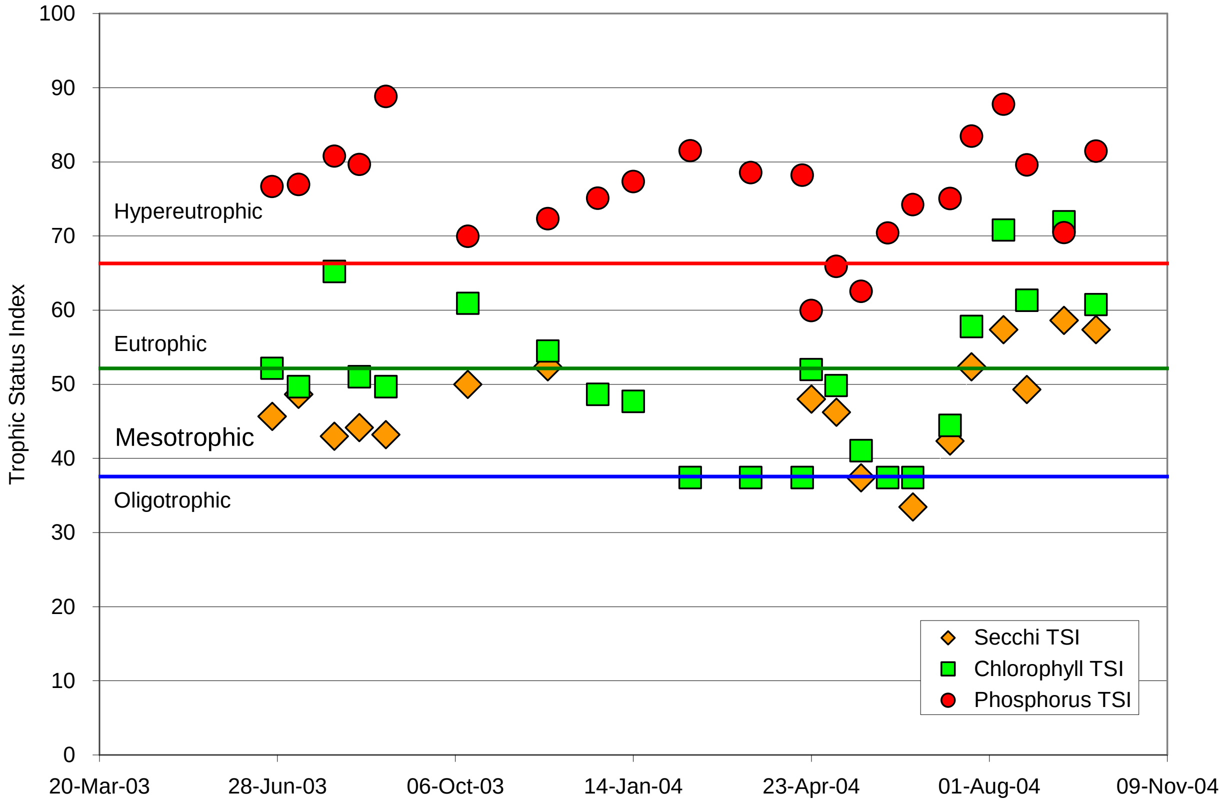

Figure 2. Temporal distribution of Carlosn's Trophic Status Index scores for McGregor Dam (12-17-2002 though 10-19-2003)

Predicted changes in trophic response to McGregor Dam were evaluated by reducing externally derived phosphorus loads by 25, 50, and 75 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, and 75 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 McGregor Dam by 50 percent the average annual total phosphorus and chlorophyll-a concentrations in the lake would decrease as well and secchi disk transparency depth would increase significantly (Table 3, Figure 3). With a 50 percent reduction in external phosphorus and nitrogen load, the model predicts a reduction in Carlson's TSI score from 61 to 55 for chlorophyll-a and from 53 to 46 for secchi disk transparency, corresponding to a trophic state of eutrophic and mesotrophic, respectively.

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

Variable	Observed	Predicted 25 %	Predicted 50 %	Predicted 75 %
Total Phosphorus as P (mg/L)	0.163	0.124	0.086	0.047
Total Dissolved Phosphorus (mg/L)	0.112	0.087	0.061	0.024
Total Nitrogen as N (mg/L)	2.769	2.188	1.606	0.994
Organic Nitrogen as N (mg/L)	2.235	1.815	1.421	NA
Chlorophyll-a (μg/L)	23.00	17.35	12.02	8.26
Secchi Disk Transparency (meters)	1.60	1.95	2.63	2.44
Carlson's TSI for Phosphorus	77.60	73.65	68.36	59.71
Carlson's TSI for Chlorophyll-a	61.53	58.59	54.99	51.31
Carlson's TSI for Secchi Disk	53.23	50.40	46.08	47.16

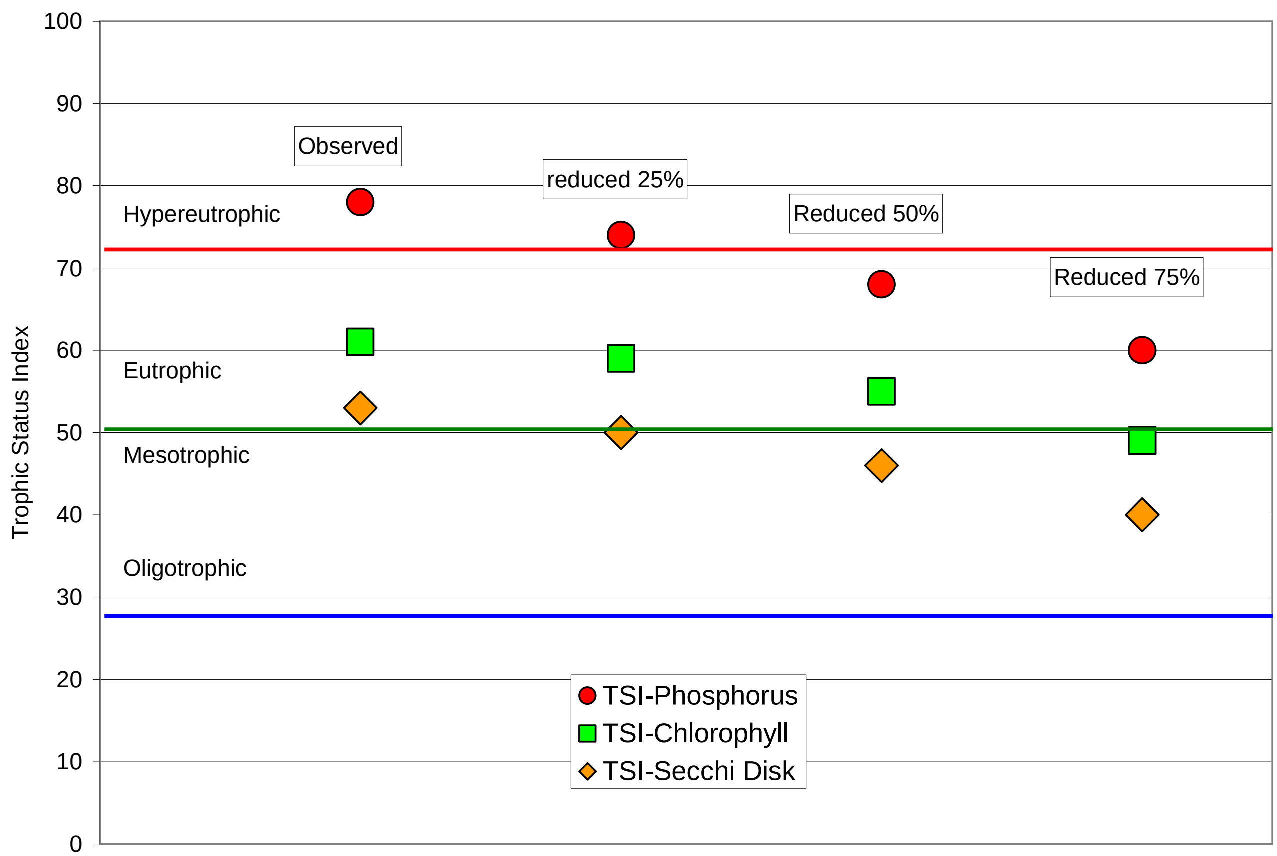

Figure 3. Predicted trophic response to phosphorus load reductions to McGregor Dam of 25, 50, and 75 percent

CASE: McGregor Calibrated

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	Inlet	21.480	.280	.000E+00	.000	.013
2	4	Outlet	21.700	.244	.000E+00	.000	.011
		TRIBUTARY INFLOW	21.480	.280	.000E+00	.000	.013
		***TOTAL INFLOW	21.700	.280	.000E+00	.000	.013
		GAUGED OUTFLOW	21.700	.244	.000E+00	.000	.011
		ADVECTIVE OUTFLOW	.000	.036	.000E+00	.000	-29462.430
		***TOTAL OUTFLOW	21.700	.280	.000E+00	.000	.013

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: CONSERV

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	.0	.0	.000E+00	.0	.000	.0	.0
2	4	Outlet	.0	.0	.000E+00	.0	.000	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	CONSERV: POOL CONC MG/M3	CONSERV: RESIDENCE TIME YRS	CONSERV: TURNOVER RATIO -	CONSERV: RETENTION COEF -
1.27	4.0857	.0	.0000	.0000	.0000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	112.8	94.5	.000E+00	.0	.000	403.0	5.3
2	4	Outlet	99.1	82.9	.000E+00	.0	.000	406.0	4.6
		PRECIPITATION	6.6	5.5	.109E+02	100.0	.500	.0	30.0
		TRIBUTARY INFLOW	112.8	94.5	.000E+00	.0	.000	403.0	5.3
		***TOTAL INFLOW	119.4	100.0	.109E+02	100.0	.028	426.6	5.5
		GAUGED OUTFLOW	39.8	33.3	.000E+00	.0	.000	163.0	1.8
		ADVECTIVE OUTFLOW	5.9	4.9	.000E+00	.0	.000	163.0	********
		***TOTAL OUTFLOW	45.6	38.2	.000E+00	.0	.000	163.0	2.1
		***RETENTION	73.8	61.8	.109E+02	100.0	.045	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P POOL CONC MG/M3	TOTAL P RESIDENCE TIME YRS	TOTAL P TURNOVER RATIO -	TOTAL P RETENTION COEF -
1.27	4.0857	163.0	1.5612	.6405	.6179

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	1150.5	83.9	.000E+00	.0	.000	4109.0	53.6
2	4	Outlet	633.7	46.2	.000E+00	.0	.000	2597.0	29.2
		PRECIPITATION	220.0	16.1	.121E+05	100.0	.500	.0	1000.0
		TRIBUTARY INFLOW	1150.5	83.9	.000E+00	.0	.000	4109.0	53.6
		***TOTAL INFLOW	1370.5	100.0	.121E+05	100.0	.080	4894.7	63.2
		GAUGED OUTFLOW	675.6	49.3	.000E+00	.0	.000	2769.0	31.1
		ADVECTIVE OUTFLOW	99.7	7.3	.000E+00	.0	.000	2769.0	********
		***TOTAL OUTFLOW	775.3	56.6	.000E+00	.0	.000	2769.0	35.7
		***RETENTION	595.2	43.4	.121E+05	100.0	.185	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N POOL CONC MG/M3	TOTAL N RESIDENCE TIME YRS	TOTAL N TURNOVER RATIO -	TOTAL N RETENTION COEF -
1.27	4.0857	2769.0	2.3113	.4326	.4343

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 McGregor Dam

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	163.00	162.37	91.3	91.3
TOTAL N	MG/M3	2769.00	2768.45	94.4	94.4
C.NUTRIENT	MG/M3	130.60	130.26	94.8	94.7
CHL-A	MG/M3	23.00	22.73	87.8	87.5
SECCHI	M	1.60	1.54	69.8	68.1
ORGANIC N	MG/M3	2235.00	2214.21	99.9	99.9
TP-ORTHO-P	MG/M3	51.00	49.73	71.2	70.3
HOD-V	MG/M3-DAY	.00	131.52	.0	76.4
MOD-V	MG/M3-DAY	.00	119.70	.0	78.7
ANTILOG PC-1		1240.58	1247.99	89.2	89.3
ANTILOG PC-2		15.31	14.80	95.0	94.4
(N - 150) / P		16.07	16.13	46.7	46.9
INORGANIC N / P		4.77	4.92	3.3	3.5
TURBIDITY	1/M	.08	.08	1.1	1.1
ZMIX * TURBIDITY		.17	.17	.0	.0
ZMIX / SECCHI		1.31	1.36	1.3	1.6
CHL-A * SECCHI		36.80	35.06	96.5	95.9
CHL-A / TOTAL P		.14	.14	30.3	29.8
FREQ(CHL-a>10) %		84.93	84.48	.0	.0
FREQ(CHL-a>20) %		46.62	45.87	.0	.0
FREQ(CHL-a>30) %		23.01	22.43	.0	.0
FREQ(CHL-a>40) %		11.45	11.09	.0	.0
FREQ(CHL-a>50) %		5.91	5.69	.0	.0
FREQ(CHL-a>60) %		3.17	3.04	.0	.0
CARLSON TSI-P		77.60	77.55	.0	.0
CARLSON TSI-CHLA		61.36	61.24	.0	.0
CARLSON TSI-SEC		53.23	53.75	.0	.0

CASE: McGregor Calibrated – 25% Load

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	FLOW (HM3/YR) MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	Inlet	21.480	.280	.000E+00	.000	.013
2	4	Outlet	21.700	.244	.000E+00	.000	.011
TRIBUTARY INFLOW			21.480	.280	.000E+00	.000	.013
***TOTAL INFLOW			21.700	.280	.000E+00	.000	.013
GAUGED OUTFLOW			21.700	.244	.000E+00	.000	.011
ADVECTIVE OUTFLOW			.000	.036	.000E+00	.000	-29462.430
***TOTAL OUTFLOW			21.700	.280	.000E+00	.000	.013

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: CONSERV

ID	T	LOCATION	LOADING KG/YR	%(I)	VARIANCE KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	.0	.0	.000E+00	.0	.000	.0	.0
2	4	Outlet	.0	.0	.000E+00	.0	.000	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	CONSERV POOL CONC MG/M3	RESIDENCE TIME YRS	TURNOVER RATIO -	RETENTION COEF -
1.27	4.0857	.0	.0000	.0000	.0000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	84.6	92.8	.000E+00	.0	.000	302.0	3.9
2	4	Outlet	99.1	108.7	.000E+00	.0	.000	406.0	4.6
		PRECIPITATION	6.6	7.2	.109E+02	100.0	.500	.0	30.0
		TRIBUTARY INFLOW	84.6	92.8	.000E+00	.0	.000	302.0	3.9
		***TOTAL INFLOW	91.2	100.0	.109E+02	100.0	.036	325.6	4.2
		GAUGED OUTFLOW	39.8	43.6	.000E+00	.0	.000	163.0	1.8
		ADVECTIVE OUTFLOW	5.9	6.4	.000E+00	.0	.000	163.0	********
		***TOTAL OUTFLOW	45.6	50.1	.000E+00	.0	.000	163.0	2.1
		***RETENTION	45.5	49.9	.109E+02	100.0	.072	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P: POOL CONC MG/M3	TOTAL P: RESIDENCE TIME YRS	TOTAL P: TURNOVER RATIO -	TOTAL P: RETENTION COEF -
1.27	4.0857	163.0	2.0455	.4889	.4993

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	863.2	79.7	.000E+00	.0	.000	3083.0	40.2
2	4	Outlet	633.7	58.5	.000E+00	.0	.000	2597.0	29.2
		PRECIPITATION	220.0	20.3	.121E+05	100.0	.500	.0	1000.0
		TRIBUTARY INFLOW	863.2	79.7	.000E+00	.0	.000	3083.0	40.2
		***TOTAL INFLOW	1083.2	100.0	.121E+05	100.0	.102	3868.7	49.9
		GAUGED OUTFLOW	675.6	62.4	.000E+00	.0	.000	2769.0	31.1
		ADVECTIVE OUTFLOW	99.7	9.2	.000E+00	.0	.000	2769.0	********
		***TOTAL OUTFLOW	775.3	71.6	.000E+00	.0	.000	2769.0	35.7
		***RETENTION	307.9	28.4	.121E+05	100.0	.357	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N: POOL CONC MG/M3	TOTAL N: RESIDENCE TIME YRS	TOTAL N: TURNOVER RATIO -	TOTAL N: RETENTION COEF -
1.27	4.0857	2769.0	2.9243	.3420	.2843

CASE: McGregor Calibrated – 25%

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 McGregor Dam

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	163.00	123.92	91.3	85.5
TOTAL N MG/M3	2769.00	2188.14	94.4	88.9
C.NUTRIENT MG/M3	130.60	100.11	94.8	90.1
CHL-A MG/M3	23.00	17.35	87.8	78.7
SECCHI M	1.60	1.95	69.8	78.1
ORGANIC N MG/M3	2235.00	1815.39	99.9	99.6
TP-ORTHO-P MG/M3	51.00	37.28	71.2	59.0
HOD-V MG/M3-DAY	.00	114.90	.0	70.4
MOD-V MG/M3-DAY	.00	104.57	.0	72.8
ANTILOG PC-1	1240.58	768.58	89.2	80.9
ANTILOG PC-2	15.31	14.70	95.0	94.2
(N - 150) / P	16.07	16.45	46.7	48.1
INORGANIC N / P	4.77	4.30	3.3	2.6
TURBIDITY 1/M	.08	.08	1.1	1.1
ZMIX * TURBIDITY	.17	.17	.0	.0
ZMIX / SECCHI	1.31	1.08	1.3	.5
CHL-A * SECCHI	36.80	33.77	96.5	95.5
CHL-A / TOTAL P	.14	.14	30.3	29.8
FREQ(CHL-a>10) %	84.93	71.86	.0	.0
FREQ(CHL-a>20) %	46.62	29.48	.0	.0
FREQ(CHL-a>30) %	23.01	11.63	.0	.0
FREQ(CHL-a>40) %	11.45	4.87	.0	.0
FREQ(CHL-a>50) %	5.91	2.18	.0	.0
FREQ(CHL-a>60) %	3.17	1.04	.0	.0
CARLSON TSI-P	77.60	73.65	.0	.0
CARLSON TSI-CHLA	61.36	58.59	.0	.0
CARLSON TSI-SEC	53.23	50.40	.0	.0

CASE: McGregor Calibrated – 50%

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	FLOW (HM3/YR) MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	Inlet	21.480	.280	.000E+00	.000	.013
2	4	Outlet	21.700	.244	.000E+00	.000	.011
TRIBUTARY INFLOW			21.480	.280	.000E+00	.000	.013
***TOTAL INFLOW			21.700	.280	.000E+00	.000	.013
GAUGED OUTFLOW			21.700	.244	.000E+00	.000	.011
ADVECTIVE OUTFLOW			.000	.036	.000E+00	.000	-29462.430
***TOTAL OUTFLOW			21.700	.280	.000E+00	.000	.013

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: CONSERV

ID	T	LOCATION	LOADING KG/YR	%(I)	VARIANCE KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	.0	.0	.000E+00	.0	.000	.0	.0
2	4	Outlet	.0	.0	.000E+00	.0	.000	.0	.0

	HYDRAULIC	CONSERV			
OVERFLOW RATE M/YR	RESIDENCE TIME YRS	POOL CONC MG/M3	RESIDENCE TIME YRS	TURNOVER RATIO -	RETENTION COEF -
1.27	4.0857	.0	.0000	.0000	.0000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	56.6	89.6	.000E+00	.0	.000	202.0	2.6
2	4	Outlet	99.1	156.8	.000E+00	.0	.000	406.0	4.6
		PRECIPITATION	6.6	10.4	.109E+02	100.0	.500	.0	30.0
		TRIBUTARY INFLOW	56.6	89.6	.000E+00	.0	.000	202.0	2.6
		***TOTAL INFLOW	63.2	100.0	.109E+02	100.0	.052	225.6	2.9
		GAUGED OUTFLOW	39.8	63.0	.000E+00	.0	.000	163.0	1.8
		ADVECTIVE OUTFLOW	5.9	9.3	.000E+00	.0	.000	163.0	********
		***TOTAL OUTFLOW	45.6	72.3	.000E+00	.0	.000	163.0	2.1
		***RETENTION	17.5	27.7	.109E+02	100.0	.188	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P POOL CONC MG/M3	TOTAL P RESIDENCE TIME YRS	TOTAL P TURNOVER RATIO -	TOTAL P RETENTION COEF -
1.27	4.0857	163.0	2.9524	.3387	.2774

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	575.4	72.3	.000E+00	.0	.000	2055.0	26.8
2	4	Outlet	633.7	79.7	.000E+00	.0	.000	2597.0	29.2
		PRECIPITATION	220.0	27.7	.121E+05	100.0	.500	.0	1000.0
		TRIBUTARY INFLOW	575.4	72.3	.000E+00	.0	.000	2055.0	26.8
		***TOTAL INFLOW	795.4	100.0	.121E+05	100.0	.138	2840.7	36.7
		GAUGED OUTFLOW	675.6	84.9	.000E+00	.0	.000	2769.0	31.1
		ADVECTIVE OUTFLOW	99.7	12.5	.000E+00	.0	.000	2769.0	********
		***TOTAL OUTFLOW	775.3	97.5	.000E+00	.0	.000	2769.0	35.7
		***RETENTION	20.1	2.5	.121E+05	100.0	5.478	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N POOL CONC MG/M3	TOTAL N RESIDENCE TIME YRS	TOTAL N TURNOVER RATIO -	TOTAL N RETENTION COEF -
1.27	4.0857	2769.0	3.9826	.2511	.0252

CASE: McGregor Calibrated – 50%

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 McGregor Dam

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	163.00	85.86	91.3	74.2
TOTAL N MG/M3	2769.00	1606.71	94.4	77.0
C.NUTRIENT MG/M3	130.60	70.10	94.8	80.1
CHL-A MG/M3	23.00	12.02	87.8	62.6
SECCHI M	1.60	2.63	69.8	87.9
ORGANIC N MG/M3	2235.00	1420.53	99.9	98.4
TP-ORTHO-P MG/M3	51.00	24.95	71.2	42.3
HOD-V MG/M3-DAY	.00	95.64	.0	61.5
MOD-V MG/M3-DAY	.00	87.04	.0	63.6
ANTILOG PC-1	1240.58	404.71	89.2	64.9
ANTILOG PC-2	15.31	14.46	95.0	93.8
(N - 150) / P	16.07	16.97	46.7	49.9
INORGANIC N / P	4.77	3.06	3.3	1.1
TURBIDITY 1/M	.08	.08	1.1	1.1
ZMIX * TURBIDITY	.17	.17	.0	.0
ZMIX / SECCHI	1.31	.80	1.3	.1
CHL-A * SECCHI	36.80	31.59	96.5	94.5
CHL-A / TOTAL P	.14	.14	30.3	29.8
FREQ(CHL-a>10) %	84.93	49.46	.0	.0
FREQ(CHL-a>20) %	46.62	12.90	.0	.0
FREQ(CHL-a>30) %	23.01	3.71	.0	.0
FREQ(CHL-a>40) %	11.45	1.23	.0	.0
FREQ(CHL-a>50) %	5.91	.45	.0	.0
FREQ(CHL-a>60) %	3.17	.19	.0	.0
CARLSON TSI-P	77.60	68.36	.0	.0
CARLSON TSI-CHLA	61.36	54.99	.0	.0
CARLSON TSI-SEC	53.23	46.08	.0	.0

CASE: McGregor Calibrated – 75%

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	FLOW (HM3/YR) MEAN	FLOW (HM3/YR) VARIANCE	FLOW (HM3/YR) CV	RUNOFF M/YR
1	1	Inlet	21.480	.280	.000E+00	.000	.013
2	4	Outlet	21.700	.244	.000E+00	.000	.011
TRIBUTARY INFLOW			21.480	.280	.000E+00	.000	.013
***TOTAL INFLOW			21.700	.280	.000E+00	.000	.013
GAUGED OUTFLOW			21.700	.244	.000E+00	.000	.011
ADVECTIVE OUTFLOW			.000	.036	.000E+00	.000	-29462.430
***TOTAL OUTFLOW			21.700	.280	.000E+00	.000	.013

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: CONSERV

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	.0	.0	.000E+00	.0	.000	.0	.0
2	4	Outlet	.0	.0	.000E+00	.0	.000	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	CONSERV POOL CONC MG/M3	CONSERV RESIDENCE TIME YRS	CONSERV TURNOVER RATIO -	CONSERV RETENTION COEF -
1.27	4.0857	.0	.0000	.0000	.0000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	28.3	81.1	.000E+00	.0	.000	101.0	1.3
2	4	Outlet	99.1	284.0	.000E+00	.0	.000	406.0	4.6
		PRECIPITATION	6.6	18.9	.109E+02	100.0	.500	.0	30.0
		TRIBUTARY INFLOW	28.3	81.1	.000E+00	.0	.000	101.0	1.3
		***TOTAL INFLOW	34.9	100.0	.109E+02	100.0	.095	124.6	1.6
		GAUGED OUTFLOW	39.8	114.0	.000E+00	.0	.000	163.0	1.8
		ADVECTIVE OUTFLOW	5.9	16.8	.000E+00	.0	.000	163.0	********
		***TOTAL OUTFLOW	45.6	130.8	.000E+00	.0	.000	163.0	2.1
		***RETENTION	-10.8	-30.8	.109E+02	100.0	.307	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P POOL CONC MG/M3	TOTAL P RESIDENCE TIME YRS	TOTAL P TURNOVER RATIO -	TOTAL P RETENTION COEF -
1.27	4.0857	163.0	5.3461	.1871	-.3085

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	Inlet	287.8	56.7	.000E+00	.0	.000	1028.0	13.4
2	4	Outlet	633.7	124.8	.000E+00	.0	.000	2597.0	29.2
		PRECIPITATION	220.0	43.3	.121E+05	100.0	.500	.0	1000.0
		TRIBUTARY INFLOW	287.8	56.7	.000E+00	.0	.000	1028.0	13.4
		***TOTAL INFLOW	507.8	100.0	.121E+05	100.0	.217	1813.7	23.4
		GAUGED OUTFLOW	675.6	133.0	.000E+00	.0	.000	2769.0	31.1
		ADVECTIVE OUTFLOW	99.7	19.6	.000E+00	.0	.000	2769.0	********
		***TOTAL OUTFLOW	775.3	152.7	.000E+00	.0	.000	2769.0	35.7
		***RETENTION	-267.5	-52.7	.121E+05	100.0	.411	.0	.0

OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N POOL CONC MG/M3	TOTAL N RESIDENCE TIME YRS	TOTAL N TURNOVER RATIO -	TOTAL N RETENTION COEF -
1.27	4.0857	2769.0	6.2377	.1603	-.5267

CASE: McGregor Calibrated – 75%

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 McGregor Dam

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	163.00	47.42	91.3	49.5
TOTAL N	MG/M3	2769.00	1025.84	94.4	51.5
C.NUTRIENT	MG/M3	130.60	39.76	94.8	55.4
CHL-A	MG/M3	23.00	6.64	87.8	32.6
SECCHI	M	1.60	4.07	69.8	95.9
ORGANIC N	MG/M3	2235.00	1021.72	99.9	93.4
TP-ORTHO-P	MG/M3	51.00	12.50	71.2	17.8
HOD-V	MG/M3-DAY	.00	71.07	.0	45.7
MOD-V	MG/M3-DAY	.00	64.68	.0	47.2
ANTILOG PC-1		1240.58	151.19	89.2	35.6
ANTILOG PC-2		15.31	13.73	95.0	92.5
(N - 150) / P		16.07	18.47	46.7	54.9
INORGANIC N / P		4.77	.12	3.3	.0
TURBIDITY	1/M	.08	.08	1.1	1.1
ZMIX * TURBIDITY		.17	.17	.0	.0
ZMIX / SECCHI		1.31	.52	1.3	.0
CHL-A * SECCHI		36.80	26.99	96.5	91.5
CHL-A / TOTAL P		.14	.14	30.3	29.8
FREQ(CHL-a>10) %		84.93	16.58	.0	.0
FREQ(CHL-a>20) %		46.62	1.84	.0	.0
FREQ(CHL-a>30) %		23.01	.31	.0	.0
FREQ(CHL-a>40) %		11.45	.07	.0	.0
FREQ(CHL-a>50) %		5.91	.02	.0	.0
FREQ(CHL-a>60) %		3.17	.01	.0	.0
CARLSON TSI-P		77.60	59.80	.0	.0
CARLSON TSI-CHLA		61.36	49.17	.0	.0
CARLSON TSI-SEC		53.23	39.79	.0	.0

Appendix B
Flux Data and Analysis

McGregor Inlet STORET # 385242 (composite)

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McGregor Inlet 385242             VAR=NH3-4     METHOD= 6 REG-3

 TABULATION OF MISSING DAILY FLOWS:

 Flow File =385242_Q.wk1                    ,   Station =Flow
 Daily Flows from 20031030 to 20041027

 Summary:
 Reported Flows =  364

 Missing Flows =     0
 Zero Flows =      231
 Positive Flows =  133

 McGregor Inlet 385242             VAR=NH3-4     METHOD= 6 REG-3
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       364  11  11 100.0         .281        3.757       1.001   .007
***       364  11  11 100.0         .281        3.757

 FLOW STATISTICS
 FLOW DURATION =     364.0 DAYS  =   .997 YEARS
 MEAN FLOW RATE =      .281 HM3/YR
 TOTAL FLOW VOLUME =        .28 HM3
 FLOW DATE RANGE   = 20031030 TO 20041027
 SAMPLE DATE RANGE = 20040331 TO 20040613

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD        1091.0         1094.8      .8015E+06    3890.46    .818
 2 Q WTD C          81.7           82.0      .1658E+04     291.43    .497
 3 IJC              89.1           89.4      .2111E+04     317.61    .514
 4 REG-1             6.1            6.1      .8449E+01      21.79    .474
 5 REG-2            34.9           35.0      .3747E+04     124.45   1.748
 6 REG-3           115.1          115.5      .4158E+05     410.30   1.766
```

McGregor Inlet 385242 VAR=NO2+NO3 METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=NO2+NO3 METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	1.093	.003
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	9259.6	9291.4	.6611E+08	33018.23	.875
2 Q WTD C	693.6	696.0	.1989E+06	2473.32	.641
3 IJC	773.2	775.8	.2614E+06	2757.02	.659
4 REG-1	40.9	41.0	.6011E+03	145.71	.598
5 REG-2	238.1	239.0	.5688E+05	849.18	.998
6 REG-3	1021.3	1024.8	.5244E+07	3641.74	2.235

McGregor Inlet 385242 VAR=INORG-N METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=INORG-N METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	1.075	.002
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	10350.7	10386.2	.8143E+08	36908.70	.869
2 Q WTD C	775.3	778.0	.2367E+06	2764.75	.625
3 IJC	862.2	865.2	.3104E+06	3074.64	.644
4 REG-1	47.8	47.9	.7725E+03	170.39	.580
5 REG-2	277.5	278.4	.8030E+05	989.46	1.018
6 REG-3	1104.9	1108.7	.6428E+07	3939.78	2.287

McGregor Inlet 385242 VAR=T-N METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=T-N METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	.283	.002
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	15384.5	15437.3	.1505E+09	54858.41	.795
2 Q WTD C	1152.4	1156.4	.2661E+06	4109.32	.446
3 IJC	1244.0	1248.3	.3529E+06	4435.85	.476
4 REG-1	553.1	555.0	.1845E+05	1972.09	.245
5 REG-2	1943.2	1949.9	.1151E+05	6929.06	.055
6 REG-3	786.3	789.0	.1023E+05	2803.79	.128

McGregor Inlet 385242 VAR=TD-P METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=TD-P METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	.324	.008
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1295.1	1299.5	.7500E+06	4618.04	.666
2 Q WTD C	97.0	97.3	.1481E+03	345.93	.125
3 IJC	99.3	99.6	.1704E+03	353.94	.131
4 REG-1	41.8	42.0	.1809E+03	149.23	.320
5 REG-2	157.2	157.7	.3361E+05	560.39	1.163
6 REG-3	97.2	97.5	.3280E+04	346.61	.587

McGregor Inlet 385242 VAR=T-P METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=T-P METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	.130	.080
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027

SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1510.0	1515.1	.9529E+06	5384.23	.644
2 Q WTD C	113.1	113.5	.6620E+02	403.32	.072
3 IJC	114.6	115.0	.7359E+02	408.70	.075
4 REG-1	80.8	81.0	.1042E+03	287.98	.126
5 REG-2	191.0	191.7	.1242E+05	681.19	.582
6 REG-3	107.3	107.7	.1670E+03	382.65	.120

McGregor Inlet 385242 VAR=TSS METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385242_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 231
Positive Flows = 133

McGregor Inlet 385242 VAR=TSS METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.281	3.757	.133	.689
***	364	11	11	100.0	.281	3.757		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .281 HM3/YR
TOTAL FLOW VOLUME = .28 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040331 TO 20040613

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	179850.7	180468.4	.2831E+11	641317.20	.932
2 Q WTD C	13472.2	13518.5	.1124E+09	48039.61	.784
3 IJC	15332.1	15384.7	.1526E+09	54671.61	.803
4 REG-1	9548.4	9581.2	.4769E+08	34048.01	.721
5 REG-2	22830.3	22908.7	.1252E+10	81409.04	1.545
6 REG-3	6470.4	6492.6	.2275E+08	23072.19	.735

McGregor Outlet STORET #385244

```
McGregor Outlet 385244            VAR=NH3+4     METHOD= 2 Q WTD C

 TABULATION OF MISSING DAILY FLOWS:

 Flow File =385244_Q.wk1                    ,   Station =Flow
 Daily Flows from 20031030 to 20041027

 Summary:
 Reported Flows =  364

 Missing Flows =     0
 Zero Flows =      285
 Positive Flows =   79

 McGregor Outlet 385244            VAR=NH3+4     METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       364  11  11 100.0         .244         .978       -.760   .127
***       364  11  11 100.0         .244         .978

 FLOW STATISTICS
 FLOW DURATION =     364.0 DAYS  =   .997 YEARS
 MEAN FLOW RATE =      .244 HM3/YR
 TOTAL FLOW VOLUME =        .24 HM3
 FLOW DATE RANGE   = 20031030 TO 20041027
 SAMPLE DATE RANGE = 20040303 TO 20040828

 METHOD          MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD          896.8          899.8      .7911E+05    3688.06    .313
 2 Q WTD C          223.6          224.4      .3575E+05     919.65    .843
 3 IJC              187.0          187.6      .4978E+05     768.92   1.189
 4 REG-1            642.6          644.8      .6747E+06    2642.72   1.274
 5 REG-2            143.5          144.0      .7105E+07     590.21  18.511
 6 REG-3            620.4          622.6      .1851E+06    2551.56    .691
```

McGregor Outlet 385244 VAR=NO2+NO3 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=NO2+NO3 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	.189	.288
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	72.4	72.6	.2744E+04	297.62	.721
2 Q WTD C	18.0	18.1	.8673E+02	74.22	.514
3 IJC	19.9	20.0	.1237E+03	81.78	.557
4 REG-1	13.9	13.9	.2994E+02	57.10	.393
5 REG-2	22.9	23.0	.1729E+03	94.32	.571
6 REG-3	13.1	13.1	.3088E+02	53.85	.423

McGregor Outlet 385244 VAR=INORG-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=INORG-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	-.437	.092
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	969.1	972.5	.7237E+05	3985.68	.277
2 Q WTD C	241.7	242.5	.3241E+05	993.86	.742
3 IJC	206.9	207.6	.4500E+05	850.70	1.022
4 REG-1	443.3	444.8	.3821E+05	1823.08	.439
6 REG-3	302.6	303.6	.1532E+05	1244.34	.408

McGregor Outlet 385244 VAR=T-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=T-N METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	-.166	.063
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2532.8	2541.5	.3959E+06	10416.53	.248
2 Q WTD C	631.6	633.7	.4968E+05	2597.45	.352
3 IJC	587.7	589.7	.7004E+05	2416.89	.449
4 REG-1	795.6	798.3	.2416E+05	3271.82	.195
5 REG-2	348.6	349.8	.6246E+05	1433.50	.715
6 REG-3	694.5	696.9	.1299E+05	2856.36	.164

McGregor Outlet 385244 VAR=TD-P METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=TD-P METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	-.284	.087
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	307.1	308.2	.6151E+04	1262.98	.255
2 Q WTD C	76.6	76.8	.2360E+04	314.93	.632
3 IJC	67.3	67.5	.3273E+04	276.65	.848
4 REG-1	113.6	114.0	.1479E+04	467.40	.337
5 REG-2	12.7	12.8	.4504E+04	52.42	5.247
6 REG-3	88.0	88.3	.9121E+03	362.10	.342

McGregor Outlet 385244 VAR=T-P METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=T-P METHOD= 6 REG-3
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	-.287	.076
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	342.4	343.6	.6699E+04	1408.13	.238
2 Q WTD C	85.4	85.7	.2936E+04	351.13	.632
3 IJC	74.9	75.1	.4096E+04	307.86	.852
4 REG-1	127.1	127.6	.1984E+04	522.86	.349
5 REG-2	13.5	13.6	.6305E+04	55.72	5.841
6 REG-3	98.8	99.2	.1114E+04	406.42	.337

McGregor Outlet 385244 VAR=TSS METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =385244_Q.wk1 , Station =Flow
Daily Flows from 20031030 to 20041027

Summary:
Reported Flows = 364
Missing Flows = 0
Zero Flows = 285
Positive Flows = 79

McGregor Outlet 385244 VAR=TSS METHOD= 3 IJC
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	364	11	11	100.0	.244	.978	-.038	.623
***	364	11	11	100.0	.244	.978		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .244 HM3/YR
TOTAL FLOW VOLUME = .24 HM3
FLOW DATE RANGE = 20031030 TO 20041027
SAMPLE DATE RANGE = 20040303 TO 20040828

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	5461.3	5480.0	.5997E+07	22460.05	.447
2 Q WTD C	1361.8	1366.5	.7933E+04	5600.61	.065
3 IJC	1376.4	1381.1	.1105E+05	5660.54	.076
4 REG-1	1435.8	1440.8	.1178E+06	5905.01	.238
5 REG-2	1243.8	1248.1	.3079E+06	5115.24	.445
6 REG-3	1369.0	1373.7	.2723E+05	5630.17	.120

Appendix C
Stream Visual Assessment Results

BLACKTAIL DAM AND MCGREGOR DAM WATERSHED STREAM ASSESSMENT
JUNE 2004

INTRODUCTION

The Williams County Soil Conservation District (SCD) conducted a riparian stream assessment as part of a comprehensive resource inventory of the natural resources in the Blacktail and McGregor Dam Watersheds (see Appendix A, map A-1). The District requested the Natural Resources Conservation Service (NRCS) to assist with a riparian stream assessment.

This assessment was done in conjunction with the North Dakota Department of Health (NDDH) water quality monitoring program and the local soil conservation district's land use assessment. These three inventories and evaluations will be the basis for determining the need to pursue additional technical and financial assistance for a land treatment watershed project.

The Natural Resources Planning Staff (NRPS) served in a leadership role in the selection of the inventory sites along the East and West branches of McGregor Dam Watershed and the north and south branches of Blacktail Dam Watershed (see Appendix A - watershed maps). The NRPS along with NDDH selected the assessment method of inventorying and evaluating these stream systems. The method chosen was the NRCS Stream Visual Assessment Protocol – Technical Note 99-1 (see Appendix B).

The Natural Resources Planning Staff (NRPS), along with NRCS and SCD personnel from the Williston Field Office, as well as an environmental scientist from the NDDH provided assistance (see Appendix C - Participant List). The field data, with the exception of the south branch of Blacktail Dam watershed, was collected May 10 and 11, 2003 prior to spring planting season.

McGregor Dam

The McGregor Dam watershed is 5,168 acres in size (see map A-2) and is comprised of two primary branches. Both branches are ephemeral streams with flows only occurring during spring runoff and significant rainfall events.

The east branch has four small wildlife dams. These dams were installed in 2003. These dams have changed the flow of this branch. The west branch has an older wildlife/livestock dam and one livestock pond located along the reach surveyed. These impoundments may have some impact on the residence time of the main pool of McGregor Dam reservoir. During drier periods, as were observed during this assessment, there appeared to be little to no surface flow into McGregor Dam reservoir.

A total of 20 sites were selected for evaluation. However, due to lack of stream flow only eleven stream sites were evaluated (see map A-3). One site on the main stem, two sites on the east branch, and eight sites on the west branch were evaluated. The assessment teams started at the main stem site and proceeded upstream until there was no stream flow present.

Blacktail Dam

The Blacktail Dam watershed is 17,139 acres in size (see map A-4) and is also comprised of two primary branches. The north branch had two defined channels, which were further identified as the north and south tributaries of the north branch. The primary or main north and south branches are classified as a first order streams (see figure 1).

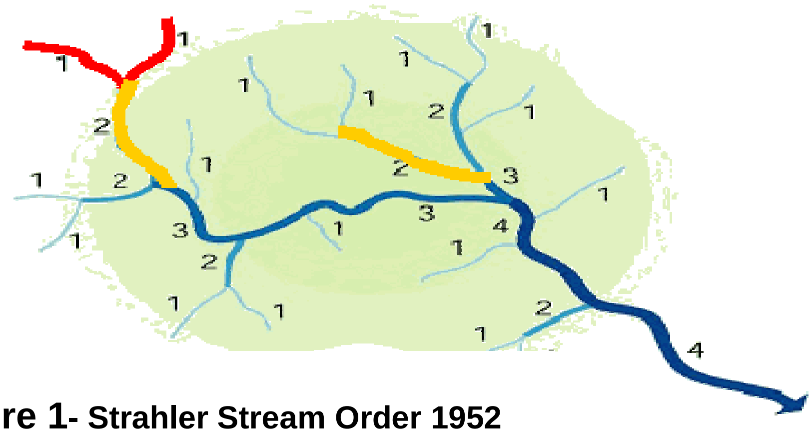

Figure 1- Strahler Stream Order 1952

Both the north and south branches are well defined intermittent streams with well defined floodplains. Moderate to heavy grazing pressure were noted on both branches. There is a livestock dam on the south branch which appears to be impacting stream morphology.

A total of 23 sites were selected for evaluation. However, only twenty-one sites were evaluated (see map A-5). Two sites on the north tributary of the north branch were not evaluated due to lack of stream flow. Table 1 below displays the evaluation site locations.

Table 1:

Branch/Tributary	No. of sites
South Branch	6
North Branch	15
Main Stem	4
North Tributary	7
South Tributary	4

Evaluation Process

Stream Visual Assessment Protocol

The "Stream Visual Assessment Protocol" (see Appendix B) provided a way to assess the current health and overall ecological condition of the stream, including the riparian zone. This protocol is the first level in a hierarchy of ecological assessments. It is very basic in nature and is to be used by local land users. This protocol also allows the evaluation of the condition of the aquatic ecosystems associated with the stream. The protocol addresses water quality and physical habitat resource concerns.

The assessment was useful in identifying specific causes for the sites current condition.

The evaluation considered three main categories:
(1) hydrology and stream banks,
(2) soil,
(3) riparian vegetation.

This assessment can be used for the inventory and analysis steps of developing individual conservation plans assist local watershed sponsors in priority setting, and doing pre- and post-assessments to evaluate the implementation of conservation practices or best management practices (BMP).

The rating of each category on each of the selected sites enables landowners/land users to define areas in which management action could enhance natural resource conditions. The management of natural resources includes soil, water, air, plants, and animals, as well as human considerations pertaining to social and economic values.

See Appendix B for the instructions in completing the Stream Visual Assessment Protocol, and a copy of the assessment itself.

STUDY RESULTS

McGregor Dam Watershed

The specific data and ranking for the eleven sites inventoried are shown on page D-1.

Using the SVAP tool, the assessment teams ranked the 11 sites as follows:

Rank	Number of Sites
Poor	8
Fair	3

Preliminary analysis of the assessment results indicate 4 of the 7 sites were ranked as poor due to the impacts of small wildlife dam structures. Two of the 11 sites were braided.

Blacktail Dam Watershed

The specific data and ranking for the twenty eleven sites inventoried are shown on page D-2.

Using the SVAP tool, the assessment teams ranked the 21 sites as follows:

Rank	Number of Sites
Poor	7
Fair	13
Good	1

Analysis of the assessment results indicate the sites ranked as poor were impacted to some degree by the watersheds road system and its impact on fish movement. The geographical position of the watershed above these first order streams has also impacted the ranking scores for instream fish cover, pools, and invertebrate habitat. Stream bank and channel conditions were generally in good condition. There was not significant encroachment from farming operations.

PRELIMINARY TREND ANALYSIS OF SVAP DATA

There does not appear to be any significant change in the streams functioning condition or in its trend. Based on a subjective analysis the following observations were made.

Hydrologically the streams appear to be incised but stable. Channel stability doesn't appear to be changing significantly. The trend of the riparian zones was not apparent. These zones have not achieved their potential extent, but it appears their filtering function is still in place. Encroachment of tame introduced species, especially brome grass could compromise the health of the riparian zone.

Vegetatively upland watershed management appears to be static with a slight trend towards more cropping rotation diversity. Riparian plant communities have moderate diversity and vigor, but could be enhanced through management practices. Cattails are providing good filtering of sediments and nutrients, but the growth appears to be excessive in the upper reaches of the watershed.

Geologically the stream system does not appear to have excessive lateral movement. The streams point bars are stable with the exception of sites heavily used season long grazing systems. It appears in the past that sediment volumes exceeded the streams abilities to transport it. Presently sediment transport has no apparent trend.

PRIORITY RESOURCE ISSUES

The watershed sponsors, landowners, and land users will need to decide on what they want as the "future desired condition" of the McGregor Dam and Blacktail Dam Watersheds. There are several natural resource considerations and needs that can be addressed by a locally led conservation effort.

Some issues, which may be addressed in this locally led process, are:

McGregor Dam Watershed

1. Nutrient management
2. Riparian health

Blacktail Dam Watershed

1. Excessive erosion and sedimentation
2. Excessive grazing (stocking rates, duration, and season of use)
3. Nutrient management
4. Riparian health

CONCLUSIONS

The assessment does point out a continued need for prescribed grazing on rangeland and pasture land. It also points out those native plant communities provide superior protection in the riparian zone, as opposed to tame or introduced plants.

Land use management, which enhances native plant communities through proper utilization and season of use, will significantly improve the watershed's riparian health. On the ground, technical assistance from a watershed conservationist would benefit those land users who want to implement resource management systems on their land.

The stream and riparian assessment can be used in developing a long-range watershed plan. This stream assessment data needs to be evaluated along with the NDDH water quality monitoring data, and the local soil conservation district land use assessment to accurately identify priority areas within both watersheds.

Watershed priority areas should be selected based on natural resource needs, social acceptance of the watersheds producers and landowners, and sound economic principles.

A strong information and education program will be an integral part of implementing a land treatment watershed. The success of any voluntary watershed project is dependent on this aspect of the watershed plan.

Financial assistance through an EPA-319 land treatment watershed project and USDA conservation programs should be requested to facilitate installation of conservation practices.

Appendix D
Review Comments Provided by US EPA Region 8

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Nutrient and Dissolved Oxygen TMDLs for McGregor Dam in Williams County, North Dakota**
Submitted by:	**Mike Ell, North Dakota Department of Health**
Date Received:	**May 4, 2009**
Review Date:	**June 3, 2009**
Reviewer:	**Vern Berry, EPA**
Rough Draft / Public Notice / Final Draft?	**Public Notice Draft**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final review only):

- ☐ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
    - 1.1. TMDL Document Submittal Letter
    - 1.2. Identification of the Waterbody, Impairments, and Study Boundaries
    - 1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
    - 4.1. Data Set Description
    - 4.2. Waste Load Allocations (WLA)
    - 4.3. Load Allocations (LA)
    - 4.4. Margin of Safety (MOS)
    - 4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered “impaired.” When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: A public notice draft version of the McGregor Dam TMDL document was submitted to EPA for review and comment via email from Mike Ell, NDDoH on May 4, 2009. The email also included a copy of the public notice request for comments.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☒ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: McGregor Dam (reservoir) is located approximately 60 miles northeast of the city of Williston in Williams County, North Dakota. It is an 57.5 acre man-made impoundment in the Lake Sakakawea sub-basin of the Missouri River basin of North Dakota (HUC 10110101). It was created by damming an unnamed tributary and was completed in 1969. McGregor Dam is listed on the State's 2008 303(d) list (ND-10110101-019-L_00) as impaired for aquatic life use by nutrients/eutrophication/biological indicators and sedimentation/siltation, and recreational use by nutrients/eutrophication. Data that was collected during the assessment showed that dissolved oxygen levels fell consistently below the State standard to the TMDL was written to address this impariment as well. The sedimentation/siltation impairent cause is proposed for delisting in 2010 based on data/information presented in the TMDL document. Approximately 5,492 acres of land drain to the reservoir from the watershed. It is classified as a Class 1 cold water fishery, and is listed as a high priority (i.e., 1A) for TMDL development. The majority of the land use in this watershed is agricultural (approximately 97 percent).

COMMENTS: The landuse percentages in the text of Section 1.3 do not match those in Table 3. The text on page 5 says that 97 percent of the landuse is agricultural and 3 percent is other landuses (e.g., farmsteads, hay, pasture). It also mentions that 82 percent of the watershed is "actively farmed" – we assume that actively farmed means farmed for crops (e.g., cropland as opposed to pasture or haylands). If 97% is agricultural and 82% is cropland, then 15% is other agricultural uses. These percentages don't match those in Table 3. In Table 3 the percent of landuse for canola, sunflowers, lentils/peas, and grains (i.e., cropland) is approximately 77%. Water, roads and farmsteads is about 5.5%, and CRP/pasture is about 17.5 percent. Also, it would be helpful to separate CRP landuse from pastureland, because typically pastureland is being actively used for livestock grazing whereas CRP lands are in reserve and not being used.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)).

Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☐ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: McGregor Dam is impaired for nutrients/eutrophication/biological indicators and dissolved oxygen. The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters of the state. The NDDoH narrative standards that apply to nutrients 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 which are toxic or harmful to humans, animals, plants, or resident aquatic biota." (See NDAC 33-16-02-08.1.a.(4))*
>
> *"No discharge of pollutants, which alone or in combination with other substances, shall:*
> *1. Cause a public health hazard or injury to environmental resources;*

2. Impair existing or reasonable beneficial uses of the receiving waters; or
3. Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters." (See NDAC 33-16-02-08.1.e.)

In addition to the narrative standards, the NDDH has set a biological goal for all surface waters of the state:
"The biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites." (See NDAC 33-16-02-08.2.a.)

Currently, North Dakota does not have a numeric standard for nutrients, however nutrient guidelines for lakes have been established. The nutrient guidelines for lakes are: NO3 as N = 0.25 mg/L; PO4 as P = 0.02 mg/L; and total phosphorus = 0.1 mg/L.

The numeric standard for dissolved oxygen is $\geq$ 5.0 mg/L (single sample minimum).

Other applicable water quality standards are included on pages 14 - 15 of the TMDL report.

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☒ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The main water quality target for this TMDL is based on interpretation of narrative provisions found in State water quality standards. In North Dakota, algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. Several algal species are considered to be nuisance aquatic species. TSI measurements can be used to estimate how much algal production may occur in lakes.   Therefore, TSI is used as a measure of the narrative standard in order to determine whether beneficial uses are being met.

The mean total phosphorus TSI for McGregor Dam during the period of the assessment was 77.60. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that a 50% reduction in phosphorus loading to the reservoir will achieve a total phosphorus TSI of 68.36, which corresponds to a phosphorus concentration of 0.086 mg/L. The 50% phosphorus reduction is also predicted to result in chlorophyll-a TSI of 54.99 and the Secchi disk TSI of 46.08. This should result in a change of trophic status for the reservoir from hypereutrophic to eutrophic during all times of the year. This target is based on best professional judgement and will fully support the beneficial uses of the reservoir.

The TMDL does not contain a target for sediment because the assessment concludes that the reservoir is not impaired for sediment. The report recommends removing McGregor Dam sediment as a cause of impairment from the next Section 303(d) list.

The water quality targets used in this TMDL are: **maintain a mean annual total phosphorus TSI at or below 68.36 (TP concentration ≤ 0.086 mg/L); and maintain a dissolved oxygen level of greater than or equal to 5 mg/L.**

COMMENTS: None.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL identifies the major sources of phosphorus as coming from nonpoint source agricultural landuses within the watershed. There are no known point source contributions in this watershed. An nutrients loading analysis was performed using the ANGPS model which looked at various agricultural land use and land management factors. Cropland and range/pasture/haylands are the primary sources identified.

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: In order to determine the cause and effect relationship between the water quality target and the identified sources, various models and loading analysis were utilized. The FLUX model was used to facilitate the analysis and reduction of the tributary inflow and the reservoir outflow water quality data for nutrients and sediment, as well as flow data into and out of McGregor Dam. Output from the FLUX program was then used as an input file to calibrate the BATHTUB eutrophication response model. The BATHTUB model was used to evaluate and predict the effects of various nutrient reduction scenarios, and the subsequent eutrophication response in McGregor Dam reservoir.

The BATHTUB model was used to predict the trophic response of McGregor Dam by reducing exteranlly derived nutrient loads. Once the BATHTUB model is calibrated using the tributary load estimates and the in-lake water quality estimates, the model can predict the total phosphorus concentrations, chlorophyll-a concentrations, and the Secchi disk transparency, and the associated TSI scores, as a means of expressing trophic response. Phosphorus was used in the initial set of simulation models based on its known relationship to eutrophication, and because it is controable with the implementation of watershed best management practices (BMPs). Simulated reductions were achieved by reducing concentrations of phosphorus and nitrogen in the contributing tributaries by 25, 50 and 75 percent while keeping the hydraulic discharge constant. The BATHTUB model predicted that a 50% reduction in external total phosphorus loads would result in attaining a eutrophic status in the reservoir. As a result of this modeling, the loading capacity for the reservoir was determined to be 59.7 kg/yr of phosphorus.

The Agricultural Non-Point Source Model (AGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The primary objective for using the AGNPS model were to: 1) evaluate nonpoint source contributions within the watershed; 2) identify critical pollutant source areas within the watershed; and 3) evaluate potential pollutant reduction estimates achievable from implementation of various BMP scenarios. The results from the nutrient loading source analysis identified 69 critical cells (i.e., those with fallow, small grains or land chiseled multiple times; feedlots; and all land with a slope greater than five percent – see Figure 14 in the TMDL document). A portion of the initial load reductions under this TMDL will be achieved through controls on the critical cells within the watershed to improve nutrient management, pasture conditions and tillage practices.

The technical analysis also addresses the McGregor Dam sediment listing. The analysis concludes that the reservoir is not impaired by sediment, and that it should be delisted from the state's Section 303(d) list. Justification for this action is based on: 1) the conclusion that the average total suspended solids (TSS) concentration in the tributary entering into McGregor Dam of 19.75 mg/L is not considered harmful to fisheries; and 2) the conclusion that the sediment accumulation rate in the reservoir is well below the average sedimentation rate of typical reservoirs - based on calculations of sediment balance and accumulation rates in the reservoir compared to NRCS and literature values.

Improvements in the dissolved oxygen concentration of the lake can be achieved through reduction of organic loading to the lake as a result of proposed BMP implementation. The TMDL contains a linkage analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorous load reduction target in McGregor Dam will address the dissolved oxygen impairment.

There are no permitted point sources in the watershed so it's not necessary to fully document reasonable assurance demostrating that the nonpoint source loadings are practicable.

COMMENTS: None.

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The McGregor Dam TMDL includes data summary tables in Sections throughout the document. The recent water quality monitoring was conducted over the period from June 2003 to October 2004.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☐ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: There are no permitted point sources in the McGregor Dam watershed. Therefore the WLA for this TMDL is zero (see Table 17 in the TMDL document).

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Technical Analysis section of the TMDL describes how the phosphorus loading capacity for the reservoir was derived. The loading capacity was derived from the current loading, the TSI target and the reduction response from the BATHTUB model. Most of the loading capacity was allocated to nonpoint sources in the watershed which is expressed as a LA of 53.73 kg/yr of phosphorus. Ten percent of the loading capacity was allocated as an explicit margin of safety equal to 5.97 kg/yr of phosphorus.

COMMENTS: None.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The McGregor Dam TMDL includes an explicit MOS derived by calculating 10 percent of the loading capacity. The explicit MOS for the McGregor Dam TMDL is 5.97 kg/yr of phosphorus.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing BMPs that can be tailored to seasonal needs.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. Copies of the draft TMDL were mailed to stakeholders in the watershed during public comment. Also, the draft TMDL was posted on NDoDH's Water Quality Division website, and a public notice for comment was published in two newspapers.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☐ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: McGregor Dam will be monitored once a watershed restoration plan is implemented and will be conducted beginning two years after implementation and extend until five years after the implementation project is complete (i.e., for a three year period).

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☐ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL Allocation section of the TMDL document includes a list of BMPs that are recommended to meet the TMDL loads. NDDoH typically works with local conservation districts or other cooperators to develop and implement a project implementation plan after the TMDL has been developed and approved.

There are no permitted point sources in the watershed so it's not necessary to fully document reasonable assurance demostrating that the nonpoint source loadings are practicable.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The McGregor Dam nutrient TMDL includes a daily phosphorus load expressed as 0.164 kg per day. The NDDoH believes that describing the phosphorus load as an annual load is more realistic and protective of the waterbody. Most phosphorus based eutrophication models use annual phosphorus loads, and seasonality and unpredictable precipitation patterns make a daily load unrealistic. EPA recognizes that, under the specific circumstances, the state may deem the annual load the most appropriate timeframe (i.e., the TSI water quality target is based on an interpretation of narrative water quality standards which naturally does not include an averaging period). EPA notes that the McGregor Dam TMDL calculations for phosphorus include an approximated daily load derived through simple division of the annual load by the number of days in a year**.** This should be considered an "average" daily load that typically will not match the actual phosphorus load reaching the reservoir on a given day.

COMMENTS: None.

Appendix E
NDDoH Response to Public Comments

Public Comments:

No public comments were received

EPA Region 8 Comment: "The landuse percentages in the text of Section 1.3 do not match those in Table 3. The text on page 5 says that 97 percent of the landuse is agricultural and 3 percent is other landuses (e.g., farmsteads, hay, pasture). It also mentions that 82 percent of the watershed is "actively farmed" – we assume that actively farmed means farmed for crops (e.g., cropland as opposed to pasture or haylands). If 97% is agricultural and 82% is cropland, then 15% is other agricultural uses. These percentages don't match those in Table 3. In Table 3 the percent of landuse for canola, sunflowers, lentils/peas, and grains (i.e., cropland) is approximately 77%. Water, roads and farmsteads is about 5.5%, and CRP/pasture is about 17.5 percent. Also, it would be helpful to separate CRP landuse from pastureland, because typically pastureland is being actively used for livestock grazing whereas CRP lands are in reserve and not being used."

North Dakota Department of Health Response: The information in the paragraph was gathered from general information, while the data in the table was specific to the land use satellite imagery data. The paragraph was corrected to reflect the specific numbers. It is not possible to differentiate between CRP and pasture land in the imagery data. While CRP lands are meant to be in reserve and not used, the CRP in North Dakota has been emergency hayed for almost the last 10 years due to disaster situations, so it is considered similar to pasture land.